# Supplemental Phase II Environmental Site Assessment and Human Health and Ecological Risk Assessment

Marystown Shipyard

Marystown, NL

Department of Municipal Affairs and Environment

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# Executive Summary

GHD was retained by the Newfoundland and Labrador Department of Municipal Affairs and Environment (NLDMAE) to carry out a Supplemental Phase II Environmental Site Assessment (ESA) and a Human Health and Ecological Health Risk Assessment (HHERA) at the Marystown Shipyard (Site or Property) located on the west side of Mortier Bay in the Town of Marystown, Newfoundland and Labrador (NL).

The scope of work was based on a Document Review, Data Gap Analyses, and Scope of Work Development previously completed by GHD in August 2018 and updated with the e-mail correspondence dated November 23, 2018. The project objectives were to complete a Supplemental Phase II ESA that included the collection of soil, sediment, groundwater, surface water and benthic invertebrate samples for laboratory analysis. The purpose of the assessment is to re-evaluate the Site conditions, close the data gaps identified where possible and use the new Site data collected to support the completion of a HHERA.

The findings from the October and December 2018 Supplemental Phase II ESA sampling program include:

- Remaining soil impacts from petroleum hydrocarbons (mTPH) on Site were reported above the Atlantic RBCA Tier I RBSLs. These samples were collected from on the north side of the assembly and erection building, north and south ends of the service building and in the fuel pump area.
- Chromium concentrations above the generic CCME screening levels were identified in two soil samples collected from the north side of the assembly and erection building and in the lower laydown area of the Shipyard.
- Elevated metals, PAHs and/or PCBs above the generic CCME sediment quality guidelines were reported in the sediment samples collected from the waterlot of the Shipyard.
- F2 carbon fraction and/or mTPH exceedances of the Atlantic RBCA Tier I RBSL and/or ESL criteria were reported in the groundwater from seven of the on-Site monitor well locations (MSBL-MW2-2018, MSBL-MW6, MFPA-MW1-2018, MAEB-MW2-2018, MGSB-MW15 and MGSB-MW17). The samples exceeding the guidelines were collected in the lower laydown area, fuel pump area, service building area, the south side of the general storage building and the north side if the assembly and erection building.
- Arsenic, Copper, Selenium and Zinc concentrations were reported to be above the Tier 2 FIGQG for commercial land use - marine exposure in the groundwater samples collected from five monitor well locations in the lower laydown area, the drum storage area and the north side of the assembly and erection building.
- Surface water samples collected from the waterlot had concentrations of chemicals of potential concern (COPCs) below applicable screening levels or were consistent with background conditions in the area.

- Anecdotal evidence indicates that shellfish harvesting, specifically scallops, occurs in Mortier Bay and macroinvertebrates were present throughout the waterlot. Detectable concentrations of several COPCs were identified in invertebrate tissue samples collected from the waterlot as well as reference locations. However, highly bioaccumulative COPCs such as mercury and PCBs were not detected in macroinvertebrates collected.

Based on the findings of the 2018 Supplemental Phase II ESA, GHD completed a HHERA to evaluate potential risks to human and ecological receptors.

### *HHRA*

Based on the HHRA, there are petroleum hydrocarbon concentrations present in the soil above the Human Health Screening Levels (HHSL) for the protection of indoor air at locations near the on-Site commercial buildings that require further assessment.

There are groundwater samples collected at the Site that have arsenic and vanadium concentrations greater than the commercial direct contact/ingestion HHSLs located in the lower laydown area of the Shipyard. There are also groundwater samples that exceeded the mTPH direct contact/ingestion HHSLs collected from monitor well MGSB-MW15, which is located on the south side of the general store building. As the on-Site groundwater is not being consumed, the only receptor with potential groundwater contact would be a construction worker.

The sediment located in the waterlot does not pose an unacceptable risk to the commercial worker receptors through direct contact pathway at the Site.

The HHRA indicated the consumption of shellfish collected from the waterlot are unlikely to pose a risk to human health based on current usage of the waterlot. However, the HHRA indicated that consumption of shellfish harvested from the waterlot, specifically scallops, could pose a risk to toddlers if consumed on subsistence or heavy consumer basis (5 days/week, 26 weeks per year). The shellfish consumption pathway was assessed based on measured concentrations of COPCs (e.g. cadmium) in composite samples of soft tissue and not specific to edible portions of shellfish. Using whole body tissue concentrations likely overstates the potential for risk as COPCs such as cadmium are known to preferentially accumulate in the digestive gland of scallops with substantially less concentrations being present in the edible portions of the shellfish such as abductor muscles. As indicated in literature provided by the Department of Fisheries and Oceans, Research Branch (J.F. Uthe and C.L. Chou, 1986), cadmium concentrations in abductor muscles typically constitute less than 1% of the total cadmium concentrations in the soft tissue of scallops. For the purposes of this risk assessment, it has been conservatively assumed that the abductor muscle is 10% of wholebody which would result in an EPC that is well below the SSTLs developed for both a toddler and adult receptor (subsistence, recreational/commercial consumption). It has also been noted that in the conditions of the DFO recreational/commercial licensing both commercial and recreational harvesters are not to consume any portion, other than the adductor muscle ("meat"), from scallops that are harvested from the shoreline and adjacent waters surrounding the province of NL. As such, it is reasonable to assume that the concentration of cadmium in the edible portion of scallops (abductor muscle) collected from the Site is well below concentrations that are considered to pose a potential risk to human health.

### *ERA*

Based on the results of the ERA, the concentrations of COPCs in sediment of the waterlot are not considered to pose an unacceptable risk to benthic invertebrates, fish, or aquatic wildlife through the direct contact and consumption exposure pathways.

If sediment is required to be excavated/removed to facilitate any future wharf upgrades, leachate analyses on the sediment has confirmed the dredged material is not classified as a toxic hazardous waste. As a result, the excavated dredged material meets the requirements outlined in the Guidance Document entitled "Protocol for the Management of Excavated Soils, Concrete Rubble and Dredged Materials (GD-PPD-045.2)" and can be disposed at an approved landfill facility, pending landfill approval.

Similarly, concentrations of COPCs in surface water of the waterlot were below applicable screening guidelines or reference conditions and considered to pose a low risk to ecological receptors. Based on the surface water analytical results, groundwater at the Site with elevated concentrations of metals and mTPH exceeding guidelines for groundwater discharging to an aquatic receptor are unlikely to pose an unacceptable risk to aquatic ecological receptors.

### *Recommendations*

The following recommendations are provided based on the results of the Supplemental Phase II ESA and HHERA:

- Conduct a groundwater monitoring program for seasonal variation including free product gauging in all of the on-Site monitor wells and recovery wells for analyses of petroleum hydrocarbons and metals (including mercury). A minimum of two monitoring events should be completed in the Spring and Summer months to assess seasonal variation and provide the analytical data to determine if a risk management plan is required.
- Due to the locations of the commercial buildings on the Site, it is recommended that the soil exceedance areas illustrated on Figures 5A to 5C be further assessed through the installation and seasonal sampling of soil vapour probes. A minimum of two monitoring events should be completed in the Summer and Winter months to assess seasonal variation and provide the analytical data to determine if a risk management plan is required.
- Although the maximum groundwater concentration (447 mg/L in MGSB-MW15, near the Carpenters & Joiners Building) does not exceed the indoor air inhalation HHSL, the groundwater at the Site is shallower than that assumed in the derivation of the HHSLs and therefore the HHSL may not be applicable, which may warrant further assessment. Although no free product was measured in groundwater during the field work, the groundwater concentration measured in MGSB-MW15 is indicative of the possible presence of free product in the area. Therefore it is recommended that consideration be given to further assessing the soil vapour to indoor air pathway in this area through the installation and seasonal sampling of soil vapour probes. Due to the monitor well's proximity to the existing building and the absence of elevated soil concentrations in the adjacent boreholes, sub-slab probes beneath the building may be preferred. As recommended above, a minimum of two groundwater events (to determine the presence/absence of free product) and a minimum of two soil vapour events would be required

to assess seasonal variation. If free phase product is detected, additional assessment would be required that includes installation of monitor wells for delineation purposes.

- It is recommended that a Risk Management Plan including Best Management Practices and a Site specific health and safety plan be developed to address possible contact with groundwater impacts should sub-surface work be required in the lower laydown area and the south side of the general store building, which specifically address arsenic, vanadium, and modified TPH. It is noted that no soil samples collected contained metals or petroleum hydrocarbons above the applicable HHSLs for direct contact; therefore, the sub-surface soil at the Site does not present a risk to construction workers.
- If a remedial program is not completed to address the soil and groundwater impacts at the Site, impacts should be risk managed or a Phase III ESA is recommended to delineate the soil and/or groundwater impacts to meet minimal site assessment requirements. The Phase III ESA program would include delineation of petroleum hydrocarbon and chromium soil impacts south of MAEB-MW2, petroleum hydrocarbon soil impacts east and south of MSBL-MW6/BH5, petroleum hydrocarbons soil impacts west of MFPA-MW1, chromium soil impacts north of MFPA-BH3, petroleum hydrocarbon soil impacts north, south and east of MLLA-MW3, as well as petroleum hydrocarbon impacts in groundwater north of MGSB-MW15. The Phase III ESA can be combined with the groundwater and soil vapour monitoring programs discussed above

Although outside the scope to develop an environmental liability for the Site, the following recommendations are carried forward from previous ESA programs reviewed as part of the data gap analyses:

- Any ASTs remaining on the Site and intended to be used, should be inspected to ensure they meet the requirements specified in the Newfoundland and Labrador Gasoline and Associated Products (GAP) and/or Heating Oil Storage Tank (HOST) Regulations for their intended usages.
- Although no major surface stains were noted in the areas assessed during the Supplemental Phase II ESA, any surface stains noted at the Site should be assessed or remediated as per provincial requirements.
- Any drums, containers or other vessels remaining at the Site should be collected and consolidated in designated Site areas and those no longer required should be disposed of at an approved facility.
- The scrap steel and debris, particularly in the lower laydown area and observed to be present in fill materials around the shoreline and ditching to the southwest of the lower laydown area, should be removed from the Site and disposed of at approved facilities.
- If existing buildings are to remain, an inspection of the existing septic sewer systems should be completed to ensure sewage discharges meet provincial regulations.
- Any ODS containing equipment or PCB containing light ballasts remaining at the Site should be disposed of in accordance with the applicable regulations.

- Although the underground fuel distribution lines on Site were documented to be drained, purged, capped and abandoned in place in 2000 and petroleum hydrocarbon impacts were not found along the pipelines in 2000, regulatory approval for abandonment in place would be required. This should be included in any future submissions for regulatory closure of the Site.

The statements made in this Executive Summary are subject to the same limitations included in Section 10.0 (Closure), and are to be read in conjunction with the remainder of this report.

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# 1. Introduction

GHD was retained by the Newfoundland and Labrador Department of Municipal Affairs and Environment (NLDMAE) to carry out a Supplemental Phase II Environmental Site Assessment (ESA) and a Human Health and Ecological Health Risk Assessment (HHERA) at the Marystown Shipyard (Site or Property) located on the west side of Mortier Bay in the Town of Marystown, Newfoundland and Labrador (NL). The purpose of this investigation is to re-evaluate the environmental Site conditions with the collection of additional soil, sediment and groundwater data to support the completion of the HHERA. A Site Location Map is included as Figure 1 and a Property Plan is presented on Figure 2.

The scope of work was based on a Document Review, Data Gap Analyses, and Scope of Work Development previously completed by GHD in August 2018 and updated with the e-mail correspondence dated November 23, 2018. The objectives of the Supplemental Phase II ESA were as follows:

- Complete a Supplemental Phase II ESA that included the collection of soil, sediment, groundwater and tissue samples for laboratory analysis. The purpose of the assessment is to re-evaluate the Site conditions and close any gaps identified.
- Use the new Site data collected to complete a HHERA.
- Complete the work within the specified timeframe.

## 1.1 Site Description

The Marystown Shipyard was established in 1968 and is located in Mortier Bay on the Burin Peninsula of NL. The Site was designed as different clusters of specialty buildings that collectively form the Shipyard and include several fabrication, storage, maintenance, and office buildings. The Site also includes a waterlot, yard areas, and areas for fuel storage and marine facilities with associated infrastructure. Based on information provided to GHD, the Shipyard has a total in-house fabrication area of 9,368 square metres ($m^2$) and a water frontage of approximately 330 metres (m).

The Site is surrounded by a mixture of residential and bulk storage tank farms to the north/northeast, a mixture of Shipyard parking areas and residential areas to the south, the waters of Mortier Bay to the east, and an access road (Ville Marie Drive) to the west. Access to the Shipyard is restricted to an access track leading from the parking area to the south, a coastal road leading to the Federal wharf just beyond the northeast corner of the Site, or by boat traffic to the Shipyard wharf.

The Site was originally created by infilling the former cove of Mortier Bay and is surrounded by steep rocky cliffs to the north, west, and south with elevations of 20 m above the Shipyard. The Site is relatively flat with surface drainage directed towards ditches surrounding the site that ultimately discharge to Mortier Bay. The Shipyard and surrounding properties are connected to the municipal water supply system. A Property Plan is shown on Figure 2.

## 1.2 Scope of Work

The scope of work for the Supplemental Phase II ESA and HHERA, based on the above objectives, included the following:

### 1.2.1 Supplemental Phase II ESA

GHD to complete a Supplemental Phase II ESA that will include the re-evaluation/assessment of the current on-Site soil, groundwater and sediment conditions as well as an assessment of the marine habitat and biological tissue within the waterlot associated with the Site. The chemicals of potential concern include petroleum hydrocarbons and metals in the soil and groundwater and petroleum hydrocarbons, metals, polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) in sediment and marine biological tissue. The chemicals of potential concern were identified based the historical shipyard activities and the results of past investigations.

### 1.2.2 Human Health and Ecological Risk Assessment (HHERA)

GHD to use the new Site data collected during the completion of the Supplemental Phase II ESA to complete a HHERA for the Site. The HHERA will evaluate the risk to both the human and ecological users of the Site based on the current Site data and aid in the development of environmental liability associated with the Site.

## 1.3 Assessment Standards

The Site former and current land use of the property is commercial/industrial.

Site soils are considered to be coarse-grained and groundwater resources are not used for human consumption; therefore, the Site is considered to be non-potable.

Regulatory guidance documents used for comparison against current analytical results are:

- Canadian Council of Ministers of the Environment (CCME), Canadian Soil Quality Guidelines (CSQGs) – Accessed online October 2018.
- Atlantic Risk-Based Corrective Action (RBCA) Tier I Risk-Based Screening Levels (RBSLs) for soil and groundwater – 2016.
- Atlantic RBCA Tier I Ecological Screening Levels (ESLs) for soil, sediment, groundwater and surface water, – 2016.
- Canadian Council of Ministers of the Environment (CCME), Interim Sediment Quality Guidelines (ISQGs) - Accessed online October 2018.
- Canadian Council of Ministers of the Environment (CCME), Probable Effects Levels (PELs) – Accessed online October 2018.
- Canadian Council of Ministers of the Environment (CCME), Water Quality Guidelines for the Protection of Aquatic Life (WQG), Marine and Freshwater - Accessed online January 2019.
- Federal Contaminated Sites Action Plan (FCSAP), Guidance Document on Federal Interim Groundwater Quality Guidelines (FIGQG) for Federal Contaminated Sites – June 2016.

# 2. Summary of Previous Investigations

Previous investigations were completed at the Site between 1997 and 2018 and are included the following table:

| Report Title | Consultant | Date |
|---|---|---|
| Phase I Environmental Site Assessment (ESA), Marystown Shipyard and Cow Head Facility | Jacques Whitford Environment Limited (JWEL) | 1997 |
| Phase II ESA, Marystown Shipyard and Cow Head Facility | JWEL | 1998 |
| Ecological Risk Assessment (ERA), Marystown Shipyard (Draft) | JWEL | 1999 |
| Asbestos Operations and Maintenance Program, Marystown Shipyard, Marystown, Newfoundland | JWEL | 2000 |
| Human Health Risk Assessment (HHRA) Program, Friede Goldman Newfoundland's Facilities at Marystown | JWEL | 2001 |
| Tank Removal and Replacement Program, Marystown Shipyard | JWEL | 2001 |
| Asbestos and Lead-Based Paint Abatement Program Friede Goldman Newfoundland Limited's Facilities, Marystown | JWEL | 2002 |
| Letter to Department of Industry, Trade and Rural Development (ITRD), Additional Testing and ERA Related to Marine Sediments, Marystown Shipyard | JWEL | 2002 |
| Phase I ESA, Marystown Shipyard and Cow Head Facility | JWEL | 2002 |
| Paint Assessment, Carpenter and Joiner's Building, Marystown Shipyard | Stantec (Formerly JWEL) | 2009 |
| Paint Assessment, Maintenance Building, Marystown Shipyard | Stantec | 2010 |
| Lead Paint Abatement, Carpenter and Joiners Building and Maintenance Building, Marystown Shipyard | Stantec | 2011 |
| Document Review, Data Gap Analysis, and Scope of Work Development, Marystown Shipyard, Marystown, Newfoundland and Labrador | GHD | 2018 |

GHD completed a detailed review of the documents provided, which are listed in the table above. The following is a summary from the historical Phase I ESAs detailing the yard areas and waterlots.

### *Yard Areas*

The Site was used as a wooden boat building facility complete with a sawmill prior to development as the Marystown Shipyard in the 1960s. The following issues were documented in the 1997 Phase I ESA:

- The presence of six underground storage tanks (USTs), several aboveground storage tanks (ASTs) and waste oil tanks, and underground fuel lines on the Site.
- The presence of several waste oil storage areas and several drum storage areas on the Site.
- The former presence of a foundry at the Murley Building.

- The presence of staining on exterior soil, asphalt and concrete surfaces throughout the Site. Significant surface staining was observed in the vicinities of the six former USTs, to the west of the Main Shed, in the lower laydown area, and in the steel and drum storage area to the north of the Outfit & Stores Building (in the vicinity of the waste oil storage area).
- The use of creosote piles on Site.
- The storage of sandblast grit and other debris at various Site locations.

An extensive subsurface investigation was conducted on Site during a Phase II ESA in 1998 to investigate these issues. Soil and/or groundwater were tested at various Site locations for petroleum hydrocarbons, PCBs, metals, PAHs and volatile organic compounds (VOCs). The results of the Phase II ESA confirmed that petroleum hydrocarbon impacts were present in soil in several areas of the Site (the UST locations, drum storage areas and the lower laydown area) and metals impacts were present in soil in some of the areas (drum storage area and lower laydown area). Free-phase petroleum products were also present at three locations on the Site in the vicinity of the USTs.

A Human Health Risk Assessment (HHRA) completed for the Site in 1999 established Site-specific target levels (SSTLs) for petroleum hydrocarbon impacts and evaluated the acceptability of the detected levels of metals. The results of the HHRA indicated that the detected levels of metals on the Site were acceptable for the Site usage and the detected levels of petroleum hydrocarbons were acceptable except in near-surface soils (less than 1 m deep) in the refuelling area, provided the identified free-phase product was removed from the Site.

Six USTs and two ASTs were removed from the Site in 2000. The underground fuel distribution line was drained, purged, capped and abandoned in place in at that time. A soil remediation program was also conducted in the refuelling area to remove the petroleum hydrocarbon impacted soil within 1 metre from the ground surface. Soil remediation was also conducted in the immediate vicinities of the six former USTs to remove soil that was heavily impacted with petroleum hydrocarbons. No other remediation of the surface stained soils identified on Site in 1997 was conducted in accordance with the results of the HHRA. Recovery wells were installed at three Site areas in 2000. As of February 2002, product recovery had been ongoing, that was complete in two of the areas; some free product remained in the refuelling area.

A lead paint survey was conducted in 1999 for the buildings located at the Shipyard. The lead survey indicated the presence of lead in paint in the Main Shed Building, the Outfit & Stores Building (now referred to as the Carpenters and Joiners Building); the Services Building (now referred to as the Maintenance Building) and the Parts Building. Most of the painted surfaces in the Services Building, Parts Building and Outfit & Stores Building were in good condition. Some of the paint in the Main Shed Building and Outfit & Stores Building was in poor condition with extensive scaling and peeling paint. Leachability testing indicated that paints in the Main Shed Building, the Outfit & Stores Building and the Parts Building contained leachable lead and; therefore, were considered to be a hazardous material for disposal purposes. A lead-based paint abatement program was conducted in 2001 and included the complete removal of accessible paints in areas where the existing paints were extensively damaged (i.e., Main Shed Building and portions of the Outfit & Stores Building). In other areas of the Site, the abatement program was limited to the removal of damaged paints only. Paint assessments of the Carpenter and Joiners Building and

Maintenance Building were conducted in 2009/2010 when excessive amounts of interior paints had fallen off inside the buildings within a one year period. A lead-based paint abatement program was performed at the Site in 2011 and included the removal and disposal of all loose, scaling or easily removed paints on the interior walls, floors and ceilings of the Carpenter and Joiners Building and Maintenance Building with the exception of painted interior galvanized roof and wall panels where all paints were removed.

An Asbestos Operations and Maintenance program was developed by JWEL in 2000 to assist Site personnel to safely perform their job function when working near asbestos-containing materials (ACMs). An asbestos abatement program was then conducted at the Shipyard in 2001 and included the removal and disposal of all known friable ACMs from the Main Shed Building, the Syncrolift Building, the Services Building and the Administration Building, with the exception of short sections of friable pipe insulation which was left in concealed wall spaces in eight locations in the Administration Building. The abatement program also included the removal and disposal of friable ACMs from pipelines above ceilings in offices and washrooms in the lower floor of the Outfit & Stores Building as necessary.

### *Waterlots*

The property at the Marystown Shipyard includes two nearshore waterlots near the wharf areas. A dive survey, as part of the 1998 Phase II ESA, indicated the presence of various debris, including old lead-acid batteries and paint cans in the waterlots around the Site.

Analysis in 1998 and 1999 indicated that sediments in the area were impacted by heavy metals and PAHs and would not be suitable for ocean dumping; the sediments would be considered as hazardous waste if disposed of at onshore facilities. A draft screening level ERA was completed for the impacted sediments; however, as of 2002 the report had not been finalized. Environment Canada indicated that additional samples would be required in the marine area near the Site (including sampling of control sites) before remedial options could be evaluated for the impacted sediments.

GHD completed a document review to identify any data gaps that may need to be addressed to document the current liability estimate at the Site in 2018. Based on GHD's review of the historical environmental reports, the following summary of outstanding issues were noted:

- The presence and/or absence of free-phase product in the recovery wells located on the south side of the Main Administration and Security Office (MASO) and the south side of the General Stores Building (MGSB) is to be confirmed.
- The soil and groundwater for petroleum hydrocarbons in the vicinity of the previous soil remediation areas at MGSB, MASO, Assembly and Erection Building (MAEB), Service Building (MSBL) and Fuel Pump Area (MFPA), as well as the previously identified petroleum hydrocarbon impacted areas at Lower Laydown Area (MLLA), MAEB, and Drum Storage Area (MDSA) require re-assessment.
- Soil and groundwater in the vicinity of the areas previously identified metal impacts at MLLA, MDSA, and MAEB require re-assessment.

- Sediment in the waterlot is to be re-assessed to confirm the presence or absence of petroleum hydrocarbons, metals, PAHs and PCBs.
- Previously debris was previously identified in the waterlot, debris in the nearshore waterlots should be collected and be disposed of at approved facilities.
- Aboveground storage tanks (ASTs) were present on the property during the previous ESA programs. The ASTs were noted in the previous studies to not be properly dyked, and therefore do not comply with the Newfoundland and Labrador Gasoline and Associated Products (GAP) Regulations for their intended usages. The installation of suitable secondary containment or removed the tanks from the Site is recommended.
- Various drums and containers of petroleum products (some full and some partly used) were observed at various locations throughout the Site during previous studies. Petroleum products should be collected and consolidated in designated Site areas and those no longer required should be disposed of at an approved facility.
- Various steel and other debris was noted to be stored on Site during previous assessments, particularly in the lower laydown area, the northern part of the Site and along the shoreline. Various debris was observed to be present in fill materials around the shoreline and in the lower laydown area. The scrap steel and debris should be removed from the Site and disposed of at approved facilities. Future infilling on Site should be completed with clean debris-free fill materials.
- Waste oil and liquid hazardous waste (i.e. waste paint thinners and degreasers) were noted to be stored in tanks and 200 L capacity drums in various locations on the Site. These waste liquids were reported to be collected from the Site regularly by an approved waste disposal contractor. All containers of liquid wastes on Site should be collected, identified by sampling if necessary and sent to an approved disposal facility. During normal operation, all containers of liquid waste should be stored on the designated storage pad. Proper workplace hazardous materials information system (WHMIS) labelling should be present on all containers used to store liquid wastes. All containers used to store liquid wastes should be properly sealed.
- The Site (exterior and interior) is to be inspected for evidence of spills and stains, based on past observations. If spills or stains are identified, they should be cleaned or removed.
- If the refueling pumps are no longer required, the surface stained soils in the vicinities of the dispensing pumps should be remediated to meet the applicable screening criteria. If still in operation, a spill containment system (e.g., spill containment trays and hydrophobic absorbent pads) should be installed at the dispensing pumps to prevent future spillage onto the ground.
- Past oil staining was observed in the lower laydown area, in an area of stored waste oil drums to the west of the Syncrolift Building and in the vehicle parking areas. It is also possible that oil stains were present in other areas on the Site. If required, remediation of surface stained areas, through removal of the stained soil, should be conducted.
- The previous assessments revealed the septic system discharged to a drainage ditch on Site which does not comply with provincial regulations. A design and specifications had been completed to extend the sewer line from the tank with an outfall in Mortier Bay. Based on information provided to GHD, the installation of the sewer line and outfall has not been

completed to date. Make the required modifications at the septic tank to comply with provincial regulations (i.e., install a new sewer line from the on-Site septic tank, with an off-shore outfall in Mortier Bay).

- Based on previous studies, the lower floor of the Parts Building contained a sump which discharged to Mortier Bay via a floor drain. There was visible oil spilled into the sump and drain during the previous field programs. A clean up the spilled oil in the area was recommended. In addition, it was recommended to block the drain or otherwise prevent oil entry into Mortier Bay if oil products were to continue to be stored in this area.
- No oil/water separator was present in the Side Transfer area. Drainage from the area discharges to Mortier Bay and can contain waste oil and/or bilge from vessels under repair in the area. It was recommended to consider the installation of an oil/water separator in the Side Transfer area to prevent incremental impacts in the nearshore marine area.
- Due to the age of Site buildings, PCBs may be present in ballasts in fluorescent and high-pressure light fixtures. During any light fixture removal or replacement, any ballast identified as containing PCBs should be disposed of by an approved contractor. Suitable precautions and approved contractors should be used for PCB handling.
- A detailed asbestos survey confirmed the presence of friable and non-friable ACMs in various Site buildings. Previous reports recommended following the Asbestos Operations and Maintenance Program when carrying out activities on Site that may disturb known or suspected ACMs. Suitable precautions and approved contractors should be used for asbestos handling.
- A detailed lead survey had confirmed the presence of lead-based paints in various Site buildings. A major remediation of lead-based paints was completed on Site in 2001, and again in 2011 to remove identified lead-based paints that were in poor condition. Lead-based paints are known to remain in the Outfit & Stores Building (now referred to as the Carpenters & Joiners Building), the Parts Building and the Services Building (now referred to as the Maintenance Building). Lead may be present in paints that were not tested during the paint survey (e.g., paints in small sheds and trailers, paints on ceilings and structural steel that were in good condition). A Lead Operations and Maintenance Program had been developed for the Site. Follow the Lead Operations and Maintenance Program when carrying out activities on Site that may disturb known or suspected lead-based paints. Suitable precautions and approved contractors should be used for lead handling. If buildings have been vacant for a period of time, an inspection should be completed of painted surfaces remaining to confirm the paint is still in good condition (i.e. not peeling or flaking).
- The ozone depleting substance (ODS) containing equipment identified on the Site should be removed from any abandoned units and the units should be disposed of properly. Suitable precautions and approved contractors should be used for ODS handling.
- A cylinder of tetra Fluor HF1340 was observed at the compressed gas storage area. If the cylinder remains, it should be removed from the Site if it is no longer required.
- The underground fuel distribution lines on Site were noted to be drained, purged, capped and abandoned in place in 2000. Petroleum hydrocarbon impacts were not found along the pipelines except at the locations of former USTs, which were removed in 2000. Soil removal

was carried out in the former tank areas. Regulatory approval has not yet been received for the pipeline abandonment. Confirm the analytical results in the area of the abandoned fuel pipeline and, if favourable, submit for Regulatory closure.

Based on the results of the document review and recommendations, GHD developed a work plan and scope document to address the data gaps identified that involve environmental liability at the Site. The objectives of the work program are as follows:

- To become familiar with the Site and review the data gap analyses; and/or delineate and quantify previously identified impacts in the soil, groundwater and sediment at the Site.
- To inspect, sample and update the previously completed Hazardous Materials Study completed at the Site – this to be completed as a separate report.
- To produce a detailed report outlining methodology used in obtaining the samples, sample Quality Assurance/Quality Control (QA/QC); the analytical results of the current sampling events and to compare to the current applicable human health and ecological based guidelines.
- To update/complete a revised Human Health and Ecological Risk Assessment (HHERA) for the Site.
- To provide a liability estimate for the Site, under separate cover, based on the results of the new data collected.

Although outside the scope to develop an environmental liability for the Site, the following recommendations are to be carried forward from the data gap analyses:

- Any ASTs remaining on the Site and intended to be used, should be inspected to ensure they meet the requirements specified in the Newfoundland and Labrador GAP and/or Heating Oil Storage Tank (HOST) Regulations for their intended usages.
- Although no major stains were noted in the areas assessed during the Supplemental Phase II ESA, any stains noted at the Site should be assessed or remediated.
- Any drums, containers or other vessels remaining at the Site should be collected and consolidated in designated Site areas and those no longer required should be disposed of at an approved facility.
- The scrap steel and debris, particularly in the lower laydown area and observed to be present in fill materials around the shoreline and ditching to the southwest of the lower laydown area, should be removed from the Site and disposed of at approved facilities.
- If existing buildings are to remain, an inspection of the existing septic sewer systems should be completed to ensure discharges meet provincial regulations.
- Any ozone depleting substance (ODS) containing equipment or PCB containing light ballasts remaining at the Site should be disposed of in accordance with the applicable regulations.
- Although the underground fuel distribution lines on Site were documented to be drained, purged, capped and abandoned in place in 2000 and petroleum hydrocarbon impacts were not found along the pipelines in 2000, regulatory approval is required. This should be included in any future submissions for regulatory closure of the Site.

# 3. Site Reconnaissance

On September 28, 2018, GHD conducted a Site walkthrough to locate and identify previously installed monitor wells at the Site prior to the drilling program. Based on information provided to GHD, there were 14 monitor wells and five recovery wells previously installed on the Site. Following the Site inspection, GHD personnel located four of the 14 previously installed monitor wells (MW-7, MDSA-MW9, MGSB-MW15 and MGSB-MW17) and two recovery wells (RW1 and RW2) located near the main administration and security office building. All monitor wells and recovery wells appeared to be in good condition. The surrounding areas adjacent to RW1 and RW2 were found to be overgrown with vegetation; however, a visual inspection revealed the recovery wells were sealed with metal covers and contained groundwater. Based on the observations and depths to groundwater, the recovery wells appeared to be functioning in an active capacity. Site photographs are included in Appendix A.

In addition to an inspection of the previous monitor wells, GHD also completed a safety inspection to determine the location of underground services, most notably underground services in areas of the proposed drilling program as well as document any signs of underground storage tanks (USTs), surface staining and/or general debris discussed in the previous ESA reports. Based on the Site inspection, it was determined that a number of proposed locations would require the use of a private locating subcontractor to clear areas prior to completing the subsurface drilling program. No surface soil staining or observations of fill/vent pipes associated with USTs were noted. Various steel and other debris was stored on Site, particularly in the lower laydown area as well as observed to be present in fill materials around the shoreline and ditching located along the southwest edge of the lower laydown area.

Following the initial Site walkthrough, a GHD representatives completed a secondary Site reconnaissance on December 12 and 13, 2018, to obtain information on the local community utilization of the waterlot portion of the Site and to collect biological tissue and surface water samples from the waterlot. At this time, several interviews were conducted with municipal representatives as well as local fishermen and residents that utilize the waterlot and were present at the Site during the December 2018 Site investigation. A summary of the major findings from the interview are presented below.

- There are no beaches located within the waterlot and swimming does not occur within the waterlot.
- A scallop bed is reportedly located within the Mortier Bay and commercial shellfish (scallops) harvesting does occur within the bay in the vicinity of the Site waterlot.
- Fishing generally does not occur within the Site waterlot but residents reported that fishing from the Transport Canada wharf located directly north of the Site does occur occasionally. Fish harvested from the Transport Canada wharf was reported to generally be limited to migratory sea trout.
- Approximately 250 metres northeast of the waterlot, a small quantity of lobster is commercially harvested within Mortier Bay and pot lines continue to extend northeast following the shoreline.
- Small recreational boats traverse the waterlot during the summer months.

- There are no municipal storm sewer or sanitary discharges located within the waterlot. However, Site related sanitary discharges as well as other effluents may discharge to the waterlot.

# 4. Supplemental Phase II Environmental Site Assessment (ESA)

The field work associated with the Supplemental Phase II ESA program was completed between October and December 2018, and involved the following:

- The advancement of 41 boreholes, of which 12 were installed as monitor wells, using a geotechnical drill rig.
- Continuous sampling of soil from the boreholes and submission of select samples for chemical analyses.
- A Site survey completed by Gary Templeton Surveys Ltd which included the collection of GPS coordinates of the new borehole/monitor well locations, existing monitor wells, existing recovery wells and selected Site features.
- Gauging for the presence of free phase product and sampling of groundwater from each monitoring well (new and pre-existing) as well as all recovery wells located on Site.
- Collection of 18 sediment samples in the area of the wharf structures referred to as the waterlot (including 3 step-out samples) and three reference sediment samples collected outside the Marystown Shipyard property boundary in Mortier Bay.
- Collection of seven sediment samples from the waterlot and one sample from a reference area for benthic invertebrate taxonomic evaluation. The benthic invertebrate sample locations were co-located with the bulk sediment samples collected for chemical characterization.
- Collection of 12 benthic invertebrate samples from the waterlot and three samples from the reference area for chemical analysis of invertebrate tissue. The intended scope of work for the project also included the collection of fish from the waterlot and reference areas for tissue analysis but fish were not observed to be present in the waterlot at the time of sampling.
- Collection of five surface water samples from the waterlot and two samples from the reference area for selected chemical analysis.

It is noted that due to time constrictions, physical impairments (i.e. rock cliffs, Site buildings, shorelines, etc.), surface covering at the Site (i.e. asphalt and/or concrete) and the shallow soil conditions encountered during the drilling program, it was decided to complete boreholes in place of the delineation test pits proposed for the Site. If visual or olfactory observations revealed soil and/or groundwater impacts, additional boreholes were completed to delineate impacts, were applicable.

A photographic log of the 2018 Supplemental Phase II ESA activities is presented in Appendix A. A Site plan with the soil and groundwater sample locations is shown as Figure 3. Site plans showing the sediment sample locations from the waterlot and the reference area are shown on Figures 4A and 4B; respectively. The surface water sample locations as well as the benthic invertebrate community samples are also included on Figures 4A and 4B.

## 4.1 Soil

### 4.1.1 Borehole Program

During the period of October 2 to 10, 2018, a total of 41 boreholes with 12 completed as monitor wells were advanced using a geotechnical drill rig. The borehole/monitor well locations are identified on Figure 3. It is noted that GHD personnel located four existing monitor wells (MW7, MDSA-MW9, MGSB-MW15 and MGSB-MW17) during the Site reconnaissance program. As a result, the monitor wells proposed in these locations were changed to boreholes to allow for collection of soil samples in these areas.

The boreholes were constructed to further characterize and delineate the areas of petroleum hydrocarbon and/or metal impacted soil historically identified on the Site. The boreholes were advanced to depths ranging from 1.8 metres to 5.1 metres below ground surface. The borehole logs are included in Appendix B.

### 4.1.2 Borehole Location Survey

As part of the Supplemental Phase II ESA, the borehole locations were surveyed by Gary Templeton Surveys Ltd. The GPS coordinates for the newly constructed and existing monitor wells are provided in Table 1 and/or in the borehole logs included in Appendix B.

### 4.1.3 Soil Sampling Program

The following acronyms were used to describe the sample locations:

- MSBL = Marystown Shipyard Service Building
- MLLA = Marystown Shipyard Lower Laydown Area
- MASO = Marystown Shipyard Main Administration and Security Office
- MAEB = Marystown Shipyard Assembly and Erection Building
- MGSB = Marystown Shipyard General Stores Building
- MDSA = Marystown Shipyard Drum Storage Area
- MFPA = Marystown Shipyard Fuel Pump Area
- MNMA = Marystown Shipyard Nearshore Marine Area
- 2018 = 2018 (year of sampling)
- MW = monitor well
- BH = borehole
- SS = soil sample

Hence, the sample designation MSBL-MW1-2018-SS1 refers to the first soil sample collected from monitor well 1 location at the Marystown Shipyard Service Building (MSBL) in 2018.

Soil samples were collected from each borehole on a continuous basis (0.6 m intervals) where possible. Select soil samples submitted for benzene, toluene, ethyl benzene, xylenes (BTEX) and total petroleum hydrocarbon (TPH) fraction ($C_6$-$C_{10}$) analysis were measured using a 10 mL Terra Core™ Sampler to collect an approximate 10 gram soil core. The soil core was immediately field preserved by placing it into a 40 mL clear glass vial containing 10 mL of purge and trap grade methanol. Samples collected for modified (m) TPH (>$C_{10}$-$C_{32}$) and metal analysis were collected with zero headspace in glass jars with Teflon lined lids. All sample containers were supplied by the laboratory.

The sample containers intended for laboratory analysis were maintained in cool dark storage for shipment to the laboratory. Samples not submitted for laboratory analysis were archived for potential future analysis.

To minimize the potential for cross-contamination, all sampling equipment was thoroughly rinsed between each sampling event. Disposable nitrile gloves were worn during all sampling work.

The soil analytical results are discussed below.

#### 4.1.4 Quality Assurance/Quality Control (QA/QC) Sampling Program

The Quality Assurance/Quality Control (QA/QC) Program consisted of the collection of duplicate samples, cleaning of sampling equipment between each sampling event location, and the use of new nitrile gloves for each sample.

All soil samples collected during the sampling program were assigned a unique sample identification, logged onto a chain-of-custody form, placed inside a cooler on ice and transported to AGAT Laboratories (AGAT) for analysis. AGAT is certified by Canadian Association of Laboratory Accreditation (CALA).

Duplicate samples were collected where possible during the soil sampling program for the Site. One blind field duplicate (MAEB-MW2-2018-DUP01) of MAEB-MW2-2018-SS4 was collected during the field program that was analyzed for petroleum hydrocarbons. It is noted that field duplicates were limited based on low recoveries encountered in the split spoon sampler during the borehole drilling program.

### 4.2 Groundwater

As noted above, GHD conducted a Site walkthrough to locate and identify previously installed monitor wells and/or recovery wells at the Site prior to the drilling program. GHD personnel located four existing monitor wells (MW7, MDSA-MW9, MGSB-MW15 and MGSB-MW17) and two recovery wells (RW1 and RW2) located near the main administration and security office building prior to the 2018 drilling program. All monitor wells and recovery wells appeared to be in good condition and were functioning in an active capacity at the time of the field program.

#### 4.2.1 Fluid Level Gauging/Surveying

Water level measurements, including direct measurement of any existing light non-aqueous phase liquids (LNAPLs, or free product, if present) were conducted prior to sampling, this information is presented in Table 1. Groundwater level measurements were carried out using an oil/water interface probe (Solinst Model 122). Gauging was conducted on October 11, 2018 and October 26, 2018 by lowering the clean probe down into each monitor well and/or recovery well until a tone was obtained indicating a liquid had been contacted. The depth at which a tone was first sounded was then carefully noted to the nearest millimeter (mm). Each newly installed monitor well was surveyed in relation to an assumed elevation benchmark by Gary Templeton Surveys Ltd. Using this information, the groundwater elevations relative to the Site were determined. Free phase product was not identified in any of the gauged monitor wells during the field program.

### 4.2.2 Groundwater Sampling

The newly constructed wells and the pre-existing wells were monitored on October 11, 2018 and sampled on October 12, 2018. The two previously installed recovery wells were also monitored and sampled on October 26, 2018. The monitoring included measurements of water levels, and the presence or absence of free phase product.

The depth to the water table and presence or absence of free product in the wells were determined with a Solinst electronic interface probe that was cleaned with a non-toxic, biodegradable cleaner/degreaser, then rinsed with clean tap water, between monitoring wells.

If measurable free product is observed in any well, a groundwater sample is not collected from that well. However, groundwater samples are collected from wells if petroleum hydrocarbon sheen is observed.

The monitor wells were then developed by removing three well volume equivalents of groundwater prior to sample collection. The monitor wells were allowed to recover and sampled using dedicated, disposable bailers. The groundwater samples were collected in laboratory supplied bottles and placed in coolers with ice immediately after they were collected and forwarded to AGAT for analyses of BTEX/TPH and/or metals.

## 4.3 Sediment

October 19, 2018, a total of 15 sediment samples were collected adjacent to the shoreline and wharf area located near the Marystown Shipyard, referred to as the waterlot. Three reference samples were also collected approximately 1,000 and 1,200 metres to the east of the Shipyard waterlot in Mortier Bay. Between December 12 and 13, 2018, additional sediment samples were collected at three locations immediately adjacent to the waterlot boundary and referred to as “step-out” samples. In addition to the step-out sediment samples for chemical characterization, selected sediment sample locations were also resampled from the waterlot and reference area for benthic invertebrate taxonomic evaluation. The sediment samples collected for benthic community characterization were co-located with bulk sediment samples collected for chemical characterization during the October sampling event. Site plans showing all sediment sample locations and GPS coordinates are presented on Figure 4A (Waterlot) and Figure 4B (Reference).

Professional divers, Sparkes Subsea Construction (Sparkes) from Corner Brook, NL were hired by GHD to collect the sediment samples at predetermined locations. In addition to collection sediment samples, Sparkes also recorded descriptions, videos and photos of the sediment samples being collected, bottom substrate and general aquatic habitat for each sample location.

A summary of the substrate, macrofauna and macroflora observed at each sample location in the Harbour and reference locations is provided in Table 4-1. Biota listed in the referenced table includes biota reportedly observed by diver, biota observed by GHD staff during sediment sample processing as well as biota observed during the review of the diver video. Identification was dependent on quality of video and prominence of identifying characteristics. Sedentary and mobile fauna were enumerated where possible and estimated for abundancy as follows:

- Abundant – Numerous observations of individuals made throughout the entire section.
- Common – Numerous observations of individuals made intermittently along the section.
- Occasional – Quantifiable observations of individuals made intermittently along the section.
- Uncommon – Quantifiable observations of individuals made infrequently along the section.

*Based on Simkanin et al. (2005) Abundant, Common, Frequent, Occasional and Rare (ACFOR) scale.*

Photos and video footage were collected and utilized to describe flora/fauna and substrate conditions at each sample location (refer to Table 4-1 and Diver's Reports in Appendix H).

### 4.3.1 Sediment Sampling

#### *Chemical Analysis*

Fifteen sediment samples (18-MNMA-SS1 to 18-MNMA-SS15), three step-out samples (18-MNMA-STEP1 to 18-MNMA-STEP3) and three reference sediment samples (18-MNMA-REF1 to 18-MNMA-REF3) were collected from the top 0.10 metres of the sediment encountered at the pre-selected sample locations.

All sediment samples collected including the reference samples were analyzed for petroleum hydrocarbons, PAHs, metals, PCBs, and fraction of organic carbon (FOC). Several of the sediment samples collected were also submitted for metals leachate analysis. All samples were submitted to AGAT in St. John's, NL for analysis.

All sediment samples collected during the sampling program were logged onto a chain-of-custody form, placed inside a cooler on ice and transported to the laboratory for analysis. As required, standard equipment decontamination procedures were followed to prevent or minimize cross-contamination.

#### *Benthic Invertebrate Taxonomic Evaluation*

A total of 7 sediment samples were collected from the waterlot for benthic invertebrate taxonomic evaluation (18-MNMA-BMI1, 18-MNMA-BMI3, 18-MNMA-BMI5, 18-MNMA-BMI6, 18-MNMA-BMI11, 18-MNMA-BMI12, and 18-MNMA-BMI14). One sediment from the reference area (18-MNMA-BMI-REF2) was also collected for benthic invertebrate taxonomic evaluation. The samples collected for benthic invertebrate evaluation were co-located with the bulk sediment samples collected for chemical characterization. Samples were collected by certified divers in 10 litre (L) plastic pails with sealable lids and brought to surface. GHD washed the samples in the field using a 0.5 millimetre (mm) sieve screen to remove fines and reduce the volume of sediment requiring preservation and subsequent sorting by the taxonomist. The washed sediment was transferred to 1 L glass mason jars and preserved in the field using a 10% buffered formalin solution. The preserved samples were then submitted to Dr. Mike Dadswell in Chester, NS, for taxonomic identification and enumeration.

#### 4.3.2 Quality Assurance/Quality Control (QA/QC) Sampling Program

The QA/QC Program consisted of the collection of duplicate samples, cleaning of sampling equipment between each sampling event/location, and the use of new nitrile gloves for each sample.

All sediment samples collected during the sampling program were assigned a unique sample identification, logged onto a chain-of-custody form, placed inside a cooler on ice, and transported to the laboratory for analysis.

Duplicate samples were collected at a 10% frequency for the entire sediment sampling program for the Site. Three blind field duplicate (18-MNMA-DUP1, 18-MNMA-DUP2 and 18-MNMA-DUP3) of 18-MNMA-S6, 18-MNMA-S11 and 18-MNMA-STEP3; respectively, were collected during the field program that were analyzed for petroleum hydrocarbons, PAHs, metals, PCBs, and FOC.

Table 4-1 Sediment Sample Location Descriptions and Biota Observed

| Sample ID | Water Depth (metres) | GPS Coordinates | | Description (sediment substrate) | Biota Observed |
|---|---|---|---|---|---|
| | | Latitude | Longitude | | |
| **Waterlot** | | | | | |
| 18-MNMA-S1 | 14 | 47° 9’ 49.22” | 55° 8’ 58.71” | Brown Silt with Gravel over Black Mud, , Shell Debris, Plastic Bag, Glass Bottle | Periwinkles (occ.), Rock Crab, Scallops (r.), Sea Star (r.), Eel Grass (com.), Tubed Weed (com.), Kelp (com.), Coraline Algae (occ.) |
| 18-MNMA-S2 | 14 | 47° 9’ 50.39” | 55° 8’ 57.95” | Brown Silt with Gravel over Black Mud, Shell Debris | Periwinkles (r.), Rock Crab, Scallops (r.), Sea Star (r.), Eel Grass (occ.), Tubed Weed (com.), Kelp (com.), Coraline Algae (com.) |
| 18-MNMA-S3 | 25 | 47° 9’ 51.42” | 55° 8’ 57.38” | Brown Silt over Black Mud, Shell Debris | Periwinkles (occ.), Scallops (r.), Sea Star (r.), Eel Grass (r.), Tubed Weed (com.), Kelp (com.) |
| 18-MNMA-S4 | 31 | 47° 9’ 51.77” | 55° 8’ 55.90” | Brown Silt over Black Mud | Periwinkles (r.), Rock Crab, Sea Star (r.), Scallops (r.), Eel Grass (r.), Tubed Weed (occ.), Kelp (com.), Coralline Algae (occ.) |
| 18-MNMA-S5 | 23 | 47° 9’ 50.82” | 55° 8’ 54.92” | Brown Silt with Minor Gravel over Black Mud, Aluminum Can, Shell Debris | Periwinkles (r.), Rock Crab, Scallops (r.), Sea Star (r.), Eel Grass (r.), Tubed Weed (r.), Kelp (com.), Coraline Algae (com.) |
| 18-MNMA-S6 | 32 | 47° 9’ 51.27” | 55° 8’ 53.71” | Brown Silt with minor Gravel over Black Mud, Old Metal Grate, Shell Debris, Old Plastic Fish Tote | Periwinkles (r.), Rock Crab, Scallops (r.), Sea Star (r.), Sea Cucumber (r.), Eel Grass, Tubed Weed (r.), Kelp (com.), Coral (r.), Coraline Algae (occ.) |
| 18-MNMA-S7 | 30 | 47° 9’ 50.29” | 55° 8’ 52.52” | Brown Silt with gravel over Black Mud, Shell Debris | Periwinkles (occ.), Sea Star (r.), Rock Crab (r.), Scallops (r.), Tubed Weed (r.), Kelp (occ.), Coraline Algae (com.) |

### Table 4-1 Sediment Sample Location Descriptions and Biota Observed

| Sample ID | Water Depth (metres) | GPS Coordinates | | Description (sediment substrate) | Biota Observed |
|---|---|---|---|---|---|
| | | Latitude | Longitude | | |
| 18-MNMA-S8 | 30 | 47° 9' 50.86" | 55° 8' 51.26" | Sand/Gravel, Shell Debris | Periwinkles (occ.), Rock Crab, Jellyfish (occ.), Mussels, Knotted Wrack (com.), Tubed Weed (r.), Coraline Algae (occ.) |
| 18-MNMA-S9 | 28 | 47° 9' 49.88" | 55° 8' 50.59" | Sand/Gravel, Shell Debris | Hermit Crab (r.), Periwinkles (r.), Sea Star (r.), Mussels, Jellyfish (occ.), Rock Crab, Kelp (r.), Knotted Wrack (r.) |
| 18-MNMA-S10 | 36 | 47° 9' 51.81" | 55° 8' 52.22" | Black Mud, Shell Debris, Glass Bottle, Aluminum Can | Scallops (r.), Sea Star (occ.), Rock Crab, Kelp (com.), Sea Colander (occ.), Coraline Algae (occ.) |
| 18-MNMA-S11 | 22 | 47° 9' 51.57" | 55° 8' 50.38" | Black Mud, Shell Debris | Mussels, Scallops, Sea Star (r.), Kelp (r.), Sea Colander (occ.), Coraline Algae (occ.), Coral (r.) |
| 18-MNMA-S12 | 32 | 47° 9' 52.60" | 55° 8' 49.32" | Black Mud, Shell Debris | Mussels, Sea Star (r.), Scallops, Rock Crab, Kelp (r.), Sea Colander (r.), Coral (r.), Coraline Algae (com.) |
| 18-MNMA-S13 | 33 | 47° 9' 53.17" | 55° 8' 51.40" | Black Mud, Shell Debris, Aluminum Cans, Building Material Debris | Scallops, Sea Star (com.), Rock Crab (r.), Kelp (com.), Edible Kelp (occ.), Tubed Weed (occ.), Coraline Algae (occ.), Coral (occ.) |
| 18-MNMA-S14 | 32 | 47° 9' 53.61" | 55° 8' 53.53" | Black Mud, Shell Debris, Metal Debris, Macro Algal Debris | Scallops, Rock Crab, Sea Star (occ.), Rockweed (r.), Kelp (occ.), Coraline Algae (occ.) ,Coral (r.), Sea Anemone (r.) |
| 18-MNMA-S15 | 32 | 47° 9' 54.03" | 55° 8' 55.23" | Black Mud, Glass Bottle | Rock Crab (r.), Periwinkle, Sea Urchin (r.), Sea Star (occ.), Scallops, Eel Grass (r.), Brown Seaweed occ.), Tube Weed (r.), Kelp (occ.), Coral (r.), Coraline Algae (r.) |
| **Step-Out** | | | | | |
| 18-MNMA-STEP1 | 25 | 47° 9' 49.81" | 55° 8' 54.01" | Grey Sand/Gravel, Shell Debris | Scallops (r.), Mussels (occ.), Sea Star (r.), Periwinkles (occ.), Tubed Weed (occ.), Rock Weed (occ.), Coral (r.), Coraline Algae (com.) |
| 18-MNMA-STEP2 | 25 | 47° 9' 51.02" | 55° 8' 48.70" | Black Mud/Sand, Shell Debris | Mussels, Scallops, Hermit Crab (r.) Periwinkles (occ.), Sea Star (r.), Rock Weed (r.), Kelp (r.), Coraline Algae (com.), Coral (r.) |

Table 4-1 Sediment Sample Location Descriptions and Biota Observed

| Sample ID | Water Depth (metres) | GPS Coordinates | | Description (sediment substrate) | Biota Observed |
|---|---|---|---|---|---|
| | | Latitude | Longitude | | |
| 18-MNMA-STEP3 | 35 | 47° 9' 53.94" | 55° 8' 50.93" | Black Mud/Sand, Macro Algal Debris, Aluminum Can | Scallops (occ.), Periwinkles (occ.), Mussels, Hermit Crab (r.), Rock Weed (r.), Kelp (occ.), Coraline Algae (occ.), Sea Colander (r.) |
| **Background/Reference** | | | | | |
| 18-MNMA-REF1 | 25 | 47° 10' 06.80" | 55° 7' 40.10" | Grey Sand/Gravel, shell debris, glass bottle | Periwinkle (occ.), Scallops (r.), Common Sea Star (r.), Rock Crab (r.), Brown Seaweed (r.), Eel Grass (com.), Knotted Wrack (r.), Tubed Weed (occ.), Kelp (r.), Coralline algae (com.) |
| 18-MNMA-REF2 | 10 | 47° 10' 06.50" | 55° 7' 46.60" | Grey Sand/Gravel | Periwinkles (occ.), Scallops (r.), Eel Grass (abu.), Kelp (occ.), Tubed Weed (com.), Coraline Algae (com.), Sea Star (occ.) |
| 18-MNMA-REF3 | 30 | 47° 10' 21.9" | 55° 8' 10.40" | Grey Sand, shell debris | Scallops (r.), Mussels (r.), Jellyfish (r.), Tubed Weed (com.), Kelp (r.), Coraline Algae (com.) |

abu. – Abundant
com. – Common
occ. – Occasional
r. - Rare

## 4.4 Biological Tissue

Samples of benthic invertebrates, specifically bivalve mollusks (e.g., mussels and scallops), were also to be collected from each bulk sediment sample location within the waterlot and at each reference location (if present) for potential chemical analysis. Consistent with the information obtained during the Site reconnaissance, scallops were present throughout the waterlot and collected for analysis. Rock crab and mussels were also observed at several waterlot and reference locations and collected for potential chemical analysis. The invertebrate samples were collected by Sparkes and provided to GHD for subsequent processing. Fish were not observed to be present in the waterlot at the time of the sampling program and, therefore, fish tissue samples could not be collected for chemical analysis.

Table 4-2 identifies the tissue samples collected at each bulk sediment sample location. A total of 15 invertebrate tissue samples were selected for chemical analysis and are outlined below:

### *Crab*

- 18-MNMA-TIS-Comp1 - Composite of crab samples collected from sample locations 18-MNMA-S1, 18-MNMA-S2 and 18-MNMA-S4

- 18-MNMA-TIS-Comp2 - Composite of crab samples collected from sample locations 18-MNMA-S5, 18-MNMA-S6, 18MNMA-S7, 18-MNMA-S8, 18-MNMA-S9 and 18-MNMA-S10
- 18-MNMA-TIS-Comp3 - Composite of crab samples collected from sample locations 18-MNMA-S12, 18-MNMA-S13, 18-MNMA-S14, and 18-MNMA-S15
- 18-MNMA-TIS-REF1B - Composite of crab samples collected from reference location 18-MNMA-REF1

### *Mussels*

- 18-MNMA-TIS-Comp4 - Composite of mussel samples collected from sample locations 18-MNMA-S8 and 18-MNMA-S9
- 18-MNMA-TIS-REF3B - Composite of mussel samples collected from Reference Location 18-MNMA-REF3

### *Scallops*

- A total of nine samples submitted for analysis from the following locations:
    - o 18-MNMA-TIS1A collected from sediment sample location 18-MNMA-S1
    - o 18-MNMA-TIS3 collected from sediment sample location 18-MNMA-S3
    - o 18-MNMA-TIS5A collected from sediment sample location 18-MNMA-S
    - o 18-MNMA-TIS6A collected from sediment sample location 18-MNMA-S6
    - o 18-MNMA-TIS10A collected from sediment sample location 18-MNMA-S10
    - o 18-MNMA-TIS11 collected from sediment sample location 18-MNMA-S11
    - o 18-MNMA-TIS12A collected from sediment sample location 18-MNMA-S12
    - o 18-MNMA-TIS14A collected from sediment sample location 18-MNMA-S14
    - o 18-MNMA-REF3A collected from sediment sample location 18-MNMA-REF3

For the scallop and mussel samples, within 48 hours of the collection, the soft tissue from the scallops and mussels were removed and frozen at GHD's St. John's office. Selected frozen tissue samples were subsequently submitted for selected laboratory analysis. The crab samples collected were frozen whole at GHD's office. Crab samples selected for chemical analysis were shipped to the laboratory whole and the soft tissue extracted at the laboratory for chemical analysis. The selected tissue samples were analyzed for PAHs, metals, PCBs and lipids. All samples were submitted to AGAT in St. John's, NL for analysis.

Table 4-2 Invertebrate Tissue Summary

| Location | Sample ID | Method | Species | Quantity | Weight (g) | Submitted for Analysis |
|---|---|---|---|---|---|---|
| 18-MNMA-S1 | 18-MNMA-TIS1A | Diver | Sea Scallop | 3 | Shucked - 343 | Yes |
| | 18-MNMA-TIS1B | | Rock Crab | 1 | Whole - 164 | Composite |
| 18-MNMA-S2 | 18-MNMA-TIS2A | Diver | Sea Scallop | 3 | Shucked - 239 | No |
| | 18-MNMA-TIS2B | | Rock Crab | 1 | Whole - 260 | Composite |
| 18-MNMA-S3 | 18-MNMA-TIS3 | Diver | Sea Scallop | 3 | Shucked - 270 | Yes |

Table 4-2 Invertebrate Tissue Summary

| Location | Sample ID | Method | Species | Quantity | Weight (g) | Submitted for Analysis |
|---|---|---|---|---|---|---|
| 18-MNMA-S4 | 18-MNMA-TIS4A | Diver | Sea Scallop | 2 | Shucked - 138 | No |
| | 18-MNMA-TIS4B | | Rock Crab | 1 | Whole - 249 | Composite |
| 18-MNMA-S5 | 18-MNMA-TIS5A | Diver | Sea Scallop | 3 | Shucked - 402 | Yes |
| | 18-MNMA-TIS5B | | Rock Crab | 1 | Whole - 98 | Composite |
| 18-MNMA-S6 | 18-MNMA-TIS6A | Diver | Sea Scallop | 2 | Shucked - 136 | Yes |
| | 18-MNMA-TIS6B | | Rock Crab | 1 | Whole - 218 | Composite |
| 18-MNMA-S7 | 18-MNMA-TIS7A | Diver | Sea Scallop | 2 | Shucked - 325 | No |
| | 18-MNMA-TIS7B | | Rock Crab | 1 | Whole - 212 | Composite |
| 18-MNMA-S8 | 18-MNMA-TIS8A | Diver | Sea Scallop | 2 | Shucked - 33 | No |
| | 18-MNMA-TIS8B | | Horse Mussel | 4 | Shucked - 115 | Composite |
| | 18-MNMA-TIS8C | | Rock Crab | 1 | Whole - 201 | Composite |
| 18-MNMA-S9 | 18-MNMA-TIS9A | Diver | Horse Mussel | 1 | Shucked - 40 | Composite |
| | 18-MNMA-TIS9B | | Rock Crab | 1 | Whole - 101 | Composite |
| 18-MNMA-S10 | 18-MNMA-TIS10A | Diver | Sea Scallop | 3 | Shucked - 351 | No |
| | 18-MNMA-TIS10B | | Rock Crab | 1 | Whole - 286 | Composite |
| 18-MNMA-S11 | 18-MNMA-TIS11 | Diver | Sea Scallop | 3 | Shucked - 355 | Yes |
| 18-MNMA-S12 | 18-MNMA-TIS12A | Diver | Sea Scallop | 3 | Shucked - 435 | Yes |
| | 18-MNMA-TIS12B | | Rock Crab | 1 | Whole - 126 | Composite |
| 18-MNMA-S13 | 18-MNMA-TIS13A | Diver | Sea Scallop | 2 | Shucked - 350 | No |
| | 18-MNMA-TIS13B | | Rock Crab | 1 | Whole - 178 | Composite |
| 18-MNMA-S14 | 18-MNMA-TIS14A | Diver | Sea Scallop | 3 | Shucked - 384 | Yes |
| | 18-MNMA-TIS14B | | Rock Crab | 1 | Whole - 228 | Composite |
| 18-MNMA-S15 | 18-MNMA-TIS15A | Diver | Sea Scallop | 3 | Shucked - 141 | No |
| | 18-MNMA-TIS15B | | Horse Mussel | 4 | Shucked - 57 | No |
| | 18-MNMA-TIS15C | | Rock Crab | 1 | Whole - 98 | Composite |
| 18-MNMA-REF1 | 18-MNMA-TIS-REF1A | Diver | Sea Scallop | 3 | Shucked - 333 | No |
| | 18-MNMA-TIS-REF1B | | Rock Crab | 1 | Whole - 98 | Yes |
| 18-MNMA-REF2 | 18-MNMA-TIS-REF2 | Diver | Sea Scallop | 2 | Shucked - 210 | No |
| 18-MNMA-REF3 | 18-MNMA-TIS-REF3A | Diver | Sea Scallop | 2 | Shucked - 204 | Yes |
| | 18-MNMA-TIS-REF3B | | Horse Mussel | 3 | Shucked - 105 | Yes |

## 4.5 Surface Water

Surface water samples were collected from various locations within the waterlot as well as the reference area in Mortier Bay. The surface water sample locations were spatial distributed across the waterlot in an effort to determine if storm water, groundwater or other discharges are adversely affecting water quality within the waterlot. The surface water sample locations are shown on Figures 4A and 4B.

#### 4.5.1 Surface Water Sampling

A total of five surface water samples (18-MNMA-W2, 18-MNMA-W6, 18-MNMA-W9, 18-MNMA-W12 and 18-MNMA-W14) plus a field duplicate sample (18-MNMA-W-DUP1) were collected from the waterlot as part of the sampling program completed at the Site between December 13 and 14, 2018. A total of two surface water samples were also collected from the reference area (18-MNMA-W-REF2 and 18-MNMA-W-REF3) for chemical analysis.

Surface water samples were collected in a dedicated polyethylene sampling container and transferred to laboratory supplied bottles for analysis of general chemistry, metals, PAHs and petroleum hydrocarbons. The surface water samples were collected using a boat supplied by Sparkes Subsea Construction and at a depth of approximately 0.5 metres below the water surface. All surface water samples were submitted to AGAT in St. John’s, NL.

All surface water samples collected during the sampling program were logged onto a chain-of-custody form, placed inside a cooler on ice and transported to the laboratory for analysis. As required, standard equipment decontamination procedures were followed to prevent or minimize cross-contamination.

#### 4.5.2 Quality Assurance/Quality Control (QA/QC) Sampling Program

The QA/QC Program consisted of the collection of duplicate samples, cleaning of sampling equipment between each sampling event/location, and the use of new nitrile gloves for each sample.

All surface water samples collected during the sampling program were assigned a unique sample identification, logged onto a chain-of-custody form, placed inside a cooler on ice, and transported to the laboratory for analysis.

Duplicate samples were collected at a 10% frequency for the entire surface water sampling program for the Site. One blind field duplicate (18-MNMA-DUP1) of 18-MNMA-W6, was collected during the field program and analyzed for petroleum hydrocarbons, PAHs, general chemistry and metals including mercury.

# 5. Results of Field Investigation

## 5.1 Soil

Soil samples were collected from the Shipyard Site in seven areas. The soil samples were analyzed for petroleum hydrocarbons and/or metals including mercury depending on past chemicals of concern identified in the sample areas. The soil samples were submitted to AGAT in St. John’s, NL for analysis.

The soil sample locations are shown on Figure 3 and the Laboratory Certificates of Analysis are included as Appendix C.

### 5.1.1 Soil Analytical Data – Petroleum Hydrocarbons

#### *Marystown Shipyard Service Building (MSBL)*

Fourteen soil samples collected in the MSBL area from six boreholes (5 boreholes and 1 monitor well) reported non-detectable BTEX concentrations. Modified TPH concentrations ranged from non-detectable to 6,810 mg/kg (see Table 2). With the exception of one sample collected from MSBL-BH5-2018-SS6, the analytical results were below the Atlantic RBCA Tier I RBSL for a commercial property with non-potable groundwater and coarse-grained soil. All samples were below applicable Tier I ESLs.

#### *Marystown Shipyard Lower Laydown Area (MLLA)*

Eight soil samples collected in the MLLA from four boreholes (1 borehole and 3 monitor wells) reported non-detectable BTEX concentrations. Modified TPH concentrations ranged from non-detectable to 4,690 mg/kg (see Table 2). With the exception of one sample collected from MLLA-MW3-2018-SS7, the analytical results were below the Atlantic RBCA Tier I RBSL for a commercial property with non-potable groundwater and coarse-grained soil. All samples were below applicable Tier I ESLs.

#### *Marystown Shipyard Fuel Pump Area (MFPA)*

Nine soil samples collected in the MFPA from five boreholes (4 boreholes and 1 monitor well) reported non-detectable BTEX concentrations. Modified TPH concentrations ranged from non-detectable to 7640 mg/kg (see Table 2). With the exception of one sample collected from MFPA-MW1-2018-SS1, the analytical results were below the Atlantic RBCA Tier I RBSL for a commercial property with non-potable groundwater and coarse-grained soil. All samples were below applicable Tier I ESLs.

#### *Marystown Shipyard Main Administration and Security Office (MASO)*

Nine soil samples collected in the MASO area from four boreholes (3 boreholes and 1 monitor well) reported non-detectable BTEX concentrations and mTPH concentrations below the Atlantic RBCA Tier I RBSL and/or Tier I ESLs for a commercial property with non-potable groundwater and coarse-grained soil. See Table 2.

#### *Marystown Shipyard Assembly and Erection Building (MAEB)*

Six soil samples collected in the MAEB area from three boreholes reported non-detectable BTEX concentrations. Modified TPH concentrations ranged from non-detectable to 5230 mg/kg (see Table 2). With the exception of one sample collected from MEAB-MW2-2018-SS4, the analytical results were below the Atlantic RBCA Tier I RBSL for a commercial property with non-potable groundwater and coarse-grained soil. All samples were below applicable Tier I ESLs.

#### *Marystown Shipyard Drum Storage Area (MDSA)*

Fourteen soil samples collected in the MDSA from seven boreholes (5 boreholes and 2 monitor wells) reported non-detectable BTEX concentrations and mTPH concentrations below the Atlantic RBCA Tier I RBSL and/or Tier I ESLs for a commercial property with non-potable groundwater and coarse-grained soil. See Table 2.

***Marystown Shipyard General Stores Building (MGSB)***

Seven soil samples collected in the MGSB area from four boreholes reported non-detectable BTEX concentrations and mTPH concentrations below the Atlantic RBCA Tier I RBSL and/or Tier I ESLs for a commercial property with non-potable groundwater and coarse-grained soil.

The soil analytical data for all soil samples analyzed for petroleum hydrocarbons is included in Table 2. The Laboratory Certificates of Analysis are included as Appendix C.

### 5.1.2 Soil Analytical Data – Metals

Five areas of the Shipyard Site were assessed for metals including mercury. A total of 32 soil samples from 17 boreholes/monitor wells were analyzed for metals including mercury. The samples submitted for analyses from the MSBL area, MDSA, and MLLA were within the CCME SQGs for commercial land use. However, two soil samples; MFPA-BH3-2018-SS1 and MAEB-MW2-2018-SS2 collected from fuel pump area and the north side of the assembly and erection building reported chromium concentrations exceeding the CCME SQGs for commercial land use.

The soil analytical data for all soil samples analyzed for metals including mercury are included in Table 3. The Laboratory Certificates of Analysis are included as Appendix C.

### 5.1.3 Soil QA/QC Sampling Program

One field duplicate soil sample (DUP01) was collected from the same sample location of MAEB-MW2-2018-SS4, which was submitted for analysis of petroleum hydrocarbons. The field duplicate soil sample (DUP01) reported non-detectable concentrations of BTEX all of which were consistent with the parent sample. The field duplicate soil sample (DUP01) reported detectable concentrations of total petroleum hydrocarbons, with a calculated relative percent difference (RPD) between the two samples ranging from non-calculable due to low levels detected to 149%.

There are no firm guidelines for the degree of correlation expected between field duplicates and parent samples due to natural heterogeneity in soil type (e.g., grain size, clay fraction); however, the results are considered to be an acceptable duplicable correlation and therefore meet the objectives for this sampling program.

## 5.2 Groundwater

Groundwater samples were collected from the 12 newly installed monitoring wells, three existing monitoring wells and two recovery wells located in the assessed areas of the Shipyard Site. Groundwater samples were collected on October 12 and October 26, 2018 and submitted for BTEX/mTPH and/or metals analyses. All samples were submitted to AGAT in St. John’s, NL for the specified analysis.

The groundwater sample locations are shown on Figure 3 and the Laboratory Certificates of Analysis are included as Appendix C.

### 5.2.1 Fluid Level Gauging/Surveying

Water level measurements were conducted on October 11 and October 26, 2018 prior to sampling. Free product was not identified in any of the gauged monitor wells during the field program. Measured groundwater depths ranged from 0.82 metres below top of riser (mbtr) at MASO-MW1-2018 to 2.62 mbtr at MSBL-MW6.

The interpreted groundwater elevations confirm the overall direction of groundwater flow for the Site is in the northeastern direction toward Mortier Bay.

### 5.2.2 Groundwater Analytical Data – Petroleum Hydrocarbons

Sixteen groundwater samples (MBSL-MW2-2018, MW-0 – field duplicate of MBSL-MW2-2018, MLLA-MW1- 2018, MFPA-MW1-2018, MASO-MW1, RW1, RW2, MAEB-MW1-2018, MAEB-MW2-2018, MDSA-MW2-2018, MDSA-MW3-2018, MDSA-MW9, MGSB-MW15, MW00-field duplicate of MGSB-MW15, and MGSB-17) were collected from the seven assessed areas of the Site.

The groundwater samples analyzed for petroleum hydrocarbons reported no detectable BTEX concentrations and therefore were within the Atlantic RBCA Tier I RBSLs for commercial land use, non-potable water and coarse-grained soil. Modified TPH concentrations were within the Atlantic RBCA Tier I RBSLs with the exception of the sample collected from MGSB-MW15 and its field duplicate.

The groundwater samples were also compared to the Atlantic RBCA Tier I Groundwater ESLs for Plants and Soil Invertebrate Direct Contact with Shallow Groundwater and Tier I Groundwater ESLs for the Protection of Freshwater and Marine Aquatic Life, adjusted for distance to receiving aquatic environment and soil type. The reported results were within these guidelines with the exception of two samples (MGSB-MW15 and MAEB-MW2-2018) that contained F2 hydrocarbon fractions exceeding the Tier I ESLs for Plant and Soil Invertebrates Direct Contact with Shallow Groundwater. Three groundwater samples (MW0 (field duplicate of MSBL-MW2-2018), MGSB-MW17, and MFPA-MW1-2018) contained mTPH concentrations exceeding the Tier I ESLs for the Protection of Freshwater and Marine Aquatic Life, adjusted for a distance of 10 and 20 metres to the closest receiving body (i.e., Mortier Bay).

The groundwater analytical data for petroleum hydrocarbons is summarized in Table 4.

### 5.2.3 Groundwater Analytical Data – Metals

Six groundwater samples (MAEB-MW2-2018, MDSA-MW1-2018, MW000 – field duplicate of MDSA-MW1-2018, MLLA-MW2-2018, MLLA-MW3-2018 and MLLA-MW4-2018) including one field duplicate were collected from three areas of the Site: the assembly and erection building area, the drum storage area, and the lower laydown area. All five groundwater samples reported detectable metals concentrations for most analytes.

As there are no provincial guidelines for metals in groundwater in NL, the groundwater results were screening using the FIGQG Tier 2 for Marine Life Exposure Pathway. Exceedances of arsenic and copper were identified in all of the samples collected for analyses. Selenium exceeded in all but one sample (MAEB-MW2-2018) submitted for analyses. Zinc concentrations above the FIGQG were present in all but two of the samples (MAEB-MW2-2018 and MLLA-MW3-2018) submitted for analyses.

The groundwater analytical data for metals is summarized in Table 5.

#### 5.2.4 Groundwater QA/QC Sampling Program

Three field duplicate groundwater samples (MW0, MW00, and MW000) were collected from the sample locations MSBL-MW2-2018, MGSB-MW15, and MDSA-MW1-2018, which were submitted for analysis of BTEX/mTPH and/or metals.

The field duplicate groundwater samples reported detectable concentrations of mTPH, and metals with calculated RPDs ranging from non-calculable to 91% for the mTPH, and RPDs ranging from non-calculable to 29% for the metal parameters.

There are no firm guidelines for the degree of correlation expected between field duplicates and parent samples; however, the results are considered to be an acceptable duplicable correlation and therefore meet the objectives for this sampling program.

### 5.3 Sediment

Fifteen sediment samples (18-MNMA-S1 to 18-MNMA-S15) were collected from the waterlot of the Marystown Shipyard Site, three step-out samples were collected directly adjacent to the waterlot boundary (18-MNMA-STEP1 to 18-MNMA-STEP3) and three reference samples (18-MNMA-REF1 to 18-MNMA-REF3) were collected from Mortier Bay. The sediment samples were collected at a depth of zero to 0.10 metres.

The sediment samples were analyzed for petroleum hydrocarbons, metals including mercury, PAHs, PCBs and FOC. Several samples were also analyzed for metals leachate to provide data to support disposal options, if required. All samples were submitted to AGAT in St. John’s, NL for chemical analysis.

In addition to chemical analysis, a total of seven samples collected from within the waterlot (18-MNMA-BMI1, 18-MNMA-BMI3, 18-MNMA-BMI5, 18-MNMA-BMI6, 18-MNMA-BMI11, 18-MNMA-BMI12, and 18-MNMA-BMI14) and one reference sample (18-MNMA-BMI-REF2) were also submitted to Dr. Mike Dadswell in Cheter, NS for benthic invertebrate taxonomic evaluation.

The sediment sample locations are shown on Figures 4A and 4B and the Laboratory Certificates of Analysis are included as Appendix C.

#### 5.3.1 Sediment Analytical Data – Petroleum Hydrocarbons

The sediment samples analyzed for petroleum hydrocarbons were within the Atlantic RBCA Tier I Sediment ESL for Other Sediment Type. It is noted that the FOC values were used to calculate the applicable mTPH value for the Site up to a maximum level of 500 mg/kg. BTEX concentrations were not detected in the any of the sediment samples analyzed.

The sediment analytical data for petroleum hydrocarbons is summarized in Table 6.

### 5.3.2 Sediment Analytical Data – Metals

The sediment samples analyzed for metals including mercury were within the CCME ISQGs and PELs, with the exception of the following metals parameters:

- **Arsenic** – CCME ISQGs exceeded in all of the sediment samples collected from the waterlot, step-out and reference areas. The CCME PELs were exceeded at sediment sample locations 18-MNMA-S12 and 18-MNMA-S13, located on the northeast corner of the waterlot but the step-out samples had concentrations of arsenic below CCME PELs.
- **Cadmium** – CCME ISQGs exceeded at sample location 18-MNMA-DUP2, a field duplicate of 18-MNMA-S11 collected on the eastern side of the waterlot. The step-out samples had concentrations of cadmium below CCME ISQGs.
- **Chromium** – CCME ISQGs exceeded at sample location 18-MNMA-S1 from southern corner of the waterlot. The step-out samples had concentrations of chromium below CCME ISQGs.
- **Copper** – CCME ISQGs exceeded in all the sediment samples collected from the waterlot. One step-out sample (18-MNMA-STEP3 and the corresponding field duplicate) also had a concentration of copper exceeding CCME ISQG. The CCME PELs were exceeded in all of the waterlot sediment sample locations except 18-MNMA-S2, 18-MNMA-DUP1 (field duplicate of 18-MNMA-S6), 18-MNMA-S7, 18-MNMA-S8 and 18-MNMA-S10. The step-out samples had concentrations of copper below CCME PELs.
- **Lead** - CCME ISQGs exceeded in all the sediment samples collected from the waterlot. One step-out sample (18-MNMA-STEP3 and the corresponding field duplicate) also had a concentration of lead exceeding CCME ISQG. The CCME PELs were also exceeded in all of the sediment sample locations with the exception of 18-MNMA-S10, and 18-MNMA-DUP2 (field duplicate of 18-MNMA-S11). The step-out samples had concentrations of lead below CCME PELs.
- **Mercury** – CCME ISQGs exceeded at sample locations 18-MNMA-S1, 18-MNMA-S4 and 18-MNMA-S14 collected from the waterlot. The field duplicate of step-out sample 18-MNMA-STEP3 (18-MNMA-DUP3) also had a concentration of mercury exceeding CCME ISQG.
- **Zinc** - CCME ISQGs exceeded in all the sediment samples collected from the waterlot. One step-out sample (18-MNMA-STEP3 and the corresponding field duplicate) also had a concentration of zinc exceeding CCME ISQG. The CCME PELs were also exceeded in all of the sediment sample locations with the exception of 18-MNMA-S2. The step-out samples had concentrations of zinc below CCME PELs.

The sediment analytical data for metals are summarized in Table 7.

### 5.3.3 Sediment Analytical Data – PAHs

The sediment samples analyzed for PAHs from the waterlot exceeded the CCME ISQGs in all of the samples analyzed for nine or more of the 13 PAH parameters having established guidelines. The CCME PELS were also exceeded in one or more of the PAH parameters having established guidelines in all of the samples analyzed from the waterlot with the exception of two samples (18-MNMA-S7 and 18-MNMA-S11).

Two of the three step-out samples collected had concentrations of PAHs below CCME ISQGs and PELs. Step-out sample location 18-MNMA-STEP3 (and the corresponding field duplicate) had concentrations of ten PAH parameters exceeding applicable CCME ISQGs. However, concentrations of PAHs in step-out sample 18-MNMA-STEP3 were below CCME PELs excluding a minor exceedance of phenanthrene.

The samples collected from the reference area were within the CCME ISQGs and PELs.

The sediment analytical data for PAHs are summarized in Table 8.

#### 5.3.4 Sediment Analytical Data – FOCs

The sediment samples were analyzed for FOC, the average FOC for the sediment samples collected from the waterlot is 0.1074. The FOC data was used for the interpretation of the hydrocarbon data as noted above. The average FOC for the samples collected from the reference area is 0.038. The sediment analytical data for FOC is summarized in Table 9.

#### 5.3.5 Sediment Analytical Data – PCBs

The sediment samples reported detectable PCB concentrations above the CCME ISQGs for a marine receptor in all but five of the 15 sediment samples analyzed from the waterlot. The CCME PELs were exceeded in three of the sediment samples (18-MNMA-S3, 18-MNMA-S6 and 18-MNMA-S12) analyzed from the waterlot.

The step-out and reference area samples collected and analyzed did not contain detectable PCB concentrations.

The sediment analytical data for PCBs is summarized in Table 10.

#### 5.3.6 Sediment QA/QC Sampling Program

Three field duplicate sediment samples (18-MNMA-DUP1, 18-MNMA-DUP2 and 18-MNMA-DUP3) were collected from the sample locations 18-MNMA-S6, 18-MNMA-S11 and 18-MNMA-STEP3; respectively, which were submitted for analysis of BTEX/mTPH, metals including mercury, PCBs and PAHs. Two field duplicates were also submitted for FOC analysis. The field duplicate sediment samples reported non-detectable concentrations of BTEX, and PCBs, all of which were consistent with the parent samples with the exception of PCBs that were detected at 18-MNMA–S6.

The field duplicate sediment samples reported detectable concentrations of mTPH, metals, FOC and PAHs, with calculated RPDs of non-calculable to 90% for the mTPH, RPD ranging from non-calculable to 116% for the metal parameters, RPD ranging from 0% to 39% for the FOC and RPD ranging from non-calculable to 145% for the PAH parameters.

There are no firm guidelines for the degree of correlation expected between field duplicates and parent samples due to natural heterogeneity in sediment type (e.g., grain size, clay fraction); however, the results are considered to be an acceptable duplicable correlation and therefore meet the objectives for this sampling program.

## 5.4 Tissue

A total of three composite crab tissue samples (18-MNMA-TIS-Comp1, 18-MNMA-TIS-Comp2 and 18-MNMA-TIS-Comp3), one composite mussel tissue sample (18-MNMA-Comp4) and eight scallop tissue samples (18-MNMA-TIS1A, 18-MNMA-TIS3, 18-MNMA-TIS5A, 18-MNMA-TIS6A, 18-MNMA-TIS10A, 18-MNMA-TIS11, 18-MNMA-TIS12A, and 18-MNMA-TIS14A) were submitted for chemical analysis as part of the sampling program. A total of three invertebrate tissue samples collected from the reference area were also submitted for chemical analysis (18-MNMA-TIS-REF1B (composite crab sample), 18-MNMA-TIS-REF3B (composite mussel sample) and 18-MNMA-REF3A (scallop sample).

The tissue samples were analyzed for metals, PAHs, PCBs and lipids. All samples were submitted to AGAT in St. John's, NL for chemical analysis.

The Laboratory Certificates of Analysis are included as Appendix C.

### 5.4.1 Tissue Analytical Data – Metals

The tissue samples collected from the waterlot and reference area did not have detectable concentrations of mercury as well as several other parameters. Detectable concentrations of metals in the waterlot and reference tissue samples were generally limited to aluminum, arsenic, boron, cadmium, copper, iron, lead, manganese, selenium, strontium, vanadium and zinc.

The tissue analytical data for selected metals are summarized in Table 11.

### 5.4.2 Tissue Analytical Data – PAHs

The tissue samples collected from the waterlot and reference area had detectable concentrations of several individual PAH parameters. However, the concentrations of PAHs detected in the tissue samples collected from the waterlot were generally equal to or below the concentrations of PAHs observed in the reference area samples.

The tissue analytical data for PAHs is summarized in Table 12.

### 5.4.3 Tissue Analytical Data – PCBs

The tissue samples collected from the waterlot and reference area had concentrations of PCBs below laboratory detection limits.

The tissue analytical data for PCBs is summarized in Table 13.

### 5.4.4 Tissue Analytical Data – Lipids

The tissue samples collected from the waterlot and reference area had lipid contents ranging from 0.22 to 1.97%. The tissue analytical data for lipids is included in the Laboratory Certificates of Analysis of Appendix C.

## 5.5 Surface Water

A total of five surface water samples (18-MNMA-W2, 18-MNMA-W6, 18-MNMA-W9, 18-MNMA-W12 and 18-MNMA-W14) plus a field duplicate sample (18-MNMA-W-DUP1) were collected from the waterlot as part of the sampling program. A total of two surface water samples were also collected from the reference area (18-MNMA-W-REF2 and 18-MNMA-W-REF3) for chemical analysis.

The surface water samples were analyzed for petroleum hydrocarbons, PAHs, general chemistry and metals including mercury. All samples were submitted to AGAT in St. John's, NL for chemical analysis.

The surface water sample locations are shown on Figures 4A and 4B and the Laboratory Certificates of Analysis are included as Appendix C.

### 5.5.1 Surface Water Analytical Data – Petroleum Hydrocarbons

Petroleum hydrocarbons (BTEX/mTPH) were not detected in the surface water samples collected from the waterlot and reference area and the laboratory detection limits are below the Atlantic RBCA Tier I ESL for surface water.

The surface water analytical data for petroleum hydrocarbons is summarized in Table 14.

### 5.5.2 Surface Water Analytical Data – Metals

The surface water samples analyzed for metals including mercury were within the CCME WQGs, with the exception of the following metals parameters:

- **Copper** – CCME WQG exceeded in all the surface water samples collected from the waterlot. However, the reference samples also had concentrations of copper exceeding the CCME WQG and the maximum concentration of copper identified in the waterlot samples was less than the reference sample 18-MNMA-W-REF3. The CCME WQG for copper used for comparison to Site data is based on protection of freshwater aquatic life as a marine specific guideline was not available from CCME.
- **Selenium** - CCME WQG marginally exceeded at sample location 18-MNMA-W14 collected from the waterlot. All other surface water samples collected from the waterlot and reference area had concentrations of selenium below CCME WQGs (if detected).

The surface water analytical data for metals are summarized in Table 15.

### 5.5.3 Surface Water Analytical Data – PAHs

The surface water samples collected from the waterlot and reference area did not contain detectable concentrations of PAHs and the laboratory detection limits are below CCME WQGs.

The surface water analytical data for PAHs are summarized in Table 16.

### 5.5.4 Surface Water Analytical Data – General Chemistry

The surface water samples were analyzed for general chemistry parameters such as pH, hardness, turbidity, nitrates, ammonia, etc. General chemistry parameters for the surface water samples collected from the waterlot and reference area were within CCME WQGs.

The surface water analytical data for general chemistry parameters is summarized in Table 17.

#### 5.5.5 Surface Water QA/QC Sampling Program

One field duplicate surface water sample (18-MNMA-W-DUP1) was collected from sample location 18-MNMA-6 and submitted for analysis of BTEX/mTPH, PAHs, general chemistry and metals including mercury. The field duplicate surface water sample reported non-detectable concentrations of BTEX/mTPH, and PAHs all of which were consistent with the parent samples.

The field duplicate surface water sample reported detectable concentrations of some metals with calculated RPDs ranging from non-calculable to 67% for the metal parameters. RPDs for general chemistry parameters ranged from non-calculable to 73%.

There are no firm guidelines for the degree of correlation expected between field duplicates and parent samples due to natural heterogeneity in water; however, the results are considered to be an acceptable duplicable correlation and therefore meet the objectives for this sampling program.

# 6. Data Evaluation

For the purposes of the assessment of human health and ecological risk, where multiple samples were collected at one location (i.e., at varying depths), only one sample (the maximum measured concentration) was chosen to represent the concentration at that location. Similarly, where duplicate samples were collected (or laboratory duplicate samples were analyzed), the sample with the highest concentration (on an analyte by analyte basis) was considered representative of the sample location. These steps were taken to ensure conservativeness in the assessment.

## 6.1 Metals of Low Concern

It is important to determine whether all parameters analyzed and/or detected are present as a result of Site activities and if they are generally considered hazardous or toxic to humans or wildlife. Several elements can be classified as major mineral forming elements or essential nutrients, each of low inherent toxicity. Government agencies often do not develop regulatory criteria for these and other innocuous substances. The following elements are generally ubiquitous in the environment and are generally not considered hazardous to humans or wildlife, although they are commonly analyzed within standard analytical chemistry or trace metal packages: aluminum, ammonia, bismuth, bromide, calcium, fluoride, iron, lithium, magnesium, manganese, nitrate, nitrite, phosphorous, potassium, rubidium, titanium, sodium and sulphide.

Elevated concentrations of iron and manganese can be associated with discharge areas of chemical plumes in groundwater, particularly plumes of organic substances that can degrade in the environment and consume oxygen. Surface deposits of iron and manganese in wetlands or streambeds are typically readily identified by iron staining. These deposits are typically not hazardous to wildlife receptors by themselves, although substances associated with the groundwater plume may be. However, such areas are typically identified in the field and sampled as areas of potential contamination. Therefore, for the purpose of the HHRA and ERA, iron and manganese are considered non-hazardous, and it is assumed that any associated contaminants will be identified and assessed on a substance specific basis.

Also, the following elements, for which limited toxicity information exists, are typically associated with seawater spray and could be expected to be present at the site due to its proximity to the ocean, and not as a result of historical site activities.

- Boron, bismuth, lithium, phosphorus, rubidium and strontium.

Thus, some metals that have a low inherent toxicity, that are associated with sea spray or that were only identified at concentrations near their detection limits were excluded from evaluation and were not carried forward in the human health or ecological risk assessments

## 6.2 Contaminant Distribution

### 6.2.1 Soil

#### 6.2.1.1 Petroleum Hydrocarbons in Soil

Based on the analytical soil BTEX/mTPH data obtained to date (shown in Table 2), concentrations of mTPH have been identified exceeding the applicable Atlantic RBCA Tier I RBSL for commercial land use with non-potable water and coarse-grained soil (Diesel/#2 Fuel Oil). The distribution of mTPH concentrations is shown on Figure 5, with individual sample locations highlighted in Figure 5A (MAEB), Figure 5B (MSBL) and Figure 5C (MLLA/MFPA).

#### 6.2.1.2 Metals in Soil

Based on the analytical soil metals data obtained to date (shown in Table 3), chromium concentrations have been identified exceeding the applicable CCME commercial SQGs. The distribution of trace metal (chromium) concentrations is shown on Figure 5, with individual sample locations highlighted in Figure 5A (MAEB) and Figure 5C (MLLA/MFPA).

### 6.2.2 Groundwater

#### 6.2.2.1 Petroleum Hydrocarbons in Groundwater

Based on the analytical groundwater BTEX/mTPH data obtained to date (shown in Table 4), concentrations of mTPH have been identified exceeding the applicable Atlantic RBCA Tier I RBSL for commercial land use with non-potable water and coarse-grained soil (Diesel/#2 Fuel Oil). The distribution of mTPH concentrations in groundwater is shown on Figure 6, with the individual sample location of MGSB highlighted in Figure 6A.

#### 6.2.2.2 Metals in Groundwater

Based on the analytical groundwater metals data obtained to date (shown in Table 5), arsenic, copper, selenium and zinc concentrations have been identified exceeding the applicable Federal Interim Groundwater Quality Guidelines Generic Guidelines for Commercial and Industrial Land Uses – Tier 2 for Marine Life Exposure Pathway. The distribution of trace metal concentrations in groundwater is shown on Figure 6.

### 6.2.3 Sediment

#### 6.2.3.1 Petroleum Hydrocarbons in Sediment

Based on the analytical sediment BTEX/mTPH data obtained to date (shown in Table 6), concentrations are within the applicable Atlantic RBCA Tier I Sediment ESLs for the Protection of Freshwater and Marine Aquatic Life.

#### 6.2.3.2 Metals in Sediment

Based on the analytical sediment metals data obtained to date (shown in Table 7), arsenic, cadmium, chromium, copper, lead, mercury and zinc concentrations have been identified exceeding the applicable CCME sediment ISQG and/or PELs. However, the concentrations of these specific metals in the three step-out samples collected directly adjacent to the waterlot boundary were below CCME ISQGs or PELs. The distribution of trace metal concentrations in sediment is shown on Figures 7A and 7B.

#### 6.2.3.3 PAHs in Sediment

Based on the analytical sediment PAH data obtained to date (shown in Table 8), 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, fluoranthene fluorine, naphthalene, phenanthrene, and pyrene concentrations have been identified exceeding the applicable CCME sediment ISQG and/or PELs. However, the concentrations of these specific PAH parameters in the three step-out samples collected directly adjacent to the waterlot boundary were below CCME ISQGs or PELs excluding a minor exceedance of phenanthrene in the field duplicate of sample 18-MNMA-STEP3. The distribution of PAH concentrations in sediment is shown on Figures 7A and 7B.

#### 6.2.3.4 PCBs in Sediment

Based on the analytical sediment PCBs data obtained to date (shown in Table 10), PCB concentrations have been identified exceeding the applicable CCME sediment ISQG and/or PELs. However, the three step-out samples did not contain detectable concentrations of PCBs.

### 6.2.4 Surface Water

Although concentrations of mTPH and selected metals in groundwater at the Site exceeded applicable screening guidelines for protection of aquatic life (groundwater discharge to surface water pathway), concentrations of mTPH and metals in surface water samples collected from the waterlot were either not detectable or below applicable CCME WQGs. The exceptions would be boron, chromium and copper which had elevated concentrations in surface water samples collected from the waterlot but the concentration of these parameters were also elevated in the reference samples. The concentration of selenium also marginally exceeded CCME WQG in one waterlot sample collected but the remainder of the samples were below laboratory detection limits.

## 6.3 Exposure Point Concentrations

As impacts have been identified at concentrations exceeding the applicable criteria, human and ecological receptors at the site could be exposed to the identified metals impacts in surface soil. Further risk assessment and possibly risk management is required. Subsequent risk assessments use maxima or exposure point concentrations (EPCs) to represent contaminant concentrations. The EPC is an estimate of a reasonable upper limit value for the average chemical concentration in the medium, determined for each exposure unit (USEPA, 1989; USEPA, 2010). EPCs are represented by upper confidence limits on the mean (UCLM) (95% or above) (or maxima, where data are not suitable or sufficient for EPC calculations) calculated from ProUCL, Version 5.1, using data from the dataset discussed above. The results of the statistical analyses are provided in Appendix D. In the case of laboratory duplicates, field duplicates, or samples from multiple depths, the sample with the highest concentration at each location was used in the calculation of the EPC. ProUCL, Version 5.1 recommends that at least 10 data points be available for conducting statistical calculations; therefore, UCLM concentrations were not calculated for parameters having less than 10 data points. EPC concentrations are also included, where applicable in the human health and ecological specific screening tables referenced in Sections 7 and 8, below.

## 6.4 Data Suitability for Risk Assessment

Decisions about whether to include or exclude outliers in the data set to be used to compute the UCLs should be made by the project team familiar with the site based on an interpretation of the physical meaning and significance of the identified outliers. Questions considered in evaluating whether to include or exclude outliers from the statistical calculations included:

- Is there a clear visual separation of the outlier from the remaining data on a graphical display of the data, such as a Q-Q plot?
- Is the outlier sample spatially related to a known source (e.g., dripline of a building)?
- Is the COPC known to be associated with a suspected source (e.g., lead is associated with paint whereas cadmium is not)?
- Is the outlier sample location sufficiently delineated to have confidence that it represents a small area in comparison to human or ecological exposure areas?

If the suspected outlier is clearly separate from the remaining data, is not spatially related to a source or is not known to be associated with that source, and is accurately delineated to a small area, then the outlier was removed from the data for calculation of an EPC. If the suspected outliers did not meet these criteria, they were generally included in the data set for calculation of the EPCs.

There were no outliers removed from the calculation of the EPCs.

## 6.5 Background Analysis

To account for the potential presence of chemical of potential concerns (COPCs) in sediment of the Shipyard waterlot that are naturally elevated in the area or from sources not associated with the Shipyard activities, the sediment sampling program included the collection and analyses of background sediment samples from three locations in Mortier Bay, between 1,000 and 1,200 metres to the east of the waterlot (18-MNMA-REF1 to 18-MNMA-REF3).

Selected sediment data from the waterlot were compared to background sediment using the two sample Wilcoxon Mann Whitney test available in ProUCL. This is a non-parametric (i.e., independent of the underlying distributions) test in which values (i.e., concentrations) are assigned a rank and the ranks for the two sample populations (waterlot and background) compared. This test also takes into account non-detected values, provided the detection limits are identified. Comparisons were made using two sided tests under the null hypotheses that concentrations in the populations of samples from waterlot and the samples from background locations are equal. If a statistically significant difference was identified using a two sided test, then a one sided test (also available in ProUCL) was conducted to determine if concentration in the waterlot were greater than the background samples.

The ProUCL output sheets for the background evaluation are provided in Appendix D

# 7. Human Health Risk Assessment

This HHRA has been conducted in accordance with current guidance documents, including:

- Atlantic RBCA (2015). Atlantic RBCA (Risk Based Corrective Action) for Petroleum Impacted Sites in Atlantic Canada, Version 3, User Guidance, July 2012 (revised January 2015).
- Health Canada (2017). Federal Contaminated Site Risk Assessment in Canada, Supplemental Guidance on Human Health Risk Assessment of Contaminated Sediments: Direct Contact Pathway, March 2017.
- Health Canada (2010a). Federal Contaminated Site Risk Assessment in Canada, Part I: Guidance on Human Health Preliminary Quantitative Risk Assessment (PQRA), Version 2.0, September 2010 (revised 2012).
- Health Canada (2010b). Federal Contaminated Site Risk Assessment in Canada, Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors, Version 2.0, September 2010.
- Health Canada (2010c). Federal Contaminated Site Risk Assessment in Canada, Part III: Guidance on Peer Review of Human Health Risk Assessments for Federal Contaminated Sites in Canada, Version 2.0.
- Health Canada (2010d). Federal Contaminated Site Risk Assessment in Canada, Part V: Guidance on Human Health Detailed Quantitative Risk Assessment for Chemicals (DQRAchem), September 2010.
- Health Canada (2010e). Federal Contaminated Site Risk Assessment in Canada, Supplemental Guidance on Human Health Risk Assessment for Country Foods (HHRAFOODs), October 2010.
- Health Canada (HC), 2007. Human Health Risk Assessment of Mercury in Fish and Health Benefits of Fish Consumption, Bureau of Chemical Safety Food Directorate, Health Products and Food Branch, March 2007.

- CCME Protocol for the Derivation of Environmental and Human Health Soil Quality Guidelines (CCME, 2006).

## 7.1 Problem Formulation

The Problem Formulation step is an information gathering and interpretation stage that focuses the assessment on the primary areas of concern for the study area. The Problem Formulation step defines the nature and scope of the risk assessment, permits practical boundaries to be placed on the overall scope of work, and ensures that the HHRA is directed at the key areas and issues of concern related to Site activities.

### 7.1.1 Human Health Chemicals of Potential Concern (COPC) Screening

The analytical data for soil, sediment and groundwater were compared to human health specific screening levels (HHSLs) developed or recognized by Atlantic RBCA, NSE, CCME, or human health screening values from other jurisdictions if a guideline was not available from these sources. Consistent with Section 1.3, the HHSLs were selected to be protective of commercial land use with non-potable groundwater use. Considering the use of the property as a shipyard, it is considered possible that commercial workers may come into contact with sediment and/or surface water in the waterlot. Although the commercial/industrial property is not used for growing consumable plants or for hunting wild game, the possibility that fishing and/or harvesting of shellfish could occur within or in close proximity to the waterlot is included in the HHRA screening.

A constituent was identified as a COPC if the maximum detected concentration or exposure point concentration is greater than its HHSL and background concentration. Unless a constituent is considered to be highly bioaccumulative, it was eliminated from further consideration if the maximum detected concentration or EPC is less than its HHSL or background concentration. If the constituent was not detected, it was not retained as a COPC.

Available human health screening criteria for soil, groundwater, sediment, and surface water do not account for humans consuming plants, wild game or fish that may accumulate bioaccumulative constituents. Therefore, regardless of screening results, exposure to bioaccumulative COPC, such as PCBs and mercury, is evaluated further in the sections below, where required.

#### 7.1.1.1 Soil

In order of preference, the following HHSLs were used for screening of chemicals in soil for inclusion in the HHRA:

- Atlantic RBCA (2012, revised 2015). Atlantic Risk-Based Corrective Action (RBCA) – Tier II Pathway Specific Screening Levels (PSSLs) for Commercial, Non-Potable Water Use, Coarse-Grained Soil, Soil Ingestion Pathway and Indoor Air Pathway.
- CCME (1999, revised to 2018). Canadian SQGHH – Commercial, non-potable, coarse-textured soil. Pathway-specific information from the individual fact sheets was reviewed to confirm human health guidelines for the soil ingestion and indoor air pathways.

- NSE (2014). Nova Scotia Environmental (NSE) Pathway Specific Standards (PSS) – NSE PSS for Commercial, Non-Potable Water Use, Coarse-Grained Soil, Soil Ingestion Pathway and indoor air pathway.
- Ontario Ministry of the Environment (OMOE, 2011), Rationale Document, Components for Table 3 - Full Depth, Non-potable Water Scenario, Coarse textured soil, Industrial/Commercial Land Use.
- United States Environmental Protection Agency (USEPA, 2018). Regional Screening Levels (RSL) Generic Tables – Industrial soil.

The Ontario MOECC component values and USEPA RSLs were adjusted (multiplied by 10) to the Health Canada and CCME target incremental cancer risk of $1.0 \times 10^{-5}$. The USEPA RSLs for a target HQ of 0.1 were adjusted (multiplied by 2) to the Health Canada and CCME target HQ of 0.2.

As indicated in Table 7-1, Modified TPH – Diesel/#2 Fuel Oil exceeds the HHSLs for soil for the indoor air pathway and; therefore, requires further assessment to evaluate the soil vapour to indoor air pathway. No soil samples collected during the field program contained Modified TPH concentrations above the HHSLs for direct contact; therefore, the petroleum hydrocarbons in the sub-surface soil does not present a risk to construction workers.

Table 7-1 Human Health Screening of Surface Soil for Marystown Shipyard, Newfoundland & Labrador

| Chemical | Maximum Concentration (mg/kg) | Exposure Point Concentration (EPC) (mg/kg) | Newfoundland and Labrador Background (mg/kg) | Human Health Screening Levels (HHSL) (mg/kg) | | | | Comment |
|---|---|---|---|---|---|---|---|---|
| | | | | Direct Contact | Reference | Vapour Inhalation | Reference | |
| ***Metals*** | | | | | | | | |
| Antimony | <1 | NC | 1 | 63 | NSE PSS (OMOE, 2011) | Not Volatile | - | Maximum meets HHSL |
| Arsenic | 23 | NC | 17 | 31 | CCME SQG | Not Volatile | - | Maximum meets HHSL |
| Barium | 343 | NC | 81 | 10000 | CCME SQG | Not Volatile | - | Maximum meets HHSL |
| Beryllium | <2 | NC | 1 | 110 | CCME SQG | Not Volatile | - | Maximum meets HHSL |
| Cadmium | 0.7 | NC | 0.8 | 49 | CCME SQG | Not Volatile | - | Maximum meets HHSL |
| Chromium | 107 | NC | 52 | 630 | CCME SQG | Not Volatile | - | Maximum meets HHSL |
| Cobalt | 34 | 20 | 17 | 250 | NSE PSS (OMOE, 2011) | Not Volatile | - | EPC meets HHSL |
| Copper | 87 | NC | 57 | 4000 | CCME SQG | Not Volatile | - | Maximum meets HHSL |
| Lead | 96.7 | NC | 35 | 260 | CCME SQG | Not Volatile | - | Maximum meets HHSL |
| Mercury | 0.06 | NC | 1 | 24 | CCME SQG | 3.9 | OMOE, 2011 | Maximum meets HHSL |
| Molybdenum | 7 | NC | 1.1 | 1200 | NSE PSS (OMOE, 2011) | Not Volatile | - | Maximum meets HHSL |
| Nickel | 69 | NC | 72 | 310 | CCME SQG | Not Volatile | - | Maximum meets HHSL |
| Selenium | <1 | NC | 1.0 | 125 | CCME SQG | Not Volatile | - | Maximum meets HHSL |
| Silver | <0.5 | NC | 0.25 | 490 | NSE PSS (OMOE, 2011) | Not Volatile | - | Maximum meets HHSL |
| Thallium | <0.1 | NC | 0.27 | 1 | CCME SQG | Not Volatile | - | Maximum meets HHSL |
| Tin | 4 | NC | 4.1 | 9400 | NSE PSS (USEPA 2018) | Not Volatile | - | Maximum meets HHSL |
| Uranium | 0.6 | NC | 2.2 | 33 | CCME SQG | Not Volatile | - | Maximum meets HHSL |
| Vanadium | 100 | 66 | 86 | 160 | NSE PSS (USEPA 2018) | Not Volatile | - | EPC meets background |
| Zinc | 329 | NC | 120 | 16000 | CCME SQG | Not Volatile | - | Maximum meets HHSL |
| ***Petroleum Hydrocarbons*** | | | | | | | | |
| Benzene | <0.03 | NC | Not Available | 360 | ARBCA Tier II PSSL [1] | 2.5 | ARBCA Tier II PSSL [2] | Maximum meets HHSL |
| Toluene | <0.04 | NC | Not Available | 31000 | ARBCA Tier II PSSL [1] | >450 | ARBCA Tier II PSSL [2] | Maximum meets HHSL |
| Ethylbenzene | <0.03 | NC | Not Available | 14000 | ARBCA Tier II PSSL [1] | >240 | ARBCA Tier II PSSL [2] | Maximum meets HHSL |
| Xylenes | <0.05 | NC | Not Available | 210000 | ARBCA Tier II PSSL [1] | 110 | ARBCA Tier II PSSL [2] | Maximum meets HHSL |
| **Modified TPH - Diesel/ #2 Fuel Oil** | **7640** | NC | Not Available | 13,000 | ARBCA Tier II PSSL [1] | **4000** | **ARBCA Tier II PSSL [2]** | **Maximum exceeds HHSL - Indoor AIr** |

**Notes**

**BOLD** - identified as a COPC

NC - Not Calculated

Human Health Screening Levels (HHSLs):

CCME SQG: Canadian Council of Ministers of the Environment, Soil Quality Guidelines for the Protection of Human Health, commercial, coarse soils.

NSE PSS - Nova Scotia Environment Pathway Specific Standards (original source reference in brackets)

Atlantic RBCA Tier II PSSL[1] - Commercial, Non-Potable Water Use with Coarse-Grained Soil, Soil Ingestion Pathway

Atlantic RBCA Tier II PSSL[2] - Commercial, Non-Potable Water Use with Coarse-Grained Soil, Indoor Air Pathway

OMOE, 2011 - Ontario Ministry of the Environment, Rationale Document, Components for Table 3 - Full Depth, Non-potable Water Scenario, Coarse textured soil, Industrial/Commercial Land Use

Adjusted to risk = 1 x 10-5 and HQ = 0.2), April 2011

USEPA 2018: United States Environmental Protection Agency Regional Screening Levels, Resident Soil (adjusted to risk = 1 x $10^{-5}$ and HQ = 0.2), May 2018.

#### 7.1.1.2 Groundwater

For groundwater, there were two potential exposure pathways identified, including: (1) direct contact (ingestion, dermal contact, and inhalation); and (2) inhalation of indoor air. Based on the GHD's recent investigations at the Site, groundwater at the Site is located at depths ranging from 0.82 to 2.95 metres below grade. Given these depths, the direct contact pathway is applicable only for subsurface workers conducting ground intrusive activities that could intersect the water table. The subsurface worker could be exposed through dermal contact and incidental ingestion through hand to mouth contact. There are no HHSLs that address this exposure pathway, and therefore, HHSLs protective of drinking water were conservatively applied in the groundwater screening to address potential direct contact with groundwater. However, to reduce some of this extreme conservatism, the drinking water HHSLs were multiplied by a factor of 10, consistent with the approach outlined in WHO (2003), since subsurface workers will only have incidental ingestion of groundwater.

The HHSLs protective of direct contact were the Maximum Acceptable Concentrations (MACs) from Health Canada's Guidelines for Canadian Drinking Water Quality Summary Table, dated February 2017 (Health Canada, 2017a).

Where Health Canada MACs were not available, screening values were selected from the following sources:

- Atlantic RBCA (2012, revised 2015). Atlantic Risk-Based Corrective Action (RBCA) – Tier II Pathway Specific Screening Levels (PSSLs) for Commercial, Non-Potable Water Use, Coarse-Grained Soil, Soil Ingestion Pathway and Indoor Air Pathway
- NSE (2014). Nova Scotia Environmental (NSE) Pathway Specific Standards (PSS) – NSE PSS for Commercial, Non-Potable Water Use, Coarse-Grained Soil, Soil Ingestion Pathway
- OMOE (2011) OMOE, 2011: Ontario Ministry of the Environment, Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario
- USEPA (2017) Tapwater RSLs

The Ontario MOECC component values and USEPA RSLs were adjusted (multiplied by 10) to the Health Canada and CCME target incremental cancer risk of $1.0 \times 10^{-5}$. The USEPA RSLs for a target HQ of 0.1 were adjusted (multiplied by 2) to the Health Canada and CCME target HQ of 0.2.

As indicated in Table 7-2, arsenic, vanadium and mTPH exceed the HHSLs for direct contact with groundwater (construction worker) and; therefore, require further assessment.

**Table 7-2 Human Health Screening of Groundwater for Marystown Shipyard, Newfoundland & Labrador**

| Chemical | Maximum Concentration (µg/L) | Exposure Point Concentration (EPC) (µg/L) | Human Health Screening Levels (HHSL) (µg/L) | | | | Comment |
|---|---|---|---|---|---|---|---|
| | | | Direct Contact (1) | Reference | Vapour Inhalation | Reference | |
| **Metals** | | | | | | | |
| Antimony | <2 | NC | 60 | NSE PSS (HC DWG) | Not Volatile | - | Maximum meets HHSL |
| **Arsenic** | **362** | **NC** | **100** | **NSE PSS (HC DWG)** | **Not Volatile** | **-** | **Maximum exceeds HHSL - Direct Contact** |
| Barium | 483 | NC | 10000 | NSE PSS (HC DWG) | Not Volatile | - | Maximum meets HHSL |
| Beryllium | <2 | NC | 40 | NSE PSS (OMOE, 2011) | Not Volatile | - | Maximum meets HHSL |
| Cadmium | 0.16 | NC | 50 | NSE PSS (HC DWG) | Not Volatile | - | Maximum meets HHSL |
| Chromium | 7 | NC | 500 | NSE PSS (HC DWG) | Not Volatile | - | Maximum meets HHSL |
| Cobalt | 2 | NC | 100 | NSE PSS (CCME 2013) | Not Volatile | - | Maximum meets HHSL |
| Copper | 7 | NC | 10000 | NSE PSS (HC DWG) | Not Volatile | - | Maximum meets HHSL |
| Lead | 0.5 | NC | 100 | NSE PSS (HC DWG) | Not Volatile | - | Maximum meets HHSL |
| Molybdenum | 5 | NC | 700 | NSE PSS (OMOE, 2011) | Not Volatile | - | Maximum meets HHSL |
| Nickel | 10 | NC | 1000 | NSE PSS (OMOE, 2011) | Not Volatile | - | Maximum meets HHSL |
| Selenium | 156 | NC | 500 | NSE PSS (HC DWG) | Not Volatile | - | Maximum meets HHSL |
| Silver | 0.2 | NC | 1000 | NSE PSS (OMOE, 2011) | Not Volatile | - | Maximum meets HHSL |
| Thallium | 0.1 | NC | 20 | NSE PSS (OMOE, 2011) | Not Volatile | - | Maximum meets HHSL |
| Tin | <2 | NC | 24000 | NSE PSS (USEPA RSL) | Not Volatile | - | Maximum meets HHSL |
| Uranium | 1.9 | NC | 200 | NSE PSS (HC DWG) | Not Volatile | - | Maximum meets HHSL |
| **Vanadium** | **494** | **NC** | **62** | **NSE PSS (OMOE, 2011)** | **Not Volatile** | **-** | **Maximum exceeds HHSL - Direct Contact** |
| Zinc | 32 | NC | 50000 | HC DWG | Not Volatile | - | Maximum meets HHSL |
| **Petroleum Hydrocarbons** | | | | | | | |
| Benzene | <1 | NC | 50 | APIRI, 2015 | 30,000 | APIRI, 2015 | Maximum meets HHSL |
| Toluene | <1 | NC | 240 | APIRI, 2015 | >515,000 | APIRI, 2015 | Maximum meets HHSL |
| Ethylbenzene | <1 | NC | 16 | APIRI, 2015 | <150,000 | APIRI, 2015 | Maximum meets HHSL |
| Xylenes | <2 | NC | 200 | APIRI, 2015 | 390,000 | APIRI, 2015 | Maximum meets HHSL |
| Modified TPH - Diesel/ #2 Fuel Oil | **447,000** | **357,200** | **32,000** | APIRI, 2015 | 39,000,000 | APIRI, 2015 | **Maximum and EPC exceed HHSL - Direct Contact** |

**Notes**

**BOLD** - identified as a COPC

NC - Not Calculated. For all metals, the EPC could not be calculated due to insufficient sample numbers.
For all other parameters the EPC was not required.

NGR - no guideline required

Human Health Screening Levels (HHSLs):

NSE PSS: Nova Scotia Environment Pathway Specific Standards for Groundwater, 2013 (Original reference source in brackets)

HC DWG: Health Canada's Guidelines for Canadian Drinking Water Quality, Summary Table, February 2017.

CCME 2013: CCME, 2013 (Draft) Canadian Council of Ministers of the Environment, Guidance Manual onSampling, Analysis and Data Management for Contaminated Sites Volume IV: Compendium of Analytical Methods for Contaminated Sites.

OMOE, 2011: Ontario Ministry of the Environment, Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario, Potable GW1, coarse soils (adjusted to target risk = 1 x 10-5 and HQ = 0.2).

USEPA RSL: United States Environmental Protection Agency Regional Screening Levels, Resident Soil (adjusted to target risk = 1 x $10^{-5}$ and HQ = 0.2).

APIRI, 2015: Atlantic Partners in RBCA Implementation, Atlantic RBCA (Risk Based Corrective Action) Version 3.0 for Impacted Site in Atlantic Canada, User Guidance, June 2012, Updated 2015. Appendix 4, Atlantic Canada Tier II Pathway Specific Screening Level (PSSL) Table

(1) Due to drinking-water guideline values relate to water ingestion and, in most cases, to lifetime exposure; WHO guidelines (2003) assume a contribution for direct contact of an equivalent of 10% of drinking-water consumption. Therefore WHO's simple screening approach is that a substance occurring in water at a concentration ten times that stipulated in the drinking-water guidelines may merit further consideration as referred to in Section 10.5. WHO, 2003: Guidelines for Safe Recreational Water Environments, Volume 1: Coastal and Freshwaters, World Health Organization, 2003.

#### 7.1.1.3 Sediment

For sediment, the most likely potential exposure pathways identified are incidental ingestion and dermal contact with waterlot sediment by commercial workers at the Site. In the absence of screening values specific to this exposure scenario, the direct contact HHSLs (ingestion and dermal contact) from the sources listed above for the soil screening were applied. This approach to sediment screening is consistent with Health Canada’s Supplemental Guidance on Human Health Risk Assessment of Contaminated Sediments (Health Canada, 2017b).

As indicated in Table 7-3, arsenic and lead concentrations exceed the HHSLs for sediment for direct contact. Therefore, further assessment of these COPCs in sediment is required.

Table 7-3 Human Health Screening of Sediment for Marystown Shipyard, Newfoundland & Labrador

| Chemical | Maximum Concentration (mg/kg) | Exposure Point Concentration (EPC) (mg/kg) | Sediment Reference Concentrations (mg/kg) | Human Health Screening Levels (HHSL) (mg/kg) | Statistically Similar to Background? Yes or No (1) | Reference | Comment |
|---|---|---|---|---|---|---|---|
| ***Metals*** | | | | | | | |
| Antimony | 28 | 11.16 | <1 | 63 | Cannot be Determined | NSE PSS (OMOE, 2011) | Maximum meets HHSL |
| **Arsenic** | **78** | **40.43** | **11** | **31** | **No** | **CCME SQG** | **Maximum and EPC exceed HHSL** |
| Barium | 250 | 149.80 | 41 | 10000 | No | CCME SQG | Maximum meets HHSL |
| Beryllium | <2 | NC | <2 | 110 | Yes | CCME SQG | Maximum meets HHSL |
| Cadmium | 1 | 0.54 | <0.3 | 49 | Cannot be Determined | CCME SQG | Maximum meets HHSL |
| Chromium | 98 | 47.36 | 16 | 630 | Yes | CCME SQG | Maximum meets HHSL |
| Cobalt | 22 | 15.23 | 8.3 | 250 | No | NSE PSS (OMOE, 2011) | Maximum meets HHSL |
| Copper | 260 | 168.20 | 9.3 | 4000 | No | CCME SQG | Maximum meets HHSL |
| **Lead** | **728** | **362.00** | **7** | **260** | **No** | **CCME SQG** | **Maximum and EPC exceed HHSL** |
| Mercury | 0.64 | 0.16 | 0.05 | 24 | Cannot be Determined | CCME SQG | Maximum meets HHSL |
| Molybdenum | 9 | 6.06 | 2.5 | 1200 | Yes | NSE PSS (OMOE, 2011) | Maximum meets HHSL |
| Nickel | 45 | 25.42 | 14 | 310 | Yes | CCME SQG | Maximum meets HHSL |
| Selenium | 3 | 1.62 | <1 | 125 | Cannot be Determined | CCME SQG | Maximum meets HHSL |
| Silver | <0.5 | NC | <0.5 | 490 | Yes | NSE PSS (OMOE, 2011) | Maximum meets HHSL |
| Thallium | <0.1 | <0.1 | 0.1 | 1 | Yes | CCME SQG | Maximum meets HHSL |
| Tin | 28 | 17.74 | 3.3 | 9400 | No | NSE PSS (USEPA 2018) | Maximum meets HHSL |
| Uranium | 2.5 | 1.69 | 1.3 | 33 | Yes | CCME SQG | Maximum meets HHSL |
| Vanadium | 63 | 47.12 | 33 | 160 | Yes | NSE PSS (OMOE, 2011) | Maximum meets HHSL |
| Zinc | 5020 | 1681 | 34 | 16000 | No | CCME SQG | Maximum meets HHSL |
| ***Polychlorinated Biphenyls*** | | | | | | | |
| PCBs | 0.65 | 0.32 | <0.02 | 33 | Cannot be Determined | NSE PSS (AEP RGV) | Maximum meets HHSL |
| ***Petroleum Hydrocarbons*** | | | | | | | |
| Benzene | <0.03 | NC | <0.03 | 360 | Yes | NSE (APIRI) | Maximum meets HHSL |
| Toluene | <0.04 | NC | <0.04 | 31000 | Yes | NSE (APIRI) | Maximum meets HHSL |
| Ethylbenzene | <0.03 | NC | <0.05 | 14000 | Yes | NSE (APIRI) | Maximum meets HHSL |
| Xylenes | <0.05 | NC | <0.05 | 210000 | Yes | NSE (APIRI) | Maximum meets HHSL |
| Modified TPH - Diesel/ #2 Fuel Oil | 419 | NC | 22 | 13,000 | No | NSE (APIRI) | Maximum meets HHSL |
| ***Polycyclic Aromatic Hydrocarbons*** | | | | | | | |
| 1-Methylnaphthalene | 0.27 | 0.13 | <0.05 | 560 | Cannot be Determined | NSE PSS (OMOE, 2011) | Maximum meets HHSL |
| 2-Methylnaphthalene | 0.38 | 0.18 | <0.01 | 560 | Cannot be Determined | NSE PSS (OMOE, 2011) | Maximum meets HHSL |
| Acenaphthene | 0.728 | 0.37 | <0.00671 | 8000 | Cannot be Determined | NSE PSS (AEP RGV) | Maximum meets HHSL |
| Acenaphthylene | 0.465 | 0.16 | <0.004 | 96 | Cannot be Determined | NSE PSS (OMOE, 2011) | Maximum meets HHSL |
| Acridine | 0.11 | 0.11 | <0.05 | 7.7 | Cannot be Determined | USEPA RSL | Maximum meets HHSL |
| Anthracene | 1.01 | 0.48 | <0.03 | 37000 | Cannot be Determined | NSE PSS (AEP RGV) | Maximum meets HHSL |
| Benzo(a)anthracene | 1.55 | 0.97 | 0.025 | see B(a)P TPE | Cannot be Determined | - | - |
| Benzo(a)pyrene | 1.42 | NC | <0.01 | see B(a)P TPE | Cannot be Determined | - | - |
| Benzo(b+j)fluoranthene | 1.96 | NC | <0.05 | see B(a)P TPE | Cannot be Determined | - | - |
| Benzo(e)pyrene | 0.93 | 0.57 | <0.05 | 7.7 | Cannot be Determined | USEPA RSL | EPC meets ESLs |
| Benzo(g,h,i)perylene | 0.86 | NC | <0.01 | see B(a)P TPE | Cannot be Determined | - | - |
| Benzo(k)fluoranthene | 0.72 | 0.41 | 0.02 | see B(a)P TPE | Cannot be Determined | - | - |
| Chrysene | 1.7 | 0.99 | 0.03 | see B(a)P TPE | No | - | - |
| Dibenzo(a,h)anthracene | <0.006 | NC | <0.006 | see B(a)P TPE | Yes | - | - |
| Fluoranthene | 3.93 | 2.19 | 0.07 | 5300 | No | NSE PSS (AEP RGV) | Maximum meets HHSL |
| Fluorene | 0.94 | 0.36 | <0.01 | 4100 | Cannot be Determined | NSE PSS (AEP RGV) | Maximum meets HHSL |
| Indeno(1,2,3-cd)pyrene | 1.13 | NC | <0.01 | see B(a)P TPE | Cannot be Determined | - | - |
| Naphthalene | 0.62 | 0.19 | <0.01 | 2800 | Cannot be Determined | NSE PSS (AEP RGV) | Maximum meets HHSL |
| Perylene | 0.41 | 0.21 | <0.05 | 3200 | Cannot be Determined | NSE PSS (AEP RGV) | Maximum meets HHSL |
| Phenanthrene | 4.05 | 1.89 | 0.05 | 2800 | No | NSE PSS (AEP RGV) | Maximum meets HHSL |
| Pyrene | 2.98 | 1.69 | 0.055 | 3200 | No | NSE PSS (AEP RGV) | Maximum meets HHSL |
| Quinoline | <0.05 | NC | <0.05 | 7.7 | Yes | USEPA RSL | Maximum meets HHSL |
| B(a)P TPE | 1.9 | 1.12 | 0.017 | 5.3 | No | CCME SQG | Maximum meets HHSL |

**Notes**

**BOLD** - identified as a COPC

NC - Not Calculated.

B(a)P TPE - benzo(a)pyrene total potency equivalents

Sediment reference concentrations are the based on the mean concentrations from 18-MNMA-REF1, 18-MNMA-REF2, and 18-MNMA-REF3.

(1) Refer to Section 2.5 for details on statistical comparison with background data. Background analysis conducted only if maximum concentration and EPC is greater than the reference concentration.
Background statistical analysis not determined for parameters where background sediment data was not detected.

Human Health Screening Levels (HHSLs):

NSE PSS - Nova Scotia Environment Pathway Specific Standards (original source reference in brackets)

CCME SQG: Canadian Council of Ministers of Environment, Soil Quality Guidelines for the Protection of Human Health, commercial, coarse soils.

AEP RGV : Alberta Environment and Parks, Alberta Tier 1 Soil and Groundwater Remediation Guidelines, Table A-4, commercial, coarse soils.
For perylene, the guideline value for pyrene was applied. For phenanthrene, the guideline value for naphthalene was applied.

OMOE, 2011 - Ontario Ministry of the Environment, Rationale Document, Components for Table 3 - Full Depth, Non-potable Water Scenario, Coarse textured soil, Industrial/Commercial Land Use
Adjusted to risk = 1 x 10-5 and HQ = 0.2), April 2011.

USEPA RSL: United States Environmental Protection Agency Regional Screening Levels, Industrial Soil (adjusted to risk = 1 x $10^{-5}$ and HQ = 0.2).
For acridine and benzo(e)pyrene, the RSL for quinoline was applied

APIRI - Tier II PSSL (Pathway Specific Screening Level), Commercial, Non-Potable Water Use with Coarse-Grained Soil, Soil Ingestion Pathway, 2012, Updated 2015

#### 7.1.1.4 Determination of COPCs for Consideration in Shellfish

As indicated in Sections 4 and 5, as part of the Supplemental Phase II ESA investigation, invertebrate tissue samples were collected from the waterlot and the reference area for selected chemical analysis. Information obtained during the Site reconnaissance indicates that shellfish harvesting, specifically scallop harvesting, does occur within the waterlot as well as Mortier Bay adjacent to the waterlot boundary. Fishing for finfish is not known to occur directly within the waterlot and finfish were not observed to be present within the waterlot at the time of the Supplemental Phase II ESA.

As the Site waterlot contains shellfish and harvesting of shellfish for human consumption is known to occur in the area, specifically scallops, risk to human health through the shellfish consumption pathway was included in the HHRA evaluation using Site-specific tissue data. However, as fishing is not known to occur directly in the waterlot, risk to human health through the fish (finfish) consumption pathway was not included in the HHERA for the following reasons:

- Finfish were generally not observed in the waterlot at the time of the Supplemental Phase II ESA.
- Anecdotal evidence indicates fishing that does occur in Mortier Bay is primarily limited to migratory sea trout that would have limited exposure to COPCs in sediment in the waterlot.
- Evaluation of risk to human health from consumption of shellfish is considered to be a conservative surrogate for the fish consumption pathway as shellfish are in direct contact with sediment.
- COPCs that are considered to be bioaccumulative in sediment such as mercury and PCBs were not detected in shellfish samples collected from the waterlot. In addition, bioaccumulation of PAHs and petroleum hydrocarbons (mTPH) in fish is expected to be low and considered to be insignificant for assessing receptors that can metabolize these compounds (Eisler, 1987; CCME, 2008).

The COPCs that were selected to be considered for human health screening based on consumption of shellfish included:

1) Those COPCs where the background analysis indicates that the sediment concentrations in the waterlot of the Shipyard are statistically greater than background levels (see Section 6.5). As identified in Table 7-3, these COPCs include metals (arsenic, barium, cobalt, copper, lead, tin and zinc), mTPH and PAHs (chrysene, fluoranthene, phenanthrene, pyrene and B(a)P TPE). However, concentrations of barium, cobalt and tin in shellfish tissue samples collected from the waterlot and reference area were below laboratory detection limits. In addition, these three metals are not considered to be bioaccumulative in sediment (TCEQ, 2006) and the Federal Contaminated Sites Action Plan Guidance for Assessing and Managing Aquatic Contaminated Sites in Working Harbours (FCSAP, 2017) indicates screening of COPCs with respect to the food ingestion pathway should focus on chemicals with the potential to bioaccumluate or biomagnify. Based in the above noted rationale, barium, cobalt and tin were not carried forward in the HHRA for consumption of shellfish. In addition, although concentrations of mTPH in waterlot sediment were identified be statistically greater than background concentrations, the concentrations of mTPH in waterlot sediment were below Atlantic RBCA screening guidelines

and mTPH is not considered to be bioaccumulative in fish or shellfish. As such, petroleum hydrocarbons (BTEX/mTPH) were eliminated as a COPC in shellfish tissue.

2) Those COPCs where the background analysis could not be conducted because the COPCs were not detected in the background data. As identified in Table 7-3, these COPCs include metals (antimony, cadmium, mercury and selenium), PCBs and PAHs (1-Methylnaphthalene, 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Acridine, Anthracene, Benzo(a)anthracene, Benzo(a)pyrene, Benzo(b+j)fluoranthene, Benzo(e)pyrene, Benzo(g,h,i)perylene, Benzo(k)fluoranthene, Fluorene, Indeno(1,2,3-cd)pyrene, Naphthalene and Perylene). Similar to several metals noted above, antimony was not detected in the shellfish tissue samples collected from the waterlot or the reference area. Antimony was not carried forward in the HHRA with respect to the consumption of shellfish as antimony is not considered to be bioaccumulative (TCEQ, 2006).

3) Beryllium, silver, thallium, benzene, toluene, ethylbenzene, and xylene were not included in the screening for consumption of shellfish because these COPCs were not detected in the waterlot sediments.

Based on the above noted rationale, the COPCs carried forward in the HHRA with respect to consumption of shellfish tissue include the following:

- Metals – specifically arsenic, cadmium, copper, lead, mercury, selenium and zinc
- PAHs – specifically 1-Methylnaphthalene, 2-Methylnaphthalene, Acenaphthene, Acenaphthylene, Acridine, Anthracene, Benzo(e)pyrene, fluoranthene, fluorine, naphthalene, perylene, phenanthrene, pyrene and B(a)P TPE
- PCBs

***Shellfish Concentrations***

In order to conduct a human health screening for this pathway, maximum concentrations of COPCs in shellfish tissue obtained from the waterlot were tabulated and are provided in Table 7-4 along with the maximum concentration identified in the tissue samples collected from the reference area. The maximum concentration of the three types of invertebrates collected from the waterlot and reference area (crab, mussels and scallops) is also provided in Table 7-4 and will be discussed in the human health risk evaluation.

**Table 7-4 Shellfish Tissue Concentrations for Assessing Human Consumption Exposure**

| Chemical of Potential Concern | Sediment Concentration (mg/kg) $C_{sed}$ | | Crab Tissue Concentration (mg/kg) | | Mussel Tissue Concentration (mg/kg) | | Scallop Tissue Concentration (mg/kg) | |
|---|---|---|---|---|---|---|---|---|
| | Maximum | EPC | Maximum Site | Maximum Reference | Maximum Site | Maximum Reference | Maximum Site | Maximum Reference |
| **Metals** | | | | | | | | |
| Arsenic | 78 | 40 | 4.0 | 5.0 | 4.0 | 5.0 | 3.0 | 2.0 |
| Cadmium | 1.0 | 0.5 | 2.9 | <0.3 | 4.8 | 3.5 | 17.8 | 4.9 |
| Copper | 260 | 168 | 20.0 | 19.0 | 9.0 | <2 | <2 | <2 |
| Lead | 728 | 362 | <0.4 | <0.4 | 0.7 | 1.1 | <0.4 | <0.4 |
| Mercury | 0.64 | 0.16 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Selenium | 3.0 | 1.6 | <1 | 1.0 | <1 | <1 | <1 | <1 |
| Zinc | 5,020 | 1,681 | 28.0 | 27.0 | 108.0 | 74.0 | 12.0 | 9.0 |
| **PAHs** | | | | | | | | |
| 1-Methylnaphthalene | 0.270 | 0.126 | 0.037 | 0.012 | 0.014 | 0.002 | 0.028 | 0.008 |
| 2-Methylnaphthalene | 0.38 | 0.2 | 0.034 | 0.021 | 0.027 | 0.027 | 0.051 | 0.015 |
| Acenaphthene | 0.73 | 0.4 | 0.013 | 0.018 | 0.011 | 0.012 | 0.016 | 0.014 |
| Acenaphthylene | 0.465 | 0.2 | 0.002 | 0.002 | 0.001 | 0.002 | 0.002 | 0.001 |
| Acridine | 0.11 | 0.1 | <0.0003 | <0.0003 | <0.0001 | <0.0002 | <0.0002 | <0.0001 |
| Anthracene | 1.01 | 0.5 | 0.001 | 0.001 | 0.002 | 0.001 | 0.001 | 0.000 |
| Benzo(e)pyrene | 0.9 | 0.6 | 0.004 | 0.016 | 0.003 | 0.002 | 0.007 | 0.004 |
| Fluoranthene | 3.9 | 2.2 | 0.022 | 0.015 | 0.011 | 0.006 | 0.015 | 0.003 |
| Fluorene | 0.94 | 0.4 | 0.004 | 0.003 | 0.002 | 0.002 | 0.002 | 0.002 |
| Naphthalene | 0.62 | 0.2 | 0.002 | 0.014 | 0.016 | 0.002 | 0.032 | 0.012 |
| Perylene | 0.41 | 0.2 | <0.0001 | <0.0001 | <0.0001 | <0.0001 | 0.002 | 0.001 |
| Phenanthrene | 4.1 | 1.9 | 0.018 | 0.008 | 0.004 | 0.005 | 0.006 | 0.003 |
| Pyrene | 3.0 | 1.7 | 0.043 | 0.012 | 0.007 | 0.007 | 0.011 | 0.002 |
| B(a)P TPE | 1.94 | 1.1 | 0.006 | 0.018 | 0.003 | 0.001 | 0.013 | 0.005 |
| **PCBs** | | | | | | | | |
| Total PCBs | 0.65 | 0.32 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |

Notes: Tissue concentrations are based on the maximum concentration detected in each specific tissue type. The results reported are based on a composite of soft tissue extracted from each organism.

#### 7.1.1.5 Shellfish Screening

The human health screening for shellfish consumption pathways involved comparing Site-specific shellfish tissue concentrations to the following human health screening levels, in order of preference:

- Canadian Food Inspection Agency (CFIA, 2014) - Appendix 3, Canadian Guidelines for Chemical Contaminants and Toxins in Fish and Fish Products, amended August 2014.
- USEPA (2015) Regional Screening Levels (RSLs) for Fish, November 2015, adjusted for non-carcinogens to reflect 20% of the USEPA RfD and adjusted for carcinogens to reflect a target ILCR of 1 x $10^{-5}$. The RSLs were adjusted for a consumption rate of 0.009 kilograms per day (kg/day) for shellfish, consistent with the consumption rate provided by Health Canada (HC, 2007) for subsistence fisher.

***Consumption of Shellfish***

Maximum concentrations in shellfish tissue are compared to human health screening levels in Table 7-5. The maximum concentrations of COPCs in shellfish tissue were below applicable screening guidelines excluding arsenic, cadmium and lead. In particular, the maximum concentrations of PAH compounds were below applicable human health screening guidelines or background concentrations. Similarly, COPCs that are considered to be highly bioaccumulative such as mercury and PCBs were not detected in the tissue samples collected.

Although the maximum concentration of arsenic in shellfish tissue (crab and mussel) collected from the waterlot (4 mg/kg) marginally exceeded the CFIA guideline for fish and fish products of 3.5 mg/kg, the waterlot samples had lower concentrations of arsenic than the tissue samples collected from the reference area of Mortier Bay (5 mg/kg). The maximum concentration of arsenic identified in the scallop tissue samples collected from the waterlot was 3 mg/kg and below the CFIA guideline. Similar to arsenic, the maximum concentration of lead in tissue from the waterlot (0.7 mg/kg) was observed in the mussel sample and only marginally exceeded the CFIA guideline of 0.5 mg/kg. In addition, the maximum concentration of lead in mussel samples from the waterlot were below the concentration of lead observed in the mussel samples collected from the reference area of Mortier Bay (1.1 mg/kg). Lead was not detected in the crab or scallop samples collected from the waterlot or reference area. As such, the concentrations of arsenic and lead observed in the invertebrate tissue samples collected from the waterlot are considered to be representative of background conditions in the area. The above noted results for arsenic and lead in shellfish tissue are also consistent with concentrations of these metals observed in reference crustaceans and mollusk samples collected from other harbours on the southern coast of Newfoundland as part of on-going work being completed by GHD on behalf of the federal government (personnel knowledge). The concentrations of arsenic and lead in lobster, mussels and scallop samples collected from other reference areas in southern Newfoundland ranged from 3 to 7 mg/kg and <0.4 to 2 mg/kg, respectively.

Based on the above noted screening results, concentrations of COPCs in shellfish tissue collected from the waterlot are below applicable screening guidelines or are consistent with background concentrations in Mortier Bay excluding cadmium. Cadmium is carried through in the HHRA for consumption of waterlot shellfish.

#### 7.1.1.6 Surface Water

For surface water, the most likely potential exposure pathways identified are incidental ingestion and dermal contact with surface water by commercial workers and recreational users. There are no HHSLs that address this exposure pathway, and therefore, HHSLs protective of drinking water were conservatively applied in the surface water screening to address potential direct contact with surface water. However, to reduce some of this extreme conservatism, the drinking water HHSLs were multiplied by a factor of 10, consistent with the approach outlined in World Health Organization (WHO, 2003), since commercial workers and recreational users will only have incidental ingestion of surface water.

The HHSLs protective of direct contact were the Maximum Acceptable Concentrations (MACs) from Health Canada's Guidelines for Canadian Drinking Water Quality Summary Table, dated February 2017 (Health Canada, 2017b). Where Health Canada MACs were not available, screening values were selected from the following sources:

- Atlantic RBCA (2015). Atlantic Risk-Based Corrective Action (RBCA) – Tier II Pathway Specific Screening Levels (PSSLs) for Groundwater, Table 5b, Ingestion, Residential
- NSE (2013). Nova Scotia Environmental (NSE) Pathway Specific Standards (PSS) – Table 3 Pathway Specific Standards for Groundwater, Potable Groundwater Drinking Water
- Ontario Ministry of the Environment, Conservation and Parks (MECP) Groundwater components for Potable Water Scenario, GW1, Coarse-Textured Soils (Ontario MOECC, 2016)
- USEPA (2018) Tapwater RSLs

The Ontario MECP component values and USEPA RSLs were adjusted (multiplied by 10) to the Health Canada and CCME target incremental cancer risk of $1.0 \times 10^{-5}$. The USEPA RSLs for a target HQ of 0.1 were adjusted (multiplied by 2) to the Health Canada and CCME target HQ of 0.2.

As indicated in Table 7-6, the maximum concentrations for all analyzed parameters in surface water are less than the HHSLs, with the exception of several general chemistry parameters (chloride, sodium and total dissolved solids). However, the concentrations of general chemistry parameters in the waterlot surface water samples are consistent with the background concentrations. Therefore, there were no COPCs carried forward for the waterlot with respect to human consumption or dermal contact with surface water.

**Table 7-5 Human Health Screening for Consumption of Shellfish**

| Chemical | Maximum Site Concentration (mg/kg) | Maximum Reference Concentration (mg/kg) | Human Health Screening Levels (mg/kg) | Reference (1) | Comment |
|---|---|---|---|---|---|
| **Metals** | | | | | |
| **Arsenic** | **4.0** | **5.0** | **3.5** | **a** | **Maximum exceed HHSL but below background** |
| **Cadmium** | **17.80** | **4.90** | **1.85** | **b** | **Maximum exceed HHSL and background** |
| Copper | 20 | 19 | 74 | b | Maximum and background below HHSL |
| **Lead** | **0.7** | **1.1** | **0.5** | **a** | **Maximum exceeds HHSL but below background** |
| Mercury | <0.05 | <0.05 | 0.5 | a | Maximum and background below HHSL |
| Selenium | <1 | 1.0 | 9.3 | b | Maximum and background below HHSL |
| Zinc | 108 | 74 | 556 | b | Maximum and background below HHSL |
| **Polycyclic Aromatic Hydrocarbons** | | | | | |
| 1-Methylnaphthalene | 0.037 | 0.120 | 8.61 | b | Maximum and background below HHSL |
| 2-Methylnaphthalene | 0.051 | 0.027 | 7.42 | b | Maximum and background below HHSL |
| Acenaphthene | 0.016 | 0.018 | 111 | b | Maximum and background below HHSL |
| Acenaphthylene | 0.002 | 0.002 | 111 | b | Maximum and background below HHSL |
| Acridine | <0.002 | <0.002 | - | b | Site and background below detection limits |
| Anthracene | 0.002 | 0.001 | 556 | b | Maximum and background below HHSL |
| Benzo(e)pyrene | 0.007 | 0.016 | 0.25 | b | Maximum and background below HHSL |
| Fluoranthene | 0.022 | 0.015 | 74.2 | b | Maximum and background below HHSL |
| Fluorene | 0.004 | 0.003 | 74.2 | b | Maximum and background below HHSL |
| Naphthalene | 0.032 | 0.014 | 37.1 | b | Maximum and background below HHSL |
| Perylene | 0.002 | 0.001 | 55.6 | b | Maximum and background below HHSL |
| Phenanthrene | 0.018 | 0.008 | 37.1 | b | Maximum and background below HHSL |
| Pyrene | 0.043 | 0.012 | 55.6 | b | Maximum and background below HHSL |
| B(a)P TPE | 0.013 | 0.018 | 0.25 | b | Maximum and background below HHSL |
| **Polychlorinated Biphenyls** | | | | | |
| Total PCBs | <0.5 | <0.5 | 2 | a | Maximum and background below HHSL |

**Notes**

**BOLD** - identified as a COPC

1. Human health screening levels sources:
   a. Canadian Food Inspection Agency - Appendix 3, Canadian Guidelines for Chemical Contaminants and Toxins in Fish and Fish Products, amended August 2014.
   b. USEPA Regional Screening Levels (RSLs) for Fish, May 2018, adjusted for target ILCR of $1 \times 10^{-5}$ and HQ of 0.2.
   Assumed a shellfish ingestion rate of 9 g/day, as indicated in Health Canada (2007).
   For acenaphthylene, the guideline value for acenaphthene was applied.
   For phenanthrene, the guideline value for naphthalene was applied
   For perylene, the guideline value for pyrene was applied.

Table 7-6 Human Health Screening for Surface Water

| Chemical | Maximum Concentration (mg/L) | EPC (mg/kg) | Human Health Screening Levels (mg/L) | Reference (1, 2) | Background Concentration Range (mg/L) | Identified as a COPC for Human Health? Yes or No | Comment |
|---|---|---|---|---|---|---|---|
| ***Petroleum Hydrocarbons*** | | | | | | | |
| Benzene | <0.001 | NC | 0.05 | a | <0.001 | No | Maximum meets Human Health Screening Level |
| Toluene | <0.001 | NC | 0.6 | a | <0.001 | No | Maximum meets Human Health Screening Level |
| Ethylbenzene | <0.001 | NC | 1.4 | a | <0.001 | No | Maximum meets Human Health Screening Level |
| Xylenes | <0.002 | NC | 0.9 | a | <0.002 | No | Maximum meets Human Health Screening Level |
| C6-C10 (less BTEX) | <0.01 | NC | - | - | <0.01 | No | Maximum meets Human Health Screening Level |
| C10-C16 | <0.05 | NC | - | - | <0.05 | No | Maximum meets Human Health Screening Level |
| C16-C21 | <0.10 | NC | - | - | <0.10 | No | Maximum meets Human Health Screening Level |
| C21-C32 | <0.1 | NC | - | - | <0.1 | No | Maximum meets Human Health Screening Level |
| Modified TPH | <0.1 | NC | 32 | b | <0.1 | No | Maximum meets Human Health Screening Level |
| ***Metals*** | | | | | | | |
| Aluminum | 0.031 | NC | 1 | a | 0.012-0.021 | No | Maximum meets Human Health Screening Level |
| Antimony | <0.002 | NC | 0.06 | a | <0.002 | No | Maximum meets Human Health Screening Level |
| Arsenic | <0.002 | NC | 0.1 | a | <0.002 | No | Maximum meets Human Health Screening Level |
| Barium | 0.009 | NC | 10 | a | 0.007 | No | Maximum meets Human Health Screening Level |
| Beryllium | <0.002 | NC | 0.04 | c | <0.002 | No | Maximum meets Human Health Screening Level |
| Bismuth | <0.002 | NC | NG | - | <0.002 | No | Maximum meets Background |
| Boron | 3.57 | NC | 50 | a | 3.41-3.95 | No | Maximum meets Human Health Screening Level |
| Cadmium | <0.00009 | NC | 0.05 | a | <0.00009 | No | Maximum meets Human Health Screening Level |
| Chromium | 0.009 | NC | 0.5 | a | 0.008 | No | Maximum meets Human Health Screening Level |
| Cobalt | 0.003 | NC | 0.1 | c | 0.003 | No | Maximum meets Human Health Screening Level |
| Copper | 0.011 | NC | 10 | a | 0.011-0.013 | No | Maximum meets Human Health Screening Level |
| Iron | 0.21 | NC | 3 | a | 0.157-0.177 | No | Maximum meets Human Health Screening Level |
| Lead | <0.0005 | NC | 0.1 | a | <0.0005 | No | Maximum meets Human Health Screening Level |
| Manganese | 0.015 | NC | 0.5 | a | 0.005-0.009 | No | Maximum meets Human Health Screening Level |
| Mercury | <0.000026 | NC | 0.01 | a | <0.000026 | No | Maximum meets Human Health Screening Level |
| Molybdenum | 0.008 | NC | 0.7 | c | 0.007-0.009 | No | Maximum meets Human Health Screening Level |
| Nickel | 0.019 | NC | 1 | c | 0.020-0.024 | No | Maximum meets Human Health Screening Level |
| Phosphorous | 0.00003 | NC | NG | - | 0.00003 | No | Maximum meets Background |
| Selenium | 0.002 | NC | 0.5 | a | <0.001 | No | Maximum meets Human Health Screening Level |
| Silver | <0.0001 | NC | 1 | c | <0.0001 | No | Maximum meets Human Health Screening Level |
| Strontium | 5.08 | NC | 44 | c | 4.62-5.69 | No | Maximum meets Human Health Screening Level |
| Thallium | <0.0001 | NC | 0.02 | c | <0.0001 | No | Maximum meets Human Health Screening Level |
| Tin | <0.002 | NC | 44 | c | <0.002 | No | Maximum meets Human Health Screening Level |

Table 7-6 Human Health Screening for Surface Water

| Chemical | Maximum Concentration (mg/L) | EPC (mg/kg) | Human Health Screening Levels (mg/L) | Reference (1, 2) | Background Concentration Range (mg/L) | Identified as a COPC for Human Health? Yes or No | Comment |
|---|---|---|---|---|---|---|---|
| Titanium | 0.01 | NC | NG | - | 0.014-0.025 | No | Maximum meets Background |
| Uranium | 0.0021 | NC | 0.2 | a | 0.0020-0.0024 | No | Maximum meets Human Health Screening Level |
| Vanadium | 1.18 | NC | 200 | a | 0.930-0.944 | No | Maximum meets Human Health Screening Level |
| Zinc | <0.005 | NC | 50 | a | <0.005 | No | Maximum meets Human Health Screening Level |
| ***Polycyclic Aromatic Hydrocarbons*** | | | | | | | |
| 1-Methylnaphthalene | <0.00001 | NC | 0.12 | c | <0.00001 | No | Maximum meets Human Health Screening Level |
| 2-Methylnaphthalene | 0.00001 | NC | 0.12 | c | <0.00001 | No | Maximum meets Human Health Screening Level |
| Acenaphthene | <0.00001 | NC | 14 | c | <0.00001 | No | Maximum meets Human Health Screening Level |
| Acenaphthylene | <0.00001 | NC | 0.045 | c | <0.00001 | No | Maximum meets Human Health Screening Level |
| Acridine | <0.00001 | NC | 0.0024 | f | <0.00001 | No | Maximum meets Human Health Screening Level |
| Anthracene | <0.000012 | NC | 70.7 | d | <0.000012 | No | Maximum meets Human Health Screening Level |
| Benz[a]anthracene | <0.000018 | NC | 0.01 | e | <0.000018 | No | Maximum meets Human Health Screening Level |
| Benzo[a]pyrene | <0.000010 | NC | 0.0004 | a | <0.000010 | No | Maximum meets Human Health Screening Level |
| Benzo[b]fluoranthene | <0.00001 | NC | 0.001 | e | <0.00001 | No | Maximum meets Human Health Screening Level |
| Benzo(b+j)fluoranthene | <0.00001 | NC | 0.001 | e | <0.00001 | No | Maximum meets Human Health Screening Level |
| Benzo(e)pyrene | <0.00001 | NC | 0.01 | e | <0.00001 | No | Maximum meets Human Health Screening Level |
| Benzo[ghi]perylene | <0.00001 | NC | 0.01 | e | <0.00001 | No | Maximum meets Human Health Screening Level |
| Benzo[k]fluoranthene | <0.00001 | NC | 0.001 | e | <0.00001 | No | Maximum meets Human Health Screening Level |
| Chrysene | <0.00001 | NC | 0.001 | e | <0.00001 | No | Maximum meets Human Health Screening Level |
| Dibenz[a,h]anthracene | <0.00001 | NC | 0.0001 | e | <0.00001 | No | Maximum meets Human Health Screening Level |
| Fluoranthene | <0.00001 | NC | 9.43 | d | <0.00001 | No | Maximum meets Human Health Screening Level |
| Fluorene | <0.00001 | NC | 9.4 | c | <0.00001 | No | Maximum meets Human Health Screening Level |
| Indeno[1,2,3-cd]pyrene | <0.00001 | NC | 0.001 | e | <0.00001 | No | Maximum meets Human Health Screening Level |
| Naphthalene | <0.00001 | NC | 4.7 | c | <0.00001 | No | Maximum meets Human Health Screening Level |
| Perylene | <0.00001 | NC | 7.1 | c | <0.00001 | No | Maximum meets Human Health Screening Level |
| Phenanthrene | <0.00001 | NC | 0.01 | e | <0.00001 | No | Maximum meets Human Health Screening Level |
| Pyrene | <0.00001 | NC | 7.1 | c | <0.00001 | No | Maximum meets Human Health Screening Level |
| Quinoline | <0.00001 | NC | 0.0024 | f | <0.00001 | No | Maximum meets Human Health Screening Level |
| ***General Chemistry*** | | | | | | | |
| Chloride | 11600 | NC | 2500 | a | 11400-12900 | No | Maximum meets Background |
| Fluoride | <24 | NC | 15 | a | <24 | No | Maximum meets Human Health Screening Level |
| Sulphate | 1500 | NC | 5000 | a | 1480-1690 | No | Maximum meets Human Health Screening Level |
| True Color | 22 TCU | NC | 150 TCU | a | <5-10 TCU | No | Maximum meets Human Health Screening Level |
| Turbidity | 1.5 NTU | NC | 3 NTU | a | 0.8-1.4 NTU | No | Maximum meets Human Health Screening Level |

**Table 7-6 Human Health Screening for Surface Water**

| Chemical | Maximum Concentration (mg/L) | EPC (mg/kg) | Human Health Screening Levels (mg/L) | Reference (1, 2) | Background Concentration Range (mg/L) | Identified as a COPC for Human Health? Yes or No | Comment |
|---|---|---|---|---|---|---|---|
| Nitrate as N | <10 | NC | 100 | a | <10 | No | Maximum meets Human Health Screening Level |
| Nitrite as N | <10 | NC | 10 | a | <10 | No | Maximum meets Human Health Screening Level |
| Total Sodium | 7930 | NC | 2000 | a | 7140-8350 | No | Maximum meets Background |
| Calculated TDS | 22200 | NC | 5000 | a | 21500-24700 | No | Maximum meets Background |

**Notes**

NC - Not Calculated

NG - No Guidelines

**BOLD** - carried forward in the HHRA for further evaluation

1. Due to drinking-water guideline values relate to water ingestion and, in most cases, to lifetime exposure; WHO guidelines (2003) assume a contribution for direct contact of an equivalent of 10% of drinking-water consumption. Therefore WHO's simple screening approach is that a substance occurring in water at a concentration ten times that stipulated in the drinking-water guidelines may merit further consideration as referred to in Section 10.5. WHO, 2003: Guidelines for Safe Recreational Water Environments, Volume 1: Coastal and Freshwaters, World Health Organization, 2003.

2. Human health screening levels sources:

   a. Health Canada Guidelines for Canadian Drinking Water Quality Summary Table, February 2017 (https://www.canada.ca/en/health-canada/services/environmental-workplace-health/water-quality/drinking-water/canadian-drinking-water-guidelines.html).

   b. ARBCA Tier II Pathway Specific Screening Levels for Groundwater, Table 5b, Ingestion, Residential, September 2015.

   c. Nova Scotia Remediation Levels Protocol, Table 3: Pathway Specific Standards for Residential Groundwater, Coarse, Minister of Environment, PRO-500, July 2013 (potable groundwater drinking water).
   For perylene, the guideline value for pyrene was applied.

   d. AEP Alberta Remediation Guidelines, Table C-11,Surface Water Quality Guidelines, Drinking Water, February 2016.

   e. Ontario MECP Groundwater Components for Potable Water Scenario, GW1, Coarse Textured Soils.
   For benzo(e)pyrene, the lowest guideline value of the non-carcinogenic PAHs (phenanthrene)was applied.

   f. USEPA Tap Water Regional Screening Level, November 2018. Note: RSLs are based on risk of 1 x $10^{-6}$, therefore quinoline RSL adjusted to a risk of 1 x $10^{-5}$.
   For acridine, the guideline value for quinoline was applied.

### 7.1.2 Receptor Identification

Existing and intended land use is an important factor in evaluating the potential exposures and estimating risk. It is important that the most protective assumptions are made about the potential receptors. The Site is currently an operating Shipyard and is expected to remain so. Therefore, the main human receptors at the Site include adult commercial workers and occasional construction workers. It is unknown if commercial or sport/subsistence fishing harvesting occurs within Mortier Bay. Although fishing and shellfish harvesting may be unlikely within the waterlot due to the commercial nature, fishing and harvesting may occur in close proximity. Therefore, fishers have been included as potential receptors in the assessment.

### 7.1.3 Exposure Pathway Assessment

The exposure assessment evaluated the likelihood that potential hazards may come into contact with potential human receptors. The likelihood of exposure is determined through consideration of the properties of individual hazards that control chemical mobility, and the various pathways through which the hazard could move to contact the receptor, or through which the receptor could move to contact the hazard. The exposure analysis also considers the possible mechanisms through which a hazard can be introduced to a human receptor (i.e., ingestion, dermal contact, and inhalation).

Exposure pathways are used to describe how a substance could move from the impacted media (soil, water, etc.) to a point where it can come in contact with the body. Only those pathways for which there is a reasonable potential for exposure were considered quantitatively in this risk assessment. The likelihood of exposure includes consideration of the duration and frequency of exposure to chemicals of potential concern. The exposure scenarios that have been considered for human receptors at the Site include:

- Ingestion/dermal contact with soil
- Inhalation/ingestion/dermal contact with dust
- Ingestion of vegetation or garden produce grown in impacted soil
- Ingestion of wild game present at the Site and exposed to impacted soil
- Ingestion/dermal contact with surface water
- Ingestion/dermal contact with groundwater
- Ingestion/dermal contact with sediment
- Ingestion of fish/shell fish present in Mortier Bay and exposed to impacted surface water and sediment
- Inhalation of vapours

GHD has identified the likelihood that the on-Site receptors may be exposed to the identified hazards through the various exposure scenarios using a qualitative method. The likelihood of exposure is considered and evaluated in terms of the series of definitions presented in Table 7-7.

Table 7-7 Exposure Definitions

| Likelihood of Exposure | Definition |
|---|---|
| Very Unlikely | Level of exposure that could result in adverse effects is not expected. |
| Unlikely | Level of exposure that could result in adverse effects would probably not occur. |
| Possible | Level of exposure that could result in adverse effects might be expected. |
| Likely | Level of exposure that could result in adverse effects is expected. Exceedance of this exposure level might be expected. |

The relevant exposure pathways are summarized in Table 7-8, which includes the qualitative evaluation of each pathway and a justification for the likelihood of exposure assigned based on Site-specific conditions. The likelihood of exposure includes consideration of the duration and frequency of exposure to each potential hazard and to the relative concentrations to which the receptor is likely to be exposed. Those hazard-exposure-receptor combinations considered to have the highest likelihood to contribute a health risk are carried forward for further quantitative analysis.

Table 7-8 Potential Exposure Scenarios - Human Receptors

| Exposure Pathway Description | Likelihood of Exposure | Carried Forward? | Justification |
|---|---|---|---|
| Ingestion of soil<br>Dermal contact with soil<br>Ingestion of dust<br>Dermal contact with dust | Possible | No | As indicated above, the concentrations of COPCs in soil are less than the HHSLs for direct contact exposure (ingestion and dermal contact). Therefore, further assessment of direct contact exposure to soil is not required in the HHRA. |
| Ingestion of vegetation naturally growing in impacted soil at the Site | Very Unlikely | No | Due to the commercial nature of the Site, it is not expected that on-Site vegetation will be harvested for human consumption. Therefore, further assessment of exposure to COPCs in soil through ingestion of vegetation grown at the Site is not required in the HHRA. |
| Ingestion of wild game present at the Site and exposed to impacted soil | Very Unlikely | No | Due to the commercial nature of the Site, it is not expected wild game will be present or hunted on the Site. Therefore, further assessment of exposure to COPCs in soil through ingestion of wild game is not required in the HHRA. |

### Table 7-8 Potential Exposure Scenarios - Human Receptors

| Exposure Pathway Description | Likelihood of Exposure | Carried Forward? | Justification |
|---|---|---|---|
| Ingestion and dermal contact of surface water | Possible | No | Commercial and recreational vessels use the harbour for docking, loading/off-loading of equipment, boat maintenance, and re-fueling. Local residents are known to harvest shellfish from the harbour. It is considered possible that commercial workers and recreational users could come into contact with surface water from the harbour. However, there were no COPCs carried forward in the HHRA for direct contact with surface water. Therefore, further assessment of surface water exposure in the HHRA was not required. |
| Ingestion and dermal contact of sediment | Possible | Yes | It Is considered possible that commercial workers at the shipyard could come into contact with sediment from the waterlot during the course of their work. Although workers are assumed to be working under a site specific health and safety program, COPCs identified as exceeding direct contact HHSLs (arsenic and lead) have been carried forward for further assessment in the HHRA. |
| Ingestion of fish/shellfish caught from Mortier Bay | Possible | Yes | Harvesting of shellfish occurs within the waters of Mortier Bay directly adjacent to the waterlot boundaries. However, concentrations of COPCs in shellfish tissue collected from the waterlot, specifically scallops, were below applicable guidelines and consistent with background concentrations excluding cadmium. As such, further assessment of COPCs in shellfish tissue through the ingestion pathway is limited to cadmium. Fishing for finfish is not known to occur directly in the waterlot boundary and finfish were not observed to be present in the waterlot at the time of the Supplemental Phase II ESA. Fishing reportedly occasionally occurs in other areas of Mortier Bay adjacent to the waterlot for migratory species. Given the shellfish results and the absence of observed finfish directly in the waterlot, it is reasonable to assume that migratory fish exposure to COPCs in sediment or food items from within the waterlot would be insignificant. Further evaluation of risk to human health through the fish consumption pathway is not deemed warranted. |

### Table 7-8 Potential Exposure Scenarios - Human Receptors

| Exposure Pathway Description | Likelihood of Exposure | Carried Forward? | Justification |
|---|---|---|---|
| Ingestion and dermal contact of groundwater | Possible | Yes | As indicated previously, groundwater is currently not used as a potable source and this is not expected to change in the future. However, construction workers conducting ground intrusive activities at the Site during future redevelopment could intersect the water table and become exposed to groundwater. The concentrations of arsenic, vanadium and mTPH in groundwater at the Site exceed the direct contact HHSLs (incidental ingestion and dermal contact). Therefore, further assessment of direct contact exposure to groundwater is required in the HHRA. |
| Inhalation of vapours (indoors) | Possible | Yes | There are currently a number of buildings located at the Site. Petroleum-related (mTPH) impacts exceeding the indoor air HHSLs in soil have been identified at the Site that could potentially migrate into the indoor air space of on-Site buildings. Although groundwater mTPH impacts do not exceed the indoor air HHSLs, the depth to groundwater is in some cases significantly shallower than that assumed in the derivation of the HHSLs. Therefore, further assessment of this pathway is required. |
| Inhalation of vapours (outdoors) | Possible | No | Petroleum-related impacts in soil and groundwater could potentially volatilize to outdoor air; however, it can be expected that any petroleum hydrocarbon vapours emitted to the ambient air from soil and/or groundwater will be immediately dispersed and diluted in the atmosphere to negligible levels. Therefore, the human receptor inhalation of vapours emitted to the outdoor air pathway is considered insignificant and was not considered further in this HHRA. |

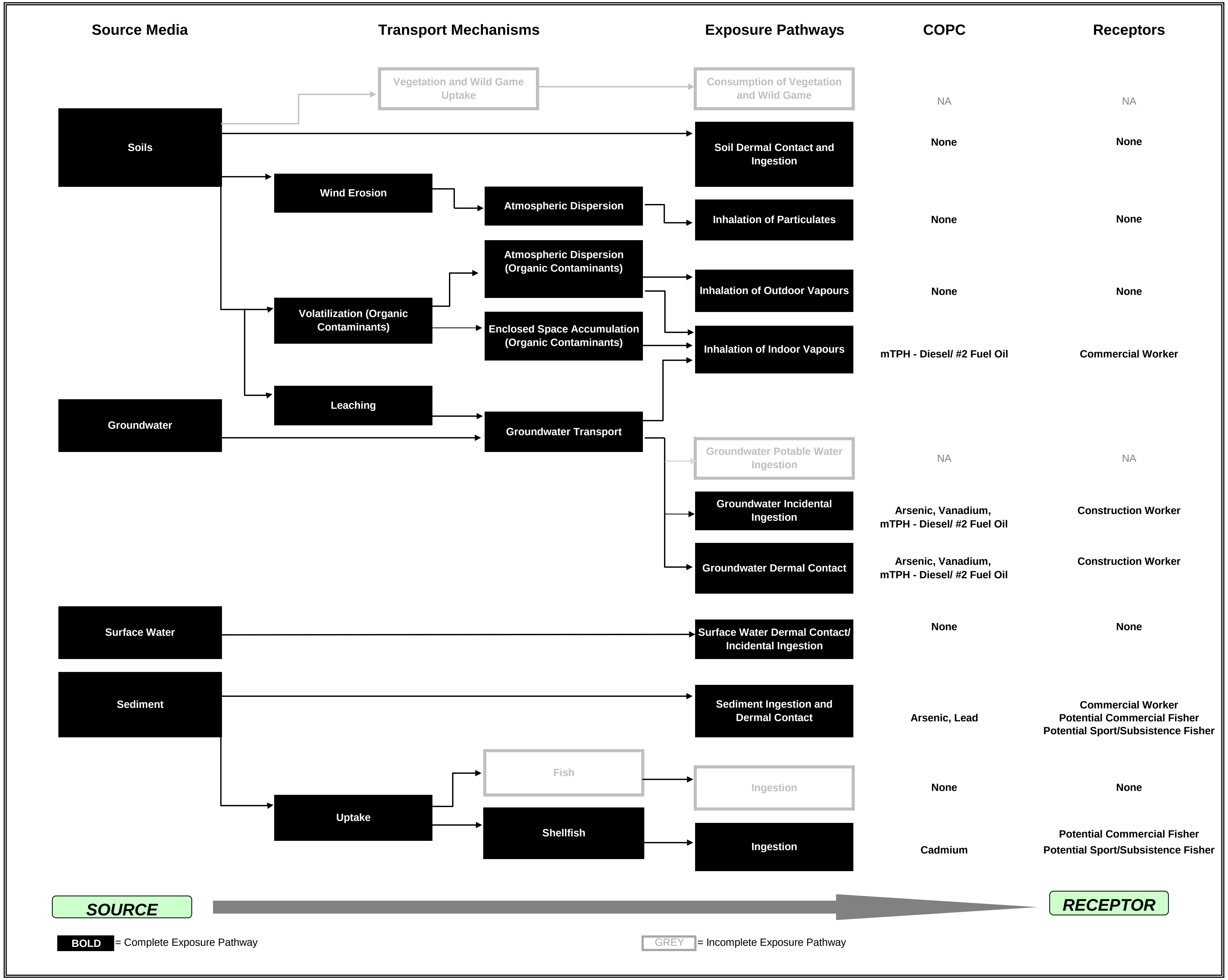
### 7.1.4 Human Health Conceptual Site Model

Based on the qualitative risk evaluation, the conceptual site model (CSM) developed for evaluating the quantitative exposure of the human receptor includes:

- Modified TPH in soil and groundwater for potential indoor air exposure within an enclosed structure utilized for commercial purposes (commercial worker).
- Arsenic, vanadium, and mTPH in groundwater for potential direct contact/incidental ingestion for commercial land use (construction worker).
- Arsenic and lead in sediment for direct contact/soil ingestion (commercial worker and potential fishers).
- Cadmium for potential consumption of shellfish (commercial and recreational fisher).

The CSM constructed for this HHRA is presented as Figure 7.1. The CSM provides a simplified representation of potential exposure pathways, linking COPC to each identified receptor.

Figure 7.1 Conceptual Site Model for Human Receptors - Marystown Shipyard, Newfoundland & Labrador



## 7.2 Exposure Assessment

### 7.2.1 Assessment Tools

A risk assessment model was used to develop the SSTLs and calculate the human health risk associated with the sediment impacts identified in the waterlot of the Shipyard Site. The specific methods employed to calculate risks and develop the SSTLs are consistent with CCME and HC protocols and with standard HHRA methodologies. The equations used in the modelling of impacts are shown on the spreadsheets in Appendix E.

### 7.2.2 Receptor Characteristics and Exposures

Important receptor characteristics for the adult Commercial worker exposed to sediment are presented in Table 7-9 and in Appendix E.

Table 7-9 Receptor Characteristics – Adult Commercial Worker

| Characteristic | | Adult Commercial Worker |
|---|---|---|
| Exposure | $EF_1$ (hours per day worked per 24 hour/day) | 8 |
| | $EF_2$ (days per week worked per 7 d/wk) | 5 |
| | $ET_3$ (weeks per year worked per 52 wks/yr) | 48 |
| | ED (years exposed) | 80 |
| BW | Body Weight (kg) | Adult: 70.7 |
| $IR_{soil}$ | Soil Ingestion Rate (kg/day) | Adult: 0.00002 |
| SDR | Soil dermal contact rate (kg/day) = (SA hands x M hands) + (SA body x M body) x 1E-6 (kg/mg) | Adult: 0.000114 |
| $IR_{air}$ | daily inhalation rate ($m^3$ air/day) | Adult: 16.6 |
| LE | Life Expectancy (yr) | 80 |

Note:
ED and LE – To be employed for the assessment of carcinogens only.

Important receptor characteristics for the sport/subsistence fisher are presented in Table 7-10 and in Appendix E.

Table 7-10 Receptor Characteristics – Commercial/Subsistence Fisher

| Characteristic | | Commercial/Subsistence Fisher |
|---|---|---|
| Exposure | $EF_1$ (days per week shellfish consumed per 7 d/wk) | 5 |
| | $ET_2$ (weeks per year shellfish consumed per 52 wks/yr) | 26 |
| BW | Body Weight (kg) | Toddler: 16.5 |
| $IR_{shellfish}$ | Shellfish Ingestion Rate (kg/day) – applied for crab/scallop/mussel ingestion | Toddler: 0.009 |

For non-carcinogenic COPCs, exposure is calculated for the most sensitive receptors (i.e., toddler). There were no carcinogenic COPC for this pathway.

For the commercial/subsistence fisher, it was assumed that the commercial fisher would bring fish/shellfish catches home for family consumption and; therefore, potential exposure to all life stages was assumed for the commercial worker.

## 7.3 Toxicity Assessment

The potential hazards associated with exposures to non-carcinogenic (threshold) substances are assessed based on the assumption that there is a dose (or concentration) of the chemical of concern that does not produce any adverse effect. A TDI is an estimate of a chemical intake that is unlikely to cause an increased incidence of deleterious health effects during a lifetime of exposure.

The potential cancer risks associated with exposures to carcinogenic (non-threshold) substances are assessed based on the assumption that there is no dose below which an adverse effect will not occur, but at very low doses the probability of an adverse effect is very low. A CSF is an estimate of a chemical intake that meets HC's acceptable cancer risk benchmark of 1 in 100,000 (one additional cancer per 100,000 population).

Toxicity values have been established by several agencies including HC, the USEPA, and the WHO. Preference has been given to HC or other Canadian values and where these are not established, values from the USEPA's IRIS have been employed as the best basis upon which to evaluate health risks. The toxicity profiles for the COPCs are provided in Appendix E. Summaries of the toxicity values (TDI for non-carcinogens and CSF for carcinogens) selected for inclusion in the HHRA are provided in Table 7-11 (Non-Carcinogens) and Table 7-12 (Carcinogens).

Table 7-11 Selected Toxicity Values for Non-Carcinogens

| Chemical | Route of Exposure | Toxicological Reference Value (mg/kg-day) | Toxicological Basis | Source Agency |
|---|---|---|---|---|
| Cadmium | Ingestion | 0.001 | Renal effects | Health Canada (2010a) |
| Lead | Ingestion | 0.0011 | Behavioural effects and learning disabilities in children | AFWEI (2015) |

Table 7-12 Selected Toxicity Values for Carcinogens

| Chemical | Route of Exposure | Cancer Slope Factor (mg/kg-day) | Source Agency |
|---|---|---|---|
| Arsenic | Ingestion | 1.8 | HC (2010b) |

Bioavailability refers to "the fraction of the total amount of material in contact with a body portal of entry (lung, gut, skin) that enters the blood". For example, not all COPCs incidentally ingested in sediment may be absorbed through the gut. Relative bioavailability is the amount of a substance entering the blood via a particular route of exposure (e.g., gastrointestinal) relative to the study used to derive the toxicity values. These factors were then applied in the risk assessment to more realistically represent the portion of contaminants that are available. An assumed bioavailability factor of 1.0 was applied for ingestion exposure.

## 7.4 Risk Characterization

***Non-Carcinogens***

Risk characterization compares the estimated exposures to the identified toxicity values for each non-carcinogenic substance to determine the potential for an adverse effect, also known as the Hazard Quotient (HQ). The Health Canada target HQ of 0.2 was used to determine whether the calculated health risks were acceptable or unacceptable. Based on the published toxicity value (TDI), and calculation of intake rate from ingestion, safe chemical concentrations in sediment, fish tissue and shellfish tissue (SSTLs) were calculated at the acceptable HQ of 0.2.

***Carcinogens***

Risk characterization compares the estimated exposures to the identified toxicity values for each carcinogenic substance to determine the potential for an adverse effect, also known as the Incremental Lifetime Cancer Risk (ILCR). The Health Canada target ILCR of 1 in 100,000 (one additional cancer per 100,000 population, or $10^{-5}$) was used to determine whether the calculated health risks were acceptable or unacceptable. Based on the published toxicity value (CSF) and calculation of intake rate from ingestion, a chemical concentration in sediment (SSTL) was calculated at the acceptable cancer risk benchmark of 1 in 100,000 (one additional cancer per 100,000 population, or $10^{-5}$).

Details of the equations and parameter values used in the analysis are provided in Appendix E.

### 7.4.1 Site Specific Target Level Calculation Results

#### 7.4.1.1 Commercial Worker Exposure to Sediment

The calculated sediment SSTL for the commercial worker (adult) direct contact with sediment, and the corresponding EPC in sediment for arsenic and lead are presented in Table 7-13.

Table 7-13 Human Health Risk Assessment Results – Commercial Worker Exposure to Sediment

| Chemical | Sediment EPC (mg/kg) | Sediment SSTL (mg/kg) |
|---|---|---|
| Arsenic | 40.43 | 69 |
| Lead | 362 | 8588 |

Note:
**BOLD** = EPC > SSTL

As indicated in Table 7-13, the calculated SSTLs for the Commercial worker exposure to arsenic and lead through direct contact to sediment are greater than the corresponding sediment EPCs.

#### 7.4.1.2 Shellfish Consumption

The calculated shellfish tissue SSTLs for the sport and commercial fisher consumption of shellfish, and the corresponding shellfish tissue EPCs are presented in Table 7-14. As indicated in Table 7-14, the calculated SSTLs for cadmium for the commercial/subsistence fisher consumption of shellfish exceeds the corresponding shellfish EPC concentrations (EPC value calculated based on cadmium concentrations in all shellfish collected from the Site; see Appendix D). Further evaluation of risk associated with the shellfish consumption pathway is discussed in Section 7.5.

Table 7-14 Human Health Risk Assessment Results –Commercial or Subsistence Fisher Consumption of Shellfish

| Chemical | Shellfish Tissue EPC (mg/kg) | Shellfish Tissue SSTL (mg/kg) |
|---|---|---|
| **Cadmium** | **8.6** | **5.9** |

Note:
**BOLD** = EPC > SSTL

## 7.5 Human Health Risk Assessment Results

### 7.5.1 Commercial Land Use – Indoor Air

Table 7-15 compares the soil and groundwater HHSLs protective of commercial indoor air inhalation exposure (Atlantic RBCA Tier II PSSLs) to the concentrations of mTPH in soil and groundwater. Since there are buildings on the Site, and specifically in the area where the maximum soil and groundwater concentrations are located, the maximum concentrations were used in this comparison.

Table 7-15 Human Health Risk Results – Commercial Indoor Air

| COPC | Commercial Indoor Air Inhalation HHSL | Maximum Concentration |
|---|---|---|
| **Soil (mg/kg)** | | |
| Modified TPH | 4,000 | **7640** |
| **Groundwater (mg/L)** | | |
| Modified TPH | 39,000 | 447 |

As indicated in Table 7-15, the maximum concentration for mTPH in soil exceeds the commercial indoor air inhalation HHSLs (Atlantic RBCA Tier II PSSLs). This indicates that there is the potential for unacceptable health risks from exposure to indoor air if there is a commercial building located in the vicinity of the soil impacts at the Site.

There were four soil samples collected at the Site that have mTPH concentrations greater than the commercial indoor air inhalation HHSLs: MSBL-BH5-2018-SS6 (Service Building), MLLA-MW3-2015-SS7 (Maintenance Parts Building) and MFPA-MW1-2018-SS5 (no building with 5 metres) as well as MAEB-MW2-2018-S4 near the Preparation Shop building. As illustrated on Figures 5A to 5C, it is estimated that the areas of impacts exceeding the commercial indoor air criteria total 431 square metres, at an average thickness of 1 metre.

Due to the locations of the commercial buildings on the Site, it is recommended that the soil exceedance areas illustrated on Figures 5A to 5C be further assessed through the installation and seasonal sampling of soil vapour probes.

Although the maximum groundwater concentration (447 mg/L in MGSB-MW15, near the Carpenters & Joiners Building) does not exceed the indoor air inhalation HHSL (Atlantic RBBC Tier II PSSL), the groundwater at the Site is shallower than that assumed in the derivation of the HHSLs and therefore the HHSL may not be applicable, which may warrant further assessment. Although no free product was measured in groundwater during the field work, the groundwater concentration measured in MGSB-MW15 is indicative of the possible presence of free product in the area. Therefore, it is recommended that consideration be given to further assessing the soil vapour to indoor air pathway in this area through the installation and seasonal sampling of soil vapour probes. Due to the monitor well's proximity to the existing building and the absence of elevated soil concentrations in the adjacent boreholes, sub-slab probes beneath the building may be preferred.

### 7.5.2 Construction Worker Direct Contact with Groundwater

Table 7-16 compares the groundwater HHSLs protective of commercial direct contact/incidental ingestion exposure to the concentrations of arsenic, manganese, vanadium and mTPH in groundwater.

Table 7-16 Human Health Risk Results – Construction Worker Direct Contact/Incidental Ingestion

| COPC | Construction Worker Direct Contact/Incidental Ingestion HHSL | Maximum Concentration |
|---|---|---|
| **Groundwater (mg/L)** | | |
| Arsenic | 0.100 | **0.362** |
| Vanadium | 0.062 | **0.494** |
| Modified TPH | 32 | **447** |

As indicated in Table 7-16, the maximum concentrations for arsenic, vanadium and mTPH in groundwater exceed the direct contact/incidental ingestion HHSLs. This indicates that there may be the potential for unacceptable health risks to a construction worker on the Site from direct contact with the groundwater unless protected.

The groundwater samples collected at the Site that have arsenic and vanadium concentrations greater than the commercial direct contact/ingestion HHSLs were collected from the lower laydown area of the Shipyard. The groundwater samples that exceeded the mTPH direct contact/ingestion HHSLs were collected from monitor well MGSB-MW15, which is located on the south side of the general store building. The estimated groundwater plume exceeding the HHSLs for direct contact/ingestion exposure is illustrated on Figure 6 and further highlighted on Figure 6A. As the on-Site groundwater is not being consumed, the only receptor with potential groundwater contact would be a construction worker. Therefore, it is recommended that a Site specific health and safety plan be developed to address possible contact with groundwater should sub-surface work (where groundwater will be intersected) be planned in the lower laydown area and the south side of the general store building.

### 7.5.3 Commercial Worker Direct Contact with Sediment

Table 7-17 compares the sediment HHSLs protective of commercial direct contact/soil ingestion exposure to the concentrations of arsenic and lead in sediment.

Table 7-17 Human Health Risk Results – Commercial Direct Contact/Incidental Ingestion

| COPC | Commercial Direct Contact / Incidental Ingestion HHSL | EPC Concentration |
|---|---|---|
| **Sediment (mg/kg)** | | |
| Arsenic | 69 | 40.43 |
| Lead | 8588 | 362 |

As indicated in Table 7-17, the EPC concentrations for arsenic and lead in sediment are within the commercial direct contact/soil ingestion HHSLs. This indicates no further work is required to assess health risks to a commercial worker from direct contact with sediment at the Site.

### 7.5.4 Potential Consumption of Shellfish

Table 7-18 compares the shellfish SSTLs calculated to be protective of potential consumption of shellfish from the waterlot by commercial or subsistence shellfish eaters. As indicated in Table 7-18, the EPC concentration for cadmium in shellfish collected from the waterlot exceed the shellfish SSTL for the protection of shellfish consumption (heavy eater). However, the commercial/subsistence SSTL developed for the Site is based on the most sensitive receptor (toddler) consuming shellfish collected from the waterlot 5 days/week, 26 weeks/year (heavy consumer). This is a very conservative assumption as subsistence or commercial fishing is not known to occur directly in the waterlot and it is considered unlikely a toddler would be consuming 5 meals of shellfish collected exclusively from the waterlot on a weekly basis. As such, an additional SSTL was developed for the Site that assumes a toddler would consume shellfish from the waterlot 2 days/week, 26 weeks per year and is considered to be representative of a recreational consumer. An SSTL was also developed specific for an adult receptor that may consume shellfish from the waterlot 5 days/week, 26 weeks per year (commercial/subsistence fisher). The revised SSTLs based on an adult subsistence fisher and a recreational toddler with reduced shellfish consumption are included in Table 7-18.

Table 7-18 Human Health Risk Results –Shellfish Consumption Pathway

| COPC | Shellfish SSTL – Subsistence Toddler Consumption of Shellfish (5 days/wk, 26 wks/year) | Shellfish SSTL – Recreational Toddler Consumption of Shellfish(2 days/wk, 26 wks/year) | Shellfish SSTL – Subsistence/ Commercial Adult Consumption of Shellfish (5 days/wk, 26 wks/year) | EPC based on whole body concentration | EPC based on abductor muscle only |
|---|---|---|---|---|---|
| **Shellfish Tissue (mg/kg)** | | | | | |
| Cadmium | **5.9** | 10.1 | 9.3 | **8.6** | 0.86 |
| **Note:** Abductor muscle conservatively assumed to be 10% of wholebody as per Department of Fisheries and Oceans, Research Branch (J.F. Uthe and C.L. Chou, 1986) | | | | | |

As indicated in Table 7-18, the EPC for cadmium in shellfish is below the SSTLs developed for the recreational toddler consumption of shellfish with reduced exposure frequency. The EPC for cadmium in shellfish is also below the SSTL developed for an adult subsistence/commercial (heavy) consumer of shellfish. As such, it is reasonable to assume that the concentrations of cadmium in shellfish at the Site is unlikely to pose a risk to human health based on the current/historical waterlot usage as a shipyard.

A review of the shellfish tissue data also indicated that the elevated cadmium EPC was primarily related to concentrations of cadmium in scallop tissue. The maximum concentrations of cadmium in crab and mussel tissue collected from the Site were 2.9 and 4.8 mg/kg, respectively, and well below the SSTL. However, concentrations of cadmium in scallops collected from the waterlot ranged from 2.7 to 17.8 mg/kg with the reference sample being 4.9 mg/kg. A literature review indicates that cadmium can be naturally elevated in sea scallops and not specifically associated with contaminated sediment or surface water (J.F. Uthe and C.L. Chou, 1986; S.Ray and V. Jerome, 1987 and G.M. Krusynski, 2003). The above noted results for cadmium in shellfish tissue are also consistent with concentrations of these metals observed in reference crustaceans and mollusk samples collected from other harbours on the southern coast of NL as part of on-going work being completed by GHD on behalf of the federal government (personnel knowledge). Specific to scallops, concentrations of cadmium in tissue samples collected from other reference areas in southern NL ranged from 5.1 to 7.0 mg/kg. As concentrations of cadmium in soil, groundwater, sediment and surface water at the Site were either below detection limits or applicable screening guidelines, it is reasonable to assume that the elevated concentrations of cadmium in tissue samples collected from the waterlot are related background conditions in the Mortier Bay area and not specific to the Site.

Although the maximum concentration of cadmium in scallop tissue samples collected from the waterlot exceeded the SSTL, the scallop tissue concentration is based on a composite of soft tissue within the scallop shell and not just the abductor muscle which is generally considered the edible portion of sea scallops. A study conducted by the Department of Fisheries and Oceans, Research Branch (J.F. Uthe and C.L. Chou, 1986) indicates that 75 to over 90% of the total cadmium in the soft tissue of scallops is concentrated in the digestive gland, with less than 1% in the abductor muscle. This same study identified the mean concentration of cadmium in digestive glands of scallops collected from various areas in the Maritime Provinces being 94.68 mg/kg wet weight. The corresponding whole abductor muscle had a cadmium concentration of 0.117 mg/kg wet weight. As indicated in Table 7-18, it has been conservatively assumed that the abductor muscle is 10% of wholebody which would result in an EPC that is well below the SSTLs developed for both a toddler and adult receptor (subsistence, recreational/commercial consumption). As such, it is reasonable to assume that the concentration of cadmium in the edible portion of scallops (abductor muscle) collected from the Site is well below concentrations that are considered to pose a potential risk to human health.

In addition to natural bioaccumulation of cadmium in digestive glands of scallops with the negligible concentrations present in the edible abductor muscles, the health risks for consumption of shellfish were calculated using other highly conservative assumptions, including:

1) Absorption into the bloodstream from shellfish ingestion was assumed to be 100 percent.

2) It was assumed that the shellfish consumed by the receptors have spent their entire lives within the waterlot limits. This is highly conservative given the mobile nature of these food items.

3) It was assumed that the sport/subsistence and commercial fish consumers only harvest and consume shellfish collected from within the waterlot.

Based on the above noted rationale, the concentrations of cadmium in shellfish tissue in the waterlot (specifically scallops) are considered to be related to background conditions in the area and unlikely to pose an unacceptable risk to human health based on current Site usage. It has been confirmed recreational fishing for scallops does occur in the waterlot or adjacent areas; however, the DFO recreational and commercial harvesting licenses specify “On the recommendation of the Canadian Food Inspection Agency (CFIA), DFO wishes to advise both commercial and recreational harvesters not to consume any portion, other than the adductor muscle ("meat"), from scallops that are harvested from the shoreline and adjacent waters surrounding the province of Newfoundland and Labrador”.  As indicated above, cadmium concentrations in abductor muscles typically constitute less than 1% of the total cadmium concentrations in the soft tissue of scallops and; therefore, below the SSTLs developed for substance/commercial for both a toddler and adult receptor.

## 7.6 Summary of Uncertainty Analysis

As a result of the scientific investigations, literature reviews, and risk assessment guidance that have been undertaken or followed in the preparation of this HHRA, it is believed that the risk assessment results present a reasonable yet conservative evaluation of the risk to human receptors present at the Site. Where uncertainty or lack of knowledge were encountered in the development of the risk estimates, reasonable yet conservative assumptions were made, or data were selected, in order to ensure that risks were not underestimated.

The soil and groundwater to indoor air exposure pathways were assessed using published pathway specific guidelines. These guidelines are based on default assumptions that may or may not be consistent with all conditions at the Site. For example, the depth to groundwater at the site appears to be shallower than the default depth to groundwater used to derive the guidelines. In addition, the soil mTPH impacts observed appear to occur below the groundwater table in some cases and therefore may not be available to release soil vapour to indoor air. Therefore, additional work to further assess this pathway has been recommended for risk management. It is noted that in areas of shallow groundwater, there is potential for groundwater elevations to vary based on seasonal conditions and would account for the soil impacts in the vadose zone.

The shellfish ingestion pathway was evaluated using tissue data collected directly from the waterlot and reference areas. However, risk from the fish ingestion pathway was inferred based on the results of the Site-specific shellfish data, anecdotal evidence that fishing for finfish does not occur in the waterlot and the lack of observable finfish in the waterlot. The risk to human health from consumption of fish caught in Mortier Bay or the waterlot was not quantitatively evaluated as part of this evaluation given the lack of available Site-specific fish tissue.

Harvesting and consumption of shellfish specifically caught from within the waterlot boundaries is a major uncertainty. Anecdotal reports indicate that commercial harvesting of scallops occurs in Mortier Bay and, as noted previously, recreational harvesting is noted to occur in the waterlot and adjacent areas. In addition, the risk assessment conservatively assumes harvesting of shellfish for subsistence purposes occurs in the waterlot but the actual usage of waterlot as a subsistence food supply is considered unlikely. The risk to human health also assumed that it is unlikely a toddler would consume shellfish from the waterlot 5 meals/week, 26 weeks per year. However, the actual usage of the waterlot for harvesting shellfish, specifically scallops, and the actual consumption rate of shellfish collected from the waterlot is not known.

The elevated concentrations of cadmium in scallop tissue was assumed to be related to natural background conditions given the low concentrations of cadmium in soil, groundwater, sediment and surface water at the Site; however, the mechanism for bioaccumulation of cadmium in shellfish tissue is not known. The risk evaluation is based on the concentration of COPCs detected in soft tissue of shellfish and is not specific to edible portions of shellfish. Based on a literature review, it is reasonable to assume that the concentration of COPCs such as cadmium are significantly reduced in the edible portions of shellfish compared to whole body concentrations but the actual concentrations of cadmium in edible shellfish tissue from the waterlot was not evaluated.

# 8. Ecological Risk Assessment

The purpose of this ERA is to evaluate the potential for adverse effects to occur to ecological receptors as a result of exposure to concentrations of COPCs in environmental media at the Site. As with the HHRA, the ERA process follows a recognized framework that progresses from a qualitative initial phase (i.e., problem formulation), through exposure and toxicity (effects) analysis, and culminates in a quantitative risk characterization. Following this framework, the limitations and uncertainties inherent to the ERA process, and the relevance of these limitations and uncertainties to the conclusions stemming from the assessment, are discussed. This ERA has been conducted in a manner consistent with accepted ERA methodologies and guidance published by regulatory agencies, including the CCME (1996; 1997).

The framework used for this ERA considered effects at the community level for common plants and invertebrates, at the population level for mammals and birds, and at the individual level for species identified as endangered, threatened, or extirpated under the *Species at Risk Act* (SARA) or similar provincial legislation (where they occur).

As there is no single set of ecological values or resources to be protected that can be generally applied to every site. Ecological receptors were selected by focusing on wildlife species that are indigenous to the area (i.e., taking into consideration the types, quality and quantity of habitat present at the site), are most likely to receive the greatest exposure to contaminants (due to their habitat, behavioral traits, and home ranges), and are representative of various feeding guilds or trophic levels.

## 8.1 Ecological Screening

The analytical data for soil, groundwater, sediment and surface water were compared to ecological specific screening values (ESLs) developed or recognized by the CCME or other ecological screening values, if a CCME guideline was not available.

### 8.1.1 Soil

The following guidelines (in order of preference) were used for the screening of chemicals in soil for inclusion in the ERA.

- CCME (1999, revised 2018). Canadian Soil Quality Guidelines for Environmental Health ($SQG_E$). Pathway-specific information from the individual fact sheets was reviewed to confirm environmental health guidelines protective of eco soil contact (terrestrial plants and invertebrates) and soil and food ingestion (terrestrial wildlife). For soil eco contact, the CCME commercial SQGs were applied consistent with the land use of the Site. For soil and food ingestion, the CCME agricultural SQGs were applied given that corresponding commercial guidelines are not available.
- Atlantic Risk-Based Corrective Action Tier 1 Soil Ecological Screening Levels for Protection of Plants and Soil Invertebrates (Table 1a; commercial, coarse) and Wildlife (Table 1b), September 2015.
- Ontario MOECC (Ontario MOECC, 2016). Mammals & Birds component values, residential/parkland land use, coarse-textured soil.

As indicated in Table 8-1, petroleum hydrocarbon (PHC) fraction F2, and PHC fraction F3 exceed the soil ESLs and therefore require further assessment in the ERA. All other parameters were detected at concentrations below the soil ESLs or background soil concentrations. For lead, the maximum concentration is less than the ESL protective of terrestrial plants and invertebrates but is greater than the ESL protective of terrestrial wildlife. However, since the EPC for lead is less than the ESL protective of terrestrial wildlife, lead was not carried through the ERA for further evaluation. For PHC F2 and PHC F3, the concentrations (maximum or EPC) in soil exceed the ESLs for plants and soil invertebrates but do not exceed the ESLs protective of terrestrial wildlife. Therefore, PHC

F2 and PHC F3 are carried forward for further evaluation of plants and soil invertebrates only. Further evaluation of terrestrial wildlife in the ERA was not required.

#### 8.1.2 Groundwater

For groundwater, the potential exposure pathway identified for the Site was groundwater discharging to surface water for the protection of aquatic life. The following guidelines (in order of preference) were used for the screening of chemicals in groundwater for inclusion in the ERA.

- CCME (1999, revised 2018). Canadian Water Quality Guidelines for the Protection to Aquatic Life (WQG), marine water.
- Atlantic Risk-Based Corrective Action Tier 1 Surface Water Ecological Screening Levels for Protection of Freshwater and Marine Aquatic Life, Table 3a, September 2015. Based on predominant fuel oil resemblance.
- NSE EQS: Nova Scotia Environment Tier 1 Environmental Quality Standards, Marine Water, July 2013.

Given that the Site is adjacent to Mortier Bay, the screening values for groundwater discharging to surface water do not account for any dilution due to groundwater migration.

As indicated in Table 8-2, arsenic, cadmium, copper, nickel, selenium, vanadium, zinc, and mTPH have concentrations exceeding the groundwater ESLs and therefore require further assessment in the ERA. Since titanium was detected in groundwater but does not have a groundwater ESL, it also requires further assessment in the ERA.

Many of these parameters were also detected in sediment at concentrations exceeding the sediment ESLs protective of aquatic life (see below sediment screening). Given the proximity to Mortier Bay, surface water samples were collected from the waterlot as well as a reference area in Mortier Bay to directly assess COPCs in surface water that may be associated with the Site. Additional assessment of sediment and surface water is provided in the subsequent sections.

#### 8.1.3 Sediment

For the protection of aquatic life, the sediment ESLs were CCME's Interim Sediment Quality Guidelines (ISQGs) and Probable Effect Levels (PELs), marine. In the development of the sediment quality guidelines, CCME considered all components of the aquatic ecosystem, if the data were available.

The CCME ISQGs are described as the lowest concentrations, below which adverse effects are rarely observed, whereas the CCME PELs are concentrations above which adverse effects are likely to occur. No-effect benchmarks such as the CCME ISQGs are appropriate for site screening but are not appropriate to guide remedial decisions. This approach is supported in:

- Criteria for the Assessment of Sediment Quality in Quebec and Application Frameworks: Prevention, Dredging and Remediation, Environment Canada and the Province of Quebec (2008).

This document recommends that there is no need to initiate a remediation process for concentrations lower than the CCME PELs, unless development projects or dredging work is planned. The CCME PELs are considered to be protective of valued environmental components (VECs). Therefore, parameters with concentrations below the CCME PELs were not identified as COPCs requiring further evaluation in the ERA.

Where CCME PELs were not available, screening values were selected from the following sources:

- Atlantic Risk-Based Corrective Action (RBCA) (2015). Sediment ecological screening levels (ARBCA ESL), marine.
- NSE EQS: Nova Scotia Environment Tier 1 Environmental Quality Standards for Sediment, marine sediment, July 2013.
- Ontario MOECC's Sediment Quality Guidelines, Lowest Effect Levels (LELs), Guidelines for the Protection and Management of Aquatic Sediment Quality in Ontario (Ontario MOE, 1993).
- Maximum permissible concentrations (MPCs), obtained from Crommentuijn et al. (2000). Maximum permissible and negligible concentrations for metals and metalloids in the Netherlands, taking into account background concentrations. Journal of Environmental Management 60: 121-143.

The sediment concentrations from the reference sample locations were also considered in the ecological screening for sediment. If the maximum concentration or EPC is less than the mean concentration in the reference sediment samples, or if the background analysis (see Section 6.3) indicates that COPC concentrations in sediment are statistically similar to the concentrations in the reference sediment samples, then the parameter was not identified as sediment COPC.

As indicated in Table 8-3, antimony, arsenic, copper, lead, selenium, zinc, PCBs, 1-methylnaphthalene, 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and pyrene have concentrations exceeding the sediment ESLs and are present at concentrations greater than the reference sediment samples. Therefore, these parameters require further assessment in the ERA. Acridine and benzo(e)pyrene also require further assessment in the ERA since these PAHs were detected in sediment but do not have sediment ESLs and/or are present at concentrations greater than the reference sediment samples.

### 8.1.4 Surface Water

For the protection of aquatic life, the surface water ESLs were CCME's Canadian Water Quality Guidelines for the Protection to Aquatic Life (WQG) (CCME, 1999, and updates), marine.

Where CCME WQGs were not available, screening values were selected from the following sources:

- Atlantic Risk-Based Corrective Action Tier 1 Surface Water Ecological Screening Levels for Protection of Freshwater and Marine Aquatic Life, Table 3a, September 2015. Based on predominant fuel oil resemblance.
- NSE EQS: Nova Scotia Environment Tier 1 Environmental Quality Standards, Marine Water, July 2013.

- AEP (2016) Alberta Environment and Parks (AEP) Alberta Remediation Guidelines, Table C-11 Surface Water Quality Guidelines, Aquatic Life, February.
- Ontario MECP Aquatic Protection Values (APVs), Modified Generic Risk Assessment Model, Version 2, November 2016 (Ontario MOECC, 2016).

The surface water concentrations from the reference sample locations were also considered in the ecological screening for surface water. If the maximum concentration is equal to or less than the surface water concentration in the reference surface water samples, then the parameter was not identified as a surface water COPC.

As indicated in Table 8-4, concentrations of COPCs in surface water were below applicable ESLs or background conditions in the area excluding vanadium. The maximum concentration of vanadium in surface water of the waterlot exceeded the surface water ESL and also marginally exceeded the concentrations observed in the reference surface water samples. However, the average concentration of vanadium in the five waterlot samples (1.1 mg/L) is approximately equal to the average concentration of vanadium observed in the reference samples (0.94 mg/L). In addition, the RPD between the average vanadium concentration in the waterlot samples and the reference samples is approximately 16% and well within the 30% RPD accuracy objective recommended by the United States Environmental Protection Agency (USEPA) for analysis of inorganic parameters:

- EPA 2010, USEPA Contract Laboratory Program National Functional Guidelines for Inorganic Data Review, USEPA-540-R-10-011, October, 2010

The USEPA guidance considers a <30% RPD between duplicate samples to be an acceptable level of accuracy in analytical measurements. As such, it is reasonable to apply this level of accuracy when comparing Site concentrations that are based on accepted laboratory methodologies to the reference samples. As such, it is reasonable to assume that the concentrations of vanadium in the waterlot surface water samples are representative of background conditions in the area.

Based on the above noted screening evaluation, concentrations of COPCs in surface water at the Site are below applicable ESLs or are consistent with background conditions in the area and unlikely to pose an incremental risk to aquatic ecological receptors. Further evaluation of risk to ecological receptors from exposure to COPCs in surface water is not considered warranted.

**Table 8-1 Ecological Screening of Surface Soil for Marystown Shipyard, Newfoundland & Labrador**

| Chemical | Maximum Concentration (mg/kg) | Exposure Point Concentration (EPC) (mg/kg) | Newfoundland and Labrador Background (mg/kg) | Ecological Screening Levels (ESL) (mg/kg) | | | | Comment |
|---|---|---|---|---|---|---|---|---|
| | | | | Plants & Invertebrates | Reference | Terrestrial Wildlife | Reference | |
| **Metals** | | | | | | | | |
| Antimony | <1 | NC | 1 | 40 | CCME SQG | 40 | CCME SQG | Maximum meets ESL |
| Arsenic | 23 | NC | 17 | 26 | CCME SQG | 380 | CCME SQG | Maximum meets ESL |
| Barium | 343 | NC | 81 | 2000 | CCME SQG | 2000 | CCME SQG | Maximum meets ESL |
| Beryllium | <2 | NC | 1 | 8 | CCME SQG | 8 | CCME SQG | Maximum meets ESL |
| Cadmium | 0.7 | NC | 0.8 | 22 | CCME SQG | 3.8 | CCME SQG | Maximum meets ESL |
| Chromium | 107 | 49 | 52 | 87 | CCME SQG | 160 | Ontario CV | EPC meets ESL and background |
| Cobalt | 34 | NC | 17 | 300 | CCME SQG | 300 | CCME SQG | Maximum meets ESL |
| Copper | 87 | NC | 57 | 91 | CCME SQG | 300 | CCME SQG | Maximum meets ESL |
| Lead | 96.7 | 43 | 35 | 600 | CCME SQG | 70 | CCME SQG | Maximum exceeds Wildlife ESL but EPC below Wildlife ESL |
| Mercury | 0.06 | NC | 1 | 50 | CCME SQG | 20 | Ontario CV | Maximum meets ESL |
| Molybdenum | 7 | NC | 1.1 | 40 | CCME SQG | 40 | CCME SQG | Maximum meets ESL |
| Nickel | 69 | NC | 72 | 89 | CCME SQG | 528 | CCME SQG | Maximum meets ESL |
| Selenium | <1 | NC | 1 | 2.9 | CCME SQG | 4.5 | CCME SQG | Maximum meets ESL |
| Silver | <0.5 | NC | 0.25 | 40 | CCME SQG | 40 | CCME SQG | Maximum meets ESL |
| Thallium | <0.1 | NC | 0.27 | 3.6 | CCME SQG | 1 | CCME SQG | Maximum meets ESL |
| Tin | 4 | NC | 4.1 | 300 | CCME SQG | 300 | CCME SQG | Maximum meets ESL |
| Uranium | 0.6 | NC | 2.2 | 2000 | CCME SQG | 33 | CCME SQG | Maximum meets ESL |
| Vanadium | 100 | 66 | 86 | 130 | CCME SQG | 18 | Ontario CV | EPC meets background |
| Zinc | 329 | NC | 120 | 450 | CCME SQG | 960 | CCME SQG | Maximum meets ESL |
| **Petroleum Hydrocarbons** | | | | | | | | |
| Benzene | <0.03 | NC | Not Available | 180 | CCME SQG | 25 | CCME SQG | Maximum meets ESL |
| Toluene | <0.04 | NC | Not Available | 250 | CCME SQG | 1400 | CCME SQG | Maximum meets ESL |
| Ethylbenzene | <0.03 | NC | Not Available | 300 | CCME SQG | 910 | CCME SQG | Maximum meets ESL |
| Xylenes | <0.05 | NC | Not Available | 350 | CCME SQG | 3700 | CCME SQG | Maximum meets ESL |
| F1 C6-C10 | 70 | NC | Not Available | 320 | ARBCA ESL | 11000 | ARBCA ESL | Maximum meets ESL |
| **F2 >C10-C16** | **3910** | **1062** | **Not Available** | **260** | **ARBCA ESL** | **9800** | **ARBCA ESL** | **Maximum exceeds ESL** |
| **F3 >C16-C32** | **4090** | **1255** | **Not Available** | **1700** | **ARBCA ESL** | **16000** | **ARBCA ESL** | **Maximum exceeds ESL** |

**Notes**

NC - Not Calculated.

Ecological Screening Levels (ESLs):

CCME SQG: Canadian Council of Ministers of Environment, Soil Quality Guidelines for the Protection of Environmental Health, agricultural, coarse soils.

For plants & invertebrates, the commercial SQGs were applied. For mammals & birds, the agricultural SQGs were applied since there are no available commercial SQGs protective of these receptors.

ARBCA ESL: Atlantic Risk-Based Corrective Action Tier 1 Soil Ecological Screening Levels for Protection of Plants and Soil Invertebrates (Table 1a; commercial, coarse) and Wildlife (Table 1b), September 2015.

Ontario CV: Ontario Ministry of the Environment, Conservation and Parks Component Values, Modified Generic Risk Assessment, Mammals & Birds - residential/parkland, coarse soils.

**Table 8-2 Ecological Screening of Groundwater for Marystown Shipyard, Newfoundland & Labrador**

| Chemical | Maximum Concentration (µg/L) | Exposure Point Concentration (EPC) (µg/L) | Ecological Screening Levels (ESL) (µg/L) | Reference | Comment |
|---|---|---|---|---|---|
| **Metals** | | | | | |
| Antimony | <2 | NC | 500 | NSE EQS | Maximum meets ESL |
| **Arsenic** | **362** | **NC** | **12.5** | **CCME WQG** | **Maximum exceeds ESL** |
| Barium | 483 | NC | 500 | NSE EQS | Maximum meets ESL |
| Beryllium | <2 | NC | 100 | NSE EQS | Maximum meets ESL |
| **Cadmium** | **0.16** | **NC** | **0.12** | **CCME WQG** | **Maximum exceeds ESL** |
| Chromium | 7 | NC | 56 | CCME WQG | Maximum meets ESL |
| Cobalt | 2 | NC | 10 | NSE EQS | Maximum meets ESL |
| **Copper** | **7** | **NC** | **2** | **NSE EQS** | **Maximum exceeds ESL** |
| Lead | 0.5 | NC | 2 | NSE EQS | Maximum meets ESL |
| Molybdenum | 5 | NC | 73 | NSE EQS | Maximum meets ESL |
| **Nickel** | **10** | **NC** | **8.3** | **NSE EQS** | **Maximum exceeds ESL** |
| **Selenium** | **156** | **NC** | **2** | **NSE EQS** | **Maximum exceeds ESL** |
| Silver | 0.2 | NC | 1.5 | NSE EQS | Maximum meets ESL |
| Thallium | 0.1 | NC | 21.3 | NSE EQS | Maximum meets ESL |
| Tin | <2 | NC | - | - | Not detected |
| **Titanium** | **6** | **NC** | **-** | **-** | **Detected** |
| Uranium | 1.9 | NC | 100 | NSE EQS | Maximum meets ESL |
| **Vanadium** | **494** | **NC** | **50** | **NSE EQS** | **Maximum exceeds ESL** |
| **Zinc** | **32** | **NC** | **10** | **NSE EQS** | **Maximum exceeds ESL** |
| **Petroleum Hydrocarbons** | | | | | |
| Benzene | <1 | NC | 110 | CCME WQG | Maximum meets ESL |
| Toluene | <1 | NC | 215 | CCME WQG | Maximum meets ESL |
| Ethylbenzene | <1 | NC | 25 | CCME WQG | Maximum meets ESL |
| Xylenes | <2 | NC | 330 | NSE EQS | Maximum meets ESL |
| **Modified TPH** | **447000** | **357200** | **100** | **ARBCA ESL** | **Maximum and EPC exceed ESL** |

**Notes**

NC - Not Calculated. For all metals, the EPC could not be calculated due to insufficient sample numbers.
For all other parameters the EPC was not required.

Ecological Screening Levels (ESLs): freshwater guidelines applied in the absence of marine guidelines

CCME WQG: Canadian Council of Ministers of Environment, Water Quality Guidelines for the Protection of Aquatic Life, marine.

ARBCA ESL: Atlantic Risk-Based Corrective Action Tier 1 Surface Water Ecological Screening Levels for Protection of Freshwater and Marine Aquatic Life, Table 3a, September 2015. Based on predominant fuel oil resemblance.

NSE EQS: Nova Scotia Environment Tier 1 Environmental Quality Standards, Marine Water, July 2013.

**Table 8-3 Ecological Screening of Sediment for Marystown Shipyard, Newfoundland & Labrador**

| Chemical | Maximum Concentration (mg/kg) | Exposure Point Concentration (EPC) (mg/kg) | Sediment Reference Concentrations (mg/kg) | Ecological Screening Levels (ESL) (mg/kg) | Statistically Similar to Background? Yes or No (1) | Reference | Comment |
|---|---|---|---|---|---|---|---|
| **Metals** | | | | | | | |
| **Antimony** | **28** | **11** | **<1** | **25** | **Cannot be Determined** | **NSE EQS** | **Maximum exceeds ESL** |
| **Arsenic** | **78** | **40** | **11** | **41.6** | **No** | **CCME SeQG** | **Maximum exceeds ESL** |
| Barium | 250 | NC | 41 | 300 | No | Crommentuijn et al., 2000 | Maximum meets ESL |
| Beryllium | <2 | NC | <2 | 1.2 | Yes | Crommentuijn et al., 2000 | Not detected |
| Cadmium | 1 | NC | <0.3 | 4.2 | Cannot be Determined | CCME SeQG | Maximum meets ESL |
| Chromium | 98 | NC | 16 | 160 | Yes | CCME SeQG | Maximum meets ESL |
| Cobalt | 22 | NC | 8.3 | 50 | No | Ontario LEL | Maximum meets ESL |
| **Copper** | **260** | **168** | **9.3** | **108** | **No** | **CCME SeQG** | **Maximum exceeds ESL** |
| **Lead** | **728** | **362** | **7** | **112** | **No** | **CCME SeQG** | **Maximum exceeds ESL** |
| Mercury | 0.64 | NC | 0.05 | 0.7 | Cannot be Determined | CCME SeQG | Maximum meets ESL |
| Molybdenum | 9 | NC | 2.5 | 250 | Yes | Crommentuijn et al., 2000 | Maximum meets ESL |
| Nickel | 45 | NC | 14 | 75 | Yes | NSE EQS | Maximum meets ESL |
| **Selenium** | **3** | **1.6** | **<1** | **2** | **Cannot be Determined** | **NSE EQS** | **Maximum exceeds ESL** |
| Silver | <0.5 | NC | <0.5 | 2.2 | Yes | NSE EQS | Maximum meets ESL |
| Thallium | <0.1 | NC | 0.1 | 2.6 | Yes | Crommentuijn et al., 2000 | Maximum meets ESL |
| Tin | 28 | NC | 3.3 | 22000 | No | Crommentuijn et al., 2000 | Maximum meets ESL |
| Uranium | 2.5 | 1.7 | 1.3 | - | Yes | - | Site statistically similar to background |
| Vanadium | 63 | 47 | 33 | 56 | Yes | Crommentuijn et al., 2000 | Site statistically similar to background |
| **Zinc** | **5020** | **1681** | **34** | **271** | **No** | **CCME SeQG** | **Maximum exceeds ESL** |
| **Polychlorinated Biphenyls** | | | | | | | |
| **PCBs** | **0.65** | **0.32** | **<0.02** | **0.189** | **Cannot be Determined** | **CCME SeQG** | **Maximum exceeds ESL** |
| **Petroleum Hydrocarbons** | | | | | | | |
| Benzene | <0.03 | NC | <0.03 | 5.4 | Yes | ARBCA ESL | Maximum meets ESL |
| Toluene | <0.04 | NC | <0.04 | 6.1 | Yes | ARBCA ESL | Maximum meets ESL |
| Ethylbenzene | <0.03 | NC | <0.05 | 5 | Yes | ARBCA ESL | Maximum meets ESL |
| Xylenes | <0.05 | NC | <0.05 | 5.5 | Yes | ARBCA ESL | Maximum meets ESL |
| Modified TPH | 419 | NC | <20 | 500 | Cannot be Determined | ARBCA ESL | Maximum meets ESL |
| **Polycyclic Aromatic Hydrocarbons** | | | | | | | |
| **1-Methylnaphthalene** | **0.27** | **0.13** | **<0.05** | **0.201** | **Cannot be Determined** | **CCME SeQG** | **Maximum exceeds ESL** |
| **2-Methylnaphthalene** | **0.38** | **0.18** | **<0.01** | **0.201** | **Cannot be Determined** | **CCME SeQG** | **Maximum exceeds ESL** |
| **Acenaphthene** | **0.728** | **0.37** | **<0.00671** | **0.0889** | **Cannot be Determined** | **CCME SeQG** | **Maximum exceeds ESL** |
| **Acenaphthylene** | **0.465** | **0.16** | **<0.004** | **0.128** | **Cannot be Determined** | **CCME SeQG** | **Maximum exceeds ESL** |
| **Acridine** | **0.11** | **NC** | **<0.05** | **-** | **Cannot be Determined** | **-** | **Detected** |
| **Anthracene** | **1.01** | **0.48** | **<0.03** | **0.245** | **Cannot be Determined** | **CCME SeQG** | **Maximum exceeds ESL** |
| **Benzo(a)anthracene** | **1.55** | **0.97** | **0.025** | **0.693** | **Cannot be Determined** | **CCME SeQG** | **Maximum exceeds ESL** |
| **Benzo(a)pyrene** | **1.42** | **0.81** | **<0.01** | **0.763** | **Cannot be Determined** | **CCME SeQG** | **Maximum exceeds ESL** |
| Benzo(b)fluoranthene | 1.96 | NC | <0.05 | 4.5 | Cannot be Determined | NSE EQS | Maximum meets ESL |
| **Benzo(e)pyrene** | **0.93** | **0.57** | **<0.05** | **-** | **Cannot be Determined** | **-** | **Detected** |
| Benzo(g,h,i)perylene | 0.86 | NC | <0.01 | 3.2 | Cannot be Determined | NSE EQS | Maximum meets ESL |
| Benzo(k)fluoranthene | 0.72 | NC | 0.02 | 4.5 | Cannot be Determined | NSE EQS | Maximum meets ESL |
| **Chrysene** | **1.7** | **0.99** | **0.03** | **0.846** | **No** | **CCME SeQG** | **Maximum exceeds ESL** |
| Dibenzo(a,h)anthracene | <0.006 | NC | <0.006 | 0.135 | Yes | CCME SeQG | Maximum meets ESL |
| **Fluoranthene** | **3.93** | **2.2** | **0.07** | **1.494** | **No** | **CCME SeQG** | **Maximum exceeds ESL** |
| **Fluorene** | **0.94** | **0.36** | **<0.01** | **0.144** | **Cannot be Determined** | **CCME SeQG** | **Maximum exceeds ESL** |
| **Indeno(1,2,3-cd)pyrene** | **1.13** | **0.58** | **<0.01** | **0.88** | **Cannot be Determined** | **NSE EQS** | **Maximum exceeds ESL** |
| **Naphthalene** | **0.62** | **0.19** | **<0.01** | **0.391** | **Cannot be Determined** | **CCME SeQG** | **Maximum exceeds ESL** |
| Perylene | 0.41 | NC | <0.05 | 1.398 | Cannot be Determined | CCME SeQG | Maximum meets ESL |
| **Phenanthrene** | **4.05** | **1.90** | **0.05** | **0.544** | **No** | **CCME SeQG** | **Maximum exceeds ESL** |
| **Pyrene** | **2.98** | **1.9** | **0.055** | **1.398** | **No** | **CCME SeQG** | **Maximum exceeds ESL** |
| Quinoline | <0.05 | NC | <0.05 | 1.398 | Cannot be Determined | CCME SeQG | Maximum meets ESL |

**Notes**

NC - Not Calculated.

Sediment reference concentrations are the based on the mean concentrations from 18-MNMA-REF1, 18-MNMA-REF2, and 18-MNMA-REF3.

Ecological Screening Levels (ESLs): freshwater guidelines applied in the absence of marine guidelines

CCME SeQG: Canadian Council of Ministers of Environment, Sediment Quality Guidelines for the Protection of Marine Aquatic Life, Probable Effects Level (PEL).

ARBCA ESL: Atlantic Risk-Based Corrective Action Tier 1 Sediment Ecological Screening Levels for Protection of Freshwater and Marine Aquatic Life, Table 4, September 2015. Based on predominant lube oil resemblance and average sediment foc of 0.1074.

NSE EQS: Nova Scotia Environment Environmental Quality Standards, Sediment Environment for Marine Sediment, July 2013. Note: For perylene and quinoline, the guideline value for pyrene was applied.

Ontario LEL: Ontario Sediment Quality Guidelines, Lowest Effect Levels, August 1993.

Crommentuijn et al., 2000: Crommentuijn et al., 2000. Maximum permissible and negligible concentrations for metals and metalloids in the Netherlands, taking into account background concentrations, Sediment - Maximum Permissible Concentration (MPC), J. Environ. Manag. 60: 121-143.

**Table 8-4 Ecological Screening of Surface Water**

| Chemical | Maximum Concentration (mg/L) | EPC (mg/kg) | Ecological Screening Levels (µg/L) | Reference (1) | Background Concentration Range (mg/L) | Identified as a COPC for Ecological Health? Yes or No | Comment |
|---|---|---|---|---|---|---|---|
| ***Petroleum Hydrocarbons*** | | | | | | | |
| Benzene | <0.001 | NC | 0.11 | a | <0.001 | No | Maximum meets Ecological Screening Level |
| Toluene | <0.001 | NC | 0.215 | a | <0.001 | No | Maximum meets Ecological Screening Level |
| Ethylbenzene | <0.001 | NC | 0.025 | a | <0.001 | No | Maximum meets Ecological Screening Level |
| Xylenes | <0.002 | NC | 0.33 | b | <0.002 | No | Maximum meets Ecological Screening Level |
| C6-C10 (less BTEX) | <0.01 | NC | NG | - | <0.01 | No | Maximum meets Background |
| C10-C16 | <0.05 | NC | NG | - | <0.05 | No | Maximum meets Background |
| C16-C21 | <0.10 | NC | NG | - | <0.10 | No | Maximum meets Background |
| C21-C32 | <0.1 | NC | NG | - | <0.1 | No | Maximum meets Background |
| Modified TPH | <0.1 | NC | 0.1 | b | <0.1 | No | Maximum meets Ecological Screening Level |
| ***Metals*** | | | | | | | |
| Aluminum | 0.031 | NC | 0.1 | a | 0.012-0.021 | No | Maximum meets Ecological Screening Level |
| Antimony | <0.002 | NC | 0.5 | c | <0.002 | No | Maximum meets Ecological Screening Level |
| Arsenic | <0.002 | NC | 0.0125 | a | <0.002 | No | Maximum meets Ecological Screening Level |
| Barium | 0.009 | NC | 0.5 | c | 0.007 | No | Maximum meets Ecological Screening Level |
| Beryllium | <0.002 | NC | 0.1 | c | <0.002 | No | Maximum meets Ecological Screening Level |
| Bismuth | <0.002 | NC | NG | - | <0.002 | No | Maximum meets Background |
| Boron | 3.57 | NC | 1.2 | c | 3.41-3.95 | No | Maximum meets Background |
| Cadmium | <0.00009 | NC | 0.00012 | a | <0.00009 | No | Maximum meets Ecological Screening Level |
| Chromium | 0.009 | NC | 0.056 | a | 0.008 | No | Maximum meets Ecological Screening Level |
| Cobalt | 0.003 | NC | 0.01 | c | 0.003 | No | Maximum meets Ecological Screening Level |
| Copper | 0.011 | NC | 0.002 | c | 0.011-0.013 | No | Maximum meets Background |
| Iron | 0.21 | NC | 0.3 | c | 0.157-0.177 | No | Maximum meets Ecological Screening Level |
| Lead | <0.0005 | NC | 0.002 | c | <0.0005 | No | Maximum meets Ecological Screening Level |
| Manganese | 0.015 | NC | 0.82 | c | 0.005-0.009 | No | Maximum meets Ecological Screening Level |
| Mercury | <0.000026 | NC | 0.000016 | a | <0.000026 | No | Maximum meets Background |
| Molybdenum | 0.008 | NC | 0.073 | a | 0.007-0.009 | No | Maximum meets Ecological Screening Level |
| Nickel | 0.019 | NC | 0.0083 | c | 0.020-0.024 | No | Maximum meets Background |
| Phosphorous | 0.00003 | NC | NG | - | 0.00003 | No | Maximum meets Background |

## Table 8-4 Ecological Screening of Surface Water

| Chemical | Maximum Concentration (mg/L) | EPC (mg/kg) | Ecological Screening Levels (µg/L) | Reference (1) | Background Concentration Range (mg/L) | Identified as a COPC for Ecological Health? Yes or No | Comment |
|---|---|---|---|---|---|---|---|
| Selenium | 0.002 | NC | 0.002 | c | <0.001 | No | Maximum meets Ecological Screening Level |
| Silver | <0.0001 | NC | 0.0015 | a | <0.0001 | No | Maximum meets Ecological Screening Level |
| Strontium | 5.08 | NC | 21 | c | 4.62-5.69 | No | Maximum meets Ecological Screening Level |
| Thallium | <0.0001 | NC | 0.0213 | c | <0.0001 | No | Maximum meets Ecological Screening Level |
| Tin | <0.002 | NC | NG | - | <0.002 | No | Maximum meets Background |
| Titanium | 0.01 | NC | NG | - | 0.014-0.025 | No | Maximum meets Background |
| Uranium | 0.0021 | NC | 0.1 | c | 0.0020-0.0024 | No | Maximum meets Ecological Screening Level |
| **Vanadium** | **1.18** | **NC** | **0.05** | **c** | **0.930-0.944** | **Yes** | **Maximum exceeds Ecological Screening Level and Background** |
| Zinc | <0.005 | NC | 0.01 | c | <0.005 | No | Maximum meets Ecological Screening Level |
| ***Polycyclic Aromatic Hydrocarbons*** | | | | | | | |
| 1-Methylnaphthalene | <0.00001 | NC | 0.001 | c | <0.00001 | No | Maximum meets Ecological Screening Level |
| 2-Methylnaphthalene | 0.00001 | NC | 0.002 | c | <0.00001 | No | Maximum meets Ecological Screening Level |
| Acenaphthene | <0.00001 | NC | 0.006 | c | <0.00001 | No | Maximum meets Ecological Screening Level |
| Acenaphthylene | <0.00001 | NC | 0.006 | c | <0.00001 | No | Maximum meets Ecological Screening Level |
| Acridine | <0.00001 | NC | 0.0034 | a | <0.00001 | No | Maximum meets Ecological Screening Level |
| Anthracene | <0.000012 | NC | 0.000012 | a | <0.000012 | No | Maximum meets Ecological Screening Level |
| Benzo(a)anthracene | <0.000018 | NC | 0.000018 | a | <0.000018 | No | Maximum meets Ecological Screening Level |
| Benzo(a)pyrene | <0.000010 | NC | 0.00001 | c | <0.000010 | No | Maximum meets Ecological Screening Level |
| Benzo(b)fluoranthene | <0.00001 | NC | 0.00042 | e | <0.00001 | No | Maximum meets Ecological Screening Level |
| Benzo(b+j)fluoranthene | <0.00001 | NC | 0.00048 | c | <0.00001 | No | Maximum meets Ecological Screening Level |
| Benzo(e)pyrene | <0.00001 | NC | 0.00001 | c | <0.00001 | No | Maximum meets Ecological Screening Level |
| Benzo(g,h,i)perylene | <0.00001 | NC | 0.00002 | e | <0.00001 | No | Maximum meets Ecological Screening Level |
| Benzo(k)fluoranthene | <0.00001 | NC | 0.00014 | e | <0.00001 | No | Maximum meets Ecological Screening Level |
| Chrysene | <0.00001 | NC | 0.0001 | c | <0.00001 | No | Maximum meets Ecological Screening Level |
| Dibenzo(a,h)anthracene | <0.00001 | NC | 0.00004 | e | <0.00001 | No | Maximum meets Ecological Screening Level |
| Fluoranthene | <0.00001 | NC | 0.011 | c | <0.00001 | No | Maximum meets Ecological Screening Level |
| Fluorene | <0.00001 | NC | 0.012 | c | <0.00001 | No | Maximum meets Ecological Screening Level |
| Indeno(1,2,3-cd)pyrene | <0.00001 | NC | 0.00014 | e | <0.00001 | No | Maximum meets Ecological Screening Level |

**Table 8-4 Ecological Screening of Surface Water**

| Chemical | Maximum Concentration (mg/L) | EPC (mg/kg) | Ecological Screening Levels (µg/L) | Reference (1) | Background Concentration Range (mg/L) | Identified as a COPC for Ecological Health? Yes or No | Comment |
|---|---|---|---|---|---|---|---|
| Naphthalene | <0.00001 | NC | 0.0014 | a | <0.00001 | No | Maximum meets Ecological Screening Level |
| Perylene | <0.00001 | NC | 0.00002 | c | <0.00001 | No | Maximum meets Ecological Screening Level |
| Phenanthrene | <0.00001 | NC | 0.0046 | c | <0.00001 | No | Maximum meets Ecological Screening Level |
| Pyrene | <0.00001 | NC | 0.00002 | c | <0.00001 | No | Maximum meets Ecological Screening Level |
| Quinoline | <0.00001 | NC | 0.0034 | a | <0.00001 | No | Maximum meets Ecological Screening Level |
| ***General Chemistry*** | | | | | | | |
| pH | 7.93 | NC | 7.0-8.7 | a | 7.92-7.96 | No | Maximum meets Ecological Screening Level |
| Chloride | 11600 | NC | 120 | a | 11400-12900 | No | Maximum meets Background |
| Fluoride | <24 | NC | 0.12 | a | <24 | No | Maximum meets Ecological Screening Level |
| Nitrate as N | <10 | NC | 200 | a | <10 | No | Maximum meets Ecological Screening Level |
| Nitrite as N | <10 | NC | 0.06 | a | <10 | No | Maximum meets Background |

**Notes**

NC - Not Calculated

NG - No Guideline

**BOLD** - carried forward in the PQERA for further evaluation

1. Ecological screening levels sources: note freshwater guideline used in the absence of marine guidelines

   a. CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life, Marine (http://ceqg-rcqe.ccme.ca/en/index.html#void).

      For aluminum, the guideline value for freshwater aquatic life was applied due to the lack of marine values.

      For acridine, the guideline value for quinoline was applied.

   b. ARBCA Tier II Pathway Specific Screening Levels for Groundwater, Table 3a, Tier 1 Surface Water and Groundwater Ecological Screening Levels for the Protection of Freshwater and Marine Aquatic Life, September 2015.

   c. Nova Scotia Remediation Levels Protocol, Table 3: Tier 1 Environmental Quality Standards for Surface Water, Marine, July 2013.

      For benzo(e)pyrene, the lowest guideline value of the PAHs was applied.

      For perylene, the guideline value for pyrene was applied.

   d. AEP Alberta Remediation Guidelines, Table C-11, Surface Water Quality Guidelines, Aquatic Life, February 2016.

   e. Ontario MECP Table 3.1 Aquatic Protection Values (APV) to Protect Aquatic Biota Exposed to Contaminants from Migration of Contaminated Groundwater to Surface Water.

## 8.2 Problem Formulation

The Problem Formulation step is an important information gathering and interpretation stage, which serves to plan and focus the approach of the ERA. For the current assessment, key tasks requiring evaluation within the Problem Formulation Step included the following:

- Identification of potential hazards.
- Identification of potential ecological receptors (i.e., biological communities, populations, individuals or habitats that could potentially be affected by the site, including rare, threatened, or endangered species).
- Assessment of potential exposure pathways and routes through which ecological receptors may be exposed to COPCs in soil.
- Consideration of appropriate assessment and measurement endpoints for the ecological risk assessment.

The outcome of these tasks forms the basis of the approach taken in the current assessment. A more detailed methodology for each of these tasks is described in the sections that follow. The risk assessment is being conducted to establish whether ecological risks may exist as a step in identifying the need for further evaluation or action.

### 8.2.1 Receptor Identification

For the purpose of the ERA, is it not practical or necessary to individually assess each species that may potentially visit or occupy the site. Instead, the potential for adverse effects imposed on a selected subset of receptors exposed to COPCs at the site was evaluated. The receptors or valued environmental components (VECs) were selected for the ERA by focusing on ecological species that:

- Are indigenous to the area (taking into consideration the habitat types and areas available within the site)
- Are likely to be highly exposed to COPCs due to their habitat preference, behavioral traits and home range
- Are representative of various feeding guilds or trophic levels (e.g., herbivore, insectivore, carnivore)
- Are of cultural, economic or social importance

VECs are not always identified at the species level; rather, VECs can represent communities deemed to be important. The following VECs were identified based on the results of the ecological screening:

- Terrestrial Plant and Invertebrate Community
- Benthic Invertebrates Community
- Fish Community
- Aquatic Wildlife (Mammals and Birds)

### *Species at Risk*

Species at Risk (SAR) that appear on Schedule 1 of the federal Species at Risk Act (SARA) benefit from the legal protection afforded and the mandatory recovery planning required under SARA. Similar protection is afforded to species listed on the Newfoundland and Labrador Endangered Species Act. A review and evaluation of SAR that may be found at the Site was conducted based on the ACCDC report presented in Appendix G.

The following species listed under Schedule 1 of SARA and/or the Newfoundland and Labrador Endangered Species Act have been recorded within 5 km of the site: harlequin duck (*Histrionicus histrionicus*) and seaside goldenrod (*Solidago sempervirens subsp. sempervirens*).

The harlequin duck prefers shallow, fast-flowing water with concentrations of aquatic invertebrates and adjacent available shelter for nesting, but breeding and brood rearing habitat varies geographically. Harlequin ducks overwinter in rocky outer marine coastlines, where the sea breaks against the shore. Here, they feed over or near subtidal ledges and close to shore near exposed headlands and archipelagos. They congregate on preferred rock shoals and may form large groups in coastal areas rich in food concentrations. The average distance from shore was approximately 11 metres in one study conducted in Newfoundland, in water less than 10 metres in depth. On the breeding grounds, harlequin ducks primarily eat freshwater aquatic invertebrates, such as chironimids, whereas on marine habitat they consume subtidal and intertidal aquatic invertebrates. During the non-breeding season, harlequin ducks feed mostly on marine crustaceans (Decapoda, Amphipoda, Isopoda, Cirridedia) and molluscs (Gastropoda, Polyplacophora, Bivalvia), and complement their diet with a variety of other marine prey, such as fish, fish eggs, insects, echinoderms, and sea cucumbers. The ACCDC report indicates that the harlequin duck was last sighted in 1995 several kilometres from the site. Therefore, the harlequin duck was not carried through the ERA. [Source: https://www.registrelep-sararegistry.gc.ca/virtual_sara/files/cosewic/sr_Harlequin%20Duck_2013_e.pdf]

There were no observations of the seaside goldenrod during the Site investigations. Furthermore, the ACCDC report indicates that the seaside goldenrod is not provincially or nationally listed, and is considered to be rare only in Newfoundland. Therefore, the seaside goldenrod has not been carried through the ERA.

The Expert Opinion Range Maps provided by ACCDC also indicated that the boreal felt lichen (*Erioderma pedicellatum*), banded killifish (*Fundulus diaphanus*), short-eared owl (*Asio flammeus*), and Barrow's Goldeneye (*Bucephala islandica*) could possibly be present in the vicinity of the Site. Specific observations of these species within 5 km of the site have not been identified and therefore, these species have not been carried through the ERA.

### 8.2.2 Exposure Pathway Identification

In order for chemicals to have deleterious effects, they need to gain access to the organism or receptor. The means by which a receptor is exposed to COPCs is referred to as an exposure pathway, and is dependent on the nature of both the chemical and receptor. A complete exposure pathway is one that meets the following four criteria (USEPA, 1989):

- A source of COPCs must be present

- Transport mechanisms and media must be available to move the chemicals from the source to the ecological receptors
- An opportunity must exist for the ecological receptors to contact the affected media
- A means must exist by which the chemical is taken up by ecological receptors, such as direct contact, ingestion or inhalation

The relevant exposure pathways are summarized in Table 8-5, which includes the qualitative evaluation of each pathway and a justification for the likelihood of exposure assigned. Those hazard-exposure-receptor combinations considered to have the highest likelihood to contribute to an ecological health risk were carried forward in the quantitative ERA.

Table 8-5 Potential Exposure Scenarios - Ecological Receptors

| Exposure Pathway Description | Likelihood of Exposure | Carried Forward for Analysis? | Justification |
|---|---|---|---|
| Ingestion of soil | Likely | Yes | PHC impacts are present in soils at the site. Plants and invertebrates could be exposed to these PHC impacts through direct contact. As indicated in the ecological screening, the identified soil COPCs are not considered to be a concern for terrestrial wildlife. Therefore, terrestrial mammals and birds were not identified as VECs for the Site. |
| Dermal contact with soil | | | |
| Ingestion of terrestrial invertebrates, vegetation, or small animal prey living at the site and exposed to contaminated soil | Likely | No | As indicated in the ecological screening, the identified soil COPCs are not considered to be a concern for terrestrial wildlife. Therefore, terrestrial mammals and birds were not identified as VECs for the Site. |
| Ingestion of surface water, freshwater, sediments, plants, invertebrates or fish | Likely | No | Freshwater sediment or surface water are not present within the water and all sediment and surface water data collected was considered marine. |
| Dermal contact with surface water or freshwater sediments | | | |
| Ingestion of marine water, sediments, plants, invertebrates or fish | Likely | Yes | Sediment COPCs were identified in the ecological screening and therefore benthic invertebrates, fish, and aquatic wildlife were identified as VECs for the Site. |
| Dermal contact with marine water or sediments | | | |

### 8.2.3 Ecological Conceptual Site Model

The ecological CSM (Figure 8.1) illustrates contaminant fate and transport mechanisms, complete exposure pathways, and primary and secondary receptors. Generic endpoints were used in the COPC screening, but specific endpoints were considered in the subsequent analysis. The ecological conceptual site model is based on the current understanding of the Site conditions, and serves as a framework for evaluating ecological exposure and risk. The ecological CSM for the Site describes:

- The source media (i.e., surface soil)
- Transport mechanisms (processes that introduce contaminants into environmental media)
- Exposure media (those environmental media through which organisms may be exposed to chemicals)
- Exposure route (direct contact, incidental ingestion, and dietary ingestion)
- Potential receptor organisms based on site ecological investigations

This figure schematically represents the interactions between the receptors and the COPCs, via the exposure pathways identified in previous elements of the Problem Formulation phase of the assessment. In Figure 8.1, the relevant exposure pathways are designated by arrows leading from the contaminant source media to each receptor. The pathway is considered to be complete (i.e., functioning) for a receptor when the exposure pathway box is marked with an “X”.

## 8.3 Evaluation of Terrestrial Plants and Invertebrates

Terrestrial plants and soil invertebrates were identified as VECs as explained below.

- **Terrestrial Plants**: The terrestrial plant community was selected as a VEC. As primary producers, plants are the base of the food chain in terrestrial ecosystems. Plants provide forage for herbivores and provide habitat for terrestrial animal species. Terrestrial plants are important in soil stabilization in floodplain and upland communities. Terrestrial plants may be exposed to and accumulate COPC from soil solution, where ions and dissolved fractions are freely available for absorption by plant roots. Plants may accumulate COPC in roots, stems, leaves, or fruits, which are then transferred to herbivores when consumed.
- **Invertebrates:** The soil invertebrate community was identified as a VEC. Soil invertebrates, such as insects and earthworms, may be exposed to and accumulate COPC. Exposure could result from direct contact between soil and outer membranes and respiratory surfaces, from the direct ingestion of soil during feeding activities, and from the consumption of affected prey or detritus, depending on species-specific feeding habits. Consumers, including birds and mammals, may be exposed to COPC accumulated in tissues of terrestrial invertebrate such as insects and earthworms.

Concentrations of chemicals in soil were screened against ecological health benchmark values based on CCME guidelines or equivalent sources (see Table 8-1). These guidelines are considered indicative of thresholds that could potentially lead to effects on plants and/or soil invertebrates, although they incorporate conservative assumptions in their derivation. Where soil concentrations of COPCs exceed the screening benchmarks, this alone should not be interpreted as evidence of effects. A weight-of-evidence approach is used in which benchmark comparisons are considered in combination with other lines of evidence; requirement for risk management or remedial action are generally not be based on screening guidelines. Other lines of evidence relevant to an assessment of plant and invertebrate communities are discussed below.

**Figure 8.1 Conceptual Site Model for Ecological Receptors - Marystown Shipyard, Newfoundland & Labrador**

| Source Media | | Exposure Media | Potential Exposure Pathways | Terrestrial Plant Community | Soil Invertebrate Community | Benthic Invertebrate Community | Fish Community | Lesser Scaup (Insectivore) | Common Loon (Piscivore) | River Otter (Insectivore/Piscivore) |
|---|---|---|---|---|---|---|---|---|---|---|
| Surface Soil | → | Surface Soil | Direct Exposure | X | X | | | | | |
| Sediment | → | Sediment | Direct Exposure | | | X | X | X | X | X |
| | [Uptake] → | Marine Plants | Ingestion | | | | X | X | | |
| | [Uptake] → | Marine Invertebrates | Ingestion | | | | X | X | X | X |
| | [Uptake] → | Marine Fish | Ingestion | | | | | | X | X |
| Surface Water | → | Surface Water | Direct Exposure/Ingestion | | | | | | | |

***SOURCE*** → ***RECEPTOR***

Note:
1) **X** - Indicates a potentially complete exposure pathway
2) Grey Shading indicates pathway is incomplete

Table 8-6 provides a summary of the number of locations with PHC F2 and PHC F3 concentrations exceeding the soil ESLs protective of terrestrial plants and invertebrates. As indicated in the table below, the concentrations of PHC F2 in 10 of 37 sample locations exceed the ESL and for PHC F3, five of the 37 sample locations exceed the ESL. However, the table below also indicates that the depths of these exceeding samples range from 1.8 to 4.2 metres below grade. At many of these exceeding locations, shallower soil samples were collected and the PHC concentrations in these shallower soils met the soil ESLs. Plant and invertebrate communities are typically concentrated in the top 0.5 metres of soil, and therefore, most of these communities will not be exposed to the soil impacts at depths greater than 1.8 metres. Furthermore, the depths of the PHC impacts in soil are largely below the depth of shallow groundwater at the Site and since most plant and invertebrate communities would tend to avoid heavily saturated soils, exposure to the PHC impacts would be less likely to occur. In addition, the majority of the PHC-impacted soils are located in heavily disturbed areas adjacent to existing buildings or in areas that are currently devoid of vegetation.

Given these lines of evidence (i.e., PHC impacts are present at depths where potential exposure is not likely to occur; PHC impacts are present in areas of the Site with limited to no vegetation), the PHC impacts in soils at the Site are not likely to be a concern to terrestrial plant and invertebrate communities based on the existing conditions at the Site.

Table 8-6 Ecological Risk Results – Plants and Invertebrates

| COPC | Soil ESL– Plants and Invertebrates (mg/kg) | Number of Sample Locations Exceeding | Exceeding Location Depths |
|---|---|---|---|
| PHC F2 | 260 | 10/37 | 1.8 to 4.2 metres |
| PHC F3 | 1700 | 5/37 | 1.8 to 4.2 metres |

## 8.4 Evaluation of Benthic Invertebrates

Benthic invertebrates are an important group of organisms in marine environments and are critical components of a functioning ecosystem. Benthic invertebrates also serve as a food source for many fish species, as well as semi-aquatic birds and mammals. Benthic invertebrates are in direct contact with sediments and, therefore, are directly exposed to COPCs in sediment. Invertebrates, as a group, are also generally considered sensitive to environmental contaminants and are commonly used as an indicator of environmental degradation or chemical impacts.

Sediment dwelling organisms are potentially exposed to COPCs in sediment via several pathways, including ingestion, dermal contact, and uptake across respiratory membranes. All pathways are potentially complete for benthic invertebrates and may contribute in part to the overall exposure of chemicals in sediment. However, for the purposes of this evaluation, direct exposure to COPCs in sediment was primarily limited to quantifying concentrations of COPCs in bulk sediment and benthic community characterizations. Body burdens, or tissue concentrations, are useful for estimating uptake to other organisms (e.g., wildlife), and can also be used to evaluate effects to benthic organisms if data is available in literature.

A weight of evidence approach using the lines of evidence listed below were used to evaluate potential risks to benthic invertebrates from exposure to COPCs.

1. Chemical Characterization - comparison of chemical concentrations in bulk sediment to concentrations protective of benthic invertebrates, and review of the identified exceedances, including spatial extent, representative concentrations, and magnitude of exceedances.
2. Benthic invertebrate community assessment.
3. Field evidence for ecological impairment.
4. Use of invertebrate tissue concentration to qualitatively evaluate body burdens.

### 8.4.1 Chemical Characterization

As indicated in the ecological screening, concentrations of COPCs exceeding the sediment ESLs are limited to metals (antimony, arsenic, copper, lead, selenium, and zinc), PCBs, and PAHs.

#### 8.4.1.1 Spatial Extent of Metals Exceedances

***Waterlot***

For antimony, arsenic, and selenium, two or less samples of the 15 sediment sample locations have concentrations exceeding the sediment ESLs and therefore, these metal exceedances are limited to a couple localized areas of the waterlot. Conversely, between 12 and 14 of the 15 sediment sample locations have concentrations of copper, lead, and zinc exceeding the ESLs, which indicates that the exceedances of the sediment ESLs for these metals are located throughout the waterlot. However, the concentrations of all metals (including copper, lead and zinc) in the three step-out samples collected adjacent to the waterlot boundaries were below applicable ESLs indicating the elevated metal concentrations in sediment do not extend off-Site.

***Reference***

All metal concentrations in the sediment samples collected from the reference sites are below the sediment ESLs. Based on the above results, it is reasonable to assume that elevated concentrations of metals are not widespread in Mortier Bay.

#### 8.4.1.2 Spatial Extent of PAH Exceedances

***Waterlot***

Several PAH compounds (1-methylnaphthalene, 2-methylnaphthalene, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, fluoranthene, fluorene, indeno(1,2,3-cd)pyrene, naphthalene, phenanthrene, and/or pyrene) were detected in 14 of the 15 sample locations at concentrations that exceeded the sediment ESLs. Based on these results, the PAH concentrations above the sediment ESLs are located throughout the entire waterlot. However, the concentrations of PAHs in the three step-out samples collected adjacent to the waterlot boundaries were below applicable ESLs indicating the elevated PAHs concentrations in sediment do not extend off-Site.

*Reference*

Most of the PAHs were not detected in the sediment samples collected from the reference sites or detected at concentrations less than the sediment ESL. Based on the above results, it is reasonable to assume that elevated concentrations of PAHs are not widespread in Mortier Bay.

#### 8.4.1.3 Spatial Extent of PCB Exceedances

*Waterlot*

Concentrations of PCBs exceeded the sediment ESL at 3 of the 15 sediment sample locations (18-MNMA-S3, 18-MNMA-S6, and 18-MNMA-S12). These results suggest that PCB concentrations exceeding the sediment ESLs are limited to a few localized areas of the waterlot. However, PCBs were not detected in the three step-out samples collected adjacent to the waterlot boundaries indicating the elevated PCB concentrations in sediment do not extend off-Site.

*Reference*

PCBs were not detected in the sediment samples collected from the reference sites. Based on the above results, it is reasonable to assume that elevated concentrations of PCBs are not widespread in Mortier Bay.

#### 8.4.1.4 Magnitude of Exceedances

The magnitude of exceedance for each COPC was expressed as a hazard quotient (HQ).

The goal of this ecological risk review for benthic invertebrates is to protect against adverse effects at the community level. Therefore, exposure is best represented by the EPC of the data. Though less conservative than applying the maximum concentration, the EPC better represents the concentrations to which populations of receptors would be exposed over time and across the waterlot. The EPC provides a more reasonable, though still conservative, estimate of the mean concentration and will be used to represent Site concentrations in the context of assessing requirements for remediation and/or risk management. In addition, given the inherent conservatism of the screening guidelines, comparing the EPC to the screening guideline is considered to be a better indicator of the magnitude of risk at the community level.

The maximum concentration and the EPC were both applied as the measured sediment sample concentration in the HQ calculation indicated above.

The HQ values are interpreted as follows:

- If the HQ is less than or equal to one, risk to ecological receptors is considered negligible because concentrations are below levels expected to cause adverse effects. In this case, no further assessment is required.
- If the HQ exceeds one, it may be inferred that adverse effects are possible. It is important to note that exceeding an HQ of one does not necessarily mean adverse effects will occur; rather, the possibility of adverse effects could not be discounted.

The higher the HQ, the greater the confidence that adverse effects will occur, but at low HQs close to one, confidence that adverse effects will actually occur is low.

Table 8-7 presents the calculated HQ values using the maximum concentrations and EPCs. As indicated in Table 8-7, the calculated HQ values for several PAHs (acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, fluoranthene, fluorene, phenanthrene, and pyrene), copper, lead, zinc, and PCBs are greater than one using both the maximum concentrations and EPCs. The HQ values for 1-methylnaphthalene, 2-methylnaphthalene, indeno(1,2,3-cd)pyrene, naphthalene, antimony, arsenic, and selenium exceed the target HQ of one using the maximum concentrations, but are less than one using the EPCs.

Table 8-7 Hazard Quotients for Benthic Invertebrates in Sediment

| Parameter | Sediment Concentration (mg/kg) | | Sediment ESL (mg/kg) | Hazard Quotient | |
|---|---|---|---|---|---|
| | Maximum | EPC | | Maximum | EPC |
| **PAHs** | | | | | |
| 1-Methylnaphthalene | 0.27 | 0.13 | 0.201 | **1.3** | 0.65 |
| 2-Methylnaphthalene | 0.38 | 0.18 | 0.201 | **1.9** | 0.90 |
| Acenaphthene | 0.728 | 0.37 | 0.0889 | **8.2** | **4.2** |
| Acenaphthylene | 0.465 | 0.16 | 0.128 | **3.6** | **1.3** |
| Anthracene | 1.01 | 0.48 | 0.245 | **4.1** | **2.0** |
| Benzo(a)anthracene | 1.55 | 0.97 | 0.693 | **2.2** | **1.4** |
| Benzo(a)pyrene | 1.42 | 0.81 | 0.763 | **1.9** | **1.1** |
| Chrysene | 1.7 | 0.99 | 0.846 | **2** | **1.2** |
| Fluoranthene | 3.93 | 2.2 | 1.494 | **2.6** | **1.5** |
| Fluorene | 0.94 | 0.36 | 0.144 | **6.5** | **2.5** |
| Indeno(1,2,3-cd)pyrene | 1.13 | 0.58 | 0.88 | **1.3** | 0.66 |
| Naphthalene | 0.62 | 0.19 | 0.391 | **1.6** | 0.49 |
| Phenanthrene | 4.05 | 1.9 | 0.544 | **7.4** | **3.5** |
| Pyrene | 2.98 | 1.7 | 1.398 | **2.1** | **1.2** |
| **Metals** | | | | | |
| Antimony | 28 | 11 | 25 | **1.1** | 0.44 |
| Arsenic | 78 | 40 | 41.6 | **1.9** | 0.96 |
| Copper | 260 | 168 | 108 | **2.4** | **1.6** |
| Lead | 728 | 362 | 112 | **6.5** | **3.2** |
| Selenium | 3 | 1.6 | 2 | **1.5** | 0.80 |
| Zinc | 5020 | 1681 | 271 | **19** | **6.2** |
| **PCBs** | | | | | |
| PCBs | 0.65 | 0.32 | 0.189 | **3.4** | **1.7** |

Notes:
**Bold** = HQ>1

#### 8.4.1.5 Evaluation of Metals

Concentrations of antimony, arsenic, and selenium in sediment from the waterlot exceed the sediment ESLs in two or less samples and the EPCs for these metals are less than the sediment

ESLs (i.e., HQ values less than one using the EPC). Therefore, antimony, arsenic, and selenium are considered to pose a low risk to benthic invertebrate communities in the waterlot.

Concentrations of copper, lead, and zinc in sediment from the waterlot exceed the sediment ESLs at 12 or more of the 15 sediment sample locations and the EPCs for these metals are greater than the sediment ESLs. The HQ values for copper (1.6), lead (3.2), and zinc (6.2) exceed the target HQ of one using the EPCs. Therefore, concentrations of copper, lead, and zinc above the sediment ESLs are located across the entire waterlot. Further assessment of risk to benthic invertebrates from exposure to these metals in waterlot sediments is warranted.

#### 8.4.1.6 Evaluation of PAHs

The FOC and PAHs results were used to calculate the equilibrium partitioning sediment benchmark toxic unit (ESBTU) as per the *Procedures for the Derivation of Equilibrium Partitioning Sediment Benchmarks (ESBs) for the Protection of Benthic Organisms: PAH Mixtures* (USEPA, November 2003). A sample calculation based on phenanthrene in 18-MNMA-S2 is as follows:

For each sediment sample, the dry weight concentration for each PAH, normalized to organic carbon content ($C_{OC}$ [micrograms COPC / gram organic carbon]), is calculated by dividing by the sample-specific FOC:

$$C_{OC} = \frac{C_{onc}\ (\mu g_{COPC}/g_{SED}\ \text{dry weight})}{FOC\ (g_{OC}/g_{SED})}$$

$$= 0.94/0.062$$
$$= 15.16\ \mu g_{COPC}/g_{OC}$$

The $C_{OC}$ is then divided by the PAH-specific sediment benchmark ($C_{OC}$, PAH, FCV) for each individual PAH provided in the supporting document referenced above to calculate the ESBTUs:

$$ESBTU_{FCVi} = \frac{C_{OC}\ (\mu g/g_{OC})}{C_{OC,PAH,FCV}\ (\mu g/g_{OC})}$$

$$= 15.16/596$$
$$= 0.025$$

The sum of the toxicological contributions of the PAHs was used to calculate a HQ. Uncertainty factors have been developed since common practice usually includes the analyses of 13 or 23 commonly quantified PAHs instead of the full suite of 34 parent and alkylated PAHs. Laboratory analysis of PAHs in Atlantic Canada typically includes 20 individual PAH compounds. A correction factor of 4.14 based on the 95$^{th}$ percentile for measuring 23 PAH parameters provided by the USEPA (Table 6.1; USEPA, 2003) was applied to the calculated HQ to account for the potentially lower ESBTU value calculated using only 20 PAH parameters in the site specific analysis. Recent studies have shown that this method has a tendency to overestimate toxicity and a value equal to or less than one is protective of sensitive species, whereas a value of 3 is considered protective of common species (McDonough, et al., 2010; Kane-Driscoll and Burgess, 2007). Therefore, a threshold range of 1 to 3 for protecting sensitive and common species is used in the ERA. The results are provided in Table F-1 for the waterlot and reference sites (Appendix F).

*Waterlot*

As indicated in Table F-1 (Appendix F), none of the 15 sediment sample locations have calculated ESBTU HQ values greater than three, which is protective of common species. Only four (18-MNMA-S1, 18-MNMA-S3, 18-MNMA-S5, and 18-MNMA-S14) of the 15 sediment sample locations have calculated ESBTU HQ values greater than one, which is protective of sensitive species. Three of these four exceeding locations had HQ values ranging from 1.1 to 1.7, which only marginally exceed the HQ of one. These exceeding locations also correspond to the locations with the lowest FOC values (0.019 to 0.075) compared to the mean FOC (0.107), which has a significant effect on the calculated ESBTU HQs. Based on these results, the PAH concentrations in sediment samples collected from the waterlot are considered to pose a low risk to benthic invertebrates.

*Reference*

As indicated in Table F-1 (Appendix F), the calculated ESBTU HQ values were less than one for all reference site sediment samples. Based on the above results, it is reasonable to assume that elevated concentrations of PAHs are not widespread in Mortier Bay.

#### 8.4.1.7 Evaluation of PCBs

Three of the 15 sediment sample locations have concentrations of PCBs exceeding the sediment ESL (18-MNMA-S3, 18-MNMA-S6, and 18-MNMA-S12). These sample locations are not associated with any particular location of the waterlot and therefore are considered to be localized exceedances. In addition, the HQ values for PCBs using both the maximum (3.4) and EPC (1.7) are greater than one. Further assessment of PCBs in waterlot sediments is considered warranted.

### 8.4.2 Benthic Invertebrate Community Assessment

A total of seven sediment samples from the waterlot (18-MNMA-BMI1, 18-MNMA-BMI3, 18-MNMA-BMI5, 18-MNMA-BMI6, 18-MNMA-BMI11, 18-MNMA-BMI12, and 18-MNMA-BMI14) and one sediment sample from a reference location (18-MNMA-BMI-REF2) were submitted for benthic invertebrate community assessment. The benthic invertebrate community assessment included analysis of species abundance, taxon richness, and biomass. In addition, the Shannon-Weaver diversity index (DI) was calculated for each of the sample locations using the formula:

$$DI = -sumN_i/NT \times LogN_i/NT$$

where N is the number of individuals of species i and NT is the total number of organisms in the sample.

The taxonomic results including a characterization of the benthic invertebrate community at each sample location is provided in Table F-2 in Appendix F and summarized below in Table 8-8.

### Table 8-8 Benthic Invertebrate Community Results

| Parameter | 18-MNMA-BMI1 | 18-MNMA-BMI3 | 18-MNMA-BMI5 | 18-MNMA-BMI6 | 18-MNMA-BMI11 | 18-MNMA-BMI12 | 18-MNMA-BMI14 | 18-MNMA-BMI-REF2 |
|---|---|---|---|---|---|---|---|---|
| Abundance (#/sample) | 243 | 7 | 91 | 97 | 28 | 124 | 2 | 243 |
| Taxon Richness (# taxa/sample) | 33 | 5 | 17 | 24 | 14 | 17 | 1 | 7 |
| Shannon-Weaver Diversity Index | 2.75 | 1.55 | 2.2 | 1.6 | 2.3 | 1.5 | NA | 0.4 |
| Copper Concentration (mg/kg) | 147 | 171 | 207 | 170 | 144 | 159 | 260 | 8 |
| Lead Concentration (mg/kg) | 358 | 284 | 125 | 252 | 252 | 728 | 135 | 6.5 |
| Zinc Concentration (mg/kg) | 799 | 282 | 397 | 297 | 585 | 5020 | 375 | 34 |
| HMW PAH Concentration (mg/kg) | 3.13 | 5.59 | 12.76 | 4.89 | 2.33 | 2.15 | 9.64 | 0.11 |
| LMW PAH Concentration (mg/kg) | 2.38 | 5.12 | 12.13 | 3.62 | 1.63 | 1.23 | 8.36 | 0.11 |
| PAH ESBTU HQ | 1.7 | 1.1 | 2.9 | 0.59 | 0.21 | 0.096 | 1.4 | 0.048 |
| PCB Concentration (mg/kg) | 0.1 | 0.65 | 0.1 | 0.53 | <0.02 | 0.27 | 0.07 | <0.02 |

For samples collected from the waterlot, abundance values ranged from 2 to 243 individuals (average of 85 individuals) and taxon richness ranged from 1 to 33 taxa (average of 16 taxa). In comparison, abundance values for the reference sample was 243 individuals with a taxon richness of 7. These results indicate that the benthic community indices in the waterlot generally had a lower number of individual organisms but a substantially greater diversity of taxa.

The waterlot sediment samples were dominated by Polychaeta species (36 to 50% of the organisms observed). Polychaeta organisms are generally considered to be pollution tolerant and typically associated with soft substrate. However, these benthic invertebrates are integral to most sediment infaunal communities and provide a significant food source for fish (Fadhullah and Syakir, 2016). In addition, six of the seven samples collected from the waterlot had numerous pollution sensitive Polychaeta organisms such as *Eteone* sp., *Glycera capitata*, *Nephtys* sp., *Pherusa plumosa*, and *Phyllodoce groenlandica* (Borja et al., 2000; Simboura and Zenetos, 2002). In addition to the pollution sensitive Polychaeta species, four of the six samples also had Amphipoda organisms which are generally considered to be pollution sensitive and also associated with soft substrate (Dauvin et al., 2016). The only waterlot sample that did not contain pollution sensitive Polychaeta or Amphipoda organisms was sample 18-MNMA-BMI14. This sample only contained two individual Polychaeta organisms (*Goniada norvegica*). Although the invertebrates at this sample location was limited to this specific species, *Goniada* sp. organisms are considered to be pollution sensitive (Borja et al., 2000; Simboura and Zenetos, 2002).

Converse to the waterlot samples, the reference sample was dominated by one Nematoda species (*Oncholaimellus brevicauda*). Danovaro et al. (2009) indicates nematodes such as *Oncholaimellus* are generally insensitive to organic impacts or are able to recover quickly after an organic contaminant release. However, the majority of marine Nematode species are sensitive to metal impacted sediment and nematode diversity is sensitive to chemical concentrations.

Based on the benthic invertebrate data, the two samples collected from the waterlot with substantially decreased abundance or taxon richness compared to other waterlot samples or the reference sample is limited to 18-MNMA-BMI3 and 18MNMA-BMI14. These samples correspond to elevated PAH and metal concentrations, specifically copper. However, waterlot samples 18-MNMA-BMI1 and 18-MNMA-BMI5 also contained elevated concentrations of these same COPCs but have the highest abundance and diversity of all the samples collected. As such, it is reasonable to assume that concentrations of COPCs in sediment are not the primary factor affecting benthic invertebrate abundance and diversity. It is also noted that samples18-MNMA-BMI3 and 18MNMA-BMI14 are located in close proximity to the existing wharf structures and likely susceptible to physical disturbances related to boat traffic and propeller wash or other anthropogenic influences. The samples collected from the waterlot boundaries such as 18-MNMA-BMI1, 18-MNMA-BMI5 and 18-MNMA-BMI12 corresponded to samples with the highest invertebrate abundance and also contained the greatest diversity of organisms.

Based on the results of the benthic taxonomic evaluation, several samples collected from the waterlot had invertebrate abundance similar to the reference location but the waterlot samples had substantially higher diversity of organisms compared to the reference sample. In addition, the presence of numerous pollution sensitive invertebrates in the majority of the waterlot samples indicates that the concentrations of COPCs in waterlot sediments are unlikely to be adversely affecting the benthic invertebrate community in the area.

### 8.4.3 Field Evidence

Between October and December 2018, Sparkes Subsea Construction completed a dive survey to collect sediment samples and to document flora/fauna and substrate conditions at the sampling locations. Photos and video footage were collected and utilized to describe flora/fauna and substrate conditions at each sediment sampling locations (refer to Divers Report in Appendix H). The dive survey results are presented in Table 4-1 of Section 4.0, and summarized below.

***Waterlot***

The diver's notes and photos indicate that marine flora (kelp, algae and/or tubed weed) was present at most of the waterlot sampling locations but in relatively low abundance in most locations. However, marine macroinvertebrates (periwinkles, mussels, scallops, sea star and crab) were present at all of the sediment sampling locations within the waterlot. Sediment in the waterlot was generally characterized as silt with gravel or sand and gravel with the area north side of the wharf being characterized as fine grained sediment (black mud). Garage and debris such as cans and glass bottles were observed at most of the sample locations located directly adjacent to the wharf.

An overview of biota observed at each sample location is provided in Table 4-1.

### *Background/Reference Sites*

The diver's notes and photos indicate that marine flora (specifically tubed weed, eel grass and algae) were common or abundant at the sample locations with marine macroinvertebrates (mussels, periwinkles, sea star, crab, and/or scallops) also present at all of the reference sediment sampling locations. Garage and debris were not observed in the reference samples.

An overview of biota observed at each sample location is provided in Table 4-1.

### 8.4.4 Invertebrate Tissue

As indicated in Section 4.0, scallop, crab, and mussel tissue samples were collected from several locations within the waterlot as well as the reference area and analyzed for metals, PCBs, and PAHs. The tissue analytical results provide qualitative evidence of body burdens for macroinvertebrates exposed to COPCs in sediment within the waterlot.

Only arsenic, boron, cadmium, copper, lead, selenium, strontium, vanadium, zinc, and PAHs were detected in the invertebrate tissues. Table 8-9 summarizes the maximum concentrations of these compounds in invertebrates collected from waterlot and compares them to the maximum concentration detected in the background invertebrate tissues collected from the reference sites. Aluminum, iron and manganese were also detected in several tissue samples but these are considered to essential elements with low inherent toxicity and therefore, not carried forward for further evaluation.

As indicated in Table 8-9, the concentrations of the majority of COPCs in the waterlot invertebrates are approximately equal to or less than the concentrations in the background invertebrates, with the exception of cadmium, zinc and total PAHs. For zinc, the EPC for the invertebrate tissue is 57.6 mg/kg, which is less than the background invertebrate tissue concentration (74 mg/kg). In addition, the maximum zinc concentration from the waterlot tissue samples was related to the mussel sample. The mussels from the reference area also contained elevated concentrations of zinc (74 mg/kg) compared to other tissue samples collected. The crab and scallop tissue samples collected from the waterlot had zinc concentrations approximately equal to the zinc concentrations in the crab and scallop samples collected from the reference area. Similarly for total PAHs, the EPC for the invertebrate tissue is 0.141 mg/kg, which is less than the concentration observed in the reference samples (0.179 mg/kg). Therefore, the concentrations of these detected compounds in the waterlot invertebrates are not expected to result in adverse toxicological effects. However, the EPC for cadmium (8.6 mg/kg) in tissue samples collected from waterlot exceeds the maximum concentration observed in the reference tissue samples collected.

Potential adverse effects on shellfish were also evaluated using data relating tissue concentrations of the COPCs with toxicological effects on aquatic organisms as provided by the USEPA (Jarvinen and Ankley, 1999; Linkage of effects to tissue residues: development of a comprehensive database for aquatic organisms exposed to inorganic and organic chemicals, SETAC Technical Publication Series). Although the EPC of cadmium in waterlot invertebrates marginally exceeded the reference area tissue concentrations, the concentrations of cadmium in tissue samples are below the toxicological effects levels for shellfish (no adverse effect on reproduction, growth, and survival based on body burdens ranging from approximately 0.1 – 534.4 mg/kg with a 25$^{th}$ percentile of

13.1 mg/kg). In addition, only one scallop sample collected from the waterlot had a cadmium concentration exceeding the 25th percentile body burden effect level of 13.1 mg/kg.

Table 8-9 Invertebrate Tissue Concentration

| Parameter | Measured Shellfish Tissue Concentration – Maximum (mg/kg wet weight) | Measured Shellfish Tissue Concentration – EPC (mg/kg wet weight) | Background Shellfish Concentrations (mg/kg wet weight) | No Adverse Effect Range – Body Burdens (mg/kg |
|---|---|---|---|---|
| Arsenic | 4 | Not Evaluated | 5 | Not Evaluated |
| Boron | 6 | Not Evaluated | 6 | Not Evaluated |
| Cadmium | 17.8 | 8.6 | 4.8 | 0.1 – 534.4 mg/kg - (25th percentile - 13.1) |
| Copper | 20 | Not Evaluated | 19 | Not Evaluated |
| Lead | 0.7 | Not Evaluated | 1.1 | Not Evaluated |
| Selenium | <1 | Not Evaluated | 1 | Not Evaluated |
| Strontium | 113 | Not Evaluated | 210 | Not Evaluated |
| Vanadium | 6 | Not Evaluated | 6 | Not Evaluated |
| Zinc | 108 | 57.6 | 74 | Not Evaluated |
| PAHs | 0.194 | 0.141 | 0.179 | Not Evaluated |

**Note:** PAHs is the sum of all PAH compounds.

Based on the results of the tissue analysis, concentrations of COPCs in tissue samples collected from the waterlot are similar to concentrations observed in the reference tissue samples or were below levels expected to result in toxicological effects levels.

## 8.5 Evaluation of Fish

Although the waterlot portion of the Site is small, for the purposes of this ecological risk review, potential risk to fish that may consume flora and fauna from the waterlot or be directly exposed to COPCs in sediment from the waterlot were evaluated. The evaluation of risk to fish is considered a qualitative evaluation as fish were not directly observed to be present in the waterlot at the time of the field sampling program and, therefore, fish tissue samples could not be collected for quantitative evaluation.

### 8.5.1 Target Constituents for Assessing Fish

All parameters with concentrations exceeding the sediment ESLs from the ecological screening were carried through for evaluation of risks to fish. In addition, the primary route for exposure to COPCs in sediment of the waterlot for fish is considered to be via ingestion of benthic invertebrates, which have accumulated COPCs from sediment. To address potential bioaccumulation, parameters with detectable concentrations of COPCs in shellfish tissue samples collected from the waterlot were also carried through for evaluation of risks to fish.

Bioaccumulation of PAHs in fish is expected to be low and considered to be insignificant for assessing upper trophic level receptors that can metabolize these compounds (Eisler, 1987). Therefore, accumulation of PAHs in fish is assumed to be negligible. Therefore, PAHs were not carried forward for evaluation of fish.

Similarly, bioaccumulation of mTPH is expected to be low and considered to be insignificant for assessing upper trophic level receptors that can metabolize these compounds (CCME, 2008). Therefore, accumulation of mTPH in fish is assumed to be negligible. Further assessment of mTPH for fish was not required.

Based on the above discussion, antimony, arsenic, boron, cadmium, copper, lead, selenium, strontium, vanadium, and zinc were the only COPCs evaluated for fish. Aluminum, iron and manganese were also detected in several shellfish tissue samples but these are considered to essential elements with low inherent toxicity and therefore, not carried forward for further evaluation. In addition, highly bioaccumulative COPCs such as mercury and PCBs were not detected in shellfish tissue samples and, therefore, not carried forward for further evaluation with respect to fish.

### 8.5.2 Exposure of Fish to COPCs

The level to which contaminants accumulate in fish is a function of the physicochemical properties of the COPC, the rate of uptake into invertebrate tissue and subsequently into fish, and the ability of the COPC to be sequestered, metabolized, or otherwise eliminated. Potential risk to fish from exposure to COPCs in sediment was evaluated based on measured concentrations of COPCs in shellfish and assuming an uptake factor into fish tissue of 1 to predict fish tissue concentrations (body burden) and associated potential adverse effects. Although several metals were detected in the shellfish tissue samples collected from the waterlot, the concentrations of COPCs in the waterlot invertebrates are approximately equal to or less than the concentrations in the background invertebrates. As such, fish exposure to COPCs associated with the waterlot through the invertebrate consumption pathway is considered similar to background conditions in the Mortier Bay area.

The exception would be concentrations of cadmium in shellfish tissue samples collected from the waterlot, specifically scallops. As previously discussed in Sections 7.0 and 8.4.4, cadmium is preferentially accumulated in the digestive gland of scallops and can have significantly elevated concentrations in undisturbed or uncontaminated waters. In addition, concentrations of cadmium in sediment and surface water of the waterlot were generally below or approximately equal to laboratory detection limits with no known source of cadmium associated with the Site that would be contributing to the elevated concentrations in shellfish tissue. As all other metals had concentrations in shellfish tissue considered representative of background conditions in the area, it is reasonable to assume that exposure of fish to cadmium from consumption of invertebrate tissue at the Site would be similar to background conditions and does not pose an incremental risk to fish populations in the area.

### 8.5.3 Risk Characterization for Fish

The primary route for exposure to COPCs for fish is generally considered to be through contaminants dissolved in surface water and exposure to bioaccumulative COPCs via ingestion of benthic invertebrates that have accumulated COPCs from sediment. As COPCs in surface water at the Site were below applicable ecological screening levels or background conditions, it is reasonable to assume COPC dissolved in water at the Site pose a low risk to fish or fish populations in the area. In addition, COPCs detected in sediment at the Site which are considered to be highly bioaccumulative such as mercury and PCBs were not detected in shellfish tissue collected from the Site. As such, it is reasonable to assume that these bioaccumulative COPCs pose a low risk to fish through the invertebrate consumption pathway. Other potentially bioaccumulative COPCs in sediment such as arsenic, cadmium, copper, lead and zinc had concentrations in shellfish tissue that were considered representative of background conditions in the area and also considered to pose a low incremental risk to fish or fish populations.

In addition to low concentrations of COPCs in invertebrates, the waterlot only covers an area of 17,000 $m^2$ and it is unlikely most fish species would spend significant periods of time in the waterlot or use the waterlot for a significant portion of their food source, specifically migratory fish.

Based on the rationale provided above, it is reasonable to assume COPCs in sediment, surface water and shellfish tissue of the waterlot do not pose a risk to fish or fish populations in the Mortier Bay area.

## 8.6 Evaluation of Aquatic Wildlife

Although the waterlot portion of the Site is small, for the purposes of this ERA, it was assumed that the waterlot might potentially serve as a source of food for a variety of aquatic bird and mammal species that forage on aquatic prey. Potential risk to aquatic avian and mammalian insectivores and piscivores, that may consume flora and fauna from the waterlot or be directly exposed to COPCs in sediment from the waterlot were evaluated.

### 8.6.1 Target Constituents for Assessing Aquatic Wildlife

Parameters with concentrations exceeding the sediment ESLs from the ecological screening were carried through for evaluation of risks to aquatic life and include arsenic, lead, selenium, zinc, PCBs and PAHs. Although mercury was below screening guidelines in sediment and not detectable in shellfish tissue samples, mercury is considered to be potentially bioaccumulative and also carried forward in the evaluation of risk to aquatic wildlife as a conservative measure. Maximum concentrations of antimony in sediment of the waterlot also exceeded screening guidelines but the EPC was below applicable screening guidelines and antimony was not detected in shellfish tissue collected from the Site. As such, antimony was not carried forward in the ERA with respect to evaluation of aquatic wildlife.

In addition to screening COPCs in sediment, potentially bioaccumulation parameters such as cadmium and copper were also detected in invertebrate tissue samples collected from the Site and carried forward in the ERA. The remainder of COPCs detected in shellfish tissue samples collected from the Site (aluminum, boron, iron, manganese, strontium and vanadium) were not carried forward in the risk evaluation as the tissue concentrations were similar to background conditions and these COPC are not considered to be bioaccumulative.

Bioaccumulation of PAHs in fish is expected to be low and considered to be insignificant for assessing upper trophic level receptors that can metabolize these compounds (Eisler, 1987). Therefore, accumulation of PAHs in fish and other upper trophic levels receptors is assumed to be negligible. However, detectable (low level) concentrations of PAHs were identified in the shellfish samples collected from the waterlot and further evaluation of risk to birds and mammals from exposure to PAHs was completed. To assess cumulative effects of PAHs, the individual PAHs were assessed as the combined risks for low molecular weight (LMW) and high molecular weight (HMW) PAHs.

Bioaccumulation of mTPH is also expected to be low and insignificant for assessing upper trophic level receptors that can metabolize these compounds (CCME, 2008). In addition, concentrations of mTPH in sediment of the waterlot were below applicable screening guidelines and further evaluation of risks to birds and mammals from exposure to mTPH was not considered warranted.

Based on the above discussion, arsenic, cadmium, copper, lead, selenium, zinc, PCBs, LMW PAHs and HMW PAHs were the only COPCs evaluated for aquatic receptors.

### 8.6.2 Receptors of Concern

It is not practical to evaluate the effects of COPCs for all species that potentially forage within the waterlot. Therefore, indicator species were used to represent ecological guilds, or groups of organisms within a taxonomic class of the same trophic level. Exposure factors and toxicological guidelines have been identified for the selected indicator species, which allows for evaluation of risk with a limited number of assumptions. For birds and mammals, three indicator species were selected to evaluate the potential for risk: lesser scaup (*Aythya affinis*; avian insectivore), common loon (*Gavia immer*; avian piscivore), and river otter (*Lontra canadensis*; mammalian insectivore/piscivore).

As previously indicated, further assessment of SAR was not required.

### 8.6.3 Exposure of Aquatic Wildlife to COPCs

Simple food chain models were used to evaluate the potential risk to upper trophic level receptors from exposure to COPCs identified in the sediment screening evaluation. To evaluate exposure of a wildlife receptor to a COPC, it is necessary to estimate the concentration of the COPC in sediment, aquatic plants, benthic invertebrates, and fish.

Concentrations of COPCs in benthic invertebrates was based on the EPC of the shellfish tissue samples collected from the waterlot. As fish were not present in the waterlot for analysis of fish tissue, the EPCs for COPCs in shellfish tissue were also assumed to be representative of COPCs in fish tissue at the Site (uptake factor of 1). The term “uptake factor” (UF) refers to the accumulation of a COPC in an organism or biological tissue (e.g., fish) from a source medium (e.g., benthic invertebrates). This is considered to be a conservative assumption as highly bioaccumulative COPCs such as mercury and PCBs were not detected in shellfish tissue for uptake to fish tissue. The methods for calculating the concentrations of COPCs in aquatic plants, benthic invertebrates, and fish are presented in Table F-4 of Appendix F, and summarized below.

For metals, the UFs for aquatic plants, benthic invertebrates, and fish are based on the following:

- Regression equations from Efroymson et al. (2001) to estimate concentrations in aquatic plants from sediment concentrations[1]. In the absence of regression equations from Efroymson et al. (2001), UFs from USEPA (2007) and Baes et al. (1984) were applied.
- EPCs based on measured concentrations of metals in shellfish tissue collected from the waterlot were used to estimate concentrations of COPCs in benthic invertebrates. As mercury was not detected in shellfish, the method detection limit was conservatively applied to as the concentration in benthic invertebrates.
- EPCs based on measured concentrations of metals in shellfish tissue collected from the waterlot were also conservatively applied as the estimated concentration of COPCs in fish.

The analysis of mercury in bulk sediment is based on total mercury. In cases when mercury is not speciated, it is typical practice to assume that total mercury is composed entirely of methylmercury as a conservative approach since methylmercury is more toxic than inorganic mercury. To reduce the conservativeness of this assumption, this ecological risk review evaluated both inorganic mercury and methylmercury separately and summed the risks to provide an overall risk associated with total mercury. The following assumptions were used for this mercury assessment:

- Kannan et al. (1998) reports that methylmercury accounts for 0.77% of total mercury in sediment and 83% of total mercury in fish tissue. Based in this information, the concentration of methylmercury in bulk sediment was assumed to be zero. Since methylmercury concentrations in bulk sediment are assumed to be zero, then the concentration of methylmercury in aquatic plants was also assumed to be zero.
- CCME (2003) indicates that benthic invertebrates are comprised of 50% inorganic mercury and 50% methylmercury; therefore, methylmercury and inorganic mercury concentrations in benthic invertebrates were calculated by multiplying the total mercury concentrations by 0.5.
- Inorganic mercury was calculated as the difference between the total mercury concentration and methylmercury concentration.

For PAHs, UFs for aquatic plants, benthic invertebrates, and fish are based on the following:

- Regression equations from USEPA (2007) to estimate concentrations in aquatic plants from sediment concentrations[2].
- EPCs based on measured concentrations of PAHs in shellfish tissue collected from the waterlot were used to estimate concentrations of COPCs in benthic invertebrates.

[1] USEPA (1999) considers soil-to-plant uptake to be similar to sediment-to-plant uptake. In the absence of sediment-to-plant uptake equations, soil-to-plant equations are used.

[2] See Footnote 1.

- Bioaccumulation of PAHs in fish is expected to be low and considered to be insignificant for assessing upper trophic level receptors that can metabolize these compounds (Eisler, 1987). Therefore, accumulation of PAHs in fish is assumed negligible.

For PCBs, UFs for aquatic plants, benthic invertebrates, and fish are based on the following:

- Regression equation presented in Travis and Arms (1988) to estimate concentrations in aquatic plants from sediment concentrations[3].
- PCBs were not detected in EPCs based on measured concentrations of metals in shellfish tissue collected from the waterlot were used to estimate concentrations of COPCs in benthic invertebrates.
- EPCs based on measured concentrations of metals in shellfish tissue collected from the waterlot were also conservatively applied as the estimated concentration of COPCs in fish.

The UFs use the sediment EPCs to calculate concentrations in aquatic plants. The tissue concentrations calculated using the regression equations for aquatic plants (all COPCs) are reported in dry weight units (i.e., mg/kg dry weight plant / mg/kg dry weight sediment) and subsequently converted to wet weight assuming that aquatic plants typically have approximately 85% water content (Sample et al., 1994). The conversion to wet-weight is accomplished by multiplying the estimated concentrations derived from the regression equations by the dry solids fraction of 0.15 for aquatic plants. The measured concentration of COPCs in shellfish tissue collected from the Site was reported as wet weight (as received by the lab) and do not require additional conversion.

Equations for calculating EPCs for aquatic plants, benthic invertebrates, and fish using UFs or regression equations are identified in Table F-3 of Appendix F. The EPCs for shellfish tissue were generated using USEPA ProUCL Version 5.1 (USEPA, 2015) and the output sheets are provided in Appendix D.

### *Daily Dose*

For representative wildlife receptors, exposure to a COPC was calculated as the average daily dose (ADD) ingested. The ADD is the amount of a COPC a modeled species might be exposed to, expressed as mg/kg-body weight (bw)/day. For each modeled species and COPC combination, the ADD was calculated by summing the intake from each applicable exposure pathway.

For exposure pathway j, the generalized equation for ADD is:

$$ADDj = (IRj \times AFj \times EPCj) / BW$$

Where:

| | | |
|---|---|---|
| ADDj | = | average daily dose for exposure pathway j (mg/kg – bw/day); |
| IRj | = | ingestion rate (kg medium/day); |
| AFj | = | absorption factor (default value of 1; most conservative); |

[3] See Footnote 1.

EPCj = exposure point concentration (mg COPC/kg medium); and

BW = receptor body weight (kg).

The AF relates to the potential for COPCs to be absorbed across the gut wall following ingestion. Trace elements are part of the natural environment and exist in many different forms, having potentially differing relative bioavailability. In this risk review, the AF is conservatively assumed to have a value of 1, or 100% of the COPC is bioavailable, for all ingested food items. In addition, for the purposes of the risk review, it is conservatively assumed that wildlife receptors obtain all their food from the waterlot.

Input parameters and exposure factors used to calculate average daily dose for the three indicator species are identified in Table F-4 of Appendix F. Module 3 of FCSAP (2012) is the source for all input parameters and exposure factors.

### 8.6.4 Effects Levels for Aquatic Wildlife

Similar to fish, the potential for risk to avian and mammalian wildlife was calculated by dividing the total ingestion of a COPC, as estimated by calculating an ADD, by a toxicological reference value (TRV) to produce an HQ. The HQ values for birds and mammals were calculated as follows:

$$HQ = ADD_{Total} / TRV$$

Where:

$ADD_{Total}$ = total average daily dose (mg/kg – bw/day)

A potential for risk was identified if the HQ for a COPC was greater than one. An HQ value above one does not automatically indicate that there is an unacceptable level of potential for risk but that additional evaluation of predicted exposure levels and exposure limit derivations is likely required.

The toxicological database supporting a TRV preferably includes a number of chronic or multi-generational exposure studies involving exposure of relevant test species (i.e., the ecological receptor of interest or a phylogenetically similar species) to appropriate chemical forms of the COPC of interest. Ideally, one or more relevant biological endpoints such as growth, reproductive effects, or survival were measured in the study. Databases that meet this requirement are available for some chemicals, but in most cases, available toxicity data are limited to studies conducted with laboratory animals (e.g., mammals: mice, rats, rabbits; birds: quail, chicken, and ducks). Wildlife TRVs used for this ecological risk review are summarized in Table F-5 of Appendix F.

The TRVs used for indicator species were primarily derived from data presented in USEPA Ecological Soil Screening Level (EcoSSL) rationale documents (USEPA, 2010) or from Sample et al. (1996).

For species with no conservation status, the geomean of Lowest Observed Adverse Effect Levels (LOAELs) for survival, growth and reproduction endpoints are typically used to derive a TRV. The LOAEL-based benchmark represents a threshold level at which adverse effects are likely to become evident (Sample et al., 1996).

COPCs in sediment, aquatic plant, benthic invertebrate, and fish tissue are conservatively assumed to have bioaccessibility equivalent to that present in the TRV studies.

### 8.6.5 Hazard Assessment for Aquatic Wildlife

#### 8.6.5.1 Mammals

Table 8-10 presents HQs for the river otter. The contribution of each exposure pathway to the HQ is provided in Table F-6 of Appendix F.

Table 8-10 Hazard Quotients for Mammalian Species

| COPC | HQ |
|---|---|
| | River Otter (Piscivore/Insectivore) |
| **Target HQ** | **≤1.0** |
| Arsenic | 0.071 |
| Cadmium | 0.14 |
| Copper | 0.017 |
| Lead | 0.0017 |
| Mercury (total) | 0.03 |
| Selenium | 0.073 |
| Zinc | 0.026 |
| LMW PAHs | 0.000016 |
| HMW PAHs | 0.00016 |
| PCBs | 0.085 |

The HQ values for the river otter exposed to all COPCs in waterlot sediment were less than one indicating that COPCs in sediment of the waterlot are unlikely to pose a significant potential for risk to mammalian piscivore/insectivore populations in the area.

#### 8.6.5.2 Birds

Table 8-11 presents the HQs for the lesser scaup and common loon. The contribution of each exposure pathway to the HQ is provided in Tables F-7 and F-8 of Appendix F.

Table 8-11 Hazard Quotients for Avian Species

| COPC | HQ | |
|---|---|---|
| | Lesser Scaup (Insectivore) | Common Loon (Piscivore) |
| **Target HQ** | **<1.0** | **<1.0** |
| Arsenic | 0.19 | 0.15 |
| Cadmium | 0.27 | 0.21 |
| Copper | 0.077 | 0.058 |
| Lead | 0.014 | 0.01 |
| Mercury (total) | 0.10 | 0.12 |
| Selenium | 0.11 | 0.081 |

| COPC | HQ | |
|---|---|---|
| | Lesser Scaup (Insectivore) | Common Loon (Piscivore) |
| Zinc | 0.09 | 0.067 |
| LMW PAHs | - | - |
| HMW PAHs | 0.0011 | 0.00042 |
| PCBs | 0.069 | 0.053 |

Notes:
**Bold** = HQ>1

The HQ values for the lesser scaup and common loon are less than one for all COPCs indicating that the waterlot sediments are unlikely to pose a significant risk to avian insectivore or piscivore populations in the area.

## 8.7 Summary of Ecological Risks

***Terrestrial Plant and Invertebrate Communities***

- Only PHC F2 and PHC F3 were carried through the ERA for evaluation of risks to terrestrial plants and invertebrates. Based on the combined weight of evidence discussed above, adverse effects to existing plant and soil invertebrate communities at the Site under current conditions are not expected. This conclusion is based on the following lines of evidence: (1) PHC-impacted soils are located at depths (greater than 1.8 metres below grade) well below the depths where the majority of the plant and invertebrate communities reside; (2) PHC-impacted soils are located below the water table and since most terrestrial receptors would avoid heavily saturated soils, exposure to these PHC-impacted soils is expected to be limited; and (3) PHC-impacted soils are located in heavily disturbed areas adjacent to existing buildings where vegetation is currently not present.

***Benthic Invertebrate Communities***

- As indicated in the ecological screening, concentrations of COPCs exceeding the sediment ESLs are limited to select metals (antimony, arsenic, copper, lead, selenium, and zinc), PCBs, and PAHs.

The following lines of evidence were used to assess potential impacts to benthic invertebrates posed by specific metals, PAHs and PCBs:

- For antimony, arsenic, and selenium, two or less sediment samples out of the 15 total samples collected within the waterlot have concentrations greater than the sediment ESLs, and the EPCs for these metals are less than the sediment ESLs. PCBs were detected at concentrations exceeding the sediment ESL in three of the 15 sediment sample locations. Given the low number of exceedances, antimony, arsenic, selenium and PCBs are unlikely to result in significant adverse effects to benthic invertebrate communities. For copper, lead, and zinc, 12 or more sediment samples out of the 15 total samples collected within the waterlot have concentrations greater than the sediment ESLs, and the EPCs for these metals also exceed the sediment ESLs. Similarly, several PAHs were detected at concentrations exceeding the sediment ESLs in 14 of the 15 sediment samples collected from the waterlot. In addition, the EPCs for most of the PAHs also exceed the sediment ESLs. Therefore, concentrations of copper, lead, zinc and PAHs above the sediment ESLs are located across the entire waterlot portion of the Site. However, the concentrations of all metals (including copper, lead and zinc), PAHs and PCBs in the three step-out samples collected adjacent to the waterlot boundaries were below applicable ESLs indicating the elevated concentrations of COPCs in sediment do not extend off-Site.

- ESBTU HQ: Potential impact posed by PAHs was also evaluated by calculating an ESBTU HQ for each sample location. There were no sediment samples with calculated ESBTU HQ values greater than 3 for common species. Furthermore, only four of the 15 sediment sample locations had a calculated ESBTU HQ values marginally greater than one for sensitive species (1.1 to 1.7). Based on these results, concentrations of PAHs in sediment of the waterlot are unlikely to result in significant adverse effects to benthic invertebrate communities.
- Benthic Invertebrate Community Assessment: Seven sediment samples from the waterlot and one reference sample were submitted for characterization of the benthic community. The benthic community assessment conducted in the waterlot focused on areas of maximum COPC concentrations in sediment and likely reflective of worst-case conditions. The benthic community in the waterlot samples were dominated by Polychaeta organisms whereas the reference sample was dominated almost exclusively by one Nematoda species. Although Polychaeata organisms are generally considered to be pollution tolerant and typically associated with soft substrate, six of the seven waterlot samples contained numerous Polychaeta species that are considered to be pollution sensitive. In addition, four of these samples had Amphipoda organisms which are generally considered to be pollution sensitive. Based on the results of the benthic taxonomic evaluation, several samples collected from the waterlot had invertebrate abundance similar to the reference but the waterlot samples had substantially higher diversity of organisms compared to the reference sample. In addition, the presence of numerous pollution sensitive invertebrates in the majority of the waterlot samples indicates that the COPC concentrations in waterlot sediments are unlikely to be adversely affecting the benthic invertebrate community in the area.
- Field Observations: The diver's notes and photos indicated that flora (kelp, algae or tube weed) and marine macroinvertebrates (periwinkles, mussels, scallops, sea star or crab) were present at all of the sediment sampling locations within waterlot, including locations with the highest concentrations of metals, PCBs, and PAHs.
- Tissue Concentrations: Only arsenic, boron, cadmium, copper, lead, selenium, strontium, vanadium, zinc, and PAHs were detected in the invertebrate tissues collected from the waterlot. However, the majority of COPCs concentrations in the invertebrate tissue samples were equal to or less than the concentrations measured in invertebrate tissue collected from the reference locations, with the exception of cadmium, zinc and total PAHs. For zinc and total PAHs, the EPCs for the waterlot invertebrates are less than the concentrations in the background invertebrates. These results indicate that the concentrations of COPCs invertebrate tissue concentration in the waterlot are consistent with background concentrations and unlikely to pose adverse toxicological effects. The EPC for cadmium in waterlot invertebrates exceeded the reference tissue concentrations. However, the concentrations of cadmium in shellfish tissue samples were generally less than benthic invertebrate body burden concentrations that result in toxicological effects based on survival, growth, and reproduction.

Based on the multiple lines of evidence discussed above, it is reasonable to assume the elevated concentrations of COPCs in sediment of the waterlot are not adversely affecting the benthic invertebrate communities in the area.

### *Fish Communities*

- Fish were not observed to be present in the waterlot at the time of the field investigation and therefore, the evaluation of risk to fish is considered to be qualitative.
- The primary route for exposure to COPCs for fish is generally considered to be through contaminants dissolved in surface water, and exposure to bioaccumulative COPCs via ingestion of benthic invertebrates that have accumulated COPCs from sediment. As COPCs in surface water at the Site were below applicable ecological screening levels or background concentrations, it is reasonable to assume COPCs dissolved in water at the Site pose a low risk to fish or fish populations in the area. In addition, COPCs detected in sediment at the Site which are considered to be highly bioaccumulative such as mercury and PCBs were not detected in shellfish tissue collected from the Site. As such, it is reasonable to assume that these bioaccumulative COPCs pose a low risk to fish through the invertebrate consumption pathway. Other potentially bioaccumulative COPCs in sediment such as arsenic, cadmium, copper, lead and zinc had concentrations in shellfish tissue that were considered representative of background conditions in the area and also considered to pose a low incremental risk to fish or fish populations.
- The waterlot only covers an area of 17,000 $m^2$ and it is unlikely most fish species would spend significant periods of time in the waterlot or use the waterlot for a significant portion of their food source, specifically migratory fish.

Based on the rationale provided above, it is reasonable to assume COPCs in sediment, surface water and shellfish tissue of the waterlot do not pose an unacceptable risk to fish or fish populations in the Mortier Bay area.

### *Upper Trophic Level Receptors (Aquatic Wildlife)*

- Arsenic, cadmium, copper, lead, mercury, selenium, zinc, LMW PAHs, HMW PAHs, and PCBs were the only COPCs carried through the ERA for evaluation of aquatic wildlife. The receptors evaluated were river otter (mammalian piscivore/insectivore); lesser scaup (avian insectivore); and common loon (avian piscivore). The ADD based on sediment ingestion and ingestion of prey were estimated for each COPC/receptor and compared to a TRV protective of survival, growth, and reproduction. A HQ was calculated by dividing the ADD by the TRV. Calculated HQs less than 1 indicate that a low potential for unacceptable health risks to aquatic wildlife receptors.
- The HQs for mammalian and avian receptors potentially exposed to the COPCs were less than 1 indicating that the concentrations of the COPCs in sediment are not a health concern for aquatic wildlife that may be using the waterlot for foraging.

## 8.8 Uncertainty Analysis

As a result of the scientific investigations, literature reviews, and risk assessment guidance that have been undertaken or followed in the preparation of this ERA, it is believed that the risk assessment results present a reasonable evaluation of the risk to ecological receptors present at the Site. Where uncertainty or lack of knowledge were encountered in the development of the risk estimates, reasonable assumptions were made, or data were selected, in order to ensure that risks were neither grossly underestimated nor overestimated. Uncertainties are inherent in every aspect of the ERA process, as discussed in this section. This section qualitatively discusses some significant aspects of uncertainty inherent in this risk assessment.

***Site Use***

Marine environments undergo many changes over time due to tidal fluctuations, vessel traffic and increase or decrease in use for industrial or commercial activities. Some marine environments may become susceptible to municipal or commercial/industrial discharges that may influence the overall chemistry. Other marine environments may undergo regular dredging activities due to an abundance of sediment accumulation. As part of the data review, it is important to understand the activities undergoing at the Site currently, as well as historically. Not knowing the full extent of the activities presents uncertainty to the potential cause or source of contamination. A detailed document review was conducted as part of this assessment to limit the uncertainty.

***Data Limitations***

The uncertainty of a risk assessment calculation often depends on the sample size, extent of contamination and variability of the data set. Larger sample size generally reduces uncertainty. The data used to support the ERA were collected in 2018. Using recent data has reduced the uncertainty of the assessment. Benthic invertebrates were collected from the Site when available. Several benthic invertebrate samples were collected and analyzed to support the ERA; however, fish were not present in the waterlot at the time of the 2018 field investigation. Therefore, it has been conservatively assumed that the analytical results for shellfish samples are representative of the COPCs concentrations accumulated in fish tissue from exposure to waterlot sediment and/or invertebrates. However, the actual concentration of COPCs in fish tissue that may use the waterlot for foraging is not known.

***Cadmium in Shellfish Tissue***

Elevated concentrations of cadmium were identified in shellfish tissue collected from the waterlot, specifically scallops. Although several scallops collected from the waterlot had concentrations of cadmium greater than background conditions, the elevated concentrations were considered related to background conditions as a known source of cadmium is not associated with the Site (cadmium concentrations in soil, groundwater, sediment and surface water were below laboratory detection limits or applicable guidelines). In addition, available literature indicates that elevated concentrations of cadmium in scallops can naturally occur in waters of Atlantic Canada as scallops preferentially accumulate cadmium in their digestive gland. However, the mechanism causing elevated concentrations of cadmium in scallop tissue is not known.

### *Shellfish Tissue Benchmarks*

Shellfish tissue benchmark concentrations were obtained from the Jarvinen and Ankley (1999) database, which are based primarily on limited number of species. Chemical body burden sensitivity between different shellfish species is not known.

### *Weight of Evidence*

Various lines of evidence (i.e., concentrations of COPCs, spatial extent of exceedances, observed impairment, benthic community assessment) were used to assess the potential for unacceptable ecological risks to benthic communities within the waterlot. This approach does not present risk estimates solely based on calculations and elevated hazard quotients, but presents an integrated conclusion based on all the data to determine the level of action or remedial objectives.

### *Utilization of Indicator Species to Represent Other Organisms.*

The use of indicator species is intended to limit the number of ecological receptors evaluated. The receptors selected are considered to be sensitive, and to be highly exposed to the COPCs present via relevant exposure pathways. Therefore, it is reasonable to assume that conclusions that are reached in respect of the modeled receptor organisms can be generalized to other biota that might use the waterlot.

# 9. Conclusions and Recommendations

## 9.1 Conclusions

GHD was retained by the NLDMAE to carry out a Supplemental Phase II ESA and a HHERA at the Marystown Shipyard located on the west side of Mortier Bay in the Town of Marystown, NL. A Site inspection of the area revealed various steel and other debris is stored at the Site, particularly in the lower laydown area as well as observed to be present in fill materials around the shoreline and ditching located along the southwest edge of the lower laydown area. The Supplemental Phase II ESA concluded there are petroleum hydrocarbon and/or metals impacts in the on-Site soil and groundwater. The study also reported exceedances of generic screening criteria for metals, PAHs, and PCBs in the waterlot sediment. The data collected during the completion of the Supplemental Phase II ESA was used to support the completion of a HHERA to further evaluate potential risks to human and ecological receptors at the Shipyard and associated waterlot.

### *Human Health Risk Assessment*

Based on the results of the HHRA, there are petroleum hydrocarbon concentrations present in the soil above the HHSL for the protection of indoor air at locations near the on-Site commercial buildings that require further assessment.

There are groundwater samples collected at the Site that have arsenic and vanadium concentrations greater than the commercial direct contact/ingestion HHSLs located in the lower laydown area of the Shipyard. There are also groundwater samples that exceeded the mTPH direct contact/ingestion HHSLs collected from monitor well MGSB-MW15, which is located on the south side of the general store building. As the on-Site groundwater is not being consumed, the only receptor with potential groundwater contact would be a construction worker.

The sediment located in the waterlot does not pose an unacceptable risk to the commercial worker receptors through direct contact pathway at the Site.

The HHRA indicated the consumption of shellfish collected from the waterlot are unlikely to pose a risk to human health based on current usage of the waterlot. However, the HHRA indicated that consumption of shellfish harvested from the waterlot, specifically scallops, could pose a risk to toddlers if consumed on subsistence or heavy consumer basis (5 days/week, 26 weeks per year). The shellfish consumption pathway was assessed based on measured concentrations of COPCs (e.g. cadmium) in composite samples of soft tissue and not specific to edible portions of shellfish. Using whole body tissue concentrations likely overstates the potential for risk as COPCs such as cadmium are known to preferentially accumulate in the digestive gland of scallops with substantially less concentrations being present in the edible portions of the shellfish such as abductor muscles. As indicated in literature from the Department of Fisheries and Oceans, Research Branch (J.F. Uthe and C.L. Chou, 1986), cadmium concentrations in abductor muscles typically constitute less than 1% of the total cadmium concentrations in the soft tissue of scallops. For the purposes of this risk assessment, it has been conservatively assumed that the abductor muscle is 10% of wholebody which would result in an EPC that is well below the SSTLs developed for both a toddler and adult receptor (subsistence, recreational/commercial consumption). It has also been noted that in the conditions of the DFO recreational/commercial licensing both commercial and recreational harvesters are not to consume any portion, other than the adductor muscle ("meat"), from scallops that are harvested from the shoreline and adjacent waters surrounding the province of NL. As such, it is reasonable to assume that the concentration of cadmium in the edible portion of scallops (abductor muscle) collected from the Site is well below concentrations that are considered to pose a potential risk to human health.

### *Ecological Risk Assessment*

Based on the results of the ERA, the concentrations of COPCs in sediment of the waterlot are not considered to pose an unacceptable risk to benthic invertebrates, fish, or aquatic wildlife through the direct contact and consumption exposure pathways.

If sediment is required to be excavated/removed to facilitate any future wharf upgrades, leachate analyses on the sediment has confirmed the dredged material is not classified as a toxic hazardous waste. As a result, the excavated dredged material meets the requirements outlined in the Guidance Document entitled “Protocol for the Management of Excavated Soils, Concrete Rubble and Dredged Materials (GD-PPD-045.2)” and can be disposed at an approved landfill facility, pending landfill approval.

Similarly, concentrations of COPCs in surface water of the waterlot were below applicable screening guidelines or reference conditions and considered to pose a low risk to ecological receptors. Based on the surface water analytical results, groundwater at the Site with elevated concentrations of metals and mTPH exceeding guidelines for groundwater discharging to an aquatic receptor are unlikely to pose an unacceptable risk to aquatic ecological receptors.

## 9.2 Recommendations

The following recommendations are provided based on the results of the Supplemental Phase II ESA and HHERA:

- Conduct a groundwater monitoring program for seasonal variation including free product gauging in all of the on-Site monitor wells and recovery wells for analyses of petroleum hydrocarbons and metals (including mercury). A minimum of two monitoring events should be completed in the Spring and Summer months to assess seasonal variation and provide the analytical data to determine if a risk management plan is required.
- Due to the locations of the commercial buildings on the Site, it is recommended that the soil exceedance areas illustrated on Figures 5A to 5C be further assessed through the installation and seasonal sampling of soil vapour probes. A minimum of two monitoring events should be completed in the Summer and Winter months to assess seasonal variation and provide the analytical data to determine if a risk management plan is required.
- Although the maximum groundwater concentration (447 mg/L in MGSB-MW15, near the Carpenters & Joiners Building) does not exceed the indoor air inhalation HHSL, the groundwater at the Site is shallower than that assumed in the derivation of the HHSLs and therefore the HHSL may not be applicable, which may warrant further assessment. Although no free product was measured in groundwater during the field work, the groundwater concentration measured in MGSB-MW15 is indicative of the possible presence of free product in the area. Therefore it is recommended that consideration be given to further assessing the soil vapour to indoor air pathway in this area through the installation and seasonal sampling of soil vapour probes. Due to the monitor well's proximity to the existing building and the absence of elevated soil concentrations in the adjacent boreholes, sub-slab probes beneath the building may be preferred. As recommended above, a minimum of two groundwater events (to determine the presence/absence of free product) and a minimum of two soil vapour events would be required to assess seasonal variation. If free phase product is detected, additional assessment would be required that includes installation of monitor wells for delineation purposes.
- It is recommended that a Risk Management Plan including Best Management Practices and a Site specific health and safety plan be developed to address possible contact with groundwater impacts should sub-surface work be required in the lower laydown area and the south side of the general store building, which specifically address arsenic, vanadium, and modified TPH. It is noted that no soil samples collected contained metals or petroleum hydrocarbons above the applicable HHSLs for direct contact; therefore, the sub-surface soil at the Site does not present a risk to construction workers.
- If a remedial program is not completed to address the soil and groundwater impacts at the Site, impacts should be risk managed or a Phase III ESA is recommended to delineate the soil and/or groundwater impacts to meet minimal site assessment requirements. The Phase III ESA program would include delineation of petroleum hydrocarbon and chromium soil impacts south of MAEB-MW2, petroleum hydrocarbon soil impacts east and south of MSBL-MW6/BH5, petroleum hydrocarbons soil impacts west of MFPA-MW1, chromium soil impacts north of MFPA-BH3, petroleum hydrocarbon soil impacts north, south and east of MLLA-MW3, as well

as petroleum hydrocarbon impacts in groundwater north of MGSB-MW15. The Phase III ESA can be combined with the groundwater and soil vapour monitoring programs discussed above.

Although outside the scope to develop an environmental liability for the Site, the following recommendations are carried forward from previous ESA programs reviewed as part of the data gap analyses:

- Any ASTs remaining on the Site and intended to be used, should be inspected to ensure they meet the requirements specified in the Newfoundland and Labrador Gasoline and Associated Products (GAP) and/or Heating Oil Storage Tank (HOST) Regulations for their intended usages.
- Although no major surface stains were noted in the areas assessed during the Supplemental Phase II ESA, any surface stains noted at the Site should be assessed or remediated as per provincial requirements.
- Any drums, containers or other vessels remaining at the Site should be collected and consolidated in designated Site areas and those no longer required should be disposed of at an approved facility.
- The scrap steel and debris, particularly in the lower laydown area and observed to be present in fill materials around the shoreline and ditching to the southwest of the lower laydown area, should be removed from the Site and disposed of at approved facilities.
- If existing buildings are to remain, an inspection of the existing septic sewer systems should be completed to ensure sewage discharges meet provincial regulations.
- Any ODS containing equipment or PCB containing light ballasts remaining at the Site should be disposed of in accordance with the applicable regulations.
- Although the underground fuel distribution lines on Site were documented to be drained, purged, capped and abandoned in place in 2000 and petroleum hydrocarbon impacts were not found along the pipelines in 2000, regulatory approval for abandonment in place would be required. This should be included in any future submissions for regulatory closure of the Site.

# 10. Closure

This report has been prepared for the sole benefit of Newfoundland and Labrador Department of Municipal Affairs and Environment. The report may not be used by any other person or entity without the express written consent of GHD and the Newfoundland and Labrador Department of Municipal Affairs and Environment. Any use which a third party makes of this report, or any reliance on decisions made based on it, is the responsibility of such third parties GHD accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken based on this report.

GHD makes no representation or warranty with respect to this report other than the work was undertaken by trained professional and technical staff in accordance with generally accepted engineering and scientific practices current at the time the work was performed. Any information or facts provided by others and referred to or utilized in the preparation of this report was assumed by GHD to be accurate. Conclusions presented in this report should not be construed as legal advice.

This risk assessment was undertaken exclusively for the purpose outlined herein and was limited to those contaminants, exposure pathways, receptors, and related uncertainties specifically referenced in this report. This work was specific to the site conditions and land use considerations described herein. The report cannot be used or applied under any circumstances to another location or situation or for any other purpose without further evaluation of the data and related limitations.

If any conditions become apparent that differ significantly from our understanding of conditions as presented in this report, we request that we be notified immediately to reassess the conclusions provided herein.

All of Which is Respectfully Submitted,

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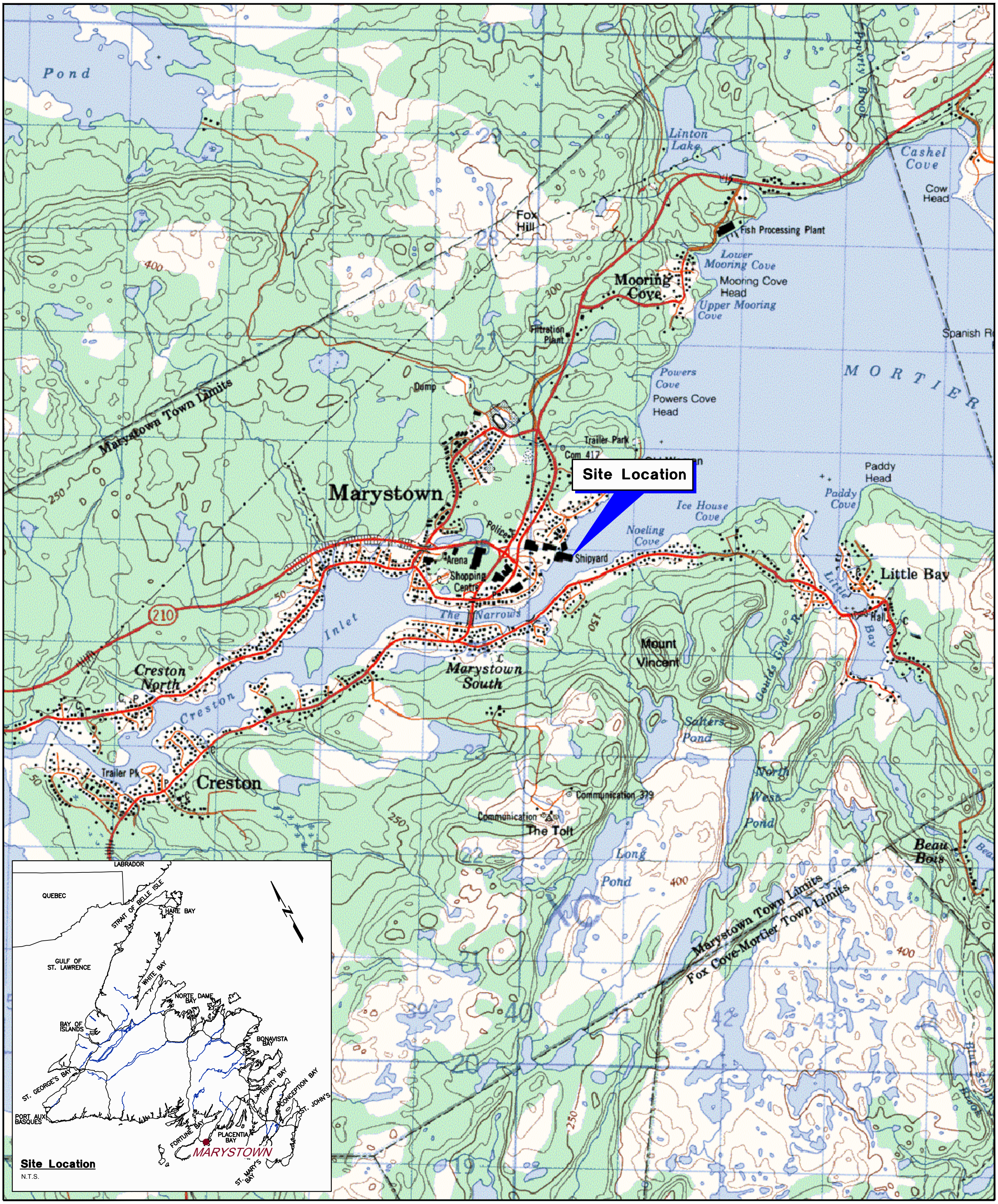


0 500 1000 1500m
SCALE: 1:50,000

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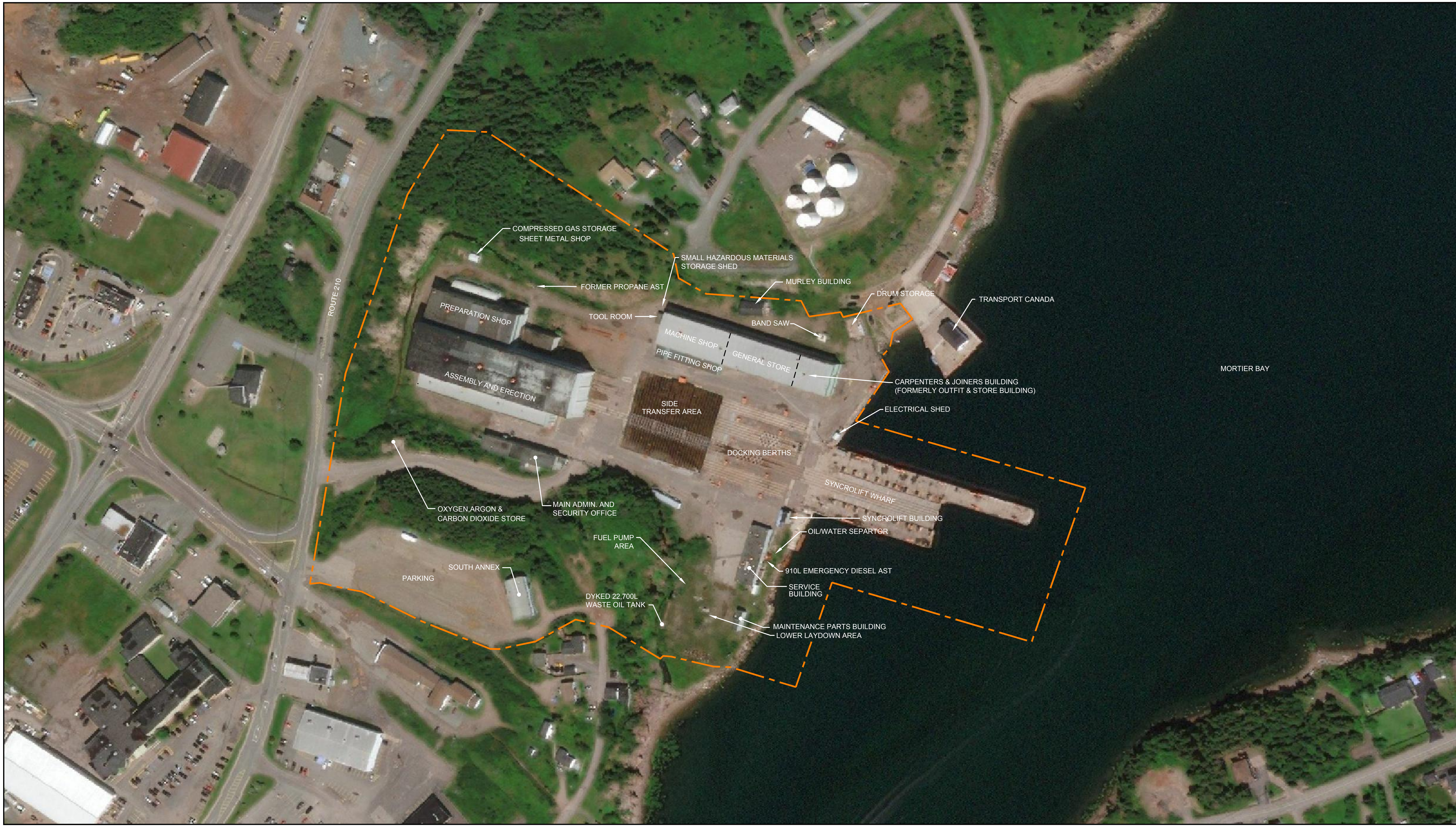
11178792-02
Nov 5, 2018

SITE LOCATION MAP

FIGURE 1

CAD File: I:\CAD\8-chars\11------\1117----\111787--\11178792\-02\11178792-02 GN-NL001.dwg

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0 25 50 75m

SCALE: 1:2,500

Coordinate System:
UTM ZONE 21 NAD83 (CSRS)

N

LEGEND:

PROPERTY BOUNDARY LINE

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SUPPLEMENTAL PHASE II ENVIRONMENTAL SITE ASSESSMENT & HHERA

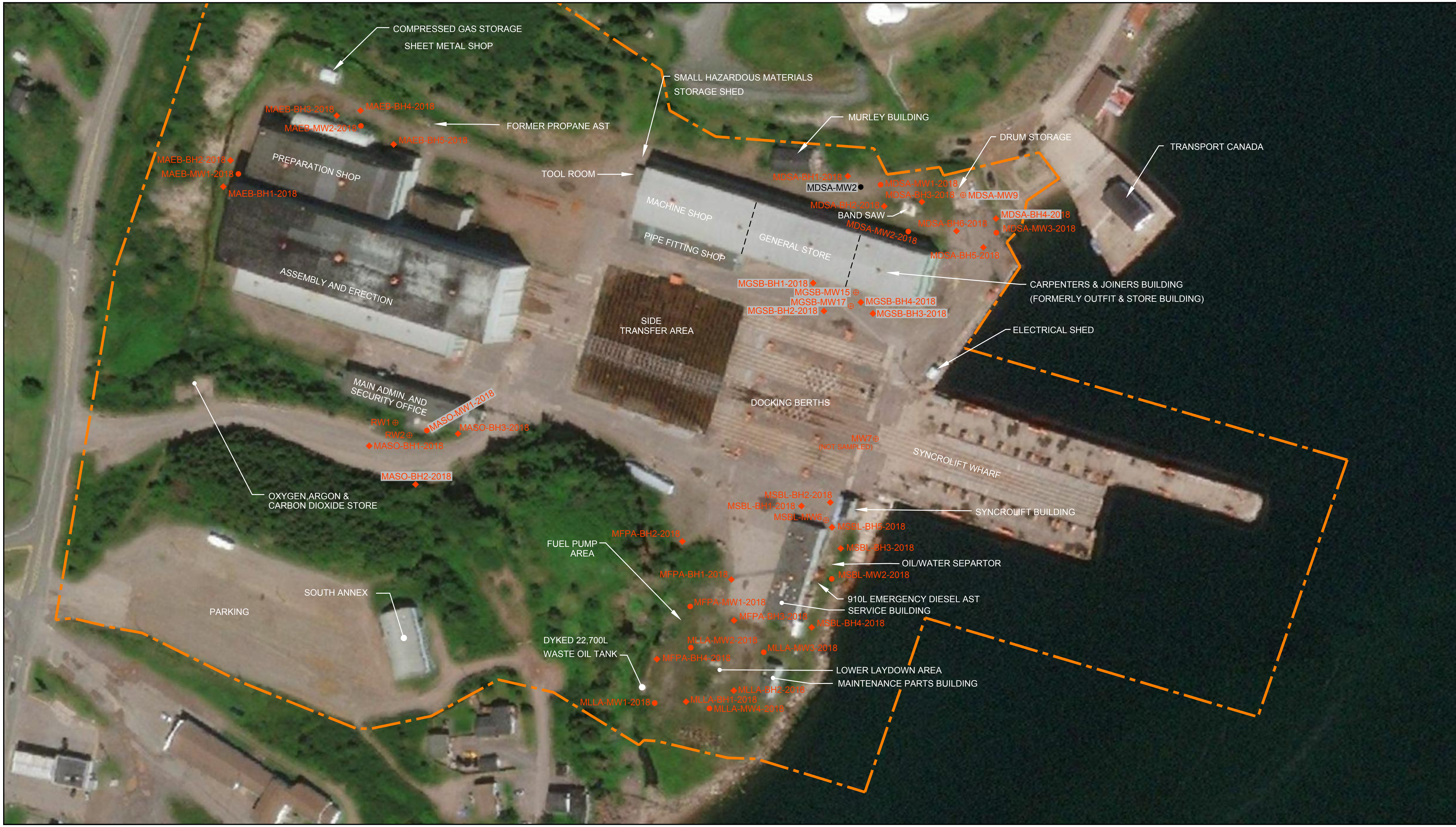
PROPERTY PLAN

11178792-02

Nov 5, 2018

FIGURE 2

CAD File: I:\CAD\8-chars\11------\1117----\111787--\11178792\-02\11178792-02 GN-NL002.dwg

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0 15 30 45m

SCALE: 1:1,500

Coordinate System:
UTM ZONE 21 NAD83 (CSRS)

N

LEGEND:

- PROPERTY BOUNDARY LINE
- xxxx-BH ◆ BOREHOLE LOCATION (GHD 2018)
- xxxx-MW ● MONITOR WELL LOCATION (GHD 2018)
- MW/RW ⊕ MONITOR WELL LOCATION (OTHERS)
- MW ● MONITOR WELL LOCATION (DESTROYED)

GHD

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11178792-02
Nov 20, 2018

SITE PLAN WITH SAMPLE LOCATIONS

FIGURE 3

CAD File: I:\CAD\8-chars\11-------\1117----\111787--\11178792\-02\11178792-02 GN-NL003.dwg

| GPS COORDINATES (UTM) | | |
|---|---|---|
| SAMPLE ID | NORTHING | EASTING |
| 18-MNMA-S1 | 5225013.556 | 640242.615 |
| 18-MNMA-S2 | 5225050.056 | 640257.753 |
| 18-MNMA-S3 | 5225082.093 | 640268.959 |
| 18-MNMA-S4 | 5225093.675 | 640299.854 |
| 18-MNMA-S5 | 5225064.835 | 640321.300 |
| 18-MNMA-S6 | 5225079.380 | 640346.264 |
| 18-MNMA-S7 | 5225049.512 | 640372.086 |
| 18-MNMA-S8 | 5225067.798 | 640398.242 |
| 18-MNMA-S9 | 5225037.832 | 640413.087 |
| 18-MNMA-S10 | 5225096.798 | 640377.345 |
| 18-MNMA-S11 | 5225090.348 | 640416.252 |
| 18-MNMA-S12 | 5225122.598 | 640437.712 |
| 18-MNMA-S13 | 5225139.204 | 640393.569 |
| 18-MNMA-S14 | 5225151.582 | 640348.381 |
| 18-MNMA-S15 | 5225163.610 | 640312.265 |
| 18-MNMA-STEP1 | 5225034.118 | 640341.740 |
| 18-MNMA-STEP2 | 5225074.374 | 640452.5035 |
| 18-MNMA-STEP3 | 5225163.481 | 640403.374 |

*ALL COORDINATES ARE NAD83 UTM ZONE 21T


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0 10 20 30m

SCALE: 1:1,000
Coordinate System:
UTM ZONE 21 NAD83 (CSRS)

N

LEGEND:

- PROPERTY BOUNDARY LINE
- S — SEDIMENT SAMPLE LOCATION (GHD 2018)
- S/W — SEDIMENT/SURFACE WATER SAMPLE LOCATION (GHD 2018)
- SAMPLE SUBMITTED FOR BENTHIC INVERTEBRATE ANALYSIS

GHD

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11178792-02
Feb 4, 2019

SITE PLAN WITH SAMPLE LOCATIONS - WATERLOT

FIGURE 4A

CAD File: I:\CAD\8-chars\11-------\1117----\111787--\11178792\-02\11178792-02 GN-NL04A.dwg


GPS COORDINATES (UTM)

| SAMPLE ID | NORTHING | EASTING |
|---|---|---|
| 18-MNMA-REF1 | 5225595.650 | 641884.540 |
| 18-MNMA-REF2 | 5225583.110 | 641747.930 |
| 18-MNMA-REF3 | 5226046.500 | 641235.570 |

*ALL COORDINATES ARE NAD83 UTM ZONE 21T

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0 50 100 150m

SCALE: 1:5,000

Coordinate System:
UTM ZONE 21 NAD83 (CSRS)

LEGEND:

PROPERTY BOUNDARY LINE

S SEDIMENT SAMPLE LOCATION (GHD 2018)

S/W SEDIMENT/SURFACE WATER SAMPLE LOCATION (GHD 2018)

SAMPLE SUBMITTED FOR BENTHIC INVERTEBRATE ANALYSIS

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11178792-02

Feb 4, 2019

SITE PLAN WITH SAMPLE LOCATIONS - REFERENCE

FIGURE 4B

CAD File: I:\CAD\8-chars\11------\1117----\111787--\11178792\-02\11178792-02 GN-NL04B.dwg


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0 15 30 45m

SCALE: 1:1,500
Coordinate System:
UTM ZONE 21 NAD83 (CSRS)

N

LEGEND:

- PROPERTY BOUNDARY LINE
- xxxx-BH BOREHOLE LOCATION (GHD 2018)
- xxxx-MW MONITOR WELL LOCATION (GHD 2018)
- MW/RW MONITOR WELL LOCATION (OTHERS)
- MW MONITOR WELL LOCATION (DESTROYED)
- AREA OF mTPH EXCEEDING ATLANTIC RBCA TIER I RBSLs FOR COMMERCIAL (NON-POTABLE)
- AREA OF CHROMIMUM EXCEEDING CCME SQGs - COMMERCIAL

GHD

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Feb 5, 2019

SITE PLAN WITH SOIL EXCEEDANCES

FIGURE 5

CAD File: I:\CAD\8-chars\11------\1117----\111787--\11178792\-02\11178792-02 GN-NL005.dwg


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0 5 10 15m

SCALE: 1:500

Coordinate System:
UTM ZONE 21 NAD83 (CSRS)

N

LEGEND:

PROPERTY BOUNDARY LINE

xxxx-BH BOREHOLE LOCATION (GHD 2018)

xxxx-MW MONITOR WELL LOCATION (GHD 2018)

?--?-- AREA OF mTPH EXCEEDING ATLANTIC RBCA TIER I RBSLs FOR COMMERCIAL (NON-POTABLE)

?--?-- AREA OF CHROMIMUM EXCEEDING CCME SQGs - COMMERCIAL

GHD

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11178792-02
Mar 8, 2019

SITE PLAN WITH SOIL EXCEEDANCES - MAEB

FIGURE 5A

CAD File: I:\CAD\8-chars\11------\1117----\111787--\11178792\-02\11178792-02 GN-NL05A.dwg


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0 5 10 15m

SCALE: 1:500

Coordinate System:
UTM ZONE 21 NAD83 (CSRS)

N

LEGEND:

| | |
|---|---|
| | PROPERTY BOUNDARY LINE |
| xxxx-BH | BOREHOLE LOCATION (GHD 2018) |
| xxxx-MW | MONITOR WELL LOCATION (GHD 2018) |
| MW/RW | MONITOR WELL LOCATION (OTHERS) |
| | AREA OF mTPH EXCEEDING ATLANTIC RBCA TIER I RBSLs FOR COMMERCIAL (NON-POTABLE) |
| | AREA OF CHROMIMUM EXCEEDING CCME SQGs - COMMERCIAL |

GHD

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MARYSTOWN SHIPYARD, MARYSTOWN, NEWFOUNDLAND AND LABRADOR
SUPPLEMENTAL PHASE II ENVIRONMENTAL SITE ASSESSMENT & HHERA

11178792-02

Mar 8, 2019

## SITE PLAN WITH SOIL EXCEEDANCES - MSBL

FIGURE 5B

CAD File: I:\CAD\8-chars\11------\1117----\111787--\11178792\-02\11178792-02 GN-NL05B.dwg


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0 5 10 15m

SCALE: 1:500
Coordinate System:
UTM ZONE 21 NAD83 (CSRS)

N

LEGEND:

PROPERTY BOUNDARY LINE
xxxx-BH BOREHOLE LOCATION (GHD 2018)
xxxx-MW MONITOR WELL LOCATION (GHD 2018)
MW/RW MONITOR WELL LOCATION (OTHERS)
AREA OF mTPH EXCEEDING ATLANTIC RBCA TIER I RBSLs FOR COMMERCIAL (NON-POTABLE)
AREA OF CHROMIMUM EXCEEDING CCME SQGs - COMMERCIAL

GHD

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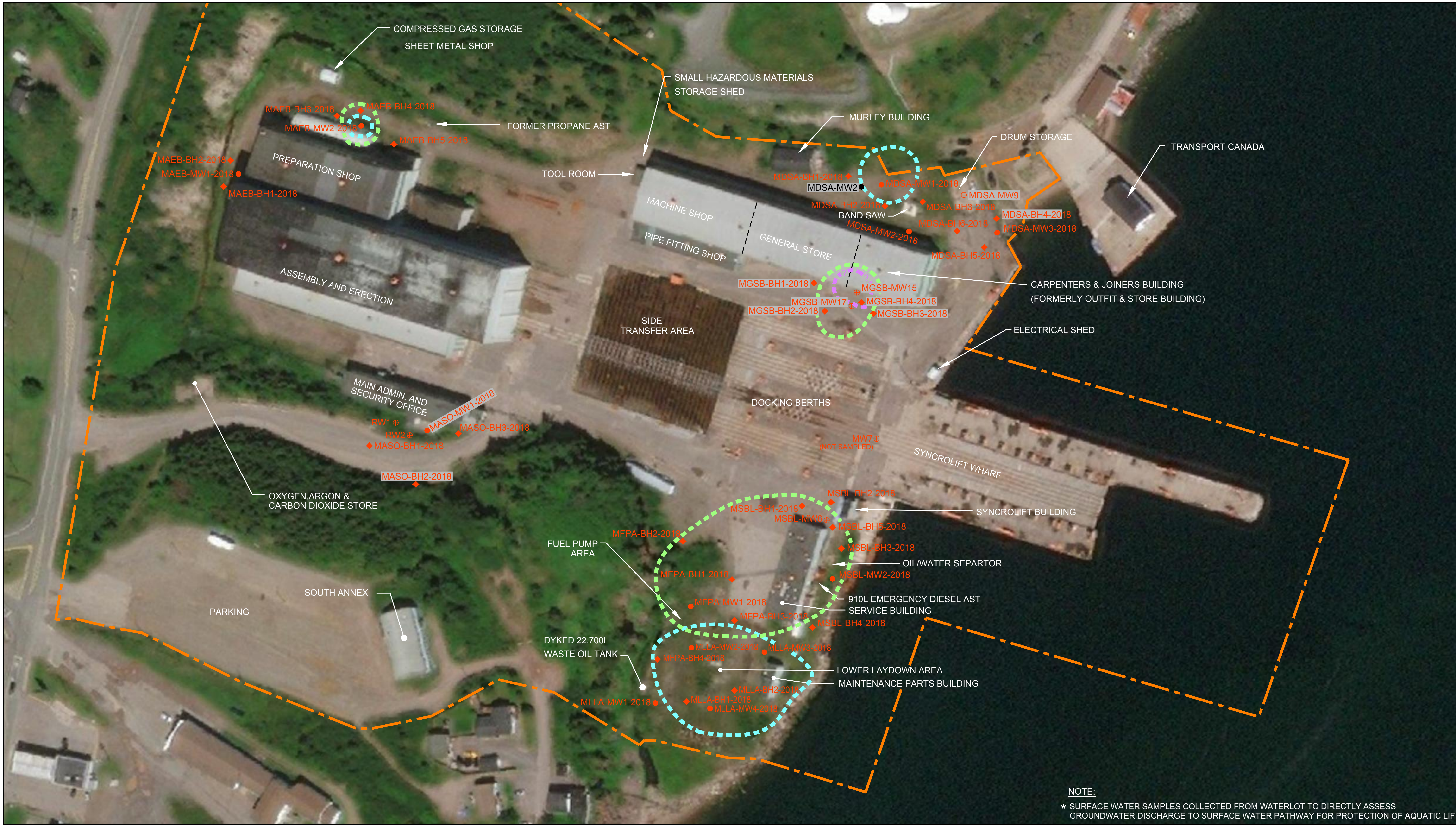
SUPPLEMENTAL PHASE II ENVIRONMENTAL SITE ASSESSMENT & HHERA

11178792-02
Mar 8, 2019

SITE PLAN WITH SOIL EXCEEDANCES - MLLA/MFPA

FIGURE 5C

CAD File: I:\CAD\8-chars\11------\1117----\111787--\11178792\-02\11178792-02 GN-NL05C.dwg

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0 15 30 45m

SCALE: 1:1,500

Coordinate System:
UTM ZONE 21 NAD83 (CSRS)

N

LEGEND:

- PROPERTY BOUNDARY LINE
- xxxx-BH ◆ BOREHOLE LOCATION (GHD 2018)
- xxxx-MW ● MONITOR WELL LOCATION (GHD 2018)
- MW/RW ⊕ MONITOR WELL LOCATION (OTHERS)
- MW ● MONITOR WELL LOCATION (DESTROYED)
- ?—?—? AREA OF mTPH EXCEEDING ATLANTIC RBCA TIER I RBSLs FOR COMMERCIAL (NON-POTABLE)
- AREA OF mTPH + F2 EXCEEDING ATLANTIC RBCA TIER I GROUNDWATER ESLs ★
- AREA OF METALS (ARSENIC, COPPER, SELENIUM, ZINC) EXCEEDING THE FIGQG FOR COMMERCIAL - MARINE EXPOSURE ★

GHD

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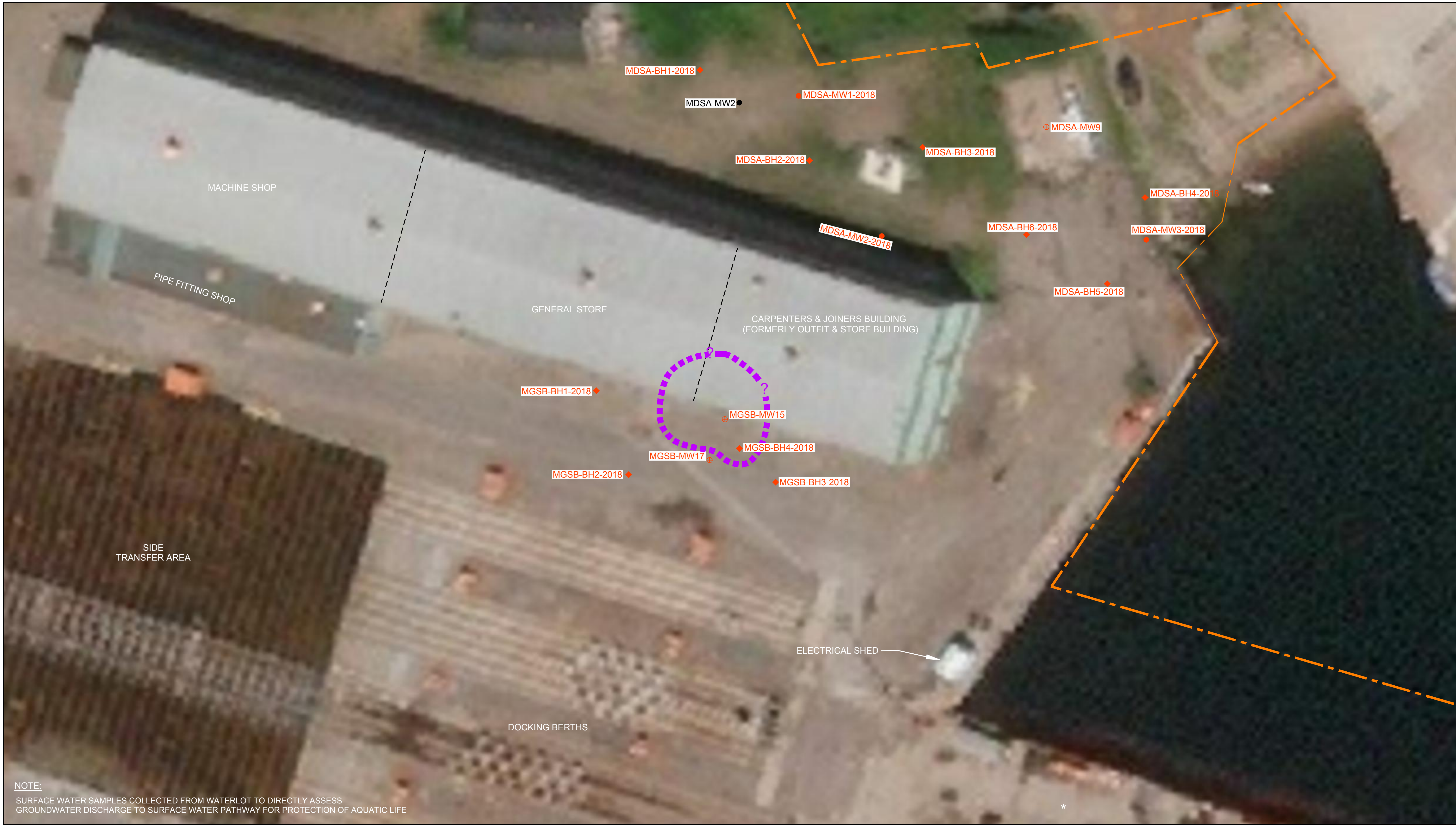
Feb 4, 2019

SITE PLAN WITH GROUNDWATER EXCEEDANCES

FIGURE 6

CAD File: I:\CAD\8-chars\11------\1117----\111787--\11178792\-02\11178792-02 GN-NL006.dwg

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0 5 10 15m

SCALE: 1:500

Coordinate System:
UTM ZONE 21 NAD83 (CSRS)

N

LEGEND:

- PROPERTY BOUNDARY LINE
- xxxx-BH ◆ BOREHOLE LOCATION (GHD 2018)
- xxxx-MW ● MONITOR WELL LOCATION (GHD 2018)
- MW/RW ⊕ MONITOR WELL LOCATION (OTHERS)
- MW ● MONITOR WELL LOCATION (DESTROYED)
- ?--?--? AREA OF mTPH EXCEEDING ATLANTIC RBCA TIER I RBSLs FOR COMMERCIAL (NON-POTABLE)

*

GHD

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11178792-02
Mar 8, 2019

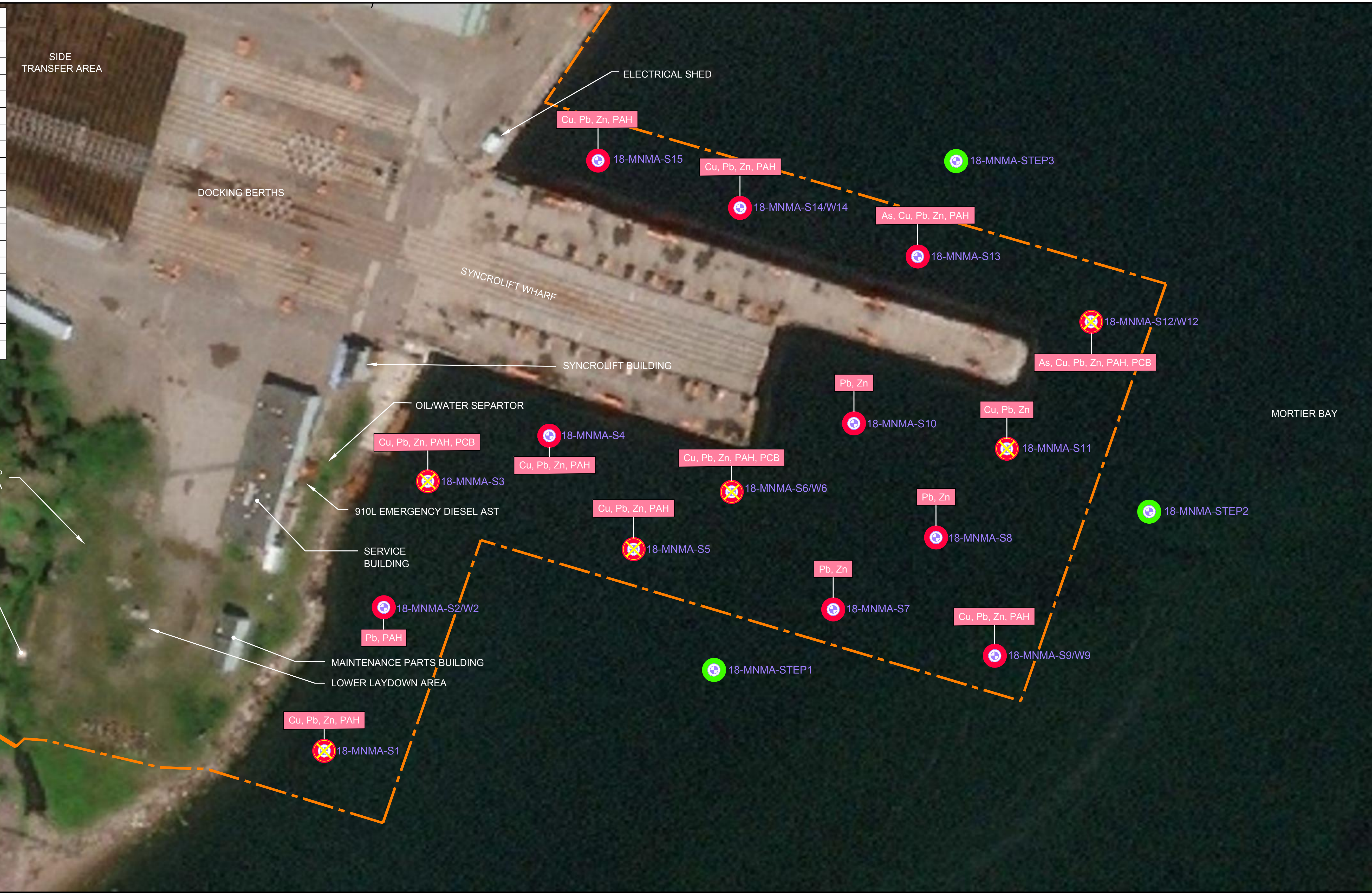
SITE PLAN WITH GROUNDWATER EXCEEDANCES - MGSB

FIGURE 6A

CAD File: I:\CAD\8-chars\11------\1117----\111787--\11178792\-02\11178792-02 GN-NL06A.dwg

| GPS COORDINATES (UTM) | | |
|---|---|---|
| SAMPLE ID | NORTHING | EASTING |
| 18-MNMA-S1 | 5225013.556 | 640242.615 |
| 18-MNMA-S2 | 5225050.056 | 640257.753 |
| 18-MNMA-S3 | 5225082.093 | 640268.959 |
| 18-MNMA-S4 | 5225093.675 | 640299.854 |
| 18-MNMA-S5 | 5225064.835 | 640321.300 |
| 18-MNMA-S6 | 5225079.380 | 640346.264 |
| 18-MNMA-S7 | 5225049.512 | 640372.086 |
| 18-MNMA-S8 | 5225067.798 | 640398.242 |
| 18-MNMA-S9 | 5225037.832 | 640413.087 |
| 18-MNMA-S10 | 5225096.798 | 640377.345 |
| 18-MNMA-S11 | 5225090.348 | 640416.252 |
| 18-MNMA-S12 | 5225122.598 | 640437.712 |
| 18-MNMA-S13 | 5225139.204 | 640393.569 |
| 18-MNMA-S14 | 5225151.582 | 640348.381 |
| 18-MNMA-S15 | 5225163.610 | 640312.265 |
| 18-MNMA-STEP1 | 5225034.118 | 640341.740 |
| 18-MNMA-STEP2 | 5225074.374 | 640452.5035 |
| 18-MNMA-STEP3 | 5225163.481 | 640403.374 |

*ALL COORDINATES ARE NAD83 UTM ZONE 21T

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0 10 20 30m

SCALE: 1:1,000

Coordinate System:
UTM ZONE 21 NAD83 (CSRS)

N

LEGEND:

PROPERTY BOUNDARY LINE

S SEDIMENT SAMPLE LOCATION (GHD 2018)

S/W SEDIMENT/SURFACE WATER SAMPLE LOCATION (GHD 2018)

SAMPLE SUBMITTED FOR BENTHIC INVERTEBRATE ANALYSIS

BTEX/TPH < ATLANTIC RBCA ESLs AND PCBs/METALS/PAHs < CCME PELs

BTEX/TPH > ATLANTIC RBCA ESLs AND /OR PCBs/METALS/PAHs > CCME PELs

PARAMETERS EXCEEDING CCME PELs OR ATLANTIC RBCA ESLs

GHD

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11178792-02

Feb 4, 2019

CONTAMINANT DISTRIBUTION - WATERLOT

FIGURE 7A

CAD File: I:\CAD\8-chars\11------\1117----\111787--\11178792\-02\11178792-02 GN-NL07A.dwg


| GPS COORDINATES (UTM) | | |
|---|---|---|
| SAMPLE ID | NORTHING | EASTING |
| 18-MNMA-REF1 | 5225595.650 | 641884.540 |
| 18-MNMA-REF2 | 5225583.110 | 641747.930 |
| 18-MNMA-REF3 | 5226046.500 | 641235.570 |

*ALL COORDINATES ARE NAD83 UTM ZONE 21T

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0 50 100 150m

SCALE: 1:5,000

Coordinate System:
UTM ZONE 21 NAD83 (CSRS)

N

LEGEND:

PROPERTY BOUNDARY LINE

S SEDIMENT SAMPLE LOCATION (GHD 2018)

S/W SEDIMENT/SURFACE WATER SAMPLE LOCATION (GHD 2018)

SAMPLE SUBMITTED FOR BENTHIC INVERTEBRATE ANALYSIS

BTEX/TPH < ATLANTIC RBCA ESLs AND PCBs/METALS/PAHs < CCME PELs

BTEX/TPH > ATLANTIC RBCA ESLs AND /OR PCBs/METALS/PAHs > CCME PELs

PARAMETERS EXCEEDING CCME PELs OR ATLANTIC RBCA ESLs

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11178792-02
Feb 4, 2019

CONTAMINANT DISTRIBUTION - REFERENCE

FIGURE 7B

CAD File: I:\CAD\8-chars\11------\1117----\111787--\11178792\-02\11178792-02 GN-NL07B.dwg

**Table 1**
**Groundwater Monitoring Results**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| Well ID | Top of Riser Elevation[1] (m) | Ground Surface Elevation[1] (m) | Date (d/m/yyyy) | Free Product Thicknesses (mm) | Depth to Water Table (mbtr) | Groundwater Elevation[1] (mard) | GPS Coordinates (UTM Zone 21) (Collected in Field) | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | Northing | Easting |
| **MSBL-MW6** | --- | 2.69 | 11/10/2018 | nd | 2.62 | --- | 5225359.931 | 369274.236 |
| **MSBL-MW2-2018** | 3.43 | 2.51 | | nd | 2.18 | 1.25 | 5225335.675 | 369279.318 |
| **MLLA-MW1-2018** | 2.49 | 2.61 | | nd | 1.71 | 0.78 | 5225285.392 | 369202.54 |
| **MLLA-MW2-2018** | 2.53 | 2.65 | | nd | 1.69 | 0.83 | 5225308.019 | 369217.751 |
| **MLLA-MW3-2018** | 2.69 | 2.81 | | nd | 1.75 | 0.94 | 5225305.741 | 369247.87 |
| **MLLA-MW4-2018** | 2.62 | 2.84 | | nd | 1.90 | 0.73 | 5225282.84 | 369225.11 |
| **MFPA-MW1-2018** | 2.58 | 2.70 | | nd | 1.85 | 0.73 | 5225325.048 | 369217.7 |
| **MASO-MW1-2018** | 2.54 | 2.66 | | nd | 0.82 | 1.71 | 5225399.054 | 369109.861 |
| **MASO-RW1** | --- | 4.24 | | nd | 0.95 | --- | 5225397.134 | 369102.617 |
| **MASO-RW2** | --- | 3.43 | | nd | 1.80 | --- | 5225402.456 | 369096.878 |
| **MAEB-MW1-2018** | 2.76 | 2.88 | | nd | 0.57 | 2.19 | 5225504.026 | 369038.542 |
| **MAEB-MW2-2018** | 2.79 | 2.91 | | nd | 0.91 | 1.88 | 5225525.081 | 369084.257 |
| **MDSA-MW1-2018** | 2.51 | 2.63 | | nd | 2.54 | -0.03 | 5225498.048 | 369298.578 |
| **MDSA-MW2-2018** | 2.60 | 2.80 | | nd | 2.24 | 0.36 | 5225478.602 | 369309.777 |
| **MDSA-MW3-2018** | 2.57 | 2.69 | | nd | 2.95 | -0.38 | 5225477.641 | 369346.153 |
| **MDSA-MW9** | --- | 2.40 | | nd | 1.40 | --- | 5225492.069 | 369334.016 |
| **MGSB-MW15** | --- | 2.73 | | nd | 2.22 | --- | 5225453.704 | 369287.86 |
| **MGSB-MW17** | --- | 2.72 | | nd | 2.28 | --- | 5225448.101 | 369285.692 |

**Notes:**
1 - Relative elevations were determined using a control monument (95G5004, 5226240.659, 369103.381), having an assigned elevation of 26.737 metres above relative datum (mard)
m - metres
mm - millimeters
mbtr - metres below top of riser
mard - metres above relative datum
nd - not detected
'---' - not available

**Table 2**
**Petroleum Hydrocarbons in Soil**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | | **Sample ID** | **MSBL-MW2-2018 SS1** | **MSBL-MW2-2018 SS4** | **MSBL-MW2-2018 SS6** | **MSBL-BH1-2018 SS6** | **MSBL-BH1-2018 SS7** | **MSBL-BH2-2018 SS5** | **MSBL-BH2-2018 SS6** | **MSBL-BH3-2018 SS4** | **MSBL-BH3-2018 SS5** | **MSBL-BH4-2018 SS5** | **MSBL-BH4-2018 SS6** | **MSBL-BH5-2018 SS1** | **MSBL-BH5-2018 SS5** | **MSBL-BH5-2018 SS6** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **Sample Depth (mbgs)** | **0 - 0.6** | **3.0 - 3.6** | **4.5 - 5.1** | **3.0 - 3.6** | **3.6 - 4.2** | **2.4 - 3.0** | **3.0 - 3.6** | **2.1 - 2.7** | **2.7 - 3.3** | **2.4 - 3.0** | **3.0 - 3.6** | **0 - 0.6** | **2.4 - 3.0** | **3.0 - 3.6** |
| | | | | **Date Collected** | **10/4/2018** | **10/9/2018** | **10/9/2018** | **10/4/2018** | **10/4/2018** | **10/4/2018** | **10/4/2018** | **10/4/2018** | **10/4/2018** | **10/9/2018** | **10/9/2018** | **10/4/2018** | **10/4/2018** | **10/4/2018** |
| | **Guidelines** | | | | | | | | | | | | | | | | | |
| **Parameter** | **Criteria [1]** | **Criteria [2]** | **Criteria [3]** | **Units** | | | | | | | | | | | | | | |
| **Petroleum Hydrocarbons** | | | | | | | | | | | | | | | | | | |
| Benzene | 2.5 | 180 | 18 | mg/kg | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | 10000 | 250 | 980 | mg/kg | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethyl Benzene | 10000 | 300 | 640 | mg/kg | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylenes | 110 | 350 | 2600 | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | - | 320 | 11000 | mg/kg | <3 | 14 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | 70 | <3 | <3 | <3 | 37 |
| C10-C16 | - | 260 | 9800 | mg/kg | 26 | 380 | <15 | 60 | 45 | 16 | 1690 | 47 | 52 | 1520 | <15 | <15 | <15 | 3250 |
| C16-C21 | - | 1700 | 16000 | mg/kg | 65 | 374 | <15 | 43 | 34 | 104 | 1470 | 94 | 109 | 1200 | 35 | <15 | <15 | 2890 |
| C21-C32 | - | | | mg/kg | 24 | 337 | 17 | <15 | <15 | 35 | 332 | 39 | 45 | 190 | 20 | <15 | <15 | 633 |
| Modified TPH | 870 - Gas<br>4000 - Diesel / #2<br>10000 - # 6 oil / Lube | - | - | mg/kg | 115 | 1110 | <20 | 103 | 79 | 155 | 3490 | 180 | 206 | 2980 | 55 | <20 | <20 | 6810 |
| Laboratory Resemblance | | | | | FOF | WFOF + LOF | LOF | WFOF | WFOF | WFOF | WFOF | FOF | FOF | WFOF | WFOF | NR | NR | WFOF |

**Notes:**

1 - Atlantic RBCA Tier I RBSL - Commercial, Non-Potable Water Use with Coarse-Grained Soil

2 - Atlantic RBCA Tier I ESLs for the Protection of Plants and Soil Invertebrates; Direct Soil Contact - Commercial Land Use with Coarse-Grained Soil - For samples collected at depths shallower than 1.5 m

3 - Atlantic RBCA Tier I ESLs for the Protection of Wildlife (mammals and birds) and Livestock; Soil & Food Ingestion

"-" - No established guideline

mbgs - metres below ground surface

mg/kg - milligrams per kilogram

Shading - Exceeds Tier I RBSLs

FOF - Fuel Oil Fraction

WFOF - Weathered Fuel Oil Fraction

NR - No Resemblance

FR - Fuel Range

LR - Lube Range

GR - Gasoline Range

UC - Unidentified Compounds

**Table 2**
**Petroleum Hydrocarbons in Soil**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | | Sample ID | MLLA-MW1-2018 SS4 | MLLA-MW1-2018 SS6 | MLLA-MW2-2018 SS5 | MLLA-MW2-2018 SS7 | MLLA-MW3-2018 SS6 | MLLA-MW3-2018 SS7 | MLLA-MW3-2018 SS8 | MLLA-BH1-2018 SS5 | MFPA-MW1-2018 SS5 | MFPA-MW1-2018 SS7 | MFPA-BH1-2018 SS4 | MFPA-BH2-2018 SS4 | MFPA-BH2-2018 SS6 | MFPA-BH3-2018 SS5 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | **Sample Depth (mbgs)** | **1.8 - 2.4** | **3.0 - 3.32** | **2.4 - 2.5** | **3.6 - 4.19** | **3.0 - 3.6** | **3.6 - 4.2** | **4.5 - 5.1** | **2.4 - 2.8** | **2.4 - 3.0** | **3.6 - 4.2** | **2.1 - 2.7** | **1.8 - 2.4** | **3.0 - 3.6** | **2.4 - 3.0** |
| | | | | **Date Collected** | **10/3/2018** | **10/3/2018** | **10/3/2018** | **10/3/2018** | **10/3/2018** | **10/3/2018** | **10/3/2018** | **10/3/2018** | **10/3/2018** | **10/3/2018** | **10/4/2018** | **10/4/2018** | **10/4/2018** | **7/25/2008** |
| | **Guidelines** | | | | | | | | | | | | | | | | | |
| **Parameter** | **Criteria [1]** | **Criteria [2]** | **Criteria [3]** | **Units** | | | | | | | | | | | | | | |
| **Petroleum Hydrocarbons** | | | | | | | | | | | | | | | | | | |
| Benzene | 2.5 | 180 | 18 | mg/kg | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | 10000 | 250 | 980 | mg/kg | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethyl Benzene | 10000 | 300 | 640 | mg/kg | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylenes | 110 | 350 | 2600 | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | - | 320 | 11000 | mg/kg | <3 | <3 | <3 | <3 | <3 | 24 | <3 | <3 | 44 | <3 | <3 | <3 | 62 | 49 |
| C10-C16 | - | 260 | 9800 | mg/kg | <15 | <15 | 122 | <15 | 332 | 2650 | 132 | <15 | 3660 | 170 | <15 | 64 | 109 | <15 |
| C16-C21 | - | 1700 | 16000 | mg/kg | <15 | <15 | 160 | <15 | 260 | 1680 | 102 | <15 | 2740 | 141 | <15 | 39 | 87 | <15 |
| C21-C32 | - | | | mg/kg | 29 | <15 | 695 | <15 | 52 | 334 | 18 | <15 | 1200 | 111 | <15 | 53 | 102 | <15 |
| Modified TPH | 870 - Gas<br>4000 - Diesel / #2<br>10000 - # 6 oil / Lube | - | - | mg/kg | 29 | <20 | 977 | <20 | 644 | 4690 | 252 | <20 | 7640 | 422 | <20 | 156 | 360 | 49 |
| Laboratory Resemblance | | | | | LOF | NR | WFOF + LOF | NR | WFOF | WFOF | WFOF | NR | FOF | FOF + LOF | NR | FOF + LOF | FOF + LOF | GR |

**Notes:**

1 - Atlantic RBCA Tier I RBSL - Commercial, Non-Potable Water Use with Coarse-Grained Soil

2 - Atlantic RBCA Tier I ESLs for the Protection of Plants and Soil Invertebrates; Direct Soil Contact - Commercial Land Use with Coarse-Grained Soil - For samples collected at depths shallower than 1.5 m

3 - Atlantic RBCA Tier I ESLs for the Protection of Wildlife (mammals and birds) and Livestock; Soil & Food Ingestion

"-" - No established guideline

mbgs - metres below ground surface

mg/kg - milligrams per kilogram

Shading - Exceeds Tier I RBSLs

FOF - Fuel Oil Fraction

WFOF - Weathered Fuel Oil Fraction

NR - No Resemblance

FR - Fuel Range

LR - Lube Range

GR - Gasoline Range

UC - Unidentified Compounds

**Table 2**
**Petroleum Hydrocarbons in Soil**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | | Sample ID | MFPA-BH3-2018 SS6 | MFPA-BH4-2018 SS4 | MFPA-BH4-2018 SS6 | MASO-MW1-2018 SS2 | MASO-MW1-2018 SS3 | MASO-BH1-2018 SS2 | MASO-BH1-2018 SS7 | MASO-BH1-2018 SS8 | MASO-BH2-2018 SS3 | MASO-BH2-2018 SS4 | MASO-BH3-2018 SS4 | MASO-BH3-2018 SS5 | MAEB-MW1-2018 SS1 | MAEB-MW1-2018 SS2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Sample Depth (mbgs) | 3.0 - 3.6 | 1.8 - 2.4 | 3.0 - 3.6 | 0.6 - 1.2 | 1.2 - 1.8 | 0.6 - 1.2 | 3.6 - 4.2 | 4.2 - 4.8 | 1.2 - 1.8 | 1.8 - 2.4 | 1.8 - 2.4 | 2.4 - 2.8 | 0 - 0.6 | 0.6 - 1.2 |
| | | | | Date Collected | 7/25/2008 | 10/4/2018 | 10/4/2018 | 10/10/2018 | 10/10/2018 | 10/10/2018 | 10/10/2018 | 10/10/2018 | 10/10/2018 | 10/10/2018 | 10/10/2018 | 10/10/2018 | 10/2/2018 | 10/2/2018 |
| | Guidelines | | | | | | | | | | | | | | | | | |
| **Parameter** | **Criteria [1]** | **Criteria [2]** | **Criteria [3]** | **Units** | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | |
| **Petroleum Hydrocarbons** | | | | | | | | | | | | | | | | | | |
| Benzene | 2.5 | 180 | 18 | mg/kg | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | 10000 | 250 | 980 | mg/kg | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethyl Benzene | 10000 | 300 | 640 | mg/kg | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylenes | 110 | 350 | 2600 | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | - | 320 | 11000 | mg/kg | <3 | <3 | 12 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 |
| C10-C16 | - | 260 | 9800 | mg/kg | <15 | <15 | 1320 | <15 | 27 | <15 | <15 | <15 | <15 | <15 | 92 | 21 | <15 | <15 |
| C16-C21 | - | 1700 | 16000 | mg/kg | <15 | <15 | 912 | <15 | <15 | <15 | <15 | <15 | <15 | <15 | 59 | <15 | <15 | <15 |
| C21-C32 | - | | | mg/kg | <15 | <15 | 176 | 67 | 90 | <15 | <15 | <15 | <15 | <15 | <15 | <15 | 84 | 30 |
| Modified TPH | 870 - Gas<br>4000 - Diesel / #2<br>10000 - # 6 oil / Lube | - | - | mg/kg | <20 | <20 | 2420 | 67 | 117 | <20 | <20 | <20 | <20 | <20 | 151 | 21 | 84 | 30 |
| Laboratory Resemblance | | | | | NR | NR | FOF | LOF | FOF, LOF | NR | NR | NR | NR | NR | FOF | FOF | LOF | LOF |

**Notes:**

1 - Atlantic RBCA Tier I RBSL - Commercial, Non-Potable Water Use with Coarse-Grained Soil

2 - Atlantic RBCA Tier I ESLs for the Protection of Plants and Soil Invertebrates; Direct Soil Contact - Commercial Land Use with Coarse-Grained Soil - For samples collected at depths shallower than 1.5 m

3 - Atlantic RBCA Tier I ESLs for the Protection of Wildlife (mammals and birds) and Livestock; Soil & Food Ingestion

"-" - No established guideline

mbgs - metres below ground surface

mg/kg - milligrams per kilogram

Shading - Exceeds Tier I RBSLs

FOF - Fuel Oil Fraction

WFOF - Weathered Fuel Oil Fraction

NR - No Resemblance

FR - Fuel Range

LR - Lube Range

GR - Gasoline Range

UC - Unidentified Compounds

**Table 2**
**Petroleum Hydrocarbons in Soil**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | | Sample ID | MAEB-MW2-2018 SS4 | Field Duplicate MAEB-MW2-2018 SS4 | MAEB-MW2-2018 SS5 | MAEB-BH1-2018 SS2 | MAEB-BH1-2018 SS4 | MAEB-BH2-2018 SS2 | MAEB-BH2-2018 SS4 | MAEB-BH3-2018 SS2 | MAEB-BH3-2018 SS3 | MAEB-BH4-2018 SS2 | MAEB-BH4-2018 SS3 | MAEB-BH5-2018 SS2 | MAEB-BH5-2018 SS3 | MDSA-MW2-2018 SS4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Sample Depth (mbgs) | 1.8 - 2.4 | 1.8 - 2.4 | 2.4 - 3.0 | 0.6 - 1.2 | 1.8 - 2.4 | 0.6 - 1.2 | 1.8 - 1.95 | 0.6 - 1.2 | 1.2 - 1.8 | 0.6 - 1.2 | 1.2 - 1.8 | 0.6 - 1.2 | 1.2 - 1.8 | 1.8 - 2.4 |
| | | | | Date Collected | 10/2/2018 | 10/2/2018 | 10/2/2018 | 10/2/2018 | 10/2/2018 | 10/2/2018 | 10/2/2018 | 10/9/2018 | 10/9/2018 | 10/9/2018 | 10/9/2018 | 10/9/2018 | 10/9/2018 | 10/2/2018 |
| | Guidelines | | | | | | | | | | | | | | | | | |
| **Parameter** | **Criteria [1]** | **Criteria [2]** | **Criteria [3]** | **Units** | | | | | | | | | | | | | | |
| **Petroleum Hydrocarbons** | | | | | | | | | | | | | | | | | | |
| Benzene | 2.5 | 180 | 18 | mg/kg | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | 10000 | 250 | 980 | mg/kg | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethyl Benzene | 10000 | 300 | 640 | mg/kg | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylenes | 110 | 350 | 2600 | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | - | 320 | 11000 | mg/kg | 9 | 4 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 |
| C10-C16 | - | 260 | 9800 | mg/kg | 3910 | 573 | <15 | 98 | <15 | <15 | <15 | 164 | <15 | <15 | <15 | <15 | <15 | <15 |
| C16-C21 | - | 1700 | 16000 | mg/kg | 2010 | 490 | <15 | 122 | <15 | <15 | <15 | 248 | <15 | <15 | <15 | <15 | <15 | <15 |
| C21-C32 | - | | | mg/kg | 305 | 140 | <15 | 74 | 15 | <15 | <15 | 103 | <15 | <15 | <15 | <15 | 21 | 15 |
| Modified TPH | 870 - Gas<br>4000 - Diesel / #2<br>10000 - # 6 oil / Lube | - | - | mg/kg | 5230 | 1180 | <20 | 294 | <20 | <20 | <20 | 515 | <20 | <20 | <20 | <20 | 21 | <20 |
| Laboratory Resemblance | | | | | FOF | FOF | NR | FOF & LOF | LOF | NR | NR | FOF | NR | NR | NR | NR | UC | LR |

**Notes:**

1 - Atlantic RBCA Tier I RBSL - Commercial, Non-Potable Water Use with Coarse-Grained Soil

2 - Atlantic RBCA Tier I ESLs for the Protection of Plants and Soil Invertebrates; Direct Soil Contact - Commercial Land Use with Coarse-Grained Soil - For samples collected at depths shallower than 1.5 m

3 - Atlantic RBCA Tier I ESLs for the Protection of Wildlife (mammals and birds) and Livestock; Soil & Food Ingestion

"-" - No established guideline

mbgs - metres below ground surface

mg/kg - milligrams per kilogram

Shading - Exceeds Tier I RBSLs

FOF - Fuel Oil Fraction

WFOF - Weathered Fuel Oil Fraction

NR - No Resemblance

FR - Fuel Range

LR - Lube Range

GR - Gasoline Range

UC - Unidentified Compounds

**Table 2**
**Petroleum Hydrocarbons in Soil**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| Sample ID | | | | | MDSA-MW2-2018 SS5 | MDSA-MW3-2018 SS2 | MDSA-MW3-2018 SS4 | MDSA-BH2-2018- SS4 | MDSA-BH2-2018- SS5 | MDSA-BH3-2018- SS4 | MDSA-BH3-2018- SS5 | MDSA-BH4-2018 SS4 | MDSA-BH4-2018 SS5 | MDSA-BH5-2018 SS3 | MDSA-BH5-2018 SS4 | MDSA-BH6-2018 SS3 | MDSA-BH6-2018 SS4 | MGSB-BH1-2018 SS4 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Depth (mbgs) | | | | | 2.4 - 3.0 | 0.6 - 1.2 | 1.8 - 2.4 | 1.8 - 2.4 | 2.4 - 2.92 | 1.8 - 2.4 | 2.4 - 3.0 | 1.8 - 2.4 | 2.4 - 2.85 | 1.2 - 1.8 | 1.8 - 2.4 | 1.2 - 1.8 | 1.8 - 2.4 | 1.65 - 1.8 |
| Date Collected | | | | | 10/2/2018 | 10/10/2018 | 10/10/2018 | 10/9/2018 | 10/9/2018 | 10/10/2018 | 10/10/2018 | 10/2/2018 | 10/2/2018 | 10/10/2018 | 10/10/2018 | 10/10/2018 | 10/10/2018 | 10/3/2018 |
| | Guidelines | | | | | | | | | | | | | | | | | |
| **Parameter** | **Criteria [1]** | **Criteria [2]** | **Criteria [3]** | **Units** | | | | | | | | | | | | | | |
| **Petroleum Hydrocarbons** | | | | | | | | | | | | | | | | | | |
| Benzene | 2.5 | 180 | 18 | mg/kg | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | 10000 | 250 | 980 | mg/kg | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethyl Benzene | 10000 | 300 | 640 | mg/kg | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylenes | 110 | 350 | 2600 | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | - | 320 | 11000 | mg/kg | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 |
| C10-C16 | - | 260 | 9800 | mg/kg | <15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 |
| C16-C21 | - | 1700 | 16000 | mg/kg | <15 | <15 | <15 | <15 | <15 | <15 | 20 | <15 | <15 | <15 | <15 | <15 | <15 | <15 |
| C21-C32 | - | | | mg/kg | 22 | 106 | 79 | 25 | 27 | 26 | 163 | 24 | 36 | 21 | 25 | 17 | 73 | <15 |
| Modified TPH | 870 - Gas<br>4000 - Diesel / #2<br>10000 - # 6 oil / Lube | - | - | mg/kg | 22 | 106 | 79 | 25 | 27 | 26 | 183 | 24 | 36 | 21 | 25 | 17 | 73 | <20 |
| Laboratory Resemblance | | | | | LR | LOF | LOF | LOF | LOF | LOF | LOF | LR | LR | LOF | LOF | LOF | LOF | NR |

**Notes:**

1 - Atlantic RBCA Tier I RBSL - Commercial, Non-Potable Water Use with Coarse-Grained Soil

2 - Atlantic RBCA Tier I ESLs for the Protection of Plants and Soil Invertebrates; Direct Soil Contact - Commercial Land Use with Coarse-Grained Soil - For samples collected at depths shallower than 1.5 m

3 - Atlantic RBCA Tier I ESLs for the Protection of Wildlife (mammals and birds) and Livestock; Soil & Food Ingestion

"-" - No established guideline

mbgs - metres below ground surface

mg/kg - milligrams per kilogram

Shading - Exceeds Tier I RBSLs

FOF - Fuel Oil Fraction

WFOF - Weathered Fuel Oil Fraction

NR - No Resemblance

FR - Fuel Range

LR - Lube Range

GR - Gasoline Range

UC - Unidentified Compounds

**Table 2**
**Petroleum Hydrocarbons in Soil**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | | Sample ID | MGSB-BH2-2018 SS3 | MGSB-BH2-2018 SS4 | MGSB-BH3-2018 SS1 | MGSB-BH3-2018 SS4 | MGSB-BH4-2018 SS4 | MGSB-BH4-2018 SS6 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | Sample Depth (mbgs) | 1.2 - 1.75 | 1.8 - 2.75 | 0.15 - 0.6 | 1.8 - 1.97 | 1.8 - 2.4 | 3.6 -4.2 |
| | | | | Date Collected | 10/3/2018 | 10/3/2018 | 10/3/2018 | 10/3/2018 | 10/2/2018 | 10/2/2018 |
| | Guidelines | | | | | | | | | |
| **Parameter** | **Criteria [1]** | **Criteria [2]** | **Criteria [3]** | **Units** | | | | | | |
| **Petroleum Hydrocarbons** | | | | | | | | | | |
| Benzene | 2.5 | 180 | 18 | mg/kg | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | 10000 | 250 | 980 | mg/kg | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethyl Benzene | 10000 | 300 | 640 | mg/kg | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylenes | 110 | 350 | 2600 | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | - | 320 | 11000 | mg/kg | 4 | <3 | <3 | 29 | 22 | 22 |
| C10-C16 | - | 260 | 9800 | mg/kg | <15 | 62 | <15 | 302 | 776 | 695 |
| C16-C21 | - | 1700 | 16000 | mg/kg | <15 | 69 | <15 | 228 | 514 | 447 |
| C21-C32 | - | | | mg/kg | <15 | 17 | <15 | 48 | 82 | 73 |
| Modified TPH | 870 - Gas<br>4000 - Diesel / #2<br>10000 - # 6 oil / Lube | - | - | mg/kg | <20 | 148 | <20 | 607 | 1390 | 1240 |
| Laboratory Resemblance | | | | | GR | WFOF | NR | FOF | FOF | FOF |

**Notes:**

1 - Atlantic RBCA Tier I RBSL - Commercial, Non-Potable Water Use with Coarse-Grained Soil

2 - Atlantic RBCA Tier I ESLs for the Protection of Plants and Soil Invertebrates; Direct Soil Contact - Commercial Land Use with Coarse-Grained Soil - For samples collected at depths shallower than 1.5 m

3 - Atlantic RBCA Tier I ESLs for the Protection of Wildlife (mammals and birds) and Livestock; Soil & Food Ingestion

"-" - No established guideline

mbgs - metres below ground surface

mg/kg - milligrams per kilogram

Shading - Exceeds Tier I RBSLs

FOF - Fuel Oil Fraction

WFOF - Weathered Fuel Oil Fraction

NR - No Resemblance

FR - Fuel Range

LR - Lube Range

GR - Gasoline Range

UC - Unidentified Compounds

**Table 3**
**Metals in Soil**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | Sample ID | MAEB-MW2-2018 SS1 | MAEB-MW2-2018 SS2 | MAEB-BH3-2018 SS1 | MAEB-BH3-2018 SS2 | MAEB-BH4-2018 SS1 | MAEB-BH4-2018 SS2 | MAEB-BH5-2018 SS1 | MAEB-BH5-2018 SS2 | MDSA-MW1-2018 SS1 | MDSA-MW1-2018 SS2 | MDSA-BH1-2018 SS1 | MDSA-BH1-2018 SS2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sample Depth (mbgs) | 0 - 0.6 | 0.6 - 1.2 | 0 - 0.6 | 0.6 - 1.2 | 0 - 0.6 | 0.6 - 1.2 | 0 - 0.6 | 0.6 - 1.2 | 0 - 0.6 | 0.6 - 1.2 | 0-0.6 | 0.6 - 1.2 |
| | | Date Collected | 10/2/2018 | 10/2/2018 | 10/9/2018 | 10/9/2018 | 10/9/2018 | 10/9/2018 | 10/9/2018 | 10/9/2018 | 10/2/2018 | 10/2/2018 | 10/9/2018 | 10/9/2018 |
| **Parameter** | **Guidelines Criteria [1]** | **Units** | | | | | | | | | | | | |
| **Metals** | | | | | | | | | | | | | | |
| Aluminum | - | mg/kg | 27300 | 31600 | 8940 | 8890 | 10500 | 12500 | 10700 | 8520 | 23100 | 19900 | 19600 | 9840 |
| Antimony | 40 | mg/kg | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Arsenic | 26 | mg/kg | 6 | 8 | 14 | 15 | 13 | 19 | 13 | 11 | 9 | 9 | 12 | 11 |
| Barium | 2000 | mg/kg | 30 | 34 | 38 | 75 | 44 | 111 | 44 | 36 | 53 | 63 | 48 | 37 |
| Beryllium | 8 | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Boron | - | mg/kg | 2 | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Cadmium | 22 | mg/kg | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 |
| Chromium | 87 | mg/kg | 76 | 89 | 11 | 17 | 15 | 19 | 13 | 14 | 64 | 52 | 37 | 13 |
| Cobalt | 300 | mg/kg | 27 | 30 | 6 | 10 | 9 | 11 | 8 | 9 | 25 | 20 | 17 | 9 |
| Copper | 91 | mg/kg | 66 | 87 | 18 | 18 | 20 | 25 | 18 | 18 | 63 | 58 | 40 | 17 |
| Iron | - | mg/kg | 34800 | 36700 | 16800 | 13900 | 17700 | 23700 | 18200 | 13300 | 26300 | 25600 | 23600 | 12700 |
| Lead | 260 | mg/kg | 33.6 | 38.6 | 23.8 | 12.1 | 18.3 | 22.5 | 16.1 | 8.6 | 11.9 | 15.6 | 19.6 | 6.4 |
| Lithium | - | mg/kg | 11 | 13 | 11 | 9 | 12 | 10 | 11 | 8 | 12 | 11 | 14 | 12 |
| Manganese | - | mg/kg | 1210 | 1370 | 1030 | 1060 | 1100 | 1810 | 828 | 553 | 1110 | 1160 | 1060 | 671 |
| Mercury | 24 | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Molybdenum | 40 | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Nickel | 89 | mg/kg | 59 | 59 | 6 | 12 | 10 | 14 | 8 | 10 | 40 | 31 | 23 | 11 |
| Selenium | 2.9 | mg/kg | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Silver | 40 | mg/kg | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Strontium | - | mg/kg | 42 | 62 | 12 | 21 | 16 | 15 | 13 | 20 | 78 | 49 | 29 | 20 |
| Thallium | 1 | mg/kg | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | 300 | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | 4 | 3 | <2 | <2 |
| Uranium | 33 | mg/kg | 0.3 | 0.3 | 0.5 | 0.3 | 0.6 | 0.4 | 0.5 | 0.3 | 0.2 | 0.2 | 0.3 | 0.4 |
| Vanadium | 130 | mg/kg | 92 | 100 | 33 | 47 | 44 | 50 | 37 | 46 | 87 | 77 | 73 | 45 |
| Zinc | 410 | mg/kg | 329 | 311 | 75 | 59 | 110 | 97 | 78 | 47 | 116 | 121 | 83 | 50 |

**Notes:**

1 - CCME Soil Quality Guidelines (SQGs) - Commercial Land Use, accessed online October 2018

"-" - No established guideline

mbgs - metres below ground surface

mg/kg - milligrams per kilogram

Shading - Exceeds guidelines

**Table 3**
**Metals in Soil**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | Sample ID | MDSA-BH2-2018 SS1 | MDSA-BH2-2018 SS2 | MDSA-BH3-2018 SS1 | MDSA-BH3-2018 SS2 | MLLA-MW2-2018 SS1 | MLLA-MW2-2018 SS2 | MLLA-MW3-2018 SS1 | MLLA-MW3-2018 SS2 | MLLA-MW4-2018 SS1 | MLLA-MW4-2018 SS2 | MLLA-BH1-2018 SS1 | MLLA-BH1-2018 SS2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sample Depth (mbgs) | 0 - 0.6 | 0.6 - 1.2 | 0 - 0.6 | 0.6 - 1.2 | 0 - 0.6 | 0.6 - 1.2 | 0 - 0.6 | 0.6 - 1.2 | 0 - 0.6 | 0.6-1.2 | 0 - 0.6 | 0.6 - 1.2 |
| | | Date Collected | 10/9/2018 | 10/9/2018 | 10/10/2018 | 10/10/2018 | 10/3/2018 | 10/3/2018 | 10/3/2018 | 10/3/2018 | 10/3/2018 | 10/3/2018 | 10/3/2018 | 10/3/2018 |
| **Parameter** | **Guidelines Criteria [1]** | **Units** | | | | | | | | | | | | |
| **Metals** | | | | | | | | | | | | | | |
| Aluminum | - | mg/kg | 15900 | 8920 | 10000 | 7190 | 4900 | 2600 | 7260 | 5750 | 5490 | 2000 | 6240 | 5120 |
| Antimony | 40 | mg/kg | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Arsenic | 26 | mg/kg | 11 | 11 | 11 | 11 | 16 | 7 | 8 | 12 | 13 | 23 | 11 | 9 |
| Barium | 2000 | mg/kg | 39 | 52 | 37 | 56 | 343 | 84 | 124 | 80 | 219 | 155 | 56 | 76 |
| Beryllium | 8 | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Boron | - | mg/kg | <2 | <2 | <2 | <2 | 2 | <2 | <2 | <2 | <2 | 2 | <2 | <2 |
| Cadmium | 22 | mg/kg | <0.3 | <0.3 | 0.3 | <0.3 | 0.3 | <0.3 | 0.7 | <0.3 | 0.3 | <0.3 | <0.3 | <0.3 |
| Chromium | 87 | mg/kg | 33 | 12 | 20 | 13 | 21 | 11 | 33 | 20 | 35 | 26 | 15 | 11 |
| Cobalt | 300 | mg/kg | 15 | 7 | 11 | 7 | 16 | 6 | 15 | 16 | 23 | 30 | 13 | 9 |
| Copper | 91 | mg/kg | 33 | 14 | 78 | 19 | 75 | 18 | 70 | 28 | 68 | 69 | 22 | 18 |
| Iron | - | mg/kg | 18500 | 12900 | 12100 | 10000 | 25000 | 7650 | 29900 | 27100 | 38600 | 23600 | 22400 | 12700 |
| Lead | 260 | mg/kg | 7.3 | 14.2 | 6.7 | 16.1 | 72.8 | 15.3 | 77 | 10.2 | 29.4 | 6.3 | 11 | 7.6 |
| Lithium | - | mg/kg | 13 | 7 | 11 | 7 | 6 | <5 | 10 | 9 | 10 | <5 | 9 | 7 |
| Manganese | - | mg/kg | 865 | 812 | 721 | 752 | 1520 | 1150 | 1290 | 1680 | 2400 | 2940 | 811 | 1740 |
| Mercury | 24 | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | 0.06 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Molybdenum | 40 | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Nickel | 89 | mg/kg | 22 | 9 | 27 | 9 | 25 | 7 | 23 | 17 | 26 | 29 | 14 | 11 |
| Selenium | 2.9 | mg/kg | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Silver | 40 | mg/kg | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Strontium | - | mg/kg | 26 | 17 | 19 | 18 | 21 | 25 | 13 | 15 | 15 | 28 | 14 | 19 |
| Thallium | 1 | mg/kg | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | 300 | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Uranium | 33 | mg/kg | 0.4 | 0.4 | 0.3 | 0.4 | 0.3 | 0.2 | 0.3 | 0.3 | 0.3 | 0.2 | 0.3 | 0.3 |
| Vanadium | 130 | mg/kg | 66 | 36 | 51 | 37 | 34 | 21 | 45 | 52 | 80 | 80 | 44 | 28 |
| Zinc | 410 | mg/kg | 62 | 50 | 87 | 51 | 236 | 48 | 231 | 81 | 154 | 84 | 63 | 55 |

**Notes:**

1 - CCME Soil Quality Guidelines (SQGs) - Commercial Land Use, accessed online October 2018

"-" - No established guideline

mbgs - metres below ground surface

mg/kg - milligrams per kilogram

Shading - Exceeds guidelines

**Table 3**
**Metals in Soil**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| Sample ID | | | MLLA-BH2-2018 SS1 | MLLA-BH2-2018 SS2 | MFPA-BH3-2018 SS1 | MFPA-BH3-2018 SS2 | MFPA-BH4-2018 SS1 | MFPA-BH4-2018 SS3 | MSBL-MW2-2018 SS1 | MSBL-BH4-2018 SS1 |
|---|---|---|---|---|---|---|---|---|---|---|
| Sample Depth (mbgs) | | | 0 - 0.6 | 0.6 - 1.2 | 0 - 0.6 | 0.6 - 1.2 | 0 - 0.6 | 1.2 - 1.8 | 0 - 0.6 | 0 - 0.6 |
| Date Collected | | | 10/3/2018 | 10/3/2018 | 10/4/2018 | 10/4/2018 | 10/4/2018 | 10/4/2018 | 10/4/2018 | 10/9/2018 |
| **Parameter** | **Guidelines Criteria [1]** | **Units** | | | | | | | | |
| **Metals** | | | | | | | | | | |
| Aluminum | - | mg/kg | 7240 | 2390 | 32000 | 19600 | 11200 | 5400 | 10800 | 11400 |
| Antimony | 40 | mg/kg | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Arsenic | 26 | mg/kg | 18 | 9 | 5 | 14 | 11 | 6 | 8 | 9 |
| Barium | 2000 | mg/kg | 152 | 50 | 20 | 79 | 238 | 35 | 40 | 35 |
| Beryllium | 8 | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Boron | - | mg/kg | 2 | <2 | <2 | <2 | 2 | <2 | <2 | <2 |
| Cadmium | 22 | mg/kg | 0.5 | <0.3 | <0.3 | <0.3 | 0.4 | <0.3 | <0.3 | <0.3 |
| Chromium | 87 | mg/kg | 14 | 8 | 107 | 33 | 43 | 46 | 13 | 9 |
| Cobalt | 300 | mg/kg | 9 | 7 | 34 | 23 | 18 | 6 | 7 | 6 |
| Copper | 91 | mg/kg | 16 | 11 | 54 | 29 | 66 | 22 | 13 | 13 |
| Iron | - | mg/kg | 17900 | 7800 | 22600 | 43400 | 32100 | 13300 | 8310 | 12100 |
| Lead | 260 | mg/kg | 13.3 | 7.5 | 5.9 | 7.6 | 96.7 | 8.5 | 8.7 | 12.5 |
| Lithium | - | mg/kg | 9 | <5 | 15 | 14 | 9 | 7 | 8 | 13 |
| Manganese | - | mg/kg | 1130 | 992 | 1240 | 1700 | 1840 | 642 | 714 | 451 |
| Mercury | 24 | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Molybdenum | 40 | mg/kg | <2 | <2 | <2 | <2 | <2 | 7 | <2 | <2 |
| Nickel | 89 | mg/kg | 12 | 7 | 69 | 24 | 23 | 11 | 9 | 6 |
| Selenium | 2.9 | mg/kg | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Silver | 40 | mg/kg | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Strontium | - | mg/kg | 19 | 19 | 67 | 26 | 29 | 22 | 14 | 9 |
| Thallium | 1 | mg/kg | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | 300 | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Uranium | 33 | mg/kg | 0.5 | 0.2 | 0.1 | 0.2 | 0.3 | 0.3 | 0.3 | 0.4 |
| Vanadium | 130 | mg/kg | 37 | 21 | 84 | 79 | 60 | 28 | 26 | 26 |
| Zinc | 410 | mg/kg | 79 | 32 | 101 | 96 | 152 | 43 | 39 | 101 |

**Notes:**

1 - CCME Soil Quality Guidelines (SQGs) - Commercial Land Use, accessed online October 2018

"-" - No established guideline

mbgs - metres below ground surface

mg/kg - milligrams per kilogram

Shading - Exceeds guidelines

**Table 4**
**Petroleum Hydrocarbons in Groundwater**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | | | | **Sample ID** | **MSBL-MW2-2018** | **MW0 Field Duplicate MSBL-MW2-2018** | **MSBL-MW6** | **MLLA-MW1-2018** | **MFPA-MW1-2018** | **MASO-MW1-20108** | **RW1** | **RW2** | **MAEB-MW1-2018** | **MAEB-MW2-2018** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **Date Collected** | **10/12/2018** | **10/12/2018** | **10/12/2018** | **10/12/2018** | **10/12/2018** | **10/12/2018** | **10/26/2018** | **10/26/2018** | **10/12/2018** | **10/12/2018** |
| | **Guidelines** | | | | | | | | | | | | | | | |
| **Parameter** | **Criteria [1]** | **Criteria [2]** | **Criteria [3]** | **Criteria [4]** | **Criteria [5]** | **Units** | | | | | | | | | | |
| | | | | | | | | | | | | | | | | |
| **Petroleum Hydrocarbons** | | | | | | | | | | | | | | | | |
| Benzene | 20 | 350 | 4.6 | 5 | 97 | mg/L | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Toluene | 20 | 200 | 4.2 | 4.6 | 88 | mg/L | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Ethyl Benzene | 20 | 110 | 3.2 | 3.5 | 67 | mg/L | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Xylenes | 20 | 120 | 2.8 | 3 | 59 | mg/L | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.001 | <0.001 | <0.002 | <0.002 |
| C6-C10 (less BTEX) | - | 11 | - | - | | mg/L | <0.01 | <0.01 | 0.04 | <0.01 | 0.24 | 0.04 | <0.01 | <0.01 | <0.01 | 0.22 |
| C10-C16 | - | 3.1 | - | - | | mg/L | 0.16 | 0.44 | 1.99 | <0.05 | 0.4 | 1.28 | 0.16 | 0.06 | <0.05 | **6.51** |
| C16-C21 | - | - | - | - | | mg/L | 0.15 | 0.51 | 2.72 | <0.10 | 0.46 | 0.64 | 0.27 | <0.05 | <0.10 | 4.88 |
| C21-C32 | - | | | | | mg/L | <0.1 | 0.2 | 0.76 | <0.1 | 0.32 | 1.29 | 0.03 | 0.02 | <0.1 | 0.68 |
| Modified TPH | 20 | - | 13 - Gas<br>0.84 - Diesel<br>0.48 - Lube Oil | 13 - Gas<br>0.85 - Diesel<br>1.3 - Lube Oil | 750 - Gas<br>>SOL - Diesel<br>>SOL - Lube Oil | mg/L | 0.3 | **1.2** | **5.5** | <0.1 | **1.4** | 3.3 | 0.5 | <0.1 | <0.1 | 12.3 |
| Laboratory Resemblance | | | | | | | WFOF | WFOF | WFOF | NR | WFOF | FOF,LOF | WFOF | FR, UC | NR | FOF |

**Notes:**
1 - Atlantic RBCA Tier I RBSL - Commercial, Non-Potable Water Use with Coarse-Grained Soil
2 - Atlantic RBCA Tier I Groundwater ESLs for Plants and Invertebrates; Direct Contact With Shallow Groundwater -Commercial Land Use with Coarse-Grained Soil
3 - Atlantic RBCA Tier I Groundwater ESLs for the Protection of Freshwater and Marine Aquatic Life, adjusted for distance to receiving aquatic environment and soil type - 10 m to receiving aquatic environment with coarse-grained soil - MSBL-MW2-2018, MDSA-MW3-2018
4 - Atlantic RBCA Tier I Groundwater ESLs for the Protection of Freshwater and Marine Aquatic Life, adjusted for distance to receiving aquatic environment and soil type - 20 m to receiving aquatic environment with coarse-grained soil - MSBL-MW6, MLLA-MW1-2018, MGPA-MW1-2018, MDSA-MW2-2018, MDSA-MW9, MGSB-MW15, MGSB-MW17
5 - Atlantic RBCA Tier I Groundwater ESLs for the Protection of Freshwater and Marine Aquatic Life, adjusted for distance to receiving aquatic environment and soil type - 150 m to receiving aquatic environment with coarse-grained soil - MASO-MW1-2018, RW1, RW2, MAEB-MW1-2018, MAEG-MW2-2018

"-" - No established guideline
mbgs - metres below ground surface
mg/kg - milligrams per kilogram
Shading - Exceeds Tier I RBSLs
**Underline/Bold** - Exceeds Tier 1 ESLs
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
NR - No Resemblance
FR - Fuel Range
LR - Lube Range
GR - Gasoline Range
UC - Unidentified Compounds

**Table 4**
**Petroleum Hydrocarbons in Groundwater**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | | | | **Sample ID** | **MDSA-MW2-2018** | **MDSA-MW3-2018** | **MDSA-MW9** | **MGSB-MW15** | **MW00 Field Duplicate MGSB-MW15** | **MGSB-MW17** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | **Date Collected** | **10/12/2018** | **10/12/2018** | **10/12/2018** | **10/12/2018** | **10/12/2018** | **10/12/2018** |
| | **Guidelines** | | | | | | | | | | | |
| **Parameter** | **Criteria [1]** | **Criteria [2]** | **Criteria [3]** | **Criteria [4]** | **Criteria [5]** | **Units** | | | | | | |
| | | | | | | | | | | | | |
| **Petroleum Hydrocarbons** | | | | | | | | | | | | |
| Benzene | 20 | 350 | 4.6 | 5 | 97 | mg/L | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Toluene | 20 | 200 | 4.2 | 4.6 | 88 | mg/L | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Ethyl Benzene | 20 | 110 | 3.2 | 3.5 | 67 | mg/L | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Xylenes | 20 | 120 | 2.8 | 3 | 59 | mg/L | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 |
| C6-C10 (less BTEX) | - | 11 | - | - | | mg/L | <0.01 | 0.01 | <0.01 | 1.08 | 1.09 | <0.01 |
| C10-C16 | - | 3.1 | - | - | | mg/L | 0.12 | <0.05 | <0.05 | **230** | **88.6** | 1.87 |
| C16-C21 | - | - | - | - | | mg/L | 0.17 | <0.10 | <0.10 | 190 | 71.2 | 3.23 |
| C21-C32 | - | | | | | mg/L | <0.1 | <0.1 | <0.1 | 26 | 10.9 | 0.92 |
| Modified TPH | 20 | - | 13 - Gas<br>0.84 - Diesel<br>0.48 - Lube Oil | 13 - Gas<br>0.85 - Diesel<br>1.3 - Lube Oil | 750 - Gas<br>>SOL - Diesel<br>>SOL - Lube Oil | mg/L | 0.3 | <0.1 | <0.1 | **447** | **172** | **6** |
| Laboratory Resemblance | | | | | | | WFOF | GR | NR | FOF | FOF | WFOF |

**Notes:**
1 - Atlantic RBCA Tier I RBSL - Commercial, Non-Potable Water Use with Coarse-Grained Soil
2 - Atlantic RBCA Tier I Groundwater ESLs for Plants and Invertebrates; Direct Contact With Shallow Groundwater -Commercial Land Use with Coarse-Grained Soil
3 - Atlantic RBCA Tier I Groundwater ESLs for the Protection of Freshwater and Marine Aquatic Life, adjusted for distance to receiving aquatic environment and soil type - 10 m to receiving aquatic environment with coarse-grained soil - MSBL-MW2-2018, MDSA-MW3-2018
4 - Atlantic RBCA Tier I Groundwater ESLs for the Protection of Freshwater and Marine Aquatic Life, adjusted for distance to receiving aquatic environment and soil type - 20 m to receiving aquatic environment with coarse-grained soil - MSBL-MW6, MLLA-MW1-2018, MGPA-MW1-2018, MDSA-MW2-2018, MDSA-MW9, MGSB-MW15, MGSB-MW17
5 - Atlantic RBCA Tier I Groundwater ESLs for the Protection of Freshwater and Marine Aquatic Life, adjusted for distance to receiving aquatic environment and soil type - 150 m to receiving aquatic environment with coarse-grained soil - MASO-MW1-2018, RW1, RW2, MAEB-MW1-2018, MAEG-MW2-2018

"-" - No established guideline
mbgs - metres below ground surface
mg/kg - milligrams per kilogram
Shading - Exceeds Tier I RBSLs
**Underline/Bold** - Exceeds Tier 1 ESLs
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
NR - No Resemblance
FR - Fuel Range
LR - Lube Range
GR - Gasoline Range
UC - Unidentified Compounds

**Table 5**
**Metals in Groundwater**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | **Sample ID** | **MAEB-MW2-2018** | **MDSA-MW1-2018** | **MW000 Field Duplicate MDSA-MW1-2018** | **MLLA-MW2-2018** | **MLLA-MW3-2018** | **MLLA-MW4-2018** |
|---|---|---|---|---|---|---|---|---|
| | | **Date Collected** | 10/12/2018 | 10/12/2018 | 10/12/2018 | 10/12/2018 | 10/12/2018 | 10/12/2018 |
| **Parameter** | **Guidelines Criteria [1]** | **Units** | | | | | | |
| **Metals** | | | | | | | | |
| Aluminum | - | µg/L | 39 | 13 | <5 | 110 | 14 | 14 |
| Antimony | - | µg/L | <2 | <2 | <2 | <2 | <2 | <2 |
| Arsenic | 12.5 | µg/L | 19 | 27 | 36 | 87 | 240 | 362 |
| Barium | 500 | µg/L | 97 | 87 | 82 | 483 | 55 | 76 |
| Beryllium | 100 | µg/L | <2 | <2 | <2 | <2 | <2 | <2 |
| Bismuth | - | µg/L | <2 | <2 | <2 | <2 | <2 | <2 |
| Boron | - | µg/L | 20 | 1930 | 1720 | 387 | 2370 | 2960 |
| Cadmium | - | µg/L | <0.09 | 0.11 | 0.11 | <0.09 | 0.13 | 0.16 |
| Chromium | 56 | µg/L | 2 | 3 | 3 | 4 | 6 | 7 |
| Cobalt | - | µg/L | <1 | <1 | <1 | 1 | 1 | 2 |
| Copper | 2 | µg/L | 3 | 5 | 4 | 3 | 4 | 7 |
| Iron | - | µg/L | 149 | <50 | <50 | 2780 | <50 | <50 |
| Lead | 2 | µg/L | <0.5 | 0.5 | <0.5 | 0.5 | <0.5 | <0.5 |
| Manganese | - | µg/L | 320 | 20 | 18 | 4790 | 176 | 33 |
| Molybdenum | - | µg/L | 4 | 2 | 2 | <2 | 4 | 5 |
| Nickel | 83 | µg/L | <2 | 7 | 8 | 4 | 8 | 10 |
| Selenium | 54 | µg/L | 3 | 97 | 96 | 43 | 109 | 156 |
| Silver | - | µg/L | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 0.2 |
| Strontium | - | µg/L | 139 | 3860 | 3630 | 969 | 4040 | 5290 |
| Thallium | - | µg/L | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | - | µg/L | <2 | <2 | <2 | <2 | <2 | <2 |
| Titanium | - | µg/L | 4 | 2 | 2 | 6 | 2 | 6 |
| Uranium | - | µg/L | 0.1 | 0.8 | 0.8 | 0.4 | 0.1 | 1.9 |
| Vanadium | - | µg/L | 18 | 25 | 32 | 152 | 2 | 494 |
| Zinc | 10 | µg/L | 9 | 17 | 15 | 12 | 5 | 32 |

**Notes:**
1 - FCSAP, Federal Interim Groundwater Quality Guidelines Generic Guidelines for Commercial and Industrial Land Uses - Tier 2 for Marine Life Exposure Pathway
"-" - No established guideline
µg/L - Micrograms per litre
Shading - Exceeds Guideline

**Table 6**
**Petroleum Hydrocarbons in Sediments**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | Sample ID | 18-MNMA-S1 | 18-MNMA-S2 | 18-MNMA-S3 | 18-MNMA-S4 | 18-MNMA-S5 | 18-MNMA-S6 | 18-MNMA-DUP1 Field Duplicate 18-MNMA-S6 | 18-MNMA-S7 | 18-MNMA-S8 | 18-MNMA-S9 | 18-MNMA-S10 | 18-MNMA-S11 | 18-MNMA-DUP2 Field Duplicate 18-MNMA-S11 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sample Depth (m) | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 |
| | | Date Collected | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 |
| **Parameter** | **Guideline Criteria [1]** | **Units** | **Waterlot Area** | | | | | | | | | | | | |
| **Hydrocarbons** | | | | | | | | | | | | | | | |
| Benzene | 5.4 | mg/kg | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | 6.1 | mg/kg | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethyl Benzene | 5 | mg/kg | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylenes | 5.5 | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | - | mg/kg | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 |
| C10-C16 | - | mg/kg | <15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 | 19 | <15 | <15 | <15 |
| C16-C21 | - | mg/kg | 76 | 54 | 56 | 66 | 76 | 103 | 48 | 19 | <15 | 77 | 51 | 28 | 75 |
| C21-C32 | | mg/kg | 203 | 139 | 179 | 187 | 226 | 316 | 129 | 81 | 63 | 178 | 149 | 70 | 182 |
| Modified TPH- Tier 1 | 67 - Gas<br>110 - Diesel / #2<br>190 - #6 Oil / Lube<br>500 - Max | mg/kg | 279 | 193 | 235 | 253 | 302 | 419 | 177 | 100 | 63 | 274 | 200 | 98 | 257 |
| Laboratory Resemblance | | | FR,LR | FR,LR | FR,LR | FR,LR | FR,LR | FR,LR | FR,LR | FR,LR | FR,LR | FR,LR | FR,LR | FR,LR | FR,LR |

**Notes:**

1 - Atlantic RBCA Tier I Sediment ESLs for the Protection of Freshwater and Marine Aquatic Life - Other Sediment, based on FOC of 0.01, the average FOC is 0.1 for waterlot sediments and 0.038 for the reference samples. The screening levels for mTPH can change proportionally with the Site FOC, but cannot exceed 500 mg/kg regardless of the FOC.

m - metres
mg/kg - milligrams per kilogram
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
NR - No Resemblance
FR - Fuel Range
LR - Lube Range
GR - Gasoline Range
UC - Unidentified Compounds
Shading - Exceeds Guidelines

**Table 6**
**Petroleum Hydrocarbons in Sediments**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | Sample ID | 18-MNMA-S12 | 18-MNMA-S13 | 18-MNMA-S14 | 18-MNMA-S15 | 18-MNMA-STEP1 | 18-MNMA-STEP2 | 18-MNMA-STEP3 | 18-MNMA-DUP3 Field Duplicate 18-MNMA-STEP3 | 18-MNMA-REF1 | 18-MNMA-REF2 | 18-MNMA-REF3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Sample Depth (m) | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 |
| | | Date Collected | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 12/13/2018 | 12/13/2018 | 12/13/2018 | 12/13/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 |
| **Parameter** | **Guideline Criteria [1]** | **Units** | **Waterlot Area** | | | | **Step Out from Waterlot Area** | | | | **Reference Area** | | |
| **Hydrocarbons** | | | | | | | | | | | | | |
| Benzene | 5.4 | mg/kg | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | 6.1 | mg/kg | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethyl Benzene | 5 | mg/kg | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylenes | 5.5 | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | - | mg/kg | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 |
| C10-C16 | - | mg/kg | <15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 |
| C16-C21 | - | mg/kg | <15 | 55 | <15 | 24 | <15 | <15 | <15 | 40 | <15 | <15 | <15 |
| C21-C32 | | mg/kg | 38 | 51 | 54 | 41 | <15 | <15 | 25 | 33 | 22 | <15 | <15 |
| Modified TPH- Tier 1 | 67 - Gas<br>110 - Diesel / #2<br>190 - #6 Oil / Lube<br>500 - Max | mg/kg | 38 | 106 | 54 | 65 | <20 | <20 | 25 | 73 | 22 | <20 | <20 |
| Laboratory Resemblance | | | FR,LR | FR,LR | FR,LR | FR,LR | NR | NR | LR | FR,LR | LR | NR | NR |

**Notes:**
1 - Atlantic RBCA Tier I Sediment ESLs for the Protection of Freshwater and Marine Aquatic Life - Other Sediment, based on FOC of 0.01, the average FOC is 0.1 for waterlot sediments and 0.038 for the reference samples. The screening levels for mTPH can change proportionally with the Site FOC, but cannot exceed 500 mg/kg regardless of the FOC.
m - metres
mg/kg - milligrams per kilogram
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
NR - No Resemblance
FR - Fuel Range
LR - Lube Range
GR - Gasoline Range
UC - Unidentified Compounds
Shading - Exceeds Guidelines

**Table 7**
**Metals in Sediment**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | Sample ID | 18-MNMA-S1 | 18-MNMA-S2 | 18-MNMA-S3 | 18-MNMA-S4 | 18-MNMA-S5 | 18-MNMA-S6 | 18-MNMA-DUP1 Field Duplicate 18-MNMA-S6 | 18-MNMA-S7 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample Depth (m) | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 |
| | | | Date Collected | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 |
| | Guideline | | | Waterlot Area | | | | | | | |
| **Parameter** | **Criteria [1]** | **Criteria [2]** | **Units** | | | | | | | | |
| Aluminum | - | - | mg/kg | 10900 | 10500 | 11900 | 14300 | 11700 | 11900 | 9980 | 9140 |
| Antimony | - | - | mg/kg | <1 | 28 | <1 | <1 | 1 | 2 | 1 | 1 |
| Arsenic | 7.24 | 41.6 | mg/kg | 22 | 17 | 19 | 19 | 24 | 19 | 22 | 20 |
| Barium | - | - | mg/kg | 250 | 83 | 79 | 97 | 148 | 92 | 73 | 58 |
| Beryllium | - | - | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Boron | - | - | mg/kg | 38 | 30 | 32 | 38 | 53 | 40 | 32 | 45 |
| Cadmium | 0.7 | 4.2 | mg/kg | 0.3 | <0.3 | <0.3 | 0.3 | 0.4 | <0.3 | <0.3 | 0.3 |
| Chromium | 52.3 | 160 | mg/kg | 71 | 32 | 31 | 26 | 35 | 38 | 19 | 39 |
| Cobalt | - | - | mg/kg | 13 | 13 | 13 | 13 | 14 | 12 | 10 | 10 |
| Copper | 18.7 | 108 | mg/kg | **147** | 98 | **171** | **161** | **207** | **170** | 99 | 63 |
| Iron | - | - | mg/kg | 27600 | 23800 | 30900 | 37900 | 31300 | 30900 | 36200 | 22400 |
| Lead | 30.2 | 112 | mg/kg | **358** | **135** | **284** | **381** | **125** | **252** | **143** | **222** |
| Lithium | - | - | mg/kg | 18 | 17 | 22 | 19 | 22 | 18 | 16 | 13 |
| Manganese | - | - | mg/kg | 326 | 288 | 351 | 397 | 321 | 338 | 390 | 387 |
| Mercury | 0.13 | 0.7 | mg/kg | 0.14 | 0.08 | 0.1 | 0.64 | 0.09 | 0.11 | 0.06 | 0.06 |
| Molybdenum | - | - | mg/kg | 4 | 4 | 4 | 5 | 6 | 5 | 2 | 3 |
| Nickel | - | - | mg/kg | 22 | 24 | 24 | 22 | 27 | 24 | 14 | 17 |
| Selenium | - | - | mg/kg | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| Silver | - | - | mg/kg | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Strontium | - | - | mg/kg | 92 | 77 | 47 | 38 | 70 | 40 | 30 | 50 |
| Thallium | - | - | mg/kg | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | - | - | mg/kg | 14 | 8 | 8 | 10 | 15 | 12 | 13 | 20 |
| Uranium | - | - | mg/kg | 1 | 1 | 1 | 1.2 | 1.1 | 0.9 | 0.8 | 1 |
| Vanadium | - | - | mg/kg | 47 | 42 | 46 | 42 | 53 | 47 | 25 | 40 |
| Zinc | 124 | 271 | mg/kg | **799** | 267 | **282** | **329** | **397** | **297** | **629** | **868** |

**Notes:**

1 - CCME Interim Sediment Quality Guidelines (ISQGs) for marine sediment, accessed online October 2018

2 - CCME Probable Effects Levels (PELs) for marine sediment, accessed online October 2018

"-" - Indicates value is not available or does not apply

Shading - Exceeds CCME ISQG

**Underline/Bold** - Exceeds CCME PEL

**Table 7**
**Metals in Sediment**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | Sample ID | 18-MNMA-S8 | 18-MNMA-S9 | 18-MNMA-S10 | 18-MNMA-S11 | 18-MNMA-DUP2 Field Duplicate 18-MNMA-S11 | 18-MNMA-S12 |
|---|---|---|---|---|---|---|---|---|---|
| | | | Sample Depth (m) | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 |
| | | | Date Collected | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 |
| | Guideline | | | Waterlot Area | | | | | |
| **Parameter** | **Criteria [1]** | **Criteria [2]** | **Units** | | | | | | |
| | | | | | | | | | |
| Aluminum | - | - | mg/kg | 7190 | 9350 | 8010 | 11400 | 10900 | 12600 |
| Antimony | - | - | mg/kg | 2 | 2 | <1 | <1 | <1 | 1 |
| Arsenic | 7.24 | 41.6 | mg/kg | 22 | 34 | 28 | 29 | 31 | **78** |
| Barium | - | - | mg/kg | 106 | 149 | 48 | 120 | 66 | 122 |
| Beryllium | - | - | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 |
| Boron | - | - | mg/kg | 26 | 50 | 104 | 60 | 152 | 65 |
| Cadmium | 0.7 | 4.2 | mg/kg | 0.3 | 0.5 | 0.5 | 0.4 | 1 | 0.4 |
| Chromium | 52.3 | 160 | mg/kg | 15 | 24 | 26 | 20 | 27 | 11 |
| Cobalt | - | - | mg/kg | 8 | 12 | 9 | 12 | 10 | 18 |
| Copper | 18.7 | 108 | mg/kg | 98 | **122** | 77 | **144** | **111** | **159** |
| Iron | - | - | mg/kg | 19400 | 28100 | 48700 | 29900 | 34600 | 50000 |
| Lead | 30.2 | 112 | mg/kg | **343** | **332** | 54.4 | **252** | 67 | **728** |
| Lithium | - | - | mg/kg | 13 | 16 | 15 | 20 | 17 | 17 |
| Manganese | - | - | mg/kg | 316 | 343 | 274 | 559 | 283 | 115 |
| Mercury | 0.13 | 0.7 | mg/kg | 0.07 | 0.07 | 0.05 | 0.05 | 0.05 | 0.05 |
| Molybdenum | - | - | mg/kg | 2 | 4 | 9 | 5 | 9 | <2 |
| Nickel | - | - | mg/kg | 9 | 17 | 16 | 14 | 17 | 14 |
| Selenium | - | - | mg/kg | 1 | 2 | <1 | <1 | <1 | 2 |
| Silver | - | - | mg/kg | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Strontium | - | - | mg/kg | 31 | 73 | 345 | 61 | 200 | 15 |
| Thallium | - | - | mg/kg | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | - | - | mg/kg | 22 | 26 | 7 | 13 | 8 | 17 |
| Uranium | - | - | mg/kg | 0.7 | 1.2 | 2.4 | 1.4 | 2.5 | 1.5 |
| Vanadium | - | - | mg/kg | 22 | 39 | 45 | 39 | 63 | 14 |
| Zinc | 124 | 271 | mg/kg | **1450** | **1660** | **334** | **585** | **379** | **5020** |

**Notes:**

1 - CCME Interim Sediment Quality Guidelines (ISQGs) for marine sediment, accessed online October 2018

2 - CCME Probable Effects Levels (PELs) for marine sediment, accessed online October 2018

"-" - Indicates value is not available or does not apply

Shading - Exceeds CCME ISQG

**Underline/Bold** - Exceeds CCME PEL

**Table 7**
**Metals in Sediment**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | Sample ID | 18-MNMA-S13 | 18-MNMA-S14 | 18-MNMA-S15 | 18-MNMA-STEP1 | 18-MNMA-STEP2 | 18-MNMA-STEP3 | 18-MNMA-DUP3 Field Duplicate 18-MNMA-STEP3 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample Depth (m) | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 |
| | | | Date Collected | 10/19/2018 | 10/19/2018 | 10/19/2018 | 12/13/2018 | 12/13/2018 | 12/13/2018 | 12/13/2018 |
| | Guideline | | | Waterlot Area | | | Step Out from Waterlot Area | | | |
| **Parameter** | **Criteria [1]** | **Criteria [2]** | **Units** | | | | | | | |
| Aluminum | - | - | mg/kg | 9940 | 10900 | 11900 | 4060 | 7550 | 8330 | 9800 |
| Antimony | - | - | mg/kg | <1 | <1 | 3 | <1 | <1 | <1 | <1 |
| Arsenic | 7.24 | 41.6 | mg/kg | **65** | 25 | 41 | 26 | 13 | 19 | 22 |
| Barium | - | - | mg/kg | 135 | 214 | 167 | 14 | 139 | 68 | 74 |
| Beryllium | - | - | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Boron | - | - | mg/kg | 86 | 51 | 100 | 14 | 12 | 61 | 82 |
| Cadmium | 0.7 | 4.2 | mg/kg | 0.5 | 0.4 | 0.6 | <0.3 | <0.3 | <0.3 | 0.4 |
| Chromium | 52.3 | 160 | mg/kg | 12 | 31 | 98 | 11 | 23 | 24 | 30 |
| Cobalt | - | - | mg/kg | 19 | 15 | 22 | 7 | 12 | 11 | 13 |
| Copper | 18.7 | 108 | mg/kg | **158** | **260** | **145** | 7 | 13 | 62 | 77 |
| Iron | - | - | mg/kg | 43100 | 27400 | 41200 | 2100 | 17600 | 21400 | 24600 |
| Lead | 30.2 | 112 | mg/kg | **236** | **135** | **466** | 7.8 | 12.6 | 38.1 | 48.3 |
| Lithium | - | - | mg/kg | 16 | 20 | 17 | 10 | 19 | 19 | 22 |
| Manganese | - | - | mg/kg | 116 | 332 | 279 | 320 | 350 | 242 | 300 |
| Mercury | 0.13 | 0.7 | mg/kg | 0.07 | 0.14 | 0.05 | <0.05 | <0.05 | 0.09 | 0.22 |
| Molybdenum | - | - | mg/kg | 2 | 6 | 9 | <2 | <2 | 5 | 7 |
| Nickel | - | - | mg/kg | 23 | 25 | 45 | 10 | 19 | 22 | 24 |
| Selenium | - | - | mg/kg | 1 | <1 | 3 | <1 | <1 | <1 | <1 |
| Silver | - | - | mg/kg | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | 0.7 |
| Strontium | - | - | mg/kg | 24 | 48 | 120 | 55 | 187 | 71 | 76 |
| Thallium | - | - | mg/kg | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | - | - | mg/kg | 10 | 10 | 28 | 3 | 4 | 11 | 7 |
| Uranium | - | - | mg/kg | 1.8 | 1.3 | 2 | 0.2 | 0.2 | 1.6 | 1.9 |
| Vanadium | - | - | mg/kg | 16 | 50 | 48 | 34 | 41 | 56 | 76 |
| Zinc | 124 | 271 | mg/kg | **662** | **375** | **1730** | 45 | 51 | 179 | 190 |

**Notes:**

1 - CCME Interim Sediment Quality Guidelines (ISQGs) for marine sediment, accessed online October 2018

2 - CCME Probable Effects Levels (PELs) for marine sediment, accessed online October 2018

"-" - Indicates value is not available or does not apply

Shading - Exceeds CCME ISQG

**Underline/Bold** - Exceeds CCME PEL

**Table 7**
**Metals in Sediment**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | Sample ID | 18-MNMA-REF1 | 18-MNMA-REF2 | 18-MNMA-REF3 |
|---|---|---|---|---|---|---|
| | | | Sample Depth (m) | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 |
| | | | Date Collected | 10/19/2018 | 10/19/2018 | 10/19/2018 |
| | Guideline | | | Reference Area | | |
| Parameter | Criteria [1] | Criteria [2] | Units | | | |
| | | | | | | |
| Aluminum | - | - | mg/kg | 8770 | 8780 | 9750 |
| Antimony | - | - | mg/kg | <1 | <1 | <1 |
| Arsenic | 7.24 | 41.6 | mg/kg | 9 | 11 | 13 |
| Barium | - | - | mg/kg | 37 | 34 | 53 |
| Beryllium | - | - | mg/kg | <2 | <2 | <2 |
| Boron | - | - | mg/kg | 15 | 16 | 20 |
| Cadmium | 0.7 | 4.2 | mg/kg | <0.3 | <0.3 | <0.3 |
| Chromium | 52.3 | 160 | mg/kg | 11 | 16 | 22 |
| Cobalt | - | - | mg/kg | 7 | 8 | 10 |
| Copper | 18.7 | 108 | mg/kg | 6 | 8 | 14 |
| Iron | - | - | mg/kg | 6990 | 7390 | 9550 |
| Lead | 30.2 | 112 | mg/kg | 5.9 | 6.5 | 7.4 |
| Lithium | - | - | mg/kg | 13 | 17 | 17 |
| Manganese | - | - | mg/kg | 197 | 211 | 183 |
| Mercury | 0.13 | 0.7 | mg/kg | <0.05 | 0.05 | 0.05 |
| Molybdenum | - | - | mg/kg | <2 | 3 | 2 |
| Nickel | - | - | mg/kg | 11 | 13 | 18 |
| Selenium | - | - | mg/kg | <1 | <1 | <1 |
| Silver | - | - | mg/kg | <0.5 | <0.5 | <0.5 |
| Strontium | - | - | mg/kg | 17 | 22 | 27 |
| Thallium | - | - | mg/kg | <0.1 | 0.1 | 0.1 |
| Tin | - | - | mg/kg | 3 | 3 | 4 |
| Uranium | - | - | mg/kg | 1.1 | 1.4 | 1.4 |
| Vanadium | - | - | mg/kg | 26 | 33 | 40 |
| Zinc | 124 | 271 | mg/kg | 30 | 34 | 38 |

**Notes:**

1 - CCME Interim Sediment Quality Guidelines (ISQGs) for marine sediment, accessed online October 2018

2 - CCME Probable Effects Levels (PELs) for marine sediment, accessed online October 2018

"-" - Indicates value is not available or does not apply

Shading - Exceeds CCME ISQG

**Underline/Bold** - Exceeds CCME PEL

**Table 8**
**PAHs in Sediments**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | Sample ID | 18-MNMA-S1 | 18-MNMA-S2 | 18-MNMA-S3 | 18-MNMA-S4 | 18-MNMA-S5 | 18-MNMA-S6 | 18-MNMA-DUP1 Field Duplicate 18-MNMA-S6 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample Depth (m) | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 |
| | | | Date Collected | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 |
| | Guidelines | | | Waterlot Area | | | | | | |
| Parameter | Criteria [1] | Criteria [2] | Units | | | | | | | |
| 1-Methylnaphthalene | - | - | mg/kg | <0.05 | 0.06 | 0.20 | 0.05 | 0.27 | 0.06 | <0.05 |
| 2-Methylnaphthalene | 0.0202 | 0.2010 | mg/kg | 0.05 | 0.07 | **0.24** | 0.06 | **0.38** | 0.07 | 0.03 |
| Acenaphthene | 0.00671 | 0.0889 | mg/kg | **0.122** | **0.146** | **0.279** | **0.168** | **0.728** | **0.179** | **0.101** |
| Acenaphthylene | 0.00587 | 0.1280 | mg/kg | 0.039 | <0.004 | 0.045 | 0.043 | 0.076 | 0.063 | 0.034 |
| Acridine | - | - | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | 0.11 | <0.05 | <0.05 |
| Anthracene | 0.0469 | 0.2450 | mg/kg | **0.19** | **0.22** | **0.31** | 0.24 | **1.01** | **0.27** | 0.17 |
| Benz[a]anthracene | 0.0748 | 0.6930 | mg/kg | 0.36 | 0.42 | 0.58 | 0.43 | 1.55 | 0.59 | 0.29 |
| Benzo[a]pyrene | 0.0888 | 0.7630 | mg/kg | 0.37 | 0.42 | 0.60 | 0.44 | 1.34 | 0.57 | 0.29 |
| Benzo[b]fluoranthene | - | - | mg/kg | 0.36 | 0.39 | 0.55 | 0.41 | 1.23 | 0.56 | 0.27 |
| Benzo(b+j)fluoranthene | - | - | mg/kg | 0.57 | 0.60 | 0.90 | 0.64 | 1.96 | 0.80 | 0.39 |
| Benzo(e)pyrene | - | - | mg/kg | 0.30 | 0.32 | 0.42 | 0.32 | 0.93 | 0.43 | 0.21 |
| Benzo[ghi]perylene | - | - | mg/kg | <0.01 | 0.28 | 0.41 | 0.29 | 0.86 | 0.38 | <0.01 |
| Benzo[k]fluoranthene | - | - | mg/kg | 0.19 | 0.23 | 0.31 | 0.26 | 0.72 | 0.29 | 0.19 |
| Chrysene | 0.1080 | 0.8460 | mg/kg | 0.47 | 0.51 | 0.67 | 0.53 | **1.70** | 0.70 | 0.33 |
| Dibenz[a,h]anthracene | 0.00622 | 0.1350 | mg/kg | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 |
| Fluoranthene | 0.1130 | 1.4940 | mg/kg | 0.92 | 0.99 | **1.59** | 1.16 | **3.62** | 1.37 | 0.80 |
| Fluorene | 0.0212 | 0.1440 | mg/kg | **0.15** | **0.17** | **0.32** | **0.19** | **0.94** | **0.20** | 0.12 |
| Indeno[1,2,3-cd]pyrene | - | - | mg/kg | <0.01 | 0.29 | 0.51 | 0.38 | 1.09 | <0.01 | <0.01 |
| Naphthalene | 0.0346 | 0.3910 | mg/kg | <0.01 | <0.01 | 0.32 | <0.01 | **0.62** | <0.01 | <0.01 |
| Perylene | - | - | mg/kg | <0.05 | 0.11 | 0.15 | 0.12 | 0.33 | 0.15 | <0.05 |
| Phenanthrene | 0.0867 | 0.5440 | mg/kg | **0.91** | **0.94** | **1.67** | **1.12** | **4.05** | **1.26** | **0.74** |
| Pyrene | 0.1530 | 1.3980 | mg/kg | 0.87 | 0.80 | 1.19 | 0.90 | **2.61** | 1.13 | 0.57 |
| Quinoline | - | - | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| PAH High Molecular Wt | - | | mg/kg | 3.13 | 3.87 | 5.59 | 4.19 | 12.76 | 4.89 | 2.27 |
| PAH Low Molecular Wt | - | | mg/kg | 2.38 | 2.71 | 5.12 | 3.15 | 12.13 | 3.62 | 2.00 |

**Notes:**

1 - CCME Interim Sediment Quality Guidelines (ISQGs) for marine sediment, accessed
2 - CCME Probable Effects Levels (PELs) for marine sediment, accessed online October
"-" - Indicates value is not available or does not apply
Shading - Exceeds CCME ISQG
**Underline/Bold** - Exceeds CCME PEL

**Table 8**
**PAHs in Sediments**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | Sample ID | 18-MNMA-S7 | 18-MNMA-S8 | 18-MNMA-S9 | 18-MNMA-S10 | 18-MNMA-S11 | 18-MNMA-DUP2 Field Duplicate 18-MNMA-S11 | 18-MNMA-S12 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample Depth (m) | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 |
| | | | Date Collected | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 |
| | Guidelines | | | Waterlot Area | | | | | | |
| Parameter | Criteria 1 | Criteria 2 | Units | | | | | | | |
| 1-Methylnaphthalene | - | - | mg/kg | <0.05 | <0.05 | 0.20 | 0.07 | <0.05 | <0.05 | <0.05 |
| 2-Methylnaphthalene | 0.0202 | 0.2010 | mg/kg | <0.01 | 0.04 | 0.20 | 0.09 | 0.02 | 0.02 | 0.02 |
| Acenaphthene | 0.00671 | 0.0889 | mg/kg | <0.00671 | 0.0831 | **0.226** | **0.269** | <0.00671 | <0.00671 | <0.00671 |
| Acenaphthylene | 0.00587 | 0.1280 | mg/kg | 0.020 | 0.058 | 0.060 | 0.095 | 0.049 | **0.465** | 0.030 |
| Acridine | - | - | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Anthracene | 0.0469 | 0.2450 | mg/kg | 0.05 | 0.17 | **0.33** | **0.49** | 0.12 | **0.56** | **0.28** |
| Benz[a]anthracene | 0.0748 | 0.6930 | mg/kg | 0.11 | 0.35 | 0.59 | **1.26** | 0.28 | **1.45** | 0.34 |
| Benzo[a]pyrene | 0.0888 | 0.7630 | mg/kg | 0.10 | 0.35 | 0.52 | **1.06** | 0.22 | **1.42** | 0.25 |
| Benzo[b]fluoranthene | - | - | mg/kg | 0.11 | 0.35 | 0.49 | 1.00 | 0.23 | 1.20 | 0.26 |
| Benzo(b+j)fluoranthene | - | - | mg/kg | 0.17 | 0.35 | 0.81 | 1.41 | 0.38 | 1.80 | 0.39 |
| Benzo(e)pyrene | - | - | mg/kg | 0.08 | 0.35 | 0.37 | 0.74 | 0.18 | 0.89 | 0.18 |
| Benzo[ghi]perylene | - | - | mg/kg | <0.01 | <0.01 | 0.32 | 0.64 | <0.01 | 0.76 | <0.01 |
| Benzo[k]fluoranthene | - | - | mg/kg | 0.05 | 0.43 | 0.25 | 0.53 | 0.11 | 0.59 | 0.19 |
| Chrysene | 0.1080 | 0.8460 | mg/kg | 0.14 | 0.41 | 0.66 | **1.63** | 0.33 | **1.37** | 0.39 |
| Dibenz[a,h]anthracene | 0.00622 | 0.1350 | mg/kg | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 |
| Fluoranthene | 0.1130 | 1.4940 | mg/kg | 0.30 | 0.92 | **1.67** | **2.76** | 1.08 | **3.93** | 0.49 |
| Fluorene | 0.0212 | 0.1440 | mg/kg | 0.03 | 0.11 | **0.26** | **0.35** | 0.04 | 0.13 | 0.06 |
| Indeno[1,2,3-cd]pyrene | - | - | mg/kg | <0.01 | <0.01 | 0.42 | 0.65 | <0.01 | 1.13 | <0.01 |
| Naphthalene | 0.0346 | 0.3910 | mg/kg | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.02 |
| Perylene | - | - | mg/kg | <0.05 | <0.05 | 0.13 | 0.25 | <0.05 | 0.41 | <0.05 |
| Phenanthrene | 0.0867 | 0.5440 | mg/kg | 0.22 | **0.78** | **1.50** | **2.41** | 0.32 | **1.42** | 0.33 |
| Pyrene | 0.1530 | 1.3980 | mg/kg | 0.24 | 0.76 | 1.27 | **2.13** | 0.83 | **2.98** | 0.41 |
| Quinoline | - | - | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| PAH High Molecular Wt | - | | mg/kg | 0.89 | 3.00 | 5.21 | 10.05 | 2.33 | 12.39 | 2.15 |
| PAH Low Molecular Wt | - | | mg/kg | 0.62 | 2.16 | 4.58 | 6.78 | 1.63 | 6.94 | 1.23 |

**Notes:**

1 - CCME Interim Sediment Quality Guidelines (ISQGs) for marine sediment, accessed
2 - CCME Probable Effects Levels (PELs) for marine sediment, accessed online October
"-" - Indicates value is not available or does not apply
Shading - Exceeds CCME ISQG
**Underline/Bold** - Exceeds CCME PEL

**Table 8**
**PAHs in Sediments**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | Sample ID | 18-MNMA-S13 | 18-MNMA-S14 | 18-MNMA-S15 | 18-MNMA-STEP1 | 18-MNMA-STEP2 | 18-MNMA-STEP3 | 18-MNMA-DUP3 Field Duplicate 18-MNMA-STEP3 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample Depth (m) | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 |
| | | | Date Collected | 10/19/2018 | 10/19/2018 | 10/19/2018 | 12/13/2018 | 12/13/2018 | 12/13/2018 | 12/13/2018 |
| | Guidelines | | | Waterlot Area | | | Step Out from Waterlot Area | | | |
| Parameter | Criteria [1] | Criteria [2] | Units | | | | | | | |
| 1-Methylnaphthalene | - | - | mg/kg | <0.05 | 0.11 | 0.08 | <0.05 | <0.05 | <0.05 | <0.05 |
| 2-Methylnaphthalene | 0.0202 | 0.2010 | mg/kg | 0.01 | 0.13 | 0.09 | <0.01 | <0.01 | <0.01 | <0.01 |
| Acenaphthene | 0.00671 | 0.0889 | mg/kg | **0.0478** | **0.480** | **0.209** | <0.00671 | <0.00671 | 0.0176 | 0.0469 |
| Acenaphthylene | 0.00587 | 0.1280 | mg/kg | 0.039 | 0.084 | 0.081 | <0.004 | <0.004 | 0.025 | 0.024 |
| Acridine | - | - | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Anthracene | 0.0469 | 0.2450 | mg/kg | 0.16 | **0.72** | **0.44** | <0.03 | <0.03 | 0.05 | 0.13 |
| Benz[a]anthracene | 0.0748 | 0.6930 | mg/kg | 0.30 | **1.08** | **0.72** | <0.01 | <0.01 | 0.13 | 0.33 |
| Benzo[a]pyrene | 0.0888 | 0.7630 | mg/kg | 0.24 | **1.04** | 0.66 | <0.01 | <0.01 | 0.13 | 0.31 |
| Benzo[b]fluoranthene | - | - | mg/kg | 0.24 | 1.00 | 0.66 | <0.05 | <0.05 | 0.14 | 0.36 |
| Benzo(b+j)fluoranthene | - | - | mg/kg | 0.38 | 1.39 | 0.94 | <0.1 | <0.1 | 0.20 | 0.56 |
| Benzo(e)pyrene | - | - | mg/kg | 0.19 | 0.74 | 0.49 | <0.05 | <0.05 | 0.11 | 0.26 |
| Benzo[ghi]perylene | - | - | mg/kg | <0.01 | 0.68 | 0.40 | <0.01 | <0.01 | 0.08 | 0.20 |
| Benzo[k]fluoranthene | - | - | mg/kg | 0.11 | 0.38 | 0.35 | <0.01 | <0.01 | 0.09 | 0.24 |
| Chrysene | 0.1080 | 0.8460 | mg/kg | 0.33 | **1.19** | 0.83 | <0.01 | <0.01 | 0.14 | 0.38 |
| Dibenz[a,h]anthracene | 0.00622 | 0.1350 | mg/kg | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 |
| Fluoranthene | 0.1130 | 1.4940 | mg/kg | 0.56 | **2.91** | **1.84** | <0.05 | <0.05 | 0.31 | 0.84 |
| Fluorene | 0.0212 | 0.1440 | mg/kg | 0.07 | **0.52** | **0.26** | <0.01 | <0.01 | 0.03 | 0.01 |
| Indeno[1,2,3-cd]pyrene | - | - | mg/kg | <0.01 | 0.87 | 0.53 | <0.01 | <0.01 | <0.01 | <0.01 |
| Naphthalene | 0.0346 | 0.3910 | mg/kg | <0.01 | 0.32 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Perylene | - | - | mg/kg | <0.05 | 0.29 | 0.18 | <0.05 | <0.05 | <0.05 | 0.09 |
| Phenanthrene | 0.0867 | 0.5440 | mg/kg | 0.42 | **2.82** | **1.51** | <0.03 | <0.03 | 0.21 | **0.57** |
| Pyrene | 0.1530 | 1.3980 | mg/kg | 0.50 | **2.27** | **1.54** | <0.05 | <0.05 | 0.28 | 0.61 |
| Quinoline | - | - | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| PAH High Molecular Wt | - | | mg/kg | 2.05 | 9.64 | 6.46 | 0.00 | 0.00 | 1.16 | 2.89 |
| PAH Low Molecular Wt | - | | mg/kg | 1.31 | 8.38 | 4.69 | 0.00 | 0.00 | 0.64 | 1.71 |

**Notes:**

1 - CCME Interim Sediment Quality Guidelines (ISQGs) for marine sediment, accessed
2 - CCME Probable Effects Levels (PELs) for marine sediment, accessed online October
"-" - Indicates value is not available or does not apply
Shading - Exceeds CCME ISQG
**Underline/Bold** - Exceeds CCME PEL

**Table 8**
**PAHs in Sediments**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | Sample ID | 18-MNMA-REF1 | 18-MNMA-REF2 | 18-MNMA-REF3 |
|---|---|---|---|---|---|---|
| | | | Sample Depth (m) | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 |
| | | | Date Collected | 10/19/2018 | 10/19/2018 | 10/19/2018 |
| | Guidelines | | | Reference Area | | |
| Parameter | Criteria [1] | Criteria [2] | Units | | | |
| 1-Methylnaphthalene | - | - | mg/kg | <0.05 | <0.05 | <0.05 |
| 2-Methylnaphthalene | 0.0202 | 0.2010 | mg/kg | <0.01 | <0.01 | <0.01 |
| Acenaphthene | 0.00671 | 0.0889 | mg/kg | <0.00671 | <0.00671 | <0.00671 |
| Acenaphthylene | 0.00587 | 0.1280 | mg/kg | <0.004 | <0.004 | <0.004 |
| Acridine | - | - | mg/kg | <0.05 | <0.05 | <0.05 |
| Anthracene | 0.0469 | 0.2450 | mg/kg | <0.03 | <0.03 | <0.03 |
| Benz[a]anthracene | 0.0748 | 0.6930 | mg/kg | 0.03 | 0.02 | <0.01 |
| Benzo[a]pyrene | 0.0888 | 0.7630 | mg/kg | <0.01 | <0.01 | <0.01 |
| Benzo[b]fluoranthene | - | - | mg/kg | <0.05 | <0.05 | <0.05 |
| Benzo(b+j)fluoranthene | - | - | mg/kg | <0.1 | <0.1 | <0.1 |
| Benzo(e)pyrene | - | - | mg/kg | <0.05 | <0.05 | <0.05 |
| Benzo[ghi]perylene | - | - | mg/kg | <0.01 | <0.01 | <0.01 |
| Benzo[k]fluoranthene | - | - | mg/kg | 0.02 | <0.01 | <0.01 |
| Chrysene | 0.1080 | 0.8460 | mg/kg | 0.03 | 0.03 | <0.01 |
| Dibenz[a,h]anthracene | 0.00622 | 0.1350 | mg/kg | <0.006 | <0.006 | <0.006 |
| Fluoranthene | 0.1130 | 1.4940 | mg/kg | 0.07 | 0.07 | <0.05 |
| Fluorene | 0.0212 | 0.1440 | mg/kg | <0.01 | <0.01 | <0.01 |
| Indeno[1,2,3-cd]pyrene | - | - | mg/kg | <0.01 | <0.01 | <0.01 |
| Naphthalene | 0.0346 | 0.3910 | mg/kg | <0.01 | <0.01 | <0.01 |
| Perylene | - | - | mg/kg | <0.05 | <0.05 | <0.05 |
| Phenanthrene | 0.0867 | 0.5440 | mg/kg | 0.06 | 0.04 | <0.03 |
| Pyrene | 0.1530 | 1.3980 | mg/kg | 0.05 | 0.06 | <0.05 |
| Quinoline | - | - | mg/kg | <0.05 | <0.05 | <0.05 |
| PAH High Molecular Wt | - | | mg/kg | 0.13 | 0.11 | 0.00 |
| PAH Low Molecular Wt | - | | mg/kg | 0.13 | 0.11 | 0.00 |

**Notes:**

1 - CCME Interim Sediment Quality Guidelines (ISQGs) for marine sediment, accessed
2 - CCME Probable Effects Levels (PELs) for marine sediment, accessed online October
"-" - Indicates value is not available or does not apply
Shading - Exceeds CCME ISQG
**Underline/Bold** - Exceeds CCME PEL

**Table 9**
**FOC in Sediments**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| Sample ID | 18-MNMA-S1 | 18-MNMA-S2 | 18-MNMA-S3 | 18-MNMA-S4 | 18-MNMA-S5 | 18-MNMA-S6 | 18-MNMA-DUP1 Field Duplicate 18-MNMA-S6 | 18-MNMA-S7 | 18-MNMA-S8 | 18-MNMA-S9 | 18-MNMA-S10 | 18-MNMA-S11 | 18-MNMA-DUP2 Field Duplicate 18-MNMA-S11 | 18-MNMA-S12 | 18-MNMA-S13 | 18-MNMA-S14 | 18-MNMA-S15 | 18-MNMA-REF1 | 18-MNMA-REF2 | 18-MNMA-REF3 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Sample Depth (m) | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 |
| Date Collected | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 |
| **Parameter** | **Waterlot Area** | | | | | | | | | | | | | | | | | **Reference Area** | | |
| Fraction Organic Carbon-1 | 0.018 | 0.062 | 0.058 | 0.054 | 0.049 | 0.079 | 0.082 | 0.112 | 0.107 | 0.088 | 0.098 | 0.109 | 0.159 | 0.198 | 0.371 | 0.075 | 0.100 | 0.034 | 0.050 | 0.029 |
| Fraction Organic Carbon-2 | 0.019 | 0.062 | 0.057 | 0.058 | 0.051 | 0.080 | 0.080 | 0.113 | 0.106 | 0.088 | 0.099 | 0.108 | 0.160 | 0.198 | 0.371 | 0.075 | 0.102 | 0.034 | 0.052 | 0.029 |
| Fraction Organic Carbon-3 | 0.019 | 0.062 | 0.055 | 0.059 | 0.049 | 0.082 | 0.083 | 0.113 | 0.105 | 0.089 | 0.099 | 0.109 | 0.159 | 0.198 | 0.369 | 0.075 | 0.100 | 0.034 | 0.051 | 0.030 |
| Fraction Organic Carbon-Avg | 0.019 | 0.062 | 0.057 | 0.057 | 0.049 | 0.080 | 0.083 | 0.113 | 0.106 | 0.088 | 0.099 | 0.109 | 0.159 | 0.198 | 0.370 | 0.075 | 0.101 | 0.034 | 0.051 | 0.029 |

**Mean FOC** 0.1074

**Mean FOC** 0.0380

**Notes:**

Samples were analyzed and are reported in triplicate.

FOC was calculated from the Total Organic Matter, which was determined using the Loss on Ignition procedure.

**Table 10**
**PCBs in Sediments**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | Sample ID | 18-MNMA-S1 | 18-MNMA-S2 | 18-MNMA-S3 | 18-MNMA-S4 | 18-MNMA-S5 | 18-MNMA-S6 | 18-MNMA-DUP1 Field Duplicate 18-MNMA-S6 | 18-MNMA-S7 | 18-MNMA-S8 | 18-MNMA-S9 | 18-MNMA-S10 | 18-MNMA-S11 | 18-MNMA-DUP2 Field Duplicate 18-MNMA-S11 | 18-MNMA-S12 | 18-MNMA-S13 | 18-MNMA-S14 | 18-MNMA-S15 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Sample Depth (m) | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 |
| | | | Date Collected | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 |
| | Guidelines | | | Waterlot Area | | | | | | | | | | | | | | | | |
| Parameter | Criteria 1 | Criteria 2 | Units | | | | | | | | | | | | | | | | | |
| Total PCBs | 0.0215 | 0.189 | mg/kg | 0.10 | 0.17 | **0.65** | 0.05 | 0.10 | **0.53** | <0.02 | <0.02 | 0.13 | 0.03 | 0.08 | <0.02 | <0.02 | **0.27** | <0.02 | 0.07 | 0.05 |

**Notes:**

1 - CCME Interim Sediment Quality Guidelines (ISQGs) for marine sediment, accessed online October 2018

2 - CCME Probable Effects Levels (PELs) for marine sediment, accessed online October 2018

"-" - Indicates value is not available or does not apply

Shading - Exceeds CCME ISQG

**Underline/Bold** - Exceeds CCME PEL

**Table 10**
**PCBs in Sediments**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | 18-MNMA-STEP1 | 18-MNMA-STEP2 | 18-MNMA-STEP3 | 18-MNMA-DUP3 Field Duplicate 18-MNMA-STEP3 | 18-MNMA-REF1 | 18-MNMA-REF2 | 18-MNMA-REF3 |
|---|---|---|---|---|---|---|---|---|---|
| | | Samp | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 | 0 - 0.10 |
| | | Da | 12/13/2018 | 12/13/2018 | 12/13/2018 | 12/13/2018 | 10/19/2018 | 10/19/2018 | 10/19/2018 |
| | Guidelines | | Step Out from Waterlot Area | | | | Reference Area | | |
| Parameter | Criteria 1 | Criteria 2 | | | | | | | |
| Total PCBs | 0.0215 | 0.189 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |

**Notes:**
1 - CCME Interim Sediment Quality Guidel
2 - CCME Probable Effects Levels (PELs)
"-" - Indicates value is not available or doe
Shading - Exceeds CCME ISQG
**Underline/Bold** - Exceeds CCME PEL

**Table 11**

**Metals in Benthic Invertebrate Tissue**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | Sample ID | 18-MNMA-TIS-COMP1 | 18-MNMA-TIS-COMP2 | 18-MNMA-TIS-COMP3 | 18-MNMA-TIS-COMP4 | 18-MNMA-TIS-REF1B | 18-MNMA-TIS-REF3B | 18-MNMA-TIS1A | 18-MNMA-TIS3 |
|---|---|---|---|---|---|---|---|---|---|
| | | S1, S2, S4 | S5-S10 | S12-S15 | S8, S9 | - | - | - | - |
| | | Rock Crabs | Rock Crabs | Rock Crabs | Mussels | Rock Crab | Mussel | Scallops | Scallops |
| | Date Collected | 12/13/2018 | 12/13/2018 | 12/14/2018 | 12/13/2018 | 12/13/2018 | 12/14/2018 | 12/13/2018 | 12/13/2018 |
| | | | | | | | | | |
| **Parameter** | **Units** | | | | | | | | |
| **Metals** | | | | | | | | | |
| Aluminum | mg/kg | 15 | <10 | <10 | <10 | <10 | 29 | <10 | <10 |
| Antimony | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Arsenic | mg/kg | 3 | 4 | 4 | 3 | 5 | 4 | 2 | 3 |
| Barium | mg/kg | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
| Beryllium | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Bismuth | mg/kg | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
| Boron | mg/kg | <2 | <2 | <2 | 6 | 2 | 6 | 4 | 5 |
| Cadmium | mg/kg | 2.9 | 1.3 | 2.3 | 4.8 | <0.3 | 3.5 | 2.7 | 6 |
| Chromium | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Cobalt | mg/kg | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Copper | mg/kg | 20 | 14 | 18 | 9 | 19 | <2 | <2 | <2 |
| Iron | mg/kg | 125 | 63 | 132 | <50 | 52 | 95 | <50 | 146 |
| Lead | mg/kg | <0.4 | <0.4 | <0.4 | 0.7 | <0.4 | 1.1 | <0.4 | <0.4 |
| Manganese | mg/kg | 4 | <2 | <2 | 43 | 2 | 23 | <2 | <2 |
| Mercury | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Molybdenum | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Nickel | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Selenium | mg/kg | <1 | <1 | <1 | <1 | 1 | <1 | <1 | <1 |
| Silver | mg/kg | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Strontium | mg/kg | 113 | 49 | 36 | 33 | 210 | 8 | 5 | 5 |
| Thallium | mg/kg | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Uranium | mg/kg | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Vanadium | mg/kg | 2 | 4 | 3 | 5 | 4 | 6 | 4 | 6 |
| Zinc | mg/kg | 25 | 28 | 27 | 108 | 27 | 74 | 10 | 10 |

**Notes:**
mg/kg - milligrams per litre

**Table 11**

**Metals in Benthic Invertebrate Tissue**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | Sample ID | 18-MNMA-TIS5A | 18-MNMA-TIS6A | 18-MNMA-TIS10A | 18-MNMA-TIS11 | 18-MNMA-TIS12A | 18-MNMA-TIS14A | 18-MNMA-TIS-REF3A |
|---|---|---|---|---|---|---|---|---|
| | | - | - | - | - | - | - | - |
| | | Scallops | Scallops | Scallops | Scallops | Scallops | Scallops | Scallops |
| | Date Collected | 12/13/2018 | 12/13/2018 | 12/13/2018 | 12/14/2018 | 12/14/2018 | 12/14/2018 | 12/13/2018 |
| | | | | | | | | |
| **Parameter** | **Units** | | | | | | | |
| **Metals** | | | | | | | | |
| Aluminum | mg/kg | <10 | <10 | <10 | <10 | <10 | 14 | <10 |
| Antimony | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Arsenic | mg/kg | 3 | 2 | 3 | 3 | 3 | 3 | 2 |
| Barium | mg/kg | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
| Beryllium | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Bismuth | mg/kg | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
| Boron | mg/kg | 5 | 4 | 5 | 5 | 5 | 5 | 4 |
| Cadmium | mg/kg | 5.6 | 6.3 | 17.8 | 6.6 | 10.2 | 8.7 | 4.9 |
| Chromium | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Cobalt | mg/kg | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Copper | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Iron | mg/kg | 70 | 115 | 142 | 66 | 58 | 74 | <50 |
| Lead | mg/kg | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 |
| Manganese | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Mercury | mg/kg | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Molybdenum | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Nickel | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Selenium | mg/kg | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Silver | mg/kg | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Strontium | mg/kg | 6 | <5 | 5 | <5 | 5 | 6 | 5 |
| Thallium | mg/kg | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | mg/kg | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Uranium | mg/kg | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Vanadium | mg/kg | 5 | 3 | 6 | 4 | 4 | 5 | 4 |
| Zinc | mg/kg | 12 | 7 | 12 | 10 | 9 | 10 | 9 |

**Notes:**
mg/kg - milligrams per litre

# Table 12
## PAHs in Benthic Invertebrate Tissue
## Supplemental Phase II ESA and HHERA
## Marystown Shipyard
## Marystown, NL

| Parameter | Units | Sample Identification and Date | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 18-MNMA-TIS-COMP1 | 18-MNMA-TIS-COMP2 | 18-MNMA-TIS-COMP3 | 18-MNMA-TIS-COMP4 | 18-MNMA-TIS-REF1B | 18-MNMA-TIS-REF3B | 18-MNMA-TIS1A | 18-MNMA-TIS3 |
| | | S1, S2, S4 | S5-S10 | S12-S15 | S8, S9 | - | - | - | - |
| | | Rock Crabs | Rock Crabs | Rock Crabs | Mussels | Rock Crab | Mussel | Scallops | Scallops |
| | | 12/13/2018 | 12/13/2018 | 12/14/2018 | 12/13/2018 | 12/13/2018 | 12/14/2018 | 12/13/2018 | 12/13/2018 |
| **Polyaromatic Hydrocarbons (PAHs)** | | | | | | | | | |
| 1-Methylnaphthalene | ng/g | 20 | 13.3 | 12.9 | 14.1 | 12.2 | 15 | 28 | 16.4 |
| 2-Methylnaphthalene | ng/g | 34 | 23.7 | 25 | 26.5 | 21.4 | 27 | 51 | 30.2 |
| Acenaphthylene | ng/g | 1.6 | 1.6 | 0.9 | 1.3 | 1.8 | 1.7 | 2.1 | 1.2 |
| Acenaphthene | ng/g | 5.3 | 12.7 | 6.3 | 10.7 | 18.4 | 12.1 | 16.4 | 10.5 |
| Acridine | ng/g | <0.3 | <0.1 | <0.1 | <0.1 | <0.3 | <0.2 | <0.1 | <0.2 |
| Anthracene | ng/g | 1.3 | 0.3 | 0.3 | 1.8 | 0.9 | 0.5 | 1.1 | 1.1 |
| Benzo(a)anthracene | ng/g | 4.30 | 0.20 | 0.1 | 0.4 | 15.6 | 0.6 | 5 | 5.6 |
| Benzo(a)pyrene | ng/g | 1.2 | 0.6 | 0.8 | 0.8 | 3.4 | 0.3 | 2.9 | 1.1 |
| Benzo(b+j)fluoranthene | ng/g | 0.9 | 0.2 | 0.2 | 0.6 | 2.3 | 0.4 | 2.6 | 1.7 |
| Benzo(e)pyrene | ng/g | 3.6 | 1.4 | 1.6 | 2.7 | 10.6 | 1.9 | 7.1 | 2.5 |
| Benzo(ghi)perylene | ng/g | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 4 | <0.5 |
| Benzo(k)fluoranthene | ng/g | 0.8 | <0.1 | 0.2 | 0.7 | 3.9 | 0.4 | 3.1 | 1.7 |
| Chrysene | ng/g | 4.9 | 0.3 | 0.3 | 0.4 | 37.8 | 1.5 | 5.3 | 3.8 |
| Dibenzo(a,h)anthracene | ng/g | <0.1 | <01 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Fluoranthene | ng/g | 22 | 1.3 | 1.2 | 10.7 | 14.6 | 5.8 | 14.9 | 12.3 |
| Fluorene | ng/g | 3.5 | 1.8 | 1.3 | 1.8 | 2.9 | 2.1 | 2.3 | 1.8 |
| Indeno(1,2,3)pyrene | ng/g | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 0.9 | <0.1 |
| Naphthalene | ng/g | 22.1 | 15.3 | 14 | 16.4 | 14 | 17.4 | 31.6 | 19.3 |
| Perylene | ng/g | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | 1.7 | <0.1 |
| Phenanthrene | ng/g | 17.8 | 2.3 | 2.4 | 4.1 | 7.7 | 5.2 | 6.1 | 5.1 |
| Pyrene | ng/g | 43.3 | 1.3 | 1.1 | 7.4 | 11.7 | 7.2 | 8 | 6.8 |
| Quinoline | ng/g | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| B(a)P TPE | ng/g | 1.9 | 0.6 | 0.9 | 1.0 | 6.0 | 0.5 | 4.2 | 2.0 |
| B(a)P TPE x 3 (creosote) | ng/g | 5.6 | 1.9 | 2.6 | 2.9 | 17.9 | 1.4 | 12.5 | 6.1 |
| PAH High Molecular Wt | ng/g | 58.10 | 3.80 | 4.10 | 12.40 | 83.00 | 11.90 | 36.30 | 21.50 |
| PAH Low Molecular Wt | ng/g | 127.6 | 72.3 | 64.3 | 87.4 | 93.9 | 86.8 | 155.2 | 97.9 |

**Notes:**
ng/g - nanograms/gram
B(a)P TPE - Benzo(a)pyrene total potency equivalents

# Table 12
# PAHs in Benthic Invertebrate Tissue
# Supplemental Phase II ESA and HHERA
# Marystown Shipyard
# Marystown, NL

| Parameter | Units | Sample Identification and Date | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | 18-MNMA-TIS5A | 18-MNMA-TIS6A | 18-MNMA-TIS10A | 18-MNMA-TIS11 | 18-MNMA-TIS12A | 18-MNMA-TIS14A | 18-MNMA-TIS-REF3A |
| | | - | - | - | - | - | - | - |
| | | Scallops | Scallops | Scallops | Scallops | Scallops | Scallops | Scallops |
| | | 12/13/2018 | 12/13/2018 | 12/13/2018 | 12/14/2018 | 12/14/2018 | 12/14/2018 | 12/13/2018 |
| **Polyaromatic Hydrocarbons (PAHs)** | | | | | | | | |
| 1-Methylnaphthalene | ng/g | 20 | 17 | 12.2 | 12 | 12 | 19.7 | 8 |
| 2-Methylnaphthalene | ng/g | 35 | 32 | 23.3 | 23 | 22 | 35.4 | 15 |
| Acenaphthylene | ng/g | 1.3 | 1.3 | 1.1 | 1.5 | 1.3 | 1.4 | 0.9 |
| Acenaphthene | ng/g | 16.3 | 14.7 | 14.6 | 9.8 | 8.7 | 6.1 | 13.7 |
| Acridine | ng/g | <0.1 | <0.2 | <0.2 | <0.2 | <0.2 | <0.2 | <0.1 |
| Anthracene | ng/g | 0.5 | 0.9 | 0.5 | 0.7 | 0.4 | 1.3 | 0.4 |
| Benzo(a)anthracene | ng/g | 1.7 | 3.3 | 6.2 | 3.4 | 2 | 5.1 | 1.6 |
| Benzo(a)pyrene | ng/g | 1.2 | 2.2 | 1.2 | 1.2 | 1 | 1.2 | 1.4 |
| Benzo(b+j)fluoranthene | ng/g | 0.8 | 1.6 | 1.2 | 1.5 | 1.4 | 2.1 | 0.7 |
| Benzo(e)pyrene | ng/g | 2.9 | 4.1 | 4.4 | 3.7 | 4.2 | 4.1 | 3.5 |
| Benzo(ghi)perylene | ng/g | <0.1 | 2.6 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Benzo(k)fluoranthene | ng/g | 1.2 | 1.8 | 1.4 | 1.4 | 1 | 1.9 | 0.5 |
| Chrysene | ng/g | 0.9 | 2.4 | 3.9 | 2.6 | 1.8 | 20.4 | 1.1 |
| Dibenzo(a,h)anthracene | ng/g | <0.1 | <0.1 | <0.1 | <0.1 | <0.6 | <0.1 | <0.1 |
| Fluoranthene | ng/g | 5.3 | 12 | 7.6 | 11.3 | 7 | 9.1 | 3.2 |
| Fluorene | ng/g | 1.7 | 1.9 | 1.6 | 2.2 | 1.5 | 1.9 | 1.6 |
| Indeno(1,2,3)pyrene | ng/g | <0.1 | 0.5 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Naphthalene | ng/g | 26.1 | 19.5 | 17.1 | 13 | 13.3 | 24.6 | 10.2 |
| Perylene | ng/g | 0.7 | 2.1 | 1.4 | <0.1 | 1 | 1.1 | 1.4 |
| Phenanthrene | ng/g | 3.8 | 4.8 | 4.2 | 6 | 3.3 | 6.2 | 3.1 |
| Pyrene | ng/g | 3 | 8 | 4.5 | 10.7 | 4 | 3.8 | 2.1 |
| Quinoline | ng/g | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| B(a)P TPE | ng/g | 1.6 | 3.0 | 2.1 | 1.9 | 1.5 | 2.3 | 1.7 |
| B(a)P TPE x 3 (creosote) | ng/g | 4.8 | 8.9 | 6.4 | 5.6 | 4.4 | 7.0 | 5.1 |
| PAH High Molecular Wt | ng/g | 10.90 | 24.90 | 21.60 | 23.00 | 14.00 | 36.50 | 10.20 |
| PAH Low Molecular Wt | ng/g | 110.7 | 106.2 | 83.6 | 79.5 | 70.5 | 106.8 | 57.5 |

**Notes:**
ng/g - nanograms/gram
B(a)P TPE - Benzo(a)pyrene total potency equivalents

**Table 13**
**PCBs in Benthic Invertebrate Tissue**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | Sample ID | 18-MNMA-TIS-COMP1 | 18-MNMA-TIS-COMP2 | 18-MNMA-TIS-COMP3 | 18-MNMA-TIS-COMP4 | 18-MNMA-TIS-REF1B | 18-MNMA-TIS-REF3B | 18-MNMA-TIS1A | 18-MNMA-TIS3 |
|---|---|---|---|---|---|---|---|---|---|
| | | S1, S2, S4 | S5-S10 | S12-S15 | S8, S9 | - | - | - | - |
| | | Rock Crabs | Rock Crabs | Rock Crabs | Mussels | Rock Crab | Mussel | Scallops | Scallops |
| | Date Collected | 12/13/2018 | 12/13/2018 | 12/14/2018 | 12/13/2018 | 12/13/2018 | 12/14/2018 | 12/13/2018 | 12/13/2018 |
| | | | | | | | | | |
| **Parameter** | **Units** | | | | | | | | |
| **Metals** | | | | | | | | | |
| PCBs | mg/kg | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |

**Notes:**
mg/kg - milligrams per litre

**Table 13**
**PCBs in Benthic Invertebrate Tissue**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | Sample ID | 18-MNMA-TIS5A | 18-MNMA-TIS6A | 18-MNMA-TIS10A | 18-MNMA-TIS11 | 18-MNMA-TIS12A | 18-MNMA-TIS14A | 18-MNMA-TIS-REF3A |
|---|---|---|---|---|---|---|---|---|
| | | - | - | - | - | - | - | - |
| | | Scallops | Scallops | Scallops | Scallops | Scallops | Scallops | Scallops |
| | Date Collected | 12/13/2018 | 12/13/2018 | 12/13/2018 | 12/14/2018 | 12/14/2018 | 12/14/2018 | 12/13/2018 |
| | | | | | | | | |
| **Parameter** | **Units** | | | | | | | |
| **Metals** | | | | | | | | |
| PCBs | mg/kg | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |

**Notes:**
mg/kg - milligrams per litre

**Table 14**
**Petroleum Hydrocarbons in Surface Water**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | Sample ID | 18-MNMA-W2 | 18-MNMA-W6 | 18-MNMA-W-DUP1 Field Duplicate 18-MNMA-W6 | 18-MNMA-W9 | 18-MNMA-W12 | 18-MNMA-W14 | 18-MNMA-W-REF2 | 18-MNMA-W-REF3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Date Collected | 12/13/2018 | 12/13/2018 | 12/13/2018 | 12/14/2018 | 12/14/2018 | 12/14/2018 | 12/13/2018 | 12/13/2018 |
| | Guidelines | | | | | | | | | | |
| **Parameter** | **Criteria [1]** | **Criteria [2]** | **Units** | | | | | | | | |
| | | | | | | | | | | | |
| **Petroleum Hydrocarbons** | | | | | | | | | | | |
| Benzene | 20 | 2.1 | mg/L | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Toluene | 20 | 0.77 | mg/L | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Ethyl Benzene | 20 | 0.32 | mg/L | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Xylenes | 20 | 0.33 | mg/L | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 |
| C6-C10 (less BTEX) | - | - | mg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| C10-C16 | - | - | mg/L | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C16-C21 | - | - | mg/L | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 |
| C21-C32 | - | - | mg/L | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Modified TPH | 20 | 1.5 - Gas<br>0.10 - Diesel<br>0.10 - Lube Oil | mg/L | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Laboratory Resemblance | | | | NR | NR | NR | NR | NR | NR | NR | NR |

**Notes:**
1 - Atlantic RBCA Tier I RBSL - Commercial, Non-Potable Water Use with Coarse-Grained Soil
2 - Atlantic RBCA Tier I Surface Water ESLs for the Protection of Freshwater and Marine
"-" - No established guideline
mg/L - milligrams per litre
Shading - Exceeds Tier I RBSLs
**Underline/Bold** - Exceeds Tier 1 ESLs
NR - No Resemblance

**Table 15**
**Metals in Surface Water**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | Sample ID | 18-MNMA-W2 | 18-MNMA-W6 | 18-MNMA-W-DUP1 Field Duplicate 18-MNMA-W6 | 18-MNMA-W9 | 18-MNMA-W12 | 18-MNMA-W14 | 18-MNMA-W-REF2 | 18-MNMA-W-REF3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Date Collected | 12/13/2018 | 12/13/2018 | 12/13/2018 | 12/14/2018 | 12/14/2018 | 12/14/2018 | 12/13/2018 | 12/13/2018 |
| | Guideline | | | | | | | | | | |
| **Parameter** | **Criteria [1]** | **Criteria [2]** | **Units** | | | | | | | | |
| Aluminum | - | - | µg/L | 23 | 21 | 22 | 30 | 31 | 27 | 21 | 12 |
| Antimony | - | - | µg/L | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Arsenic | 12.5 | 5 | µg/L | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Barium | - | - | µg/L | 9 | 8 | 8 | 9 | 9 | 8 | 7 | 7 |
| Beryllium | - | - | µg/L | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Bismuth | - | - | µg/L | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Boron | - | 1,500 | µg/L | **3,020** | **3,570** | **3,470** | **2,970** | **3,050** | **3,210** | **3,410** | **3,950** |
| Cadmium | 0.12 | 0.09 | µg/L | <0.09 | <0.09 | <0.09 | <0.09 | <0.09 | <0.09 | <0.09 | <0.09 |
| Chromium | 1.5[3] | 1[3] | µg/L | **6** | **8** | **8** | **8** | **9** | **8** | **8** | **8** |
| Cobalt | - | - | µg/L | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Copper | - | 2-4[4] | µg/L | **6** | **8** | **11** | **8** | **8** | **11** | **11** | **13** |
| Iron | - | 300 | µg/L | 179 | 180 | 174 | 200 | 202 | 210 | 177 | 157 |
| Lead | - | 1-7[5] | µg/L | <0.05 | <0.5 | <0.5 | <0.05 | <0.05 | <0.5 | <0.5 | <0.5 |
| Manganese | - | - | µg/L | 13 | 9 | 9 | 15 | 14 | 13 | 9 | 5 |
| Mercury | 0.016 | 0.026 | µg/L | <0.026[6] | <0.026[6] | <0.026[6] | <0.026[6] | <0.026[6] | <0.026[6] | <0.026[6] | <0.026[6] |
| Molybdenum | - | 73 | µg/L | 7 | 8 | 8 | 6 | 7 | 7 | 7 | 9 |
| Nickel | - | 25-150[7] | µg/L | 17 | 18 | 19 | 15 | 16 | 16 | 20 | 24 |
| Phosphorous | - | - | | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| Selenium | - | 1 | µg/L | <1 | 1 | 1 | <1 | <1 | **2** | <1 | <1 |
| Silver | - | 0.25 | µg/L | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Strontium | - | - | µg/L | 4,210 | 5,080 | 5,040 | 4,200 | 4,410 | 4,270 | 4,620 | 5,690 |
| Thallium | - | 0.8 | µg/L | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | - | - | µg/L | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Titanium | - | - | | 4 | 5 | 10 | 4 | 6 | 6 | 14 | 25 |
| Uranium | - | 15 | µg/L | 1.8 | 2.0 | 2.1 | 1.7 | 1.9 | 1.8 | 2.0 | 2.4 |
| Vanadium | - | - | µg/L | 1,140 | 1,180 | 1,040 | 1,120 | 1,120 | 1,060 | 944 | 930 |
| Zinc | - | 7.0 | µg/L | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 |

**Notes:**

1 - CCME Water Quality Guidelines (CWQG) for the Protection of Marine Aquatic Life (Long Term), accessed online January 2019
2 - CCME Water Quality Guidelines (CWQG) for the Protection of Freshwater Aquatic Life (Long Term), accessed online January 2019
3 - Chromium, hexavalent (Cr(VI))
4 - The CWQG for copper is related to water hardness (as $CaCO_3$):
When the harness is 0 to <82 mg/L, the CWQG is 2 µg/L.
At hardness ≥82 to ≤180 mg/L the CWQG is calculated using this equation: CWQG (µg/L) = $0.2*e^{\{0.8545[\ln(hardness)]-1.465\}}$.
At hardness >180 mg/L, the CWQG is 4 µg/L.

5 - The CWQG for lead is related to water hardness (as $CaCO_3$):
When the harness is 0 to ≤60 mg/L, the CWQG is 1 µg/L.
At hardness >60 to ≤180 mg/L the CWQG is calculated using this equation: CWQG (µg/L) = $e^{\{1.273[\ln(hardness)]-4.705\}}$.
At hardness >180 mg/L, the CWQG is 7 µg/L.
If hardness is unknown, the CWQG is 1 µg/L.

6 - Reportable Detection Limit (RDL) is greater than the guideline.
7 - The CWQG for nickel is related to water hardness (as $CaCO_3$):
When the harness is 0 to ≤60 mg/L, the CWQG is 25 µg/L.
At hardness >60 to ≤180 mg/L the CWQG is calculated using this equation: CWQG (µg/L) = $e^{\{0.76[\ln(hardness)]+1.06\}}$.
At hardness >180 mg/L, the CWQG is 150 µg/L.
If hardness is unknown, the CWQG is 25 µg/L.

"-" - Indicates value is not available or does not apply
Shading - Exceeds CWQG for Marine Aquatic Life
Underline/Bold - Exceeds CWQG for Freshwater Aquatic Life

**Table 16**
**PAHs in Surface Water**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | Sample ID | 18-MNMA-W2 | 18-MNMA-W6 | 18-MNMA-W-DUP1 Field Duplicate 18-MNMA-W6 | 18-MNMA-W9 | 18-MNMA-W12 | 18-MNMA-W14 | 18-MNMA-W-REF2 | 18-MNMA-W-REF3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Date Collected | 12/13/2018 | 12/13/2018 | 12/13/2018 | 12/14/2018 | 12/14/2018 | 12/14/2018 | 12/13/2018 | 12/13/2018 |
| | Guidelines | | | | | | | | | | |
| Parameter | Criteria [1] | Criteria [2] | Units | | | | | | | | |
| 1-Methylnaphthalene | - | - | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| 2-Methylnaphthalene | - | - | µg/L | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Acenaphthene | - | 5.8 | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Acenaphthylene | - | - | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Acridine | - | 4.4 | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Anthracene | - | 0.012 | µg/L | <0.012 | <0.012 | <0.012 | <0.012 | <0.012 | <0.012 | <0.012 | <0.012 |
| Benz[a]anthracene | - | 0.018 | µg/L | <0.018 | <0.018 | <0.018 | <0.018 | <0.018 | <0.018 | <0.018 | <0.018 |
| Benzo[a]pyrene | - | 0.015 | µg/L | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| Benzo[b]fluoranthene | - | - | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Benzo(b+j)fluoranthene | - | - | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Benzo(e)pyrene | - | - | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Benzo[ghi]perylene | - | - | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Benzo[k]fluoranthene | - | - | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Chrysene | - | - | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Dibenz[a,h]anthracene | - | - | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Fluoranthene | - | 0.04 | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Fluorene | - | 3 | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Indeno[1,2,3-cd]pyrene | - | - | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Naphthalene | 1.4 | 1.1 | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Perylene | - | - | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Phenanthrene | - | 0.4 | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Pyrene | - | 0.025 | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Quinoline | - | 3.4 | µg/L | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |

**Notes:**

1 - CCME Water Quality Guidelines (CWQG) for the Protection of Marine Aquatic Life, accessed online January 2019

2 - CCME Water Quality Guidelines (CWQG) for the Protection of Freshwater Aquatic Life, accessed online January 2019

"-" - Indicates value is not available or does not apply

Shading - Exceeds CWQG for Marine Aquatic Life

**Underline/Bold** - Exceeds CWQG for Freshwater Aquatic Life

**Table 17**
**General Chemistry in Surface Water**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | | | Sample ID | 18-MNMA-W2 | 18-MNMA-W6 | 18-MNMA-W-DUP1 Field Duplicate 18-MNMA-W6 | 18-MNMA-W9 | 18-MNMA-W12 | 18-MNMA-W14 | 18-MNMA-W-REF2 | 18-MNMA-W-REF3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Date Collected | 12/13/2018 | 12/13/2018 | 12/13/2018 | 12/14/2018 | 12/14/2018 | 12/14/2018 | 12/13/2018 | 12/13/2018 |
| | Guideline | | | | | | | | | | |
| **Parameter** | **Criteria [1]** | **Criteria [2]** | **Units** | | | | | | | | |
| pH | 7.0-8.7 | 6.5-9.0 | mg/L | 7.79 | 7.87 | 7.93 | 7.89 | 7.90 | 7.91 | 7.92 | 7.96 |
| Reactive Silica as $SiO_2$ | - | - | mg/L | 1.1 | 0.5 | 0.6 | 0.8 | 0.8 | 0.7 | 0.6 | <0.5 |
| Chloride | - | 120 | mg/L | **9,390** | **11,200** | **11,600** | **9,540** | **9,520** | **9,940** | **11,400** | **12,900** |
| Fluoride | - | 120 | mg/L | <24 | <24 | <24 | <24 | <24 | <24 | <24 | <24 |
| Sulphate | - | - | mg/L | 1,230 | 1,460 | 1,500 | 1,250 | 1,240 | 1,290 | 1,480 | 1,690 |
| Alkalinity | - | - | mg/L | 77 | 89 | 91 | 75 | 79 | 79 | 88 | 103 |
| True Color | - | - | TCU | 22 | 13 | 12 | 22 | 8 | 10 | 10 | <5 |
| Turbidity | - | - | NTU | 0.8 | 0.7 | 1.5 | 1.3 | 0.6 | 0.9 | 0.8 | 1.4 |
| Electrical Conductivity | - | - | umho/cm | 34,100 | 38,800 | 38,300 | 32,700 | 33,700 | 33,900 | 37,900 | 43,500 |
| Nitrate + Nitrite as N | - | - | mg/L | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| Nitrate as N | 200 | 13 | mg/L | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| Nitrite as N | - | 60 $NO_2$-N | mg/L | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| Ammonia as N | - | 0.021-231[3] | mg/L | 0.31 | 0.11 | 0.09 | 0.1 | 0.11 | 0.13 | 0.09 | 0.1 |
| Total Organic Carbon | - | - | mg/L | 3.2 | 2.2 | 2.2 | 3 | 2.8 | 2.9 | 2.2 | 1.4 |
| Ortho-Phosphate as P | - | - | mg/L | 0.06 | 0.06 | 0.06 | 0.05 | 0.06 | 0.005 | 0.05 | 0.07 |
| Total Sodium | - | - | mg/L | 6,820 | 7,930 | 7,630 | 6,530 | 6,900 | 6,570 | 7,140 | 8,350 |
| Total Potassium | - | - | mg/L | 257 | 295 | 282 | 247 | 259 | 245 | 267 | 324 |
| Total Calcium | - | - | mg/L | 247 | 303 | 275 | 228 | 243 | 244 | 274 | 330 |
| Total Magnesium | - | - | mg/L | 789 | 955 | 897 | 800 | 806 | 773 | 855 | 1,040 |
| Bicarb. Alkalinity (as $CaCO_3$) | - | - | mg/L | 77 | 89 | 91 | 75 | 79 | 79 | 88 | 103 |
| Carb. Alkalinity (as $CaCO_3$) | - | - | mg/L | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| Hydroxide | - | - | mg/L | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
| Calculated TDS | - | - | mg/L | 18,800 | 22,200 | 22,200 | 18,600 | 19,000 | 19,100 | 21,500 | 24,700 |
| Hardness | - | - | mg/L | 3,870 | 4,690 | 4,380 | 3,860 | 3,930 | 3,790 | 4,210 | 5,110 |
| Langelier Index (@20C) | - | - | NA | 0.25 | 0.48 | 0.51 | 0.31 | 0.37 | 0.38 | 0.48 | 0.66 |
| Langelier Index (@4C) | - | - | NA | -0.07 | 0.16 | 0.19 | -0.01 | 0.05 | 0.06 | 0.16 | 0.34 |
| Saturation pH (@20C) | - | - | NA | 7.54 | 7.39 | 7.42 | 7.58 | 7.53 | 7.53 | 7.44 | 7.3 |
| Saturation pH (@4C) | - | - | NA | 7.86 | 7.71 | 7.74 | 7.9 | 7.85 | 7.85 | 7.76 | 7.62 |
| Anion Sum | - | - | me/L | 292 | 348 | 360 | 297 | 296 | 309 | 354 | 401 |
| Cation sum | - | - | me/L | 380 | 446 | 426 | 367 | 385 | 367 | 401 | 473 |
| % Difference/ Ion Balance | - | - | % | 13 | 12 | 8 | 11 | 13 | 9 | 6 | 8 |

**Notes:**

1 - CCME Water Quality Guidelines (CWQG) for the Protection of Marine Aquatic Life (Long Term), accessed online January 2019

2 - CCME Water Quality Guidelines (CWQG) for the Protection of Freshwater Aquatic Life (Long Term), accessed online January 2019

3 - CWQG for total ammonia is related to temperature (see table on CCME factsheet)

"-" - Indicates value is not available or does not apply

Shading - Exceeds CWQG for Marine Aquatic Life

**Underline/Bold** - Exceeds CWQG for Freshwater Aquatic Life

# Appendix A
# Photographic Record

Photo 1 – View, looking northeast of the main Site entrance at the Marystown Shipyard Main Administration and Security Office (MASO) with the Machine Shop and General Stores Building in the background.

Photo 2 – View, looking southwest, of the Marystown Shipyard Drum Storage Area (MDSA) with existing monitor well MDSA-MW9 in the foreground.

# Site Photographs

Photo 3 – View, looking north, of the Marystown Shipyard Drum Storage Area (MDSA).

Photo 4 – View, looking southwest, of the former Maintenance Service & Maintenance Parts Buildings.

## Site Photographs

Photo 5 – View, looking north, of the former Marystown Shipyard Lower Laydown Area (MLLA).

Photo 6 – View, looking west, of the Marystown Shipyard Assembly and Erection Building (MAEB) while drilling MAEB-MW1-2018.

## Site Photographs

Photo 7 – View of existing wells near the Marystown Shipyard General Stores Building (MGSB).

Photo 8 –View, looking north, of RW1 along the west side of the Main Administration and Security Office (MASO).

## Site Photographs

Photo 9 – View, looking west, of RW2 along the south side of the Main Administration and Security Office (MASO).

Photo 10 – View, looking southwest, of the Marystown Shipyard Assembly and Erection Building (MAEB) while drilling MAEB-MW2-2018.

## Site Photographs


Photo 11 – View, looking southeast, of the Marystown Shipyard Drum Storage Area (MDSA), while drilling MDSA-MW3-2018.


Photo 12 – View, looking north, of the Marystown Shipyard Fuel Pump Area (MFPA), while drilling MFPA-BH2-2018.

## Site Photographs

Photo 13 – View, looking north, of the Marystown Shipyard Fuel Pump Area (MFPA), while drilling MFPA-MW1-2018.

Photo 14 – View, looking northwest, of the Marystown Shipyard General Stores Building (MGSB), while drilling MGSB-BH4-2018.

## Site Photographs

Photo 15 – View, looking west, of the Marystown Shipyard Lower Laydown Area (MLLA), while drilling MLLA-MW1-2018.

Photo 16 – View, looking west, of the Marystown Shipyard Lower Laydown Area (MLLA), while drilling MLLA-MW2-2018.

## Site Photographs

Photo 17 – View, looking east, of the Marystown Shipyard Lower Laydown Area (MLLA), while drilling MLLA-MW3-2018.

Photo 18 – View looking west, of the Marystown Shipyard Lower Laydown Area (MLLA), while drilling MLLA-MW4-2018.

## Site Photographs


Photo 19 – View, looking south, of the Marystown Shipyard Service Building (MSBL), while drilling MSBL-BH1-2018.

Photo 20 – View, looking northeast, while drilling MSBL-MW2-2018 in the Marystown Shipyard Service Building (MBSL) area.  Note the waterlot to the right of the photograph.

# Site Photographs

Photo 21 – View, looking northwest, of the Marystown Shipyard General Stores Building (MSGB), while drilling MSGB-BH1-2018.


Photo 22 – View of Reference Sediment Sample 1 (MNMA-REF1-2018) collected northeast of the waterlot property.


Photo 23 – View of Sediment Sample 1 (MNMA-S1-2018) collected from the south portion of the waterlot property.

## Site Photographs

# Appendix B
# Borehole/Monitor Well Logs

| | | |
|---|---|---|
| Client: NLMAE | Drilling Contractor: Logan Drilling Group | |
| Project No: 11178792-02 | Drill Type: CME 75 | |
| Civic Address: Marystown Shipyard | Drill Method: Hollow Stem Auger | |
| City & Province: Marystown, NL | Logged By: Hubert Anderson | |
| PID Number: N/A | | |
| UTM Easting: 369032.297 | GL Elevation: 2.752 metres | |
| UTM Northing: 5225498.870 | Final Depth: 2.40 metres | |
| Date Started: October 2, 2018 | Depth to Water Strike: 0.90 metres | Borehole: MAEB-BH1-2018 |
| Date Finished: October 2, 2018 | Depth to Bedrock: 2.40 metres | Page: 1 of 1 |

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2.8 | | | | | | |
| 0.0 | | | **Silty Sand and Gravel** Brown silty sand and gravel, occasional cobbles, compact, moist to wet at approximately 0.90 mbgs, odourless. | | SS1 | SS | 21 | 50 | 10 | |
| | | | | 2.0 | SS2 | SS | 25 | 50 | 25 | BTEX/TPH |
| 1.0 | | | | | | | | | | |
| | | | **Sand** Brown sand, compact, wet, odourless. | | SS3 | SS | 15 | 63 | 15 | |
| | | | | 1.0 | | | | | | |
| 2.0 | | | **Silty Gravel** Grey silty gravel, some fractured rock, compact, wet, odourless. | | SS4 | SS | 21 | 25 | 15 | BTEX/TPH |
| | | | Borehole terminated at 2.40 mbgs on probable bedrock. | 0.0 | | | | | | |
| 3.0 | | | | | | | | | | |
| | | | | -1.0 | | | | | | |
| 4.0 | | | | | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369035.425
UTM Northing: 5225509.687
Date Started: October 2, 2018
Date Finished: October 2, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson

GL Elevation: 2.738 metres
Final Depth: 2.00 metres
Depth to Water Strike: 0.60 metres
Depth to Bedrock: 2.00 metres

Borehole: MAEB-BH2-2018
Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2.7 | | | | | | |
| 0.0 | | | **Silty Sand and Gravel** Brown silty sand and gravel, occasional cobbles, compact, moist, odourless. | | SS1 | SS | 26 | 42 | 20 | |
| | | | **Silty Gravel** Light brown to grey silty gravel, some fractured rock, dense to very dense, wet at approximately 0.60 mbgs, odourless. | 2.0 | SS2 | SS | 41 | 25 | 20 | BTEX/TPH |
| 1.0 | | | | | SS3 | SS | 10 | 0 | NR | |
| | | | | 1.0 | SS4 | SS | 50\50 | 100 | 25 | BTEX/TPH |
| 2.0 | | | Borehole terminated at 2.00 mbgs on probable bedrock. | | | | | | | |
| | | | | 0.0 | | | | | | |
| 3.0 | | | | | | | | | | |
| | | | | -1.0 | | | | | | |
| 4.0 | | | | | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369074.327
UTM Northing: 5225529.443
Date Started: October 9, 2018
Date Finished: October 9, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Robert Perry

GL Elevation: 2.905 metres
Final Depth: 1.80 metres
Depth to Water Strike: 1.00 metres
Depth to Bedrock: 1.80 metres

**Borehole:** MAEB-BH3-2018
Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.9 | | | | | | |
| | | | **Silty Sand and Gravel** Brown to reddish brown silty sand and gravel, dense to very dense, wet at approximately 1.00 mbgs, odourless. | | SS1 | SS | 31 | 83 | 20 | Metals |
| 1.0 | | | | 2.0 | SS2 | SS | 39 | 75 | 55 | BTEX/TPH + Metals |
| | | | | | SS3 | SS | 59 | 83 | 20 | BTEX/TPH |
| 2.0 | | | Borehole terminated at 1.80 mbgs on probable bedrock. | 1.0 | | | | | | |
| 3.0 | | | | 0.0 | | | | | | |
| 4.0 | | | | -1.0 | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369084.225
UTM Northing: 5225531.411
Date Started: October 9, 2018
Date Finished: October 9, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Robert Perry

GL Elevation: 2.844 metres
Final Depth: 1.80 metres
Depth to Water Strike: 1.20 metres
Depth to Bedrock: 1.80 metres

**Borehole:** MAEB-BH4-2018


| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.9 | | | | | | |
| | | | **Silty Sand and Gravel** Brown silty sand and gravel, compact to dense, wet at approximately 1.20 mbgs, odourless. | | SS1 | SS | 23 | 92 | 20 | Metals |
| 1.0 | | | | 2.0 | SS2 | SS | 23 | 58 | 25 | BTEX/TPH + Metals |
| | | | | | SS3 | SS | 31 | 50 | 20 | BTEX/TPH |
| 2.0 | | | Borehole terminated at 1.80 mbgs on probable bedrock. | 1.0 | | | | | | |
| 3.0 | | | | 0.0 | | | | | | |
| 4.0 | | | | -1.0 | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369097.701
UTM Northing: 5225517.277
Date Started: October 9, 2018
Date Finished: October 9, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Robert Perry

GL Elevation: 2.782 metres
Final Depth: 1.80 metres
Depth to Water Strike: 1.20 metres
Depth to Bedrock: 1.80 metres

GHD

**Borehole:** MAEB-BH5-2018
Page: 1 of 1

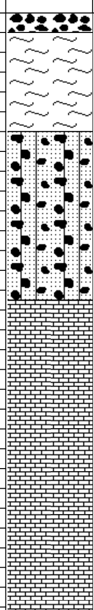
| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2.8 | | | | | | |
| 0.0 | | | **Silty Sand and Gravel**<br>Brown to black silty sand and gravel, compact to very dense, wet at approximately 1.20 mbgs, odourless. | | SS1 | SS | 25 | 79 | 15 | Metals |
| | | | | 2.0 | SS2 | SS | 51 | 58 | 20 | BTEX/TPH + Metals |
| 1.0 | | | | | SS3 | SS | 20 | 67 | 40 | BTEX/TPH |
| | | | Borehole terminated at 1.80 mbgs on probable bedrock. | 1.0 | | | | | | |
| 2.0 | | | | 0.0 | | | | | | |
| 3.0 | | | | -1.0 | | | | | | |
| 4.0 | | | | | | | | | | |

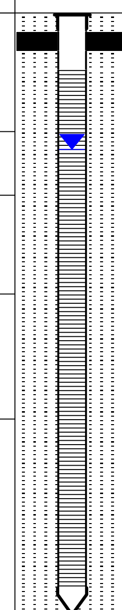
Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369038.542
UTM Northing: 5225504.026
Date Started: October 2, 2018
Date Finished: October 2, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger/Coring
Logged By: Hubert Anderson
TOC Elevation: 2.760 metres
GL Elevation: 2.880 metres
Final Depth: 3.050 metres
Depth to Water Strike: 0.690 metres
Depth to Bedrock 1.200 metres

# Monitor Well: MAEB-MW1-2018







| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | Gravel | 2.9 | | | | | | | | Flushmount<br>Bentonite seal |
| | | | Topsoil<br>Black topsoil, some rootmat and gravel, compact, moist to very moist, odourless. | | SS1 | SS | 29 | 17 | 20 | BTEX/TPH | | |
| | | | Silty Sand and Gravel<br>Brown silty sand and gravel, some fractured rock, very dense, wet at approximately 0.60 mbgs, odourless. | 2.0 | SS2 | SS | 86\175 | 38 | 40 | BTEX/TPH | | Groundwater at approx. 0.690 mbgs |
| 1.0 | | | | | | | | | | | | "No. 10" slot PVC screen |
| 2.0 | | | Bedrock<br>Fractured to very sound sedimentary rock. | 1.0 | RC1 | RC | 71 | 71 | NA | | | "No. 3" silica sand pack |
| 3.0 | | | | 0.0 | RC2 | RC | 100 | 100 | NA | | | End point |
| 4.0 | | | Monitor well terminated at 3.05 mbgs in very sound bedrock. | -1.0 | | | | | | | | |
| 5.0 | | | | -2.0 | | | | | | | | |

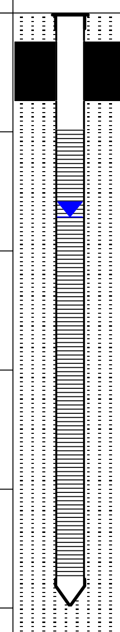
Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369084.257
UTM Northing: 5225525.081
Date Started: October 2, 2018
Date Finished: October 2, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson
TOC Elevation: 2.789 metres
GL Elevation: 2.909 metres
Final Depth: 3.150 metres
Depth to Water Strike: 1.032 metres
Depth to Bedrock 3.150 metres

## Monitor Well: MAEB-MW2-2018



| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.9 | | | | | | | | |
| | | | **Silty Sand and Gravel** Brown silty sand and gravel, occasional cobbles, some organics, compact to loose, moist, slight organic odour. | | SS1 | SS | 30 | 33 | 30 | | | Flushmount<br>Bentonite seal |
| 1.0 | | | | 2.0 | SS2 | SS | 19 | 33 | 25 | | | Groundwater at approx. 1.032 mbgs |
| | | | | | SS3 | SS | 5 | 33 | 25 | | | "No. 10" slot PVC screen |
| 2.0 | | | **Silty Gravel** Brown to dark brown silty gravel, loose to very dense, wet at approximately 1.80 mbgs, moderate to faint petroleum hydrocarbon odour. | 1.0 | SS4 | SS | 4 | 21 | NHS | BTEX/TPH + DUP01 | | "No. 3" silica sand pack |
| | | | | 0.0 | SS5 | SS | 16 | 42 | 75 | BTEX/TPH | | End point |
| 3.0 | | | | | SS6 | SS | 50\0 | 0 | NR | | | Cave-in material |
| 4.0 | | | Monitor well terminated at 3.150 mbgs on probable bedrock. | -1.0 | | | | | | | | |
| 5.0 | | | | -2.0 | | | | | | | | |



*Client:* NLMAE
*Project No:* 11178792-02
*Civic Address:* Marystown Shipyard
*City & Province:* Marystown, NL
*PID Number:* N/A
*UTM Easting:* 369085.977
*UTM Northing:* 5225393.005
*Date Started:* October 10, 2018
*Date Finished:* October 10, 2018

*Drilling Contractor:* Logan Drilling Group
*Drill Type:* CME 75
*Drill Method:* Hollow Stem Auger
*Logged By:* Robert Perry
*GL Elevation:* 7.223 metres
*Final Depth:* 4.80 metres
*Depth to Water Strike:* 4.50 metres
*Depth to Bedrock:* Not encountered

**Borehole:** MASO-BH1-2018
*Page:* 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 7.2 | | | | | | |
| 0.0 | | | Asphalt | | | | | | | |
| | | | Sand and Gravel<br>Brown sand and gravel, occasional cobbles, compact to dense, dry to moist, odourless. | | SS1 | SS | 27 | 78 | 25 | |
| 1.0 | | | | | SS2 | SS | 51 | 75 | 20 | BTEX/TPH |
| | | | | 6.0 | SS3 | SS | 36 | 63 | 20 | |
| 2.0 | | | Silty Sand and Gravel<br>Brown silty sand gravel, numerous cobbles, compact, moist to wet at approximately 4.50 mbgs, odourless. | 5.0 | SS4 | SS | 14 | 63 | 25 | |
| | | | | | SS5 | SS | 12 | 50 | 30 | |
| 3.0 | | | | 4.0 | SS6 | SS | 26 | 42 | 25 | |
| 4.0 | | | | | SS7 | SS | 29 | 50 | 25 | BTEX/TPH |
| | | | | 3.0 | SS8 | SS | 24 | 83 | 20 | BTEX/TPH |
| 5.0 | | | Borehole terminated at 4.80 mbgs in silty sand and gravel. | 2.0 | | | | | | |

Client: NLMAE

Project No: 11178792-02

Civic Address: Marystown Shipyard

City & Province: Marystown, NL

PID Number: N/A

UTM Easting: 369104.945

UTM Northing: 5225376.867

Date Started: October 10, 2018

Date Finished: October 10, 2018

Drilling Contractor: Logan Drilling Group

Drill Type: CME 75

Drill Method: Hollow Stem Auger

Logged By: Robert Perry

GL Elevation: 5.970 metres

Final Depth: 2.40 metres

Depth to Water Strike: 2.10 metres

Depth to Bedrock: Not encountered

**Borehole:** MASO-BH2-2018

Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 6.0 | | | | | | |
| | | | Grassmat/Topsoil | | | | | | | |
| | | | Sand and Gravel<br>Brown sand and gravel, occasional cobbles, compact, dry, odourless. | | SS1 | SS | 19 | 75 | 20 | |
| 1.0 | | | | 5.0 | SS2 | SS | 15 | 58 | 25 | |
| | | | | | SS3 | SS | 16 | 71 | 10 | BTEX/TPH |
| 2.0 | | | Silty Sand and Gravel<br>Brown to grey silty sand gravel, some clay, numerous cobbles, dense, wet at approximately 2.10 mbgs, odourless. | 4.0 | SS4 | SS | 36 | 63 | 10 | BTEX/TPH |
| | | | Borehole terminated at 2.40 mbgs in silty sand and gravel. | | | | | | | |
| 3.0 | | | | 3.0 | | | | | | |
| 4.0 | | | | 2.0 | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369122.782
UTM Northing: 5225397.515
Date Started: October 10, 2018
Date Finished: October 10, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Robert Perry

GL Elevation: 3.176 metres
Final Depth: 2.95 metres
Depth to Water Strike: 2.40 metres
Depth to Bedrock: 2.95 metres

**Borehole:** MASO-BH3-2018



| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 3.2 | | | | | | |
| | | | Grassmat/Topsoil | | | | | | | |
| | | | Sand and Gravel<br>Brown to grey sand and gravel, occasional cobbles, loose to dense, dry, odourless. | | SS1 | SS | 5 | 25 | 15 | |
| 1.0 | | | | | SS2 | SS | 18 | 0 | NR | |
| | | | | 2.0 | SS3 | SS | 40 | 0 | NR | |
| 2.0 | | | Silty Sand and Gravel<br>Brown to grey silty sand gravel, numerous cobbles and boulders, very dense, wet at approximately 2.40 mbgs, slight petroleum hydrocarbon odour. | 1.0 | SS4 | SS | 58 | 100 | 40 | BTEX/TPH |
| | | | | | SS5 | SS | 97\225 | 100 | 55 | BTEX/TPH |
| | | | | | SS6 | SS | 50\25 | 0 | NR | |
| 3.0 | | | Borehole terminated at 2.95 mbgs on probable bedrock. | 0.0 | | | | | | |
| 4.0 | | | | -1.0 | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369109.861
UTM Northing: 5225399.054
Date Started: October 10, 2018
Date Finished: October 10, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger/Coring
Logged By: Robert Perry
TOC Elevation: 2.535 metres
GL Elevation: 2.655 metres
Final Depth: 3.600 metres
Depth to Water Strike: 0.703 metres
Depth to Bedrock Not encountered

## Monitor Well: MASO-MW1-2018



| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2.7 | | | | | | | | |
| 0.0 | | | Grassmat/Topsoil | | | | | | | | | Flushmount |
| | | | Sandy Gravel<br>Brown sandy gravel, compact, moist to wet at approximately 1.00 mbgs, some sheen, slight petoleum hydrocarbon odour. | | SS1 | SS | 24 | 33 | 25 | | | Bentonite seal |
| | | | | 2.0 | SS2 | SS | 18 | 42 | 55 | BTEX/TPH | | Groundwater at approx. 0.703 mbgs |
| 1.0 | | | Sandy Gravel<br>Brown sandy gravel, compact, wet, odoulress. | | SS3 | SS | 17 | 54 | 40 | BTEX/TPH | | "No. 10" slot PVC screen |
| | | | | 1.0 | | | | | | | | |
| 2.0 | | | | | | | | | | | | |
| | | | | 0.0 | | | | | | | | "No. 3" silica sand pack |
| 3.0 | | | | | | | | | | | | End point |
| | | | Monitor well terminated at 3.600 mbgs in sandy gravel. | -1.0 | | | | | | | | |
| 4.0 | | | | | | | | | | | | |
| | | | | -2.0 | | | | | | | | |
| 5.0 | | | | | | | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369285.098
UTM Northing: 5225501.769
Date Started: October 9, 2018
Date Finished: October 9, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Robert Perry

GL Elevation: 2.620 metres
Final Depth: 3.00 metres
Depth to Water Strike: 2.25 metres
Depth to Bedrock: Not encountered

**Borehole:** MDSA-BH1-2018
Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.6 | | | | | | |
| | | | Grassmat/Topsoil | | | | | | | |
| | | | **Sand and Gravel** Brown to reddish brown sand and gravel, occasional cobbles, compact to very dense, dry to wet at approximately 2.25 mbgs, odourless. | | SS1 | SS | 26 | 83 | 25 | Metals |
| | | | | 2.0 | SS2 | SS | 58 | 75 | 20 | Metals |
| 1.0 | | | | | | | | | | |
| | | | | 1.0 | SS3 | SS | 19 | 67 | 20 | |
| 2.0 | | | | | SS4 | SS | 92 | 92 | 10 | |
| | | | | 0.0 | SS5 | SS | 75 | 83 | 10 | |
| 3.0 | | | Borehole terminated at 3.00 mbgs in sand and gravel. | | | | | | | |
| | | | | -1.0 | | | | | | |
| 4.0 | | | | | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369299.994
UTM Northing: 5225489.158
Date Started: October 9, 2018
Date Finished: October 9, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Robert Perry

GL Elevation: 2.711 metres
Final Depth: 2.95 metres
Depth to Water Strike: 2.40 metres
Depth to Bedrock: Not encountered

**Borehole:** MDSA-BH2-2018
Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.7 | | | | | | |
| | | | Sand and Gravel<br>Brown sand and gravel, occasional cobbles, compact to very dense, dry to wet at approximately 2.40 mbgs, odourless. | | SS1 | SS | 26 | 100 | 15 | Metals |
| | | | | 2.0 | SS2 | SS | 52 | 100 | 20 | Metals |
| 1.0 | | | | | SS3 | SS | 19 | 13 | NHS | |
| 2.0 | | | | 1.0 | SS4 | SS | 14 | 63 | 15 | BTEX/TPH |
| | | | | 0.0 | SS5 | SS | 57 | 42 | 30 | BTEX/TPH |
| 3.0 | | | Borehole terminated at 2.95 mbgs in sand and gravel. | -1.0 | | | | | | |
| 4.0 | | | | | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369315.576
UTM Northing: 5225490.768
Date Started: October 10, 2018
Date Finished: October 10, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Robert Perry

GL Elevation: 2.530 metres
Final Depth: 3.00 metres
Depth to Water Strike: 2.40 metres
Depth to Bedrock: Not encountered

Borehole: MDSA-BH3-2018
Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | Grassmat/Topsoil | 2.5 | | | | | | |
| | | | Sand and Gravel<br>Brown sand and gravel, occasional cobbles, compact to very dense, dry to wet at approximately 2.40 mbgs, odourless. | | SS1 | SS | 23 | 63 | 25 | |
| | | | | 2.0 | SS2 | SS | 41 | 71 | 20 | |
| 1.0 | | | | 1.0 | SS3 | SS | 31 | 67 | 10 | |
| 2.0 | | | | | SS4 | SS | 9 | 54 | 25 | BTEX/TPH |
| | | | | 0.0 | SS5 | SS | 6 | 42 | 15 | BTEX/TPH |
| 3.0 | | | Borehole terminated at 3.00 mbgs in sand and gravel. | -1.0 | | | | | | |
| 4.0 | | | | -2.0 | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369346.074
UTM Northing: 5225483.463
Date Started: October 2, 2018
Date Finished: October 2, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson

GL Elevation: 2.492 metres
Final Depth: 2.85 metres
Depth to Water Strike: 2.10 metres
Depth to Bedrock: 2.85 metres

Borehole: MDSA-BH4-2018
Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.5 | | | | | | |
| | | | **Gravelly Sand** Dark brown gravelly sand, occasional to numerous cobbles, loose to compact, very moist to wet at approximately 2.10 mbgs, odourless. | 2.0 | SS1 | SS | 7 | 25 | 10 | |
| 1.0 | | | | | SS2 | SS | 42 | 33 | 10 | |
| | | | | 1.0 | SS3 | SS | 19 | 13 | NHS | |
| 2.0 | | | | | SS4 | SS | 7 | 13 | NHS | BTEX/TPH |
| | | | **Sand** Brown sand, some wood debris, wet, odourless. | 0.0 | SS5 | SS | 22 | 44 | 20 | BTEX/TPH |
| 3.0 | | | Borehole terminated at 2.85 mbgs on probable bedrock. | -1.0 | | | | | | |
| 4.0 | | | | -2.0 | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369340.739
UTM Northing: 5225471.644
Date Started: October 10, 2018
Date Finished: October 10, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson

GL Elevation: 2.658 metres
Final Depth: 2.40 metres
Depth to Water Strike: 2.10 metres
Depth to Bedrock: Not encountered

**Borehole:** MDSA-BH5-2018


| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.7 | | | | | | |
| | | | Asphalt | | | | | | | |
| | | | Sand and Gravel<br>Brownish grey to brown sand and gravel, trace clay, dry to moist, dense to very dense, odourless. | | SS1 | SS | 32 | 89 | 10 | |
| | | | | 2.0 | SS2 | SS | 61 | 83 | 20 | |
| 1.0 | | | | | | | | | | |
| | | | Silty Sand and Gravel<br>Brown silty sand and gravel, occasional cobbles, compact, wet at approximately 2.10 mbgs, odourless. | 1.0 | SS3 | SS | 27 | 58 | 20 | BTEX/TPH |
| 2.0 | | | | | SS4 | SS | 14 | 50 | 30 | BTEX/TPH |
| | | | Borehole terminated at 2.40 mbgs in silty sand and gravel. | 0.0 | | | | | | |
| 3.0 | | | | | | | | | | |
| | | | | -1.0 | | | | | | |
| 4.0 | | | | | | | | | | |

*Client:* NLMAE
*Project No:* 11178792-02
*Civic Address:* Marystown Shipyard
*City & Province:* Marystown, NL
*PID Number:* N/A
*UTM Easting:* 369329.693
*UTM Northing:* 5225478.548
*Date Started:* October 10, 2018
*Date Finished:* October 10, 2018

*Drilling Contractor:* Logan Drilling Group
*Drill Type:* CME 75
*Drill Method:* Hollow Stem Auger
*Logged By:* Hubert Anderson

*GL Elevation:* 2.643 metres
*Final Depth:* 2.40 metres
*Depth to Water Strike:* 2.10 metres
*Depth to Bedrock:* Not encountered

**Borehole:** MDSA-BH6-2018
*Page:* 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) |
|---|---|---|---|---|
| 0.0 | | | Asphalt | 2.6 |
| | | | **Sand**<br>Brown sand, occasional cobbles, dry to moist, compact, odourless. | 2.0 |
| 1.0 | | | | 1.0 |
| 2.0 | | | **Silty Sand and Gravel**<br>Brown silty sand and gravel, occasional cobbles, very dense, wet at approximately 2.10 mbgs, odourless. | |
| 3.0 | | | Borehole terminated at 2.40 mbgs in silty sand and gravel. | 0.0 |
| 4.0 | | | | -1.0 |

| Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|
| SS1 | SS | 21 | 67 | 15 | Metals |
| SS2 | SS | 29 | 71 | 15 | Metals |
| SS3 | SS | 12 | 54 | 25 | BTEX/TPH |
| SS4 | SS | 58 | 46 | 30 | BTEX/TPH |

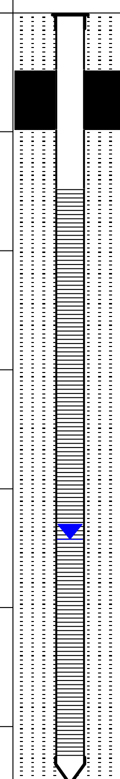
Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369298.578
UTM Northing: 5225498.048
Date Started: October 2, 2018
Date Finished: October 2, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson
TOC Elevation: 2.511 metres
GL Elevation: 2.631 metres
Final Depth: 3.900 metres
Depth to Water Strike: 2.660 metres
Depth to Bedrock Not encountered

## Monitor Well: MDSA-MW1-2018



| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2.6 | | | | | | | | |
| 0.0 | | | **Silty Sand and Gravel** Brown silty sand and gravel, occasional cobbles, some wood debris between 1.80 to 2.40 mbgs, compact, wet at approximately 2.40 mbgs, odourless. | | SS1 | SS | 19 | 33 | 15 | Metals | | Flushmount<br>Bentonite seal |
| | | | | 2.0 | SS2 | SS | 25 | 33 | 20 | Metals | | |
| 1.0 | | | | | | | | | | | | "No. 10" slot PVC screen |
| | | | | | SS3 | SS | 9 | 29 | 20 | | | |
| | | | | 1.0 | | | | | | | | "No. 3" silica sand pack |
| 2.0 | | | | | SS4 | SS | 11 | 33 | 25 | | | |
| | | | | 0.0 | SS5 | SS | 11 | 17 | NHS | | | Groundwater at approx. 2.660 mbgs |
| 3.0 | | | **Sandy Gravel** Brown sandy gravel, some silt, compact, wet, odourless. | | SS6 | SS | 10 | 50 | 15 | | | |
| | | | | -1.0 | | | | | | | | End point |
| 4.0 | | | Monitor well terminated at 3.900 mbgs in sandy gravel. | | | | | | | | | |
| | | | | -2.0 | | | | | | | | |
| 5.0 | | | | | | | | | | | | |



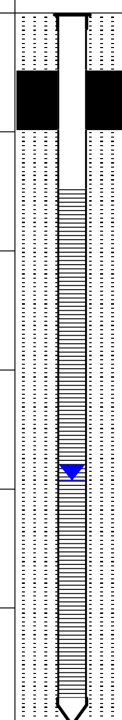
*Client:* NLMAE
*Project No:* 11178792-02
*Civic Address:* Marystown Shipyard
*City & Province:* Marystown, NL
*PID Number:* N/A
*UTM Easting:* 369309.777
*UTM Northing:* 5225478.602
*Date Started:* October 2, 2018
*Date Finished:* October 2, 2018

*Drilling Contractor:* Logan Drilling Group
*Drill Type:* CME 75
*Drill Method:* Hollow Stem Auger
*Logged By:* Hubert Anderson
*TOC Elevation:* 2.597 metres
*GL Elevation:* 2.797 metres
*Final Depth:* 3.600 metres
*Depth to Water Strike:* 2.355 metres
*Depth to Bedrock* 3.600 metres

## Monitor Well: MDSA-MW2-2018



| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.8 | | | | | | | | |
| | | | **Grassmat** | | SS1 | SS | 21 | 33 | 20 | | | Flushmount |
| | | | **Silty Sand and Gravel** Brown silty sand and gravel, some rootmat, occasional cobbles, some fractured rock, compact to very dense, moist to wet at approximately 2.40 mbgs, odourless. | | | | | | | | | Bentonite seal |
| 1.0 | | | | 2.0 | SS2 | SS | 51 | 29 | 20 | | | "No. 10" slot PVC screen |
| | | | | | SS3 | SS | 29 | 25 | 20 | | | "No. 3" silica sand pack |
| 2.0 | | | | 1.0 | SS4 | SS | 14 | 21 | 35 | BTEX/TPH | | Groundwater at approx. 2.355 mbgs |
| 3.0 | | | | 0.0 | SS5 | SS | 12 | 25 | 20 | BTEX/TPH | | |
| | | | | | SS6 | SS | 53 | 0 | NR | | | End point |
| 4.0 | | | Monitor well terminated at 3.600 mbgs on probable bedrock. | -1.0 | | | | | | | | |
| 5.0 | | | | -2.0 | | | | | | | | |



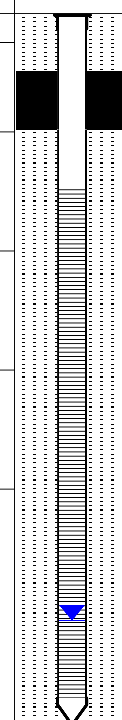
Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369346.153
UTM Northing: 5225477.641
Date Started: October 9, 2018
Date Finished: October 9, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger/Coring
Logged By: Robert Perry
TOC Elevation: 2.565 metres
GL Elevation: 2.685 metres
Final Depth: 3.600 metres
Depth to Water Strike: 3.068 metres
Depth to Bedrock 3.600 metres

# Monitor Well: MDSA-MW3-2018

Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2.7 | | | | | | | | |
| 0.0 | | | **Asphalt** | | | | | | | | | Flushmount |
| | | | **Silty Sand and Gravel** Brown silty sand and gravel, occasional cobbles, compact to dense, moist to wet at approximately 2.10 mbgs, odourless. | | SS1 | SS | 21 | 72 | 10 | | | Bentonite seal |
| 1.0 | | | | 2.0 | SS2 | SS | 31 | 50 | 15 | BTEX/TPH | | "No. 10" slot PVC screen |
| | | | | 1.0 | SS3 | SS | 35 | 75 | 15 | | | "No. 3" silica sand pack |
| 2.0 | | | | | SS4 | SS | 24 | 42 | 25 | BTEX/TPH | | |
| 3.0 | | | **Cobbles and Boulders** Numerous cobbles and boulders, very dense, wet, odourless. | 0.0 | RC1 | RC | NA | NA | NA | | | Groundwater at approx. 3.068 mbgs; End point |
| 4.0 | | | Monitor well terminated at 3.600 mbgs on probable bedrock. | -1.0 | | | | | | | | |
| 5.0 | | | | -2.0 | | | | | | | | |



Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369231.165
UTM Northing: 5225341.043
Date Started: October 4, 2018
Date Finished: October 4, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson

GL Elevation: 2.591 metres
Final Depth: 3.50 metres
Depth to Water Strike: 2.40 metres
Depth to Bedrock: 3.50 metres

**Borehole:** MFPA-BH1-2018
Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.6 | | | | | | |
| | | | **Sand and Gravel** Greyish brown sand and gravel, trace silt, compact, dry, odourless. | | SS1 | SS | 30 | 25 | 20 | |
| | | | | 2.0 | SS2 | SS | 21 | 17 | NHS | |
| 1.0 | | | | | SS3 | SS | 22 | 33 | NHS | |
| | | | | 1.0 | | | | | | |
| 2.0 | | | | | SS4 | SS | 10 | 33 | 20 | BTEX/TPH |
| | | | **Sandy Gravel** Brown sandy gravel, some fractured rock, compact, wet at approximately 2.40 mbgs, odourless. | 0.0 | SS5 | SS | 11 | 17 | NHS | |
| 3.0 | | | | | | | | | | |
| 4.0 | | | Borehole terminated at 3.50 mbgs on probable bedrock. | -1.0 | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369245.085
UTM Northing: 5225331.202
Date Started: October 4, 2018
Date Finished: October 4, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson

GL Elevation: 2.736 metres
Final Depth: 3.70 metres
Depth to Water Strike: 2.10 metres
Depth to Bedrock: 3.70 metres

GHD

**Borehole:** MFPA-BH2-2018
Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.7 | | | | | | |
| | | | Grassmat/Topsoil | | | | | | | |
| | | | Sand and Gravel<br>Brown to greyish brown sand and gravel, trace silt, compact, damp to wet at approximately 2.10 mbgs, odourless. | | SS1 | SS | 24 | 42 | 15 | |
| | | | | 2.0 | SS2 | SS | 14 | 46 | 25 | |
| 1.0 | | | | | SS3 | SS | 31 | 42 | 30 | |
| | | | | 1.0 | | | | | | |
| 2.0 | | | | | SS4 | SS | 25 | 25 | 30 | BTEX/TPH |
| | | | | 0.0 | SS5 | SS | 9 | 0 | NR | |
| 3.0 | | | Sandy Gravel<br>Brown sandy gravel, some fractured rock, compact, wet, faint petroleum hydrocarbon odour. | | SS6 | SS | 11 | 25 | 135 | BTEX/TPH |
| | | | Borehole terminated at 3.70 mbgs on probable bedrock. | -1.0 | | | | | | |
| 4.0 | | | | | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369235.786
UTM Northing: 5225319.069
Date Started: October 4, 2018
Date Finished: October 4, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson
GL Elevation: 2.658 metres
Final Depth: 3.60 metres
Depth to Water Strike: 2.40 metres
Depth to Bedrock: Not encountered

**Borehole:** MFPA-BH3-2018


| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2.7 | | | | | | |
| 0.0 | | | **Silty Sand and Gravel** Brown to dark brown silty sand and gravel, occasional cobbles, compact to loose, moist to wet at approximately 2.40 mbgs, odourless. | | SS1 | SS | 17 | 58 | 15 | Metals |
| | | | | 2.0 | SS2 | SS | 73 | 50 | 15 | Metals |
| 1.0 | | | | | SS3 | SS | 41 | 46 | 20 | |
| | | | | 1.0 | | | | | | |
| 2.0 | | | | | SS4 | SS | 29 | 42 | 30 | |
| | | | | 0.0 | SS5 | SS | 6 | 13 | NHS | BTEX/TPH |
| 3.0 | | | | | SS6 | SS | 11 | 42 | 30 | BTEX/TPH |
| | | | Borehole terminated at 3.60 mbgs in silty sand and gravel. | -1.0 | | | | | | |
| 4.0 | | | | | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369203.708
UTM Northing: 5225303.489
Date Started: October 4, 2018
Date Finished: October 4, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson

GL Elevation: 2.426 metres
Final Depth: 3.60 metres
Depth to Water Strike: 2.40 metres
Depth to Bedrock: Not encountered

**Borehole:** MFPA-BH4-2018
Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.4 | | | | | | |
| | | | Grassmat/Topsoil | | | | | | | |
| | | | Silty Sand and Gravel<br>Brown to dark brown silty sand and gravel, occasional to numerous cobbles, some fractured rock, compact to loose, moist to wet at approximately 2.40 mbgs, odourless. | 2.0 | SS1 | SS | 12 | 21 | <5 | Metals |
| 1.0 | | | | | SS2 | SS | 16 | 0 | NR | |
| | | | | 1.0 | SS3 | SS | 18 | 17 | NHS | Metals |
| 2.0 | | | | | SS4 | SS | 18 | 33 | 25 | BTEX/TPH |
| | | | | 0.0 | SS5 | SS | 5 | 0 | NR | |
| 3.0 | | | | -1.0 | SS6 | SS | 9 | 25 | 15 | BTEX/TPH |
| 4.0 | | | Borehole terminated at 3.60 mbgs in silty sand and gravel. | -2.0 | | | | | | |

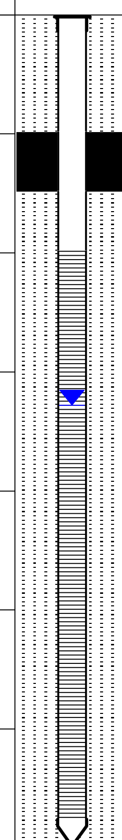
Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369217.700
UTM Northing: 5225325.048
Date Started: October 3, 2018
Date Finished: October 4, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson
TOC Elevation: 2.580 metres
GL Elevation: 2.700 metres
Final Depth: 4.200 metres
Depth to Water Strike: 1.972 metres
Depth to Bedrock 4.200 metres

# Monitor Well: MFPA-MW1-2018



| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.7 | | | | | | | | Flushmount |
| | | | **Silty Sand and Gravel** Greyish brown silty sand and gravel, occasional cobbles, compact, moist, odourless. | | SS1 | SS | 19 | 37 | 20 | | | |
| 1.0 | | | | 2.0 | SS2 | SS | 25 | 13 | 20 | | | Bentonite seal |
| | | | | 1.0 | SS3 | SS | 13 | 0 | NR | | | "No. 10" slot PVC screen |
| 2.0 | | | **Sandy Gravel** Brown to dark grey sandy gravel, numerous cobbles, compact to loose, moist to wet at approximately 2.70 mbgs, some sheen, faint to moderate petroleum hydrocarbon odours. | | SS4 | SS | 20 | 42 | 110 | | | Groundwater at approx. 1.972 mbgs |
| | | | | 0.0 | SS5 | SS | 6 | 33 | 345 | BTEX/TPH | | |
| 3.0 | | | | | SS6 | SS | 5 | 21 | 385 | | | "No. 3" silica sand pack |
| 4.0 | | | | -1.0 | SS7 | SS | 6 | 33 | 270 | BTEX/TPH | | End point |
| 5.0 | | | Monitor well terminated at 4.200 mbgs on probable bedrock. | -2.0 | | | | | | | | |



Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369270.245
UTM Northing: 5225457.857
Date Started: October 3, 2018
Date Finished: October 3, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson

GL Elevation: 2.705 metres
Final Depth: 1.80 metres
Depth to Water Strike: Not encountered
Depth to Bedrock: 1.80 metres

# Borehole: MGSB-BH1-2018

Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2.7 | | | | | | |
| 0.0 | | | Asphalt | | | | | | | |
| | | | Silty Sand and Gravel<br>Brown silty sand and gravel, some fractured rock, dense, dry, odourless. | | SS1 | SS | 41 | 13 | NHS | |
| 1.0 | | | Gravelly Sand<br>Brown gravelly sand, occasional cobbles, dense, moist, odourless. | 2.0 | SS2 | SS | 38 | 58 | 20 | |
| | | | Fractured Rock<br>Grey fractured rock, trace silt, dry, very dense, odourless. | | | | | | | |
| | | | | | SS3 | SS | 50\100 | 50 | NHS | |
| | | | | 1.0 | SS4 | Grab | NA | NA | 30 | BTEX/TPH |
| 2.0 | | | Borehole terminated at 1.80 mbgs on probable bedrock. | | | | | | | |
| | | | | 0.0 | | | | | | |
| 3.0 | | | | | | | | | | |
| | | | | -1.0 | | | | | | |
| 4.0 | | | | | | | | | | |

Client: NLMAE

Project No: 11178792-02

Civic Address: Marystown Shipyard

City & Province: Marystown, NL

PID Number: N/A

UTM Easting: 369274.546

UTM Northing: 5225446.236

Date Started: October 3, 2018

Date Finished: October 3, 2018

Drilling Contractor: Logan Drilling Group

Drill Type: CME 75

Drill Method: Hollow Stem Auger

Logged By: Hubert Anderson

GL Elevation: 2.729 metres

Final Depth: 2.75 metres

Depth to Water Strike: 2.10 metres

Depth to Bedrock: 2.75 metres

**Borehole:** MGSB-BH2-2018

Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.7 | | | | | | |
| 0.0 | | | Asphalt | | | | | | | |
| | | | Gravelly Sand<br>Brown gravelly sand, occasional cobbles, dense, moist, odourless. | | SS1 | SS | 39 | 50 | 15 | |
| 1.0 | | | | 2.0 | SS2 | SS | 46 | 0 | NR | |
| | | | Silty Sand and Gravel<br>Brown silty sand and gravel, some fractured rock, moist to wet at approximately 2.10 mbgs, odourless. | 1.0 | SS3 | SS | 113 | 81 | 25 | BTEX/TPH |
| 2.0 | | | | 0.0 | SS4 | Grab | NA | NA | 25 | BTEX/TPH |
| 3.0<br>4.0 | | | Borehole terminated at 2.75 mbgs on probable bedrock. | -1.0 | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369295.015
UTM Northing: 5225445.087
Date Started: October 3, 2018
Date Finished: October 3, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson

GL Elevation: 2.685 metres
Final Depth: 2.75 metres
Depth to Water Strike: 2.10 metres
Depth to Bedrock: 2.75 metres

**Borehole:** MGSB-BH3-2018
Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.7 | | | | | | |
| | | | Asphalt | | | | | | | |
| | | | Gravelly Sand<br>Brown gravelly sand, dense, moist, faint musty odour. | | SS1 | SS | 39 | 56 | 55 | BTEX/TPH |
| 1.0 | | | Gravelly Sand<br>Brown gravelly sand, occasional cobbles, dense, moist, odourless. | 2.0 | SS2 | SS | 43 | 42 | 30 | |
| | | | | 1.0 | SS3 | SS | 48 | 13 | 20 | |
| 2.0 | | | Silty Sand and Gravel<br>Dark Brown silty sand and gravel, some fractured rock, very moist to wet at approximately 2.10 mbgs, faint petroleum hydrocarbon odour. | | SS4 | SS | 50\50 | 25 | 85 | BTEX/TPH |
| | | | | 0.0 | SS5 | Grab | NA | NA | 100 | |
| 3.0 | | | Borehole terminated at 2.75 mbgs on probable bedrock. | -1.0 | | | | | | |
| 4.0 | | | | | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369289.817
UTM Northing: 5225449.664
Date Started: October 2, 2018
Date Finished: October 2, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson

GL Elevation: 2.683 metres
Final Depth: 4.20 metres
Depth to Water Strike: 2.10 metres
Depth to Bedrock: 4.20 metres

**Borehole:** MGSB-BH4-2018
Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.7 | | | | | | |
| | | | **Asphalt** | | | | | | | |
| | | | **Silty Sand and Gravel** Brown silty sand and gravel, trace cobbles, dense to compact, moist to very moist, odourless. | | SS1 | SS | 31 | 56 | 20 | |
| | | | | 2.0 | SS2 | SS | 17 | 42 | 20 | |
| 1.0 | | | | 1.0 | SS3 | SS | 10 | 13 | NHS | |
| 2.0 | | | **Sandy Gravel** Brown to grey sandy gravel sand, some fractured rock, compact to dense, very moist to wet at approximately 2.10 mbgs, slight to moderate petroleum hydrocarbon odour. | | SS4 | SS | 20 | 25 | 175 | BTEX/TPH |
| | | | | 0.0 | SS5 | SS | 30 | 50 | 525 | |
| 3.0 | | | **Cobbles and Boulders** Numerous cobbles and boulders, very dense, wet, moderate petroleum hydrocarbon odour. | | | | | | | |
| 4.0 | | | **Gravel** Grey gravel, trace sand, compact, wet, moderate to slight petroleum hydrocarbon odour. | -1.0 | SS6 | SS | 29 | 33 | 510 | BTEX/TPH |
| | | | Borehole terminated at 4.20 mbgs on probable bedrock. | | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369215.542
UTM Northing: 5225285.764
Date Started: October 4, 2018
Date Finished: October 4, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson

GL Elevation: 2.745 metres
Final Depth: 2.80 metres
Depth to Water Strike: 2.40 metres
Depth to Bedrock: 2.80 metres

**Borehole:** MLLA-BH1-2018


| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 2.7 | | | | | | |
| 0.0 | | | Grassmat/Topsoil | | | | | | | |
| | | | Silty Sand and Gravel<br>Brown to dark brown silty sand and gravel, compact, moist to very moist, odourless. | | SS1 | SS | 15 | 50 | 10 | Metals |
| | | | | 2.0 | SS2 | SS | 19 | 29 | 15 | Metals |
| 1.0 | | | | | SS3 | SS | 16 | 13 | NHS | |
| | | | Cobbles and Boulders<br>Numerous cobbles and boulders, trace sandy silt, compact to very dense, very moist to wet at approximately 2.40 mbgs, odourless. | 1.0 | SS4 | SS | 10 | 0 | NR | |
| 2.0 | | | | | SS5 | SS | 53\250 | 13 | NHS | BTEX/TPH |
| | | | | 0.0 | | | | | | |
| 3.0 | | | Borehole terminated at 2.80 mbgs on probable bedrock. | | | | | | | |
| | | | | -1.0 | | | | | | |
| 4.0 | | | | | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369235.294
UTM Northing: 5225290.124
Date Started: October 4, 2018
Date Finished: October 4, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson

GL Elevation: 2.799 metres
Final Depth: 2.10 metres
Depth to Water Strike: Not encountered
Depth to Bedrock: 2.10 metres

**Borehole:** MLLA-BH2-2018
Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.8 | | | | | | |
| | | | Grassmat/Topsoil | | | | | | | |
| | | | Silty Sand and Gravel<br>Brown to dark brown silty sand and gravel, some fractured rock, dense to very dense, moist to very moist, odourless. | | SS1 | SS | 43 | 54 | <5 | Metals |
| | | | | 2.0 | SS2 | SS | 90 | 67 | <5 | Metals |
| 1.0 | | | | | SS3 | SS | 54 | 25 | 10 | |
| | | | | 1.0 | | | | | | |
| 2.0 | | | | | SS4 | Grab | NA | NA | 25 | |
| | | | Borehole terminated at 2.10 mbgs on probable bedrock. | 0.0 | | | | | | |
| 3.0 | | | | -1.0 | | | | | | |
| 4.0 | | | | | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369202.540
UTM Northing: 5225285.392
Date Started: October 3, 2018
Date Finished: October 3, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger/Coring
Logged By: Hubert Anderson
TOC Elevation: 2.494 metres
GL Elevation: 2.614 metres
Final Depth: 4.500 metres
Depth to Water Strike: 1.834 metres
Depth to Bedrock 3.400 metres

## Monitor Well: MLLA-MW1-2018



| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | Grassmat/Topsoil | 2.6 | | | | | | | | Flushmount |
| | | | **Silty Sand** Brown silty sand, some topsoil, some fractured rock, dense to compact, moist to wet at approximately 2.40 mbgs, odourless. | | SS1 | SS | 43 | 67 | 15 | | | |
| | | | | 2.0 | SS2 | SS | 21 | 50 | 15 | | | Bentonite seal |
| 1.0 | | | | | SS3 | SS | 35 | 13 | NHS | | | |
| | | | | 1.0 | | | | | | | | Groundwater at approx. 1.834 mbgs |
| 2.0 | | | | | SS4 | SS | 11 | 13 | 40 | BTEX/TPH | | |
| | | | **Sandy Gravel** Reddish brown sandy gravel, compact to very dense, wet, odourless. | 0.0 | SS5 | SS | 11 | 42 | 35 | | | "No. 10" slot PVC screen |
| 3.0 | | | | | SS6 | SS | 100\175 | 42 | 20 | BTEX/TPH | | "No. 3" silica sand pack |
| | | | **Bedrock** Fractured sedimentary rock. | -1.0 | RC1 | RC | 65 | 75 | NA | | | |
| 4.0 | | | | | | | | | | | | End point |
| | | | | | | | | | | | | Cave-in material |
| 5.0 | | | Monitor well terminated at 4.500 mbgs in fractured bedrock. | -2.0 | | | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369217.751
UTM Northing: 5225308.019
Date Started: October 3, 2018
Date Finished: October 3, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson
TOC Elevation: 2.525 metres
GL Elevation: 2.645 metres
Final Depth: 4.200 metres
Depth to Water Strike: 1.814 metres
Depth to Bedrock 4.200 metres

# Monitor Well: MLLA-MW2-2018

Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | Grassmat/Topsoil | 2.6 | | | | | | | | Flushmount |
| | | | Sand and Gravel<br>Brown sand and gravel, occasional cobbles, compact, moist, odourless. | 2.0 | SS1 | SS | 28 | 42 | <5 | Metals | | |
| 1.0 | | | | | SS2 | SS | 24 | 42 | <5 | Metals | | Bentonite seal |
| | | | Silty Sand and Gravel<br>Dark brown to black silty sand and gravel, loose to compact, moist, odourless | 1.0 | SS3 | SS | 8 | 13 | NHS | | | Groundwater at approx. 1.814 mbgs |
| 2.0 | | | | | SS4 | SS | 20 | 0 | NR | | | "No. 10" slot PVC screen |
| | | | Sandy Gravel<br>Brown sandy gravel, wet at approximately 2.65 mbgs, some sheen, moderate petroleum hydrocarbon odour. | 0.0 | SS5 | SS | 9 | 25 | 395 | BTEX/TPH | | |
| 3.0 | | | | | SS6 | SS | 8 | 33 | 415 | | | "No. 3" silica sand pack |
| 4.0 | | | | -1.0 | SS7 | SS | 12 | 33 | 440 | BTEX/TPH | | End point |
| 5.0 | | | Monitor well terminated at 4.200 mbgs on probable bedrock. | -2.0 | | | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369247.870
UTM Northing: 5225305.741
Date Started: October 3, 2018
Date Finished: October 3, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson
TOC Elevation: 2.689 metres
GL Elevation: 2.809 metres
Final Depth: 5.100 metres
Depth to Water Strike: 1.874 metres
Depth to Bedrock Not encountered

# Monitor Well: MLLA-MW3-2018

Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | **Grassmat/Topsoil**<br>**Silty Sand and Gravel**<br>Brown silty sand and gravel, some fractured rock, compact, moist, odourless. | 2.8 | SS1 | SS | 27 | 42 | 10 | Metals | | Flushmount |
| 1.0 | | | | 2.0 | SS2 | SS | 14 | 29 | <5 | Metals | | |
| | | | | | SS3 | SS | 10 | 13 | NHS | | | Bentonite seal |
| 2.0 | | | **Sand and Gravel**<br>Light brown sand and gravel, occasional cobbles, compact, very moist, odourless. | 1.0 | SS4 | SS | 22 | 33 | 35 | | | Groundwater at approx. 1.874 mbgs |
| | | | | 0.0 | SS5 | SS | 11 | 33 | 45 | | | "No. 10" slot PVC screen |
| 3.0 | | | **Gravel**<br>Light brown gravel, some sand, compact to loose, wet at approximately 3.00 mbgs, faint to slight petroleum hydrocarbon odour. | | SS6 | SS | 13 | 25 | 175 | BTEX/TPH | | |
| 4.0 | | | | -1.0 | SS7 | SS | 7 | 25 | 310 | BTEX/TPH | | "No. 3" silica sand pack |
| | | | | | | | | | | | | |
| 5.0 | | | **Sand**<br>Brown sand, loose, wet, odourless. | -2.0 | SS8 | SS | 7 | 21 | NHS | BTEX/TPH | | End point |
| | | | Monitor well terminated at 5.100 mbgs in sand. | | | | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369225.110
UTM Northing: 5225282.840
Date Started: October 3, 2018
Date Finished: October 3, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger/Coring
Logged By: Hubert Anderson
TOC Elevation: 2.620 metres
GL Elevation: 2.840 metres
Final Depth: 5.100 metres
Depth to Water Strike: 2.015 metres
Depth to Bedrock 4.800 metres

## Monitor Well: MLLA-MW4-2018

Page: 1 of 1

| Depth (m) | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Details |
|---|---|---|---|---|---|---|---|---|---|
| 0.0 | **Grassmat/Topsoil** | 2.8 | SS1 | SS | 39 | 50 | <5 | Metals | Flushmount |
| | **Sand and Gravel** Dark brown sand and gravel, numerous cobbles, occasional boulders, dense to very dense, moist to very moist, odourless. | 2.0 | SS2 | SS | 51 | 46 | 15 | Metals | |
| 1.0 | | | | | | | | | Bentonite seal |
| | | 1.0 | SS3 | SS | 9 | 0 | NR | | |
| 2.0 | | | | | | | | | Groundwater at approx. 2.015 mbgs |
| | | | SS4 | SS | 50\75 | 44 | NHS | | |
| | **Boulders** Numerous boulders, some cobbles, trace to some reddish brown sandy gravel, very dense, wet at approximately 2.40 mbgs, odourless. | 0.0 | RC1 | RC | NA | NA | | | "No. 10" slot PVC screen |
| 3.0 | | -1.0 | RC2 | RC | NA | NA | | | |
| 4.0 | | | | | | | | | "No. 3" silica sand pack |
| | | | SS5 | SS | 56\150 | 17 | NHS | | |
| 5.0 | **Bedrock** Sound sedimnetary rock. | -2.0 | RC3 | RC | 100 | 100 | NA | | End point |
| | Monitor well terminated at 5.100 mbgs in sound bedrock. | | | | | | | | |

*Client:* NLMAE
*Project No:* 11178792-02
*Civic Address:* Marystown Shipyard
*City & Province:* Marystown, NL
*PID Number:* N/A
*UTM Easting:* 369264.213
*UTM Northing:* 5225365.891
*Date Started:* October 4, 2018
*Date Finished:* October 4, 2018

*Drilling Contractor:* Logan Drilling Group
*Drill Type:* CME 75
*Drill Method:* Hollow Stem Auger
*Logged By:* Hubert Anderson
*GL Elevation:* 2.720 metres
*Final Depth:* 4.35 metres
*Depth to Water Strike:* 3.30 metres
*Depth to Bedrock:* 4.35 metres

## *Borehole:* MSBL-BH1-2018



| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.7 | | | | | | |
| | | | **Asphalt** | | | | | | | |
| | | | **Gravelly Sand**<br>Brown gravelly sand, compact to dense, damp to moist, odourless. | | SS1 | SS | 18 | 67 | 15 | |
| | | | | 2.0 | SS2 | SS | 40 | 0 | NR | |
| 1.0 | | | | | | | | | | |
| | | | **Silty Gravel**<br>Brown silty gravel, occasional cobbles, compact to dense, dry to very moist, odourless. | | SS3 | SS | 23 | 13 | NHS | |
| | | | | 1.0 | | | | | | |
| 2.0 | | | | | SS4 | SS | 45 | 75 | 40 | |
| | | | | 0.0 | SS5 | SS | 42 | 75 | 45 | |
| 3.0 | | | **Sand and Gravel**<br>Brown to dark brown sand and gravel, numerous cobbles, some fractured rock, compact to very dense, very moist to wet at approximately 3.30 mbgs, faint petroleum hydrocarbon odour. | | SS6 | SS | 20 | 33 | 95 | BTEX/TPH |
| | | | | -1.0 | SS7 | SS | 17 | 25 | 60 | BTEX/TPH |
| 4.0 | | | | | | | | | | |
| | | | | | SS8 | SS | 50\0 | 0 | NR | |
| | | | Borehole terminated at 4.35 mbgs on bedrock. | | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369276.165
UTM Northing: 5225367.251
Date Started: October 4, 2018
Date Finished: October 4, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson

GL Elevation: 2.685 metres
Final Depth: 3.60 metres
Depth to Water Strike: 2.70 metres
Depth to Bedrock: 3.60 metres

**Borehole:** MSBL-BH2-2018
Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.7 | | | | | | |
| | | | Asphalt | | | | | | | |
| | | | Gravelly Sand<br>Brown gravelly sand, occasional cobbles, dense to compact, damp to wet at approximately 2.70 mbgs, odourless. | | SS1 | SS | 33 | 44 | 5 | |
| | | | | 2.0 | SS2 | SS | 31 | 13 | NHS | |
| 1.0 | | | | | | | | | | |
| | | | | 1.0 | SS3 | SS | 15 | 29 | 25 | |
| 2.0 | | | | | SS4 | SS | 17 | 33 | 40 | |
| | | | | 0.0 | SS5 | SS | 31 | 58 | 65 | BTEX/TPH |
| 3.0 | | | | | SS6 | SS | 13 | 25 | NHS | BTEX/TPH |
| | | | Borehole terminated at 3.60 mbgs on bedrock. | -1.0 | | | | | | |
| 4.0 | | | | | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369280.231
UTM Northing: 5225348.213
Date Started: October 4, 2018
Date Finished: October 4, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson

GL Elevation: 2.595 metres
Final Depth: 3.45 metres
Depth to Water Strike: 2.70 metres
Depth to Bedrock: 3.45 metres

**Borehole:** MSBL-BH3-2018
Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.6 | | | | | | |
| | | | Grassmat/Topsoil | | | | | | | |
| | | | Silty Sand and Gravel<br>Brown silty sand and gravel, occasional cobbles and boulders, loose to very dense, moist to wet at approximately 2.70 mbgs, odourless. | 2.0 | SS1 | SS | 9 | 50 | 55 | |
| 1.0 | | | | | SS2 | SS | 13 | 42 | 50 | |
| | | | | | SS3 | SS | 98\150 | 0 | NR | |
| | | | | 1.0 | | | | | | |
| 2.0 | | | | | SS4 | SS | 33 | 33 | 55 | BTEX/TPH |
| | | | | 0.0 | | | | | | |
| 3.0 | | | | | SS5 | SS | 60 | 33 | 40 | BTEX/TPH |
| | | | | | SS6 | SS | 50\0 | 0 | NR | |
| 4.0 | | | Borehole terminated at 3.45 mbgs on probable bedrock. | -1.0 | | | | | | |

Client: NLMAE

Project No: 11178792-02

Civic Address: Marystown Shipyard

City & Province: Marystown, NL

PID Number: N/A

UTM Easting: ,369267.940

UTM Northing: 5225315.665

Date Started: October 4, 2018

Date Finished: October 4, 2018

Drilling Contractor: Logan Drilling Group

Drill Type: CME 75

Drill Method: Hollow Stem Auger

Logged By: Hubert Anderson

GL Elevation: 2.649 metres

Final Depth: 3.60 metres

Depth to Water Strike: 2.70 metres

Depth to Bedrock: 3.60 metres

**Borehole:** MSBL-BH4-2018

Page: 1 of 1

| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.6 | | | | | | |
| | | | Grassmat/Topsoil | | | | | | | |
| | | | Sand and Gravel<br>Brown sand and gravel, some organics, occasional cobbles, compact to dense, moist, odourless. | | SS1 | SS | 23 | 75 | 15 | Metals |
| 1.0 | | | | 2.0 | SS2 | SS | 36 | 58 | 10 | |
| | | | | 1.0 | SS3 | SS | 39 | 75 | 15 | |
| 2.0 | | | Silty Sand and Gravel<br>Brown to black silty sand and gravel, occasional cobbles, very dense to compact, moist to wet at approximately 2.70 mbgs, slight petroleum hydrocarbon odour. | | SS4 | SS | 47 | 63 | 20 | |
| | | | | 0.0 | SS5 | SS | 27 | 54 | 40 | BTEX/TPH |
| 3.0 | | | Silty Sand and Gravel<br>Brown to black silty sand and gravel, dense, wet, odourless. | | SS6 | SS | 50 | 71 | 30 | BTEX/TPH |
| 4.0 | | | Borehole terminated at 3.60 mbgs on probable bedrock. | -1.0 | | | | | | |

Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369274.236
UTM Northing: 5225359.931
Date Started: October 4, 2018
Date Finished: October 4, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger
Logged By: Hubert Anderson

GL Elevation: 2.685 metres
Final Depth: 3.60 metres
Depth to Water Strike: 3.00 metres
Depth to Bedrock: 3.60 metres

**Borehole:** MSBL-BH5-2018



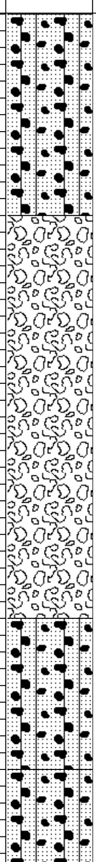
| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | | | | 2.7 | | | | | | |
| | | | Asphalt | | | | | | | |
| | | | Silty Sand and Gravel<br>Brownish grey to dark grey silty sand and gravel, some fractured rock, compact to dense, very moist, odourless. | | SS1 | SS | 18 | 33 | <5 | BTEX/TPH |
| | | | | 2.0 | SS2 | SS | 15 | 17 | <5 | |
| 1.0 | | | | | SS3 | SS | 46 | 33 | NHS | |
| 2.0 | | | | 1.0 | SS4 | SS | 12 | 33 | 20 | |
| | | | Sandy Gravel<br>Brown sandy gravel, some fractured rock, compact, wet at approximately 3.00 mbgs, faint musty odour. | 0.0 | SS5 | SS | 14 | 17 | NHS | BTEX/TPH |
| 3.0 | | | | | SS6 | SS | 12 | 33 | 150 | BTEX/TPH |
| 4.0 | | | Borehole terminated at 3.60 mbgs on probable bedrock. | -1.0 | | | | | | |

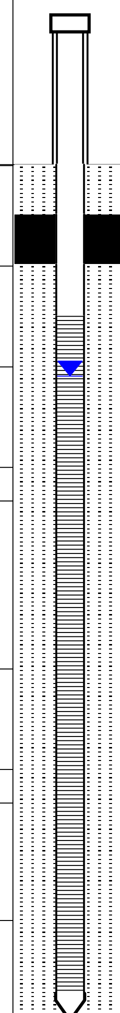
Client: NLMAE
Project No: 11178792-02
Civic Address: Marystown Shipyard
City & Province: Marystown, NL
PID Number: N/A
UTM Easting: 369276.318
UTM Northing: 5225335.675
Date Started: October 4, 2018
Date Finished: October 9, 2018

Drilling Contractor: Logan Drilling Group
Drill Type: CME 75
Drill Method: Hollow Stem Auger/Coring
Logged By: Hubert Anderson/Robert Perry
TOC Elevation: 3.425 metres
GL Elevation: 2.509 metres
Final Depth: 5.100 metres
Depth to Water Strike: 1.264 metres
Depth to Bedrock Not encountered

# Monitor Well: MSBL-MW2-2018







| Depth (m) | Lithology | USCS Classification | Description | Elevation (mamsl) | Sample ID | Sample Type | N-Value/RQD (%) | Recovery (%) | Headspace (ppm/% LEL) | Analysis | Well Construction | Well Details |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | 3.0 / 2.5 | | | | | | | | Casing stick-up protector |
| 0.0 | | | **Silty Sand and Gravel** Brown silty sand and gravel, numerous cobbles, compact to dense, moist, odourless. | 2.0 | SS1 | SS | 11 | 25 | 10 | BTEX/TPH + Metals | | Bentonite seal |
| 1.0 | | | | | SS2 | SS | 30 | 0 | NR | | | |
| | | | **Boulders and Cobbles** Numerous boulders and cobbles, trace silty sand and gravel, very dense to compact, wet at approximately 1.20 mbgs, odourless. | 1.0 | RC1 | SS | NA | NA | NA | | | Groundwater at approx. 1.264 mbgs |
| | | | | | SS3 | SS | 50\25 | 29 | 20 | | | |
| 2.0 | | | | 0.0 | RC2 | RC | NA | NA | NA | | | "No. 10" slot PVC screen |
| 3.0 | | | | -1.0 | SS4 | SS | 14 | 33 | 65 | BTEX/TPH | | |
| | | | **Silty Sand and Gravel** Black to brown silty sand and gravel, very dense, wet, slight petroleum hydrocarbon odours. | | SS5 | SS | 50\50 | 25 | 50 | | | "No. 3" silica sand pack |
| 4.0 | | | | | RC3 | RC | NA | NA | NA | | | |
| 5.0 | | | **Silty Sand and Gravel** Brown silty sand and gravel, dense, wet, odourless. | -2.0 | SS6 | SS | 32 | 37 | 25 | | | End point |
| | | | Monitor well terminated at 5.100 mbgs. | -3.0 | | | | | | | | |

# Appendix C
# Laboratory Certificates of Analysis

57 Old Pennywell Road, Unit I
St. John's, NL
CANADA A1E 6A8
TEL (709)747-8573
FAX (709 747-2139
http://www.agatlabs.com

**CLIENT NAME: GHD LIMITED**
**1118 TOPSAIL ROAD**
**ST. JOHN'S , NL A1B3N7**
**(709) 364-5353**

**ATTENTION TO: JAMES O'NEILL**

**PROJECT: 11178792-02**

**AGAT WORK ORDER: 18K395328**

**TRACE ORGANICS REVIEWED BY: Amy Hunter, Trace Organics Supervisor, B.Sc.**

**DATE REPORTED: Oct 18, 2018**

**PAGES (INCLUDING COVER): 7**

**VERSION*: 1**

Should you require any information regarding this analysis please contact your client services representative at (709)747-8573

*NOTES

**All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.**

57 Old Pennywell Road, Unit I
St. John's, NL
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# Certificate of Analysis

**AGAT WORK ORDER: 18K395328**

**PROJECT: 11178792-02**

**CLIENT NAME: GHD LIMITED**

**ATTENTION TO: JAMES O'NEILL**

**SAMPLING SITE:**

**SAMPLED BY:**

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved

**DATE RECEIVED: 2018-10-10**

**DATE REPORTED: 2018-10-18**

| | | | SAMPLE DESCRIPTION: | MSBL-BH1-2018 -SS6 | MSBL-BH1-2018 -SS7 | MSBL-BH2-2018 -SS5 | MSBL-BH2-2018 -SS6 | MSBL-BH3-2018 -SS4 | MSBL-BH3-2018 -SS5 | MSBL-BH5-2018 -SS1 | MSBL-BH5-2018 -SS5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 |
| **Parameter** | **Unit** | **G / S** | **RDL** | **9612887** | **9612892** | **9612893** | **9612894** | **9612895** | **9612896** | **9612897** | **9612898** |
| Benzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 |
| >C10-C16 Hydrocarbons | mg/kg | | 15 | 60 | 45 | 16 | 1690 | 47 | 52 | <15 | <15 |
| >C16-C21 Hydrocarbons | mg/kg | | 15 | 43 | 34 | 104 | 1470 | 94 | 109 | <15 | <15 |
| >C21-C32 Hydrocarbons | mg/kg | | 15 | <15 | <15 | 35 | 332 | 39 | 45 | <15 | <15 |
| Modified TPH (Tier 1) | mg/kg | | 20 | 103 | 79 | 155 | 3490 | 180 | 206 | <20 | <20 |
| Resemblance Comment | | | | WFOF | WFOF | WFOF | WFOF | FOF | FOF | NR | NR |
| Return to Baseline at C32 | | | | Y | Y | Y | Y | Y | Y | Y | Y |
| **Surrogate** | **Unit** | **Acceptable Limits** | | | | | | | | | |
| Isobutylbenzene - EPH | % | 60-140 | | 89 | 91 | 93 | 109 | 92 | 91 | 93 | 94 |
| Isobutylbenzene - VPH | % | 60-140 | | 91 | 93 | 89 | 88 | 86 | 91 | 86 | 88 |
| n-Dotriacontane - EPH | % | 60-140 | | 92 | 96 | 96 | 88 | 95 | 96 | 96 | 98 |

Certified By:

AGAT Laboratories

57 Old Pennywell Road, Unit I
St. John's, NL
CANADA A1E 6A8
TEL (709)747-8573
FAX (709 747-2139
http://www.agatlabs.com

# Certificate of Analysis

**AGAT WORK ORDER: 18K395328**
**PROJECT: 11178792-02**

**CLIENT NAME: GHD LIMITED**
**SAMPLING SITE:**
**ATTENTION TO: JAMES O'NEILL**
**SAMPLED BY:**

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved

**DATE RECEIVED: 2018-10-10** **DATE REPORTED: 2018-10-18**

| | | | SAMPLE DESCRIPTION: | MSBL-BH5-2018-SS6 | MSBL-MW2-2018-SS1 |
|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-04 | 2018-10-04 |
| **Parameter** | **Unit** | **G / S** | **RDL** | **9612899** | **9612900** |
| Benzene | mg/kg | | 0.03 | <0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | 37 | <3 |
| >C10-C16 Hydrocarbons | mg/kg | | 15 | 3250 | 26 |
| >C16-C21 Hydrocarbons | mg/kg | | 15 | 2890 | 65 |
| >C21-C32 Hydrocarbons | mg/kg | | 15 | 633 | 24 |
| Modified TPH (Tier 1) | mg/kg | | 20 | 6810 | 115 |
| Resemblance Comment | | | | WFOF | FOF |
| Return to Baseline at C32 | | | | Y | Y |
| **Surrogate** | **Unit** | **Acceptable Limits** | | | |
| Isobutylbenzene - EPH | % | 60-140 | | 97 | 94 |
| Isobutylbenzene - VPH | % | 60-140 | | 86 | 94 |
| n-Dotriacontane - EPH | % | 60-140 | | 93 | 96 |

**Comments:** RDL - Reported Detection Limit; G / S - Guideline / Standard

**9612887-9612900** Results are based on the dry weight of the soil.

Resemblance Comment Key:
GF - Gasoline Fraction
WGF - Weathered Gasoline Fraction
GR - Product in Gasoline Range
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
FR - Product in Fuel Oil Range
LOF - Lube Oil Fraction
LR - Lube Range
UC - Unidentified Compounds
NR - No Resemblance
NA - Not Applicable

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

57 Old Pennywell Road, Unit I
St. John's, NL
CANADA A1E 6A8
TEL (709)747-8573
FAX (709 747-2139
http://www.agatlabs.com

# Certificate of Analysis

**AGAT WORK ORDER: 18K395328**
**PROJECT: 11178792-02**

**CLIENT NAME: GHD LIMITED**
**ATTENTION TO: JAMES O'NEILL**
**SAMPLING SITE:**
**SAMPLED BY:**

## Moisture

**DATE RECEIVED: 2018-10-10** **DATE REPORTED: 2018-10-18**

| Parameter | Unit | G / S | RDL | MSBL-BH1-2018-SS6 | MSBL-BH1-2018-SS7 | MSBL-BH2-2018-SS5 | MSBL-BH2-2018-SS6 | MSBL-BH3-2018-SS4 | MSBL-BH3-2018-SS5 | MSBL-BH5-2018-SS1 | MSBL-BH5-2018-SS5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
| DATE SAMPLED: | | | | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 |
| | | | | 9612887 | 9612892 | 9612893 | 9612894 | 9612895 | 9612896 | 9612897 | 9612898 |
| % Moisture | % | | 0 | 11 | 12 | 9 | 10 | 6 | 6 | 6 | 10 |

| Parameter | Unit | G / S | RDL | MSBL-BH5-2018-SS6 | MSBL-MW2-2018-SS1 |
|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Soil | Soil |
| DATE SAMPLED: | | | | 2018-10-04 | 2018-10-04 |
| | | | | 9612899 | 9612900 |
| % Moisture | % | | 0 | 18 | 10 |

**Comments:** RDL - Reported Detection Limit; G / S - Guideline / Standard
Analysis performed at AGAT Halifax (unless marked by *)

Certified By:


*Results relate only to the items tested and to all the items tested*

57 Old Pennywell Road, Unit I
St. John's, NL
CANADA A1E 6A8
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# Quality Assurance

**CLIENT NAME: GHD LIMITED** | **AGAT WORK ORDER: 18K395328**
**PROJECT: 11178792-02** | **ATTENTION TO: JAMES O'NEILL**
**SAMPLING SITE:** | **SAMPLED BY:**

## Trace Organics Analysis

| RPT Date: Oct 18, 2018 | | | DUPLICATE | | | | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| **Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved** | | | | | | | | | | | | | | | |
| Benzene | 1 | 9614973 | < 0.03 | < 0.03 | NA | < 0.03 | 87% | 60% | 140% | 81% | 60% | 140% | | | |
| Toluene | 1 | 9614973 | < 0.04 | < 0.04 | NA | < 0.04 | 90% | 60% | 140% | 70% | 60% | 140% | | | |
| Ethylbenzene | 1 | 9614973 | < 0.03 | < 0.03 | NA | < 0.03 | 93% | 60% | 140% | 73% | 60% | 140% | | | |
| Xylene (Total) | 1 | 9614973 | < 0.05 | < 0.05 | NA | < 0.05 | 96% | 60% | 140% | 75% | 60% | 140% | | | |
| C6-C10 (less BTEX) | 1 | 9614973 | < 3 | < 3 | NA | < 3 | 116% | 60% | 140% | 103% | 60% | 140% | 117% | 30% | 130% |
| >C10-C16 Hydrocarbons | 1 | 9612900 | 26 | 25 | NA | < 15 | 100% | 60% | 140% | 100% | 60% | 140% | 130% | 30% | 130% |
| >C16-C21 Hydrocarbons | 1 | 9612900 | 65 | 65 | NA | < 15 | 97% | 60% | 140% | 100% | 60% | 140% | 130% | 30% | 130% |
| >C21-C32 Hydrocarbons | 1 | 9612900 | 24 | 21 | NA | < 15 | 98% | 60% | 140% | 100% | 60% | 140% | 130% | 30% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

Certified By:

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# Method Summary

**CLIENT NAME: GHD LIMITED** | **AGAT WORK ORDER: 18K395328**
**PROJECT: 11178792-02** | **ATTENTION TO: JAMES O'NEILL**
**SAMPLING SITE:** | **SAMPLED BY:**

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| **Trace Organics Analysis** | | | |
| Benzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Toluene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Ethylbenzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Xylene (Total) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| C6-C10 (less BTEX) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| >C10-C16 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C16-C21 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C21-C32 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Modified TPH (Tier 1) | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | CALCULATION |
| Resemblance Comment | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| Return to Baseline at C32 | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - VPH | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| n-Dotriacontane - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| % Moisture | | Calculation | GRAVIMETRIC |

Unit 122 • 11 Morris Drive
Dartmouth, NS
B3B 1M2

# AGAT Laboratories

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**Laboratory Use Only**
Arrival Condition: ☑ Good ☐ Poor (see notes)
Arrival Temperature: 1.1 3.2 1.9 °C
AGAT Job Number: 18K395328
Notes:

## Chain of Custody Record

**Report Information**
Company: GHD Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone 1-709-364-5353 Fax: 1-709-364-5368
Site # and/or Name: MARYSTOWN SHIPYARD - MSBL
Project #: 11178792-02
AGAT Quotation #: GHD Standing Offer
GHD PO #: TO FOLLOW

**Report Information**
1. Name: **James O'Neill**
Email: James.Oneill@ghd.com
2. Name: datanl
Email: datanl@ghd.com

**Report Format**
☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

**Turnaround Time Required (TAT)**
Regular TAT ☑ 5 to 7 working days
Rush TAT ☐ 1 day ☐ 2 days ☐ 3 days
Date Required:

**Invoice To** Same Yes ☑ / No ☐
Company:
Contact:
Address:
Phone: Fax:

**Regulatory Requirements** (Check):
☐ List Guidelines on Report ☑ Do Not List Guidelines on Report
☐ PIRI
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube
☐ CCME ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

Drinking Water Sample: ☐ Yes ☑ No
Reg. No.:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS - SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: MERCURY (Hg) | OTHER: | OTHER: | HOLD FOR POSS. LEAHATE | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MSBL-BH1-2018-SS6 | 2018/04/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSBL-BH1-2018-SS7 | 2018/04/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSBL-BH2-2018-SS5 | 2018/04/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSBL-BH2-2018-SS6 | 2018/04/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSBL-BH3-2018-SS4 | 2018/04/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSBL-BH3-2018-SS5 | 2018/04/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSBL-BH5-2018-SS7 1 / 2 | 2018/04/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSBL-BH5-2018-SS5 | 2018/04/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSBL-BH5-2018-SS6 | 2018/04/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSBL-MW2-2018-SS1 | 2018/04/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |

Samples Relinquished By (Print Name): Hubert Anderson
Date/Time: 2018/10/10
Samples Relinquished By (Sign): H. Anderson
Date/Time: 08:00
Samples Received By (Print Name): Emma Penney
Date/Time: Oct. 10/18
Samples Received By (Sign): [illegible]
Date/Time: 2:32 pm

Page 1 of 1

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| | |
|---|---|
| CLIENT NAME: | GHD LIMITED<br>1118 TOPSAIL ROAD<br>ST. JOHN'S , NL A1B3N7<br>(709) 364-5353 |
| ATTENTION TO: | JAMES O'NEILL |
| PROJECT: | 11178792-02 |
| AGAT WORK ORDER: | 18K395696 |
| SOIL ANALYSIS REVIEWED BY: | Jason Coughtrey, Inorganics Supervisor |
| TRACE ORGANICS REVIEWED BY: | Amy Hunter, Trace Organics Supervisor, B.Sc. |
| DATE REPORTED: | Oct 18, 2018 |
| PAGES (INCLUDING COVER): | 12 |
| VERSION*: | 1 |

Should you require any information regarding this analysis please contact your client services representative at (709)747-8573

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

# Certificate of Analysis

AGAT WORK ORDER: 18K395696

PROJECT: 11178792-02

57 Old Pennywell Road, Unit I
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FAX (709 747-2139
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CLIENT NAME: GHD LIMITED

SAMPLING SITE:

ATTENTION TO: JAMES O'NEILL

SAMPLED BY:

## Available Metals in Soil

DATE RECEIVED: 2018-10-10

DATE REPORTED: 2018-10-18

| Parameter | Unit | G / S | RDL | 9615869 | 9615873 | 9615880 | 9615882 | 9615883 | 9615884 | 9615885 | 9615886 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE DESCRIPTION: | MLLA-MW3-2018-SS1 | MLLA-MW3-2018-SS2 | MLLA-MW4-2018-SS1 | MLLA-MW4-2018-SS2 | MLLA-BH2-2018-SS1 | MLLA-BH2-2018-SS2 | MLLA-BH1-2018-SS1 | MLLA-BH1-2018-SS2 |
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 |
| Aluminum | mg/kg | | 10 | 7260 | 5750 | 5490 | 2000 | 7240 | 2390 | 6240 | 5120 |
| Antimony | mg/kg | | 1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Arsenic | mg/kg | | 1 | 8 | 12 | 13 | 23 | 18 | 9 | 11 | 9 |
| Barium | mg/kg | | 5 | 124 | 80 | 219 | 155 | 152 | 50 | 56 | 76 |
| Beryllium | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Boron | mg/kg | | 2 | <2 | <2 | <2 | 2 | 2 | <2 | <2 | <2 |
| Cadmium | mg/kg | | 0.3 | 0.7 | <0.3 | 0.3 | <0.3 | 0.5 | <0.3 | <0.3 | <0.3 |
| Chromium | mg/kg | | 2 | 33 | 20 | 35 | 26 | 14 | 8 | 15 | 11 |
| Cobalt | mg/kg | | 1 | 15 | 16 | 23 | 30 | 9 | 7 | 13 | 9 |
| Copper | mg/kg | | 2 | 70 | 28 | 68 | 69 | 16 | 11 | 22 | 18 |
| Iron | mg/kg | | 50 | 29900 | 27100 | 38600 | 23600 | 17900 | 7800 | 22400 | 12700 |
| Lead | mg/kg | | 0.5 | 77.0 | 10.2 | 29.4 | 6.3 | 13.3 | 7.5 | 11.0 | 7.6 |
| Lithium | mg/kg | | 5 | 10 | 9 | 10 | <5 | 9 | <5 | 9 | 7 |
| Manganese | mg/kg | | 2 | 1290 | 1680 | 2400 | 2940 | 1130 | 992 | 811 | 1740 |
| Molybdenum | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Nickel | mg/kg | | 2 | 23 | 17 | 26 | 29 | 12 | 7 | 14 | 11 |
| Selenium | mg/kg | | 1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Silver | mg/kg | | 0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Strontium | mg/kg | | 5 | 13 | 15 | 15 | 28 | 19 | 19 | 14 | 19 |
| Thallium | mg/kg | | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Uranium | mg/kg | | 0.1 | 0.3 | 0.3 | 0.3 | 0.2 | 0.5 | 0.2 | 0.3 | 0.3 |
| Vanadium | mg/kg | | 2 | 45 | 52 | 80 | 80 | 37 | 21 | 44 | 28 |
| Zinc | mg/kg | | 5 | 231 | 81 | 154 | 84 | 79 | 32 | 63 | 55 |

Certified By: Jason Coughtrey

AGAT Laboratories

# Certificate of Analysis

AGAT WORK ORDER: 18K395696

PROJECT: 11178792-02

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CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Available Metals in Soil

DATE RECEIVED: 2018-10-10

DATE REPORTED: 2018-10-18

| Parameter | Unit | G / S | RDL | MLLA-MW2-2018-SS1 | MLLA-MW2-2018-SS2 |
|---|---|---|---|---|---|
| | | | SAMPLE DESCRIPTION: | MLLA-MW2-2018-SS1 | MLLA-MW2-2018-SS2 |
| | | | SAMPLE TYPE: | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-03 | 2018-10-03 |
| | | | | 9615899 | 9615940 |
| Aluminum | mg/kg | | 10 | 4900 | 2600 |
| Antimony | mg/kg | | 1 | <1 | <1 |
| Arsenic | mg/kg | | 1 | 16 | 7 |
| Barium | mg/kg | | 5 | 343 | 87 |
| Beryllium | mg/kg | | 2 | <2 | <2 |
| Boron | mg/kg | | 2 | 2 | <2 |
| Cadmium | mg/kg | | 0.3 | 0.3 | <0.3 |
| Chromium | mg/kg | | 2 | 21 | 11 |
| Cobalt | mg/kg | | 1 | 16 | 6 |
| Copper | mg/kg | | 2 | 75 | 18 |
| Iron | mg/kg | | 50 | 25000 | 7650 |
| Lead | mg/kg | | 0.5 | 72.8 | 15.3 |
| Lithium | mg/kg | | 5 | 6 | <5 |
| Manganese | mg/kg | | 2 | 1520 | 1150 |
| Molybdenum | mg/kg | | 2 | <2 | <2 |
| Nickel | mg/kg | | 2 | 25 | 7 |
| Selenium | mg/kg | | 1 | <1 | <1 |
| Silver | mg/kg | | 0.5 | <0.5 | <0.5 |
| Strontium | mg/kg | | 5 | 21 | 25 |
| Thallium | mg/kg | | 0.1 | <0.1 | <0.1 |
| Tin | mg/kg | | 2 | <2 | <2 |
| Uranium | mg/kg | | 0.1 | 0.3 | 0.2 |
| Vanadium | mg/kg | | 2 | 34 | 21 |
| Zinc | mg/kg | | 5 | 236 | 48 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9615869-9615940 Results are based on the dry weight of the sample.

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

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# Certificate of Analysis

AGAT WORK ORDER: 18K395696
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Mercury Analysis in Soil

DATE RECEIVED: 2018-10-10
DATE REPORTED: 2018-10-18

| | | | SAMPLE DESCRIPTION: | MLLA-MW3-2018-SS1 | MLLA-MW3-2018-SS2 | MLLA-MW4-2018-SS1 | MLLA-MW4-2018-SS2 | MLLA-BH2-2018-SS1 | MLLA-BH2-2018-SS2 | MLLA-BH1-2018-SS1 | MLLA-BH1-2018-SS2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 |
| Parameter | Unit | G / S | RDL | 9615869 | 9615873 | 9615880 | 9615882 | 9615883 | 9615884 | 9615885 | 9615886 |
| Mercury | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |

| | | | SAMPLE DESCRIPTION: | MLLA-MW2-2018-SS1 | MLLA-MW2-2018-SS2 |
|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-03 | 2018-10-03 |
| Parameter | Unit | G / S | RDL | 9615899 | 9615940 |
| Mercury | mg/kg | | 0.05 | <0.05 | 0.06 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9615869-9615940 Results are based on the dry weight of the soil.
Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

AGAT Laboratories

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# Certificate of Analysis

AGAT WORK ORDER: 18K395696
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
SAMPLING SITE:

ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved

DATE RECEIVED: 2018-10-10

DATE REPORTED: 2018-10-18

| | | | SAMPLE DESCRIPTION: | MLLA-MW1-2018-SS4 | MLLA-MW1-2018-SS6 | MLLA-MW2-2018-SS5 | MLLA-MW2-2018-SS7 | MLLA-MW3-2018-SS6 | MLLA-MW3-2018-SS7 | MLLA-MW3-2018-SS8 | MLLA-BH1-2018-SS5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 |
| Parameter | Unit | G / S | RDL | 9615862 | 9615864 | 9615865 | 9615866 | 9615875 | 9615876 | 9615877 | 9615898 |
| Benzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | <3 | <3 | <3 | <3 | <3 | 24 | <3 | <3 |
| >C10-C16 Hydrocarbons | mg/kg | | 15 | <15 | <15 | 122 | <15 | 332 | 2650 | 132 | <15 |
| >C16-C21 Hydrocarbons | mg/kg | | 15 | <15 | <15 | 160 | <15 | 260 | 1680 | 102 | <15 |
| >C21-C32 Hydrocarbons | mg/kg | | 15 | 29 | <15 | 695 | <15 | 52 | 334 | 18 | <15 |
| Modified TPH (Tier 1) | mg/kg | | 20 | 29 | <20 | 977 | <20 | 644 | 4690 | 252 | <20 |
| Resemblance Comment | | | | LOF | NR | WFOF+LOF | NR | WFOF | WFOF | WFOF | NR |
| Return to Baseline at C32 | | | | Y | Y | Y | Y | Y | Y | Y | Y |
| Surrogate | Unit | Acceptable Limits | | | | | | | | | |
| Isobutylbenzene - EPH | % | 60-140 | | 93 | 92 | 91 | 68 | 97 | 104 | 93 | 90 |
| Isobutylbenzene - VPH | % | 60-140 | | 73 | 70 | 90 | 108 | 108 | 76 | 118 | 105 |
| n-Dotriacontane - EPH | % | 60-140 | | 106 | 100 | 79 | 66 | 96 | 103 | 98 | 95 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9615862-9615898 Results are based on the dry weight of the soil.

Resemblance Comment Key:
GF - Gasoline Fraction
WGF - Weathered Gasoline Fraction
GR - Product in Gasoline Range
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
FR - Product in Fuel Oil Range
LOF - Lube Oil Fraction
LR - Lube Range
UC - Unidentified Compounds
NR - No Resemblance
NA - Not Applicable

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

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http://www.agatlabs.com

# Certificate of Analysis

AGAT WORK ORDER: 18K395696
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
SAMPLING SITE:

ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Moisture

DATE RECEIVED: 2018-10-10

DATE REPORTED: 2018-10-18

| Parameter | Unit | G / S | RDL | MLLA-MW1-2018-SS4 | MLLA-MW1-2018-SS6 | MLLA-MW2-2018-SS5 | MLLA-MW2-2018-SS7 | MLLA-MW3-2018-SS6 | MLLA-MW3-2018-SS7 | MLLA-MW3-2018-SS8 | MLLA-BH1-2018-SS5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
| DATE SAMPLED: | | | | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 | 2018-10-03 |
| | | | | 9615862 | 9615864 | 9615865 | 9615866 | 9615875 | 9615876 | 9615877 | 9615898 |
| % Moisture | % | | 0 | 13 | 14 | 8 | 12 | 19 | 13 | 19 | 6 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

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AGAT Laboratories

# Quality Assurance

CLIENT NAME: GHD LIMITED

PROJECT: 11178792-02

SAMPLING SITE:

AGAT WORK ORDER: 18K395696

ATTENTION TO: JAMES O'NEILL

SAMPLED BY:

## Soil Analysis

| RPT Date: Oct 18, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Available Metals in Soil | | | | | | | | | | | | | | | |
| Aluminum | 9615940 | 9615940 | 3830 | 3410 | 11.6% | < 10 | 118% | 80% | 120% | 114% | 80% | 120% | NA | 70% | 130% |
| Antimony | 9615940 | 9615940 | <1 | <1 | NA | < 1 | 102% | 80% | 120% | 116% | 80% | 120% | 70% | 70% | 130% |
| Arsenic | 9615940 | 9615940 | 7 | 6 | 15.4% | < 1 | 101% | 80% | 120% | 102% | 80% | 120% | 98% | 70% | 130% |
| Barium | 9615940 | 9615940 | 87 | 73 | 17.5% | < 5 | 99% | 80% | 120% | 101% | 80% | 120% | 111% | 70% | 130% |
| Beryllium | 9615940 | 9615940 | <2 | <2 | NA | < 2 | 111% | 80% | 120% | 114% | 80% | 120% | 106% | 70% | 130% |
| Boron | 9615940 | 9615940 | <2 | 6 | NA | < 2 | 116% | 80% | 120% | 115% | 80% | 120% | 101% | 70% | 130% |
| Cadmium | 9615940 | 9615940 | <0.3 | <0.3 | NA | < 0.3 | 99% | 80% | 120% | 101% | 80% | 120% | 99% | 70% | 130% |
| Chromium | 9615940 | 9615940 | 11 | 8 | NA | < 2 | 103% | 80% | 120% | 104% | 80% | 120% | 129% | 70% | 130% |
| Cobalt | 9615940 | 9615940 | 6 | 5 | 18.2% | < 1 | 100% | 80% | 120% | 101% | 80% | 120% | 107% | 70% | 130% |
| Copper | 9615940 | 9615940 | 18 | 15 | 18.2% | < 2 | 106% | 80% | 120% | 106% | 80% | 120% | 100% | 70% | 130% |
| Iron | 9615940 | 9615940 | 8430 | 7110 | 17.0% | < 50 | 102% | 80% | 120% | 116% | 80% | 120% | 70% | 70% | 130% |
| Lead | 9615940 | 9615940 | 15.3 | 11.2 | 30.9% | < 0.5 | 106% | 80% | 120% | 107% | 80% | 120% | 93% | 70% | 130% |
| Lithium | 9615940 | 9615940 | <5 | <5 | NA | < 5 | 111% | 70% | 130% | 115% | 70% | 130% | 115% | 70% | 130% |
| Manganese | 9615940 | 9615940 | 1150 | 873 | 27.4% | < 2 | 118% | 80% | 120% | 119% | 80% | 120% | 111% | 70% | 130% |
| Molybdenum | 9615940 | 9615940 | <2 | <2 | NA | < 2 | 100% | 80% | 120% | 104% | 80% | 120% | 101% | 70% | 130% |
| Nickel | 9615940 | 9615940 | 7 | 33 | NA | < 2 | 101% | 80% | 120% | 104% | 80% | 120% | NA | 70% | 130% |
| Selenium | 9615940 | 9615940 | <1 | <1 | NA | < 1 | 100% | 80% | 120% | 103% | 80% | 120% | 87% | 70% | 130% |
| Silver | 9615940 | 9615940 | <0.5 | <0.5 | NA | < 0.5 | 103% | 80% | 120% | 105% | 80% | 120% | 98% | 70% | 130% |
| Strontium | 9615940 | 9615940 | 25 | 22 | NA | < 5 | 114% | 80% | 120% | 116% | 80% | 120% | 130% | 70% | 130% |
| Thallium | 9615940 | 9615940 | <0.1 | <0.1 | NA | < 0.1 | 103% | 80% | 120% | 103% | 80% | 120% | NA | 70% | 130% |
| Tin | 9615940 | 9615940 | <2 | <2 | NA | < 2 | 101% | 80% | 120% | 100% | 80% | 120% | 96% | 70% | 130% |
| Uranium | 9615940 | 9615940 | 0.2 | 0.2 | NA | < 0.1 | 102% | 80% | 120% | 101% | 80% | 120% | 99% | 70% | 130% |
| Vanadium | 9615940 | 9615940 | 21 | 18 | 15.4% | < 2 | 101% | 80% | 120% | 102% | 80% | 120% | 113% | 70% | 130% |
| Zinc | 9615940 | 9615940 | 48 | 54 | 11.8% | < 5 | 101% | 80% | 120% | 101% | 80% | 120% | 95% | 70% | 130% |
| Mercury Analysis in Soil | | | | | | | | | | | | | | | |
| Mercury | 1 | 9615884 | <0.05 | <0.05 | NA | < 0.05 | 115% | 70% | 130% | | 70% | 130% | 105% | 70% | 130% |

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K395696
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Trace Organics Analysis

| RPT Date: Oct 18, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits | | Recovery | Acceptable Limits | | Recovery | Acceptable Limits | |
| | | | | | | | | Lower | Upper | | Lower | Upper | | Lower | Upper |
| Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved | | | | | | | | | | | | | | | |
| Benzene | 1 | 9615862 | < 0.03 | < 0.03 | NA | < 0.03 | 100% | 60% | 140% | 103% | 60% | 140% | | | |
| Toluene | 1 | 9615862 | < 0.04 | < 0.04 | NA | < 0.04 | 110% | 60% | 140% | 108% | 60% | 140% | | | |
| Ethylbenzene | 1 | 9615862 | < 0.03 | < 0.03 | NA | < 0.03 | 108% | 60% | 140% | 105% | 60% | 140% | | | |
| Xylene (Total) | 1 | 9615862 | < 0.05 | < 0.05 | NA | < 0.05 | 119% | 60% | 140% | 107% | 60% | 140% | | | |
| C6-C10 (less BTEX) | 1 | 9615862 | < 3 | < 3 | NA | < 3 | 116% | 60% | 140% | 122% | 60% | 140% | NA | 30% | 130% |
| >C10-C16 Hydrocarbons | 1 | 9616181 | < 15 | < 15 | NA | < 15 | 103% | 60% | 140% | 94% | 60% | 140% | 108% | 30% | 130% |
| >C16-C21 Hydrocarbons | 1 | 9616181 | < 15 | < 15 | NA | < 15 | 98% | 60% | 140% | 94% | 60% | 140% | 108% | 30% | 130% |
| >C21-C32 Hydrocarbons | 1 | 9616181 | 20 | 18 | NA | < 15 | 97% | 60% | 140% | 94% | 60% | 140% | 108% | 30% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K395696
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Soil Analysis | | | |
| Aluminum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Antimony | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Arsenic | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Barium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Beryllium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Boron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cadmium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Chromium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cobalt | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Copper | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Iron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Lead | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Lithium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Manganese | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Molybdenum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Nickel | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Selenium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Silver | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Strontium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Thallium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Tin | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Uranium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Vanadium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Zinc | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Mercury | INOR-121-6101 & INOR-121-6107 | Based on EPA 245.5 & SM 3112B | CV/AA |

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:
AGAT WORK ORDER: 18K395696
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Trace Organics Analysis | | | |
| Benzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Toluene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Ethylbenzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Xylene (Total) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| C6-C10 (less BTEX) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| >C10-C16 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C16-C21 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C21-C32 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Modified TPH (Tier 1) | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | CALCULATION |
| Resemblance Comment | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| Return to Baseline at C32 | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - VPH | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| n-Dotriacontane - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| % Moisture | | Calculation | GRAVIMETRIC |

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# AGAT Laboratories

## Chain of Custody Record

**Laboratory Use Only**

Arrival Condition: ☑ Good ☐ Poor (see notes)
Arrival Temperature: 2.0 | 1.4 | 3.3 °C
AGAT Job Number: 18K395696
Notes:

### Report Information

Company: GHD Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone: 1-709-364-5353 Fax: 1-709-364-5368
**Site # and/or Name:** MARYSTOWN SHIPYARD - MLLA
Project #: 11178792-02
**AGAT Quotation #:** GHD Standing Offer
**GHD PO #:** TO FOLLOW

### Report Information

1. Name: **James O'Neill**
   Email: James.Oneill@ghd.com
2. Name: datanl
   Email: datanl@ghd.com

**Report Format**

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

**Turnaround Time Required (TAT)**

**Regular TAT** ☑ 5 to 7 working days
**Rush TAT** ☐ 1 day ☐ 2 days ☐ 3 days
Date Required:

**Drinking Water Sample:** ☐ Yes ☑ No
Reg. No.:

### Invoice To

Same Yes ☑ / No ☐

Company:
Contact:
Address:
Phone: Fax:

**Regulatory Requirements** (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ **PIRI**
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☐ **CCME** ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: MERCURY (Hg) | OTHER: | OTHER: | HOLD FOR POSS. LEAHATE | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MLLA-MW1-2018-SS4 | 2018/03/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MLLA-MW1-2018-SS6 | 2018/03/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MLLA-MW2-2018-SS5 | 2018/03/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MLLA-MW2-2018-SS7 | 2018/03/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MLLA-MW3-2018-SS1 | 2018/03/10 00:00 | Soil | 1 X 60 ML | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MLLA-MW3-2018-SS2 | 2018/03/10 00:00 | Soil | 1 X 60 ML | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MLLA-MW3-2018-SS6 | 2018/03/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MLLA-MW3-2018-SS7 | 2018/03/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MLLA-MW3-2018-SS8 | 2018/03/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MLLA-MW4-2018-SS1 | 2018/03/10 00:00 | Soil | 1 X 60 ML | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MLLA-MW4-2018-SS2 | 2018/03/10 00:00 | Soil | 1 X 60 ML | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |

| Samples Relinquished By (Print Name): | Date/Time | Samples Received By (Print Name): | Date/Time |
|---|---|---|---|
| Hubert Anderson | 2018/10/10 | Emma Kenney | Oct 10/18 |
| Samples Relinquished By (Sign): H. Anderson | Date/Time: 8:00 | Samples Received By (Sign): [signature] | Date/Time: 2:32 pm |

Page 1 of 2

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AGAT Laboratories

# Chain of Custody Record

## Laboratory Use Only

Arrival Condition: ☑ Good ☐ Poor (see notes)
Arrival Temperature:
AGAT Job Number:
Notes:

## Report Information

Company: GHD Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone 1-709-364-5353 Fax: 1-709-364-5368
Site # and/or Name: MARYSTOWN SHIPYARD - MLLA
Project #: 11178792-02
AGAT Quotation #: GHD Standing Offer
GHD PO #: TO FOLLOW

## Report Information

1. Name: **James O'Neill**
   Email: James.Oneill@ghd.com
2. Name: datanl
   Email: datanl@ghd.oom

## Report Format

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

## Turnaround Time Required (TAT)

**Regular TAT** ☑ 5 to 7 working days
**Rush TAT** ☐ 1 day ☐ 2 days ☐ 3 days
Date Required:

## Invoice To

Same Yes ☑ / No ☐
Company:
Contact:
Address:
Phone: Fax:

## Regulatory Requirements (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ **PIRI**
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☐ **CCME** ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

Drinking Water Sample: ☐ Yes ☑ No
Reg. No.:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: MERCURY (Hg) | OTHER: | OTHER: | HOLD FOR POSS. LEAHATE | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MLLA-BH2-2018-SS1 | 2018/03/10 00:00 | Soil | 1 X 60 ML | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MLLA-BH2-2018-SS2 | 2018/03/10 00:00 | Soil | 1 X 60 ML | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MLLA-BH1-2018-SS1 | 2018/03/10 00:00 | Soil | 1 X 60 ML | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MLLA-BH1-2018-SS2 | 2018/03/10 00:00 | Soil | 1 X 60 ML | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MLLA-BH1-2018-SS5 | 2018/03/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MLLA-MN2-2018-SS1 | 2018/03/10 | SOIL | 1 X 60 ML | 1 | | | | | | X | | | | | | X | | | X | | | | | | | | |
| MLLA-MW2-2018-SS2 | 2018/03/10 | SOIL | 1 X 60 ML | 1 | | | | | | X | | | | | | X | | | X | | | | | | | | |
| X | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| X | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| X | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| X | | | | | | | | | | | | | | | | | | | | | | | | | | | |

| Samples Relinquished By (Print Name): | Date/Time | Samples Received By (Print Name): | Date/Time |
|---|---|---|---|
| Hubert Anderson | 2018/10/10 | Emma Penney | Oct 10/18 |
| Samples Relinquished By (Sign): H. Anderson | Date/Time 08:00 | Samples Received By (Sign): | Date/Time 2:32 pm |

Page 2 of 2

Document ID: DIV-133-1502.001

Date revised: September 18, 2015

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| | |
|---|---|
| CLIENT NAME: | GHD LIMITED<br>1118 TOPSAIL ROAD<br>ST. JOHN'S , NL A1B3N7<br>(709) 364-5353 |
| ATTENTION TO: | JAMES O'NEILL |
| PROJECT: | 11178792-02 |
| AGAT WORK ORDER: | 18K395584 |
| SOIL ANALYSIS REVIEWED BY: | Jason Coughtrey, Inorganics Supervisor |
| TRACE ORGANICS REVIEWED BY: | Amy Hunter, Trace Organics Supervisor, B.Sc. |
| DATE REPORTED: | Oct 20, 2018 |
| PAGES (INCLUDING COVER): | 12 |
| VERSION*: | 1 |

Should you require any information regarding this analysis please contact your client services representative at (709)747-8573

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

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# Certificate of Analysis

AGAT WORK ORDER: 18K395584
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
SAMPLING SITE:
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Available Metals in Soil

DATE RECEIVED: 2018-10-10
DATE REPORTED: 2018-10-20

| | | | SAMPLE DESCRIPTION: | MAEB-MW2-2018-SS1 | MAEB-MW2-2018-SS2 |
|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-02 | 2018-10-02 |
| Parameter | Unit | G / S | RDL | 9614901 | 9614902 |
| Aluminum | mg/kg | | 10 | 27300 | 31600 |
| Antimony | mg/kg | | 1 | <1 | <1 |
| Arsenic | mg/kg | | 1 | 6 | 8 |
| Barium | mg/kg | | 5 | 30 | 34 |
| Beryllium | mg/kg | | 2 | <2 | <2 |
| Boron | mg/kg | | 2 | 2 | 2 |
| Cadmium | mg/kg | | 0.3 | <0.3 | <0.3 |
| Chromium | mg/kg | | 2 | 76 | 89 |
| Cobalt | mg/kg | | 1 | 27 | 30 |
| Copper | mg/kg | | 2 | 66 | 87 |
| Iron | mg/kg | | 50 | 34800 | 36700 |
| Lead | mg/kg | | 0.5 | 33.6 | 38.6 |
| Lithium | mg/kg | | 5 | 11 | 13 |
| Manganese | mg/kg | | 2 | 1210 | 1370 |
| Molybdenum | mg/kg | | 2 | <2 | <2 |
| Nickel | mg/kg | | 2 | 59 | 59 |
| Selenium | mg/kg | | 1 | <1 | <1 |
| Silver | mg/kg | | 0.5 | <0.5 | <0.5 |
| Strontium | mg/kg | | 5 | 42 | 62 |
| Thallium | mg/kg | | 0.1 | <0.1 | <0.1 |
| Tin | mg/kg | | 2 | <2 | <2 |
| Uranium | mg/kg | | 0.1 | 0.3 | 0.3 |
| Vanadium | mg/kg | | 2 | 92 | 100 |
| Zinc | mg/kg | | 5 | 329 | 311 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9614901-9614902 Results are based on the dry weight of the sample.
Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

AGAT Laboratories

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AGAT WORK ORDER: 18K395584
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
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ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Mercury Analysis in Soil

DATE RECEIVED: 2018-10-10

DATE REPORTED: 2018-10-20

| | | | SAMPLE DESCRIPTION: | MAEB-MW2-2018-SS1 | MAEB-MW2-2018-SS2 |
|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-02 | 2018-10-02 |
| Parameter | Unit | G / S | RDL | 9614901 | 9614902 |
| Mercury | mg/kg | | 0.05 | <0.05 | <0.05 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9614901-9614902 Results are based on the dry weight of the soil.
Analysis performed at AGAT Halifax (unless marked by *)

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Results relate only to the items tested and to all the items tested

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CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

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## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved

DATE RECEIVED: 2018-10-10

DATE REPORTED: 2018-10-20

| | | | SAMPLE DESCRIPTION: | MAEB-MW1-2018-SS1 | MAEB-MW1-2018-SS2 | MAEB-BH1-2018-SS2 | MAEB-BH1-2018-SS4 | MAEB-BH2-2018-SS2 | MAEB-BH2-2018-SS4 | MAEB-MW2-2018-SS4 | MAEB-MW2-2018-SS5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 |
| Parameter | Unit | G / S | RDL | 9614892 | 9614893 | 9614894 | 9614895 | 9614896 | 9614897 | 9614898 | 9614899 |
| Benzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | <3 | <3 | <3 | <3 | <3 | <3 | 9 | <3 |
| >C10-C16 Hydrocarbons | mg/kg | | 15 | <15 | <15 | 98 | <15 | <15 | <15 | 2910 | <15 |
| >C16-C21 Hydrocarbons | mg/kg | | 15 | <15 | <15 | 122 | <15 | <15 | <15 | 2010 | <15 |
| >C21-C32 Hydrocarbons | mg/kg | | 15 | 84 | 30 | 74 | 15 | <15 | <15 | 305 | <15 |
| Modified TPH (Tier 1) | mg/kg | | 20 | 84 | 30 | 294 | <20 | <20 | <20 | 5230 | <20 |
| Resemblance Comment | | | | LOF | LOF | FOF+LOF | LOF | NR | NR | FOF | NR |
| Return to Baseline at C32 | | | | Y | Y | Y | Y | Y | Y | Y | Y |
| Surrogate | Unit | Acceptable Limits | | | | | | | | | |
| Isobutylbenzene - EPH | % | 60-140 | | 84 | 89 | 82 | 87 | 86 | 92 | 97 | 92 |
| Isobutylbenzene - VPH | % | 60-140 | | 120 | 117 | 120 | 116 | 93 | 110 | 98 | 105 |
| n-Dotriacontane - EPH | % | 60-140 | | 86 | 86 | 82 | 88 | 83 | 88 | 74 | 89 |

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CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved

DATE RECEIVED: 2018-10-10

DATE REPORTED: 2018-10-20

| | | | SAMPLE DESCRIPTION: | MAEB-MW2-2018-DUP01 |
|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil |
| | | | DATE SAMPLED: | 2018-10-02 |
| Parameter | Unit | G / S | RDL | 9614900 |
| Benzene | mg/kg | | 0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | 4 |
| >C10-C16 Hydrocarbons | mg/kg | | 15 | 573 |
| >C16-C21 Hydrocarbons | mg/kg | | 15 | 460 |
| >C21-C32 Hydrocarbons | mg/kg | | 15 | 140 |
| Modified TPH (Tier 1) | mg/kg | | 20 | 1180 |
| Resemblance Comment | | | | FOF |
| Return to Baseline at C32 | | | | Y |
| Surrogate | Unit | Acceptable Limits | | |
| Isobutylbenzene - EPH | % | 60-140 | | 93 |
| Isobutylbenzene - VPH | % | 60-140 | | 108 |
| n-Dotriacontane - EPH | % | 60-140 | | 92 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9614892-9614900 Results are based on the dry weight of the soil.

Resemblance Comment Key:
GF - Gasoline Fraction
WGF - Weathered Gasoline Fraction
GR - Product in Gasoline Range
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
FR - Product in Fuel Oil Range
LOF - Lube Oil Fraction
LR - Lube Range
UC - Unidentified Compounds
NR - No Resemblance
NA - Not Applicable

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

# Certificate of Analysis

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CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Moisture

DATE RECEIVED: 2018-10-10
DATE REPORTED: 2018-10-20

| Parameter | Unit | G / S | RDL | MAEB-MW1-2018-SS1 | MAEB-MW1-2018-SS2 | MAEB-BH1-2018-SS2 | MAEB-BH1-2018-SS4 | MAEB-BH2-2018-SS2 | MAEB-BH2-2018-SS4 | MAEB-MW2-2018-SS4 | MAEB-MW2-2018-SS5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
| DATE SAMPLED: | | | | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 |
| | | | | 9614892 | 9614893 | 9614894 | 9614895 | 9614896 | 9614897 | 9614898 | 9614899 |
| % Moisture | % | | 0 | 7 | 12 | 12 | 13 | 11 | 9 | 12 | 12 |

| Parameter | Unit | G / S | RDL | MAEB-MW2-2018-DUP01 |
|---|---|---|---|---|
| SAMPLE TYPE: | | | | Soil |
| DATE SAMPLED: | | | | 2018-10-02 |
| | | | | 9614900 |
| % Moisture | % | | 0 | 15 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K395584
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Soil Analysis

| RPT Date: Oct 20, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits | | Recovery | Acceptable Limits | | Recovery | Acceptable Limits | |
| | | | | | | | | Lower | Upper | | Lower | Upper | | Lower | Upper |
| Available Metals in Soil | | | | | | | | | | | | | | | |
| Aluminum | 9615940 | | 3830 | 3410 | 11.7% | < 10 | 118% | 80% | 120% | 114% | 80% | 120% | NA | 70% | 130% |
| Antimony | 9615940 | | <1 | <1 | NA | < 1 | 102% | 80% | 120% | 116% | 80% | 120% | 70% | 70% | 130% |
| Arsenic | 9615940 | | 7 | 6 | 13.7% | < 1 | 101% | 80% | 120% | 102% | 80% | 120% | 98% | 70% | 130% |
| Barium | 9615940 | | 87 | 73 | 17.3% | < 5 | 99% | 80% | 120% | 101% | 80% | 120% | 111% | 70% | 130% |
| Beryllium | 9615940 | | <2 | <2 | NA | < 2 | 111% | 80% | 120% | 114% | 80% | 120% | 106% | 70% | 130% |
| Boron | 9615940 | | <2 | 6 | NA | < 2 | 116% | 80% | 120% | 115% | 80% | 120% | 101% | 70% | 130% |
| Cadmium | 9615940 | | <0.3 | <0.3 | NA | < 0.3 | 99% | 80% | 120% | 101% | 80% | 120% | 99% | 70% | 130% |
| Chromium | 9615940 | | 11 | 8 | NA | < 2 | 103% | 80% | 120% | 104% | 80% | 120% | 129% | 70% | 130% |
| Cobalt | 9615940 | | 6 | 5 | 8.2% | < 1 | 100% | 80% | 120% | 101% | 80% | 120% | 107% | 70% | 130% |
| Copper | 9615940 | | 18 | 15 | 19.0% | < 2 | 106% | 80% | 120% | 106% | 80% | 120% | 100% | 70% | 130% |
| Iron | 9615940 | | 8430 | 7110 | 17.0% | < 50 | 102% | 80% | 120% | 116% | 80% | 120% | 70% | 70% | 130% |
| Lead | 9615940 | | 15.3 | 11.2 | NA | < 0.5 | 106% | 80% | 120% | 107% | 80% | 120% | 93% | 70% | 130% |
| Lithium | 9615940 | | <5 | <5 | NA | < 5 | 111% | 70% | 130% | 115% | 70% | 130% | 115% | 70% | 130% |
| Manganese | 9615940 | | 1150 | 873 | NA | < 2 | 118% | 80% | 120% | 119% | 80% | 120% | 111% | 70% | 130% |
| Molybdenum | 9615940 | | <2 | <2 | NA | < 2 | 100% | 80% | 120% | 104% | 80% | 120% | 101% | 70% | 130% |
| Nickel | 9615940 | | 7 | 33 | NA | < 2 | 101% | 80% | 120% | 104% | 80% | 120% | NA | 70% | 130% |
| Selenium | 9615940 | | <1 | <1 | NA | < 1 | 100% | 80% | 120% | 103% | 80% | 120% | 87% | 70% | 130% |
| Silver | 9615940 | | <0.5 | <0.5 | NA | < 0.5 | 103% | 80% | 120% | 105% | 80% | 120% | 98% | 70% | 130% |
| Strontium | 9615940 | | 25 | 22 | NA | < 5 | 114% | 80% | 120% | 116% | 80% | 120% | 130% | 70% | 130% |
| Thallium | 9615940 | | <0.1 | <0.1 | NA | < 0.1 | 103% | 80% | 120% | 103% | 80% | 120% | NA | 70% | 130% |
| Tin | 9615940 | | 3 | 4 | NA | < 2 | 101% | 80% | 120% | 100% | 80% | 120% | 96% | 70% | 130% |
| Uranium | 9615940 | | 0.2 | 0.2 | NA | < 0.1 | 102% | 80% | 120% | 101% | 80% | 120% | 99% | 70% | 130% |
| Vanadium | 9615940 | | 21 | 18 | 17.9% | < 2 | 101% | 80% | 120% | 102% | 80% | 120% | 113% | 70% | 130% |
| Zinc | 9615940 | | 48 | 54 | 11.7% | < 5 | 101% | 80% | 120% | 101% | 80% | 120% | 95% | 70% | 130% |
| Mercury Analysis in Soil | | | | | | | | | | | | | | | |
| Mercury | 1 | 9615884 | <0.05 | <0.05 | NA | < 0.05 | 115% | 70% | 130% | | 70% | 130% | 105% | 70% | 130% |

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K395584
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Trace Organics Analysis

| RPT Date: Oct 20, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits | | Recovery | Acceptable Limits | | Recovery | Acceptable Limits | |
| | | | | | | | | Lower | Upper | | Lower | Upper | | Lower | Upper |
| **Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved** | | | | | | | | | | | | | | | |
| Benzene | 1 | 9584397 | < 0.03 | < 0.03 | NA | < 0.03 | 121% | 60% | 140% | 109% | 60% | 140% | | | |
| Toluene | 1 | 9584397 | < 0.04 | < 0.04 | NA | < 0.04 | 128% | 60% | 140% | 114% | 60% | 140% | | | |
| Ethylbenzene | 1 | 9584397 | < 0.03 | < 0.03 | NA | < 0.03 | 122% | 60% | 140% | 105% | 60% | 140% | | | |
| Xylene (Total) | 1 | 9584397 | < 0.05 | < 0.05 | NA | < 0.05 | 126% | 60% | 140% | 107% | 60% | 140% | | | |
| C6-C10 (less BTEX) | 1 | 9584397 | < 3 | < 3 | NA | < 3 | 127% | 60% | 140% | 101% | 60% | 140% | 115% | 30% | 130% |
| >C10-C16 Hydrocarbons | 1 | 9614973 | < 15 | < 15 | NA | < 15 | 126% | 60% | 140% | 95% | 60% | 140% | 96% | 30% | 130% |
| >C16-C21 Hydrocarbons | 1 | 9614973 | < 15 | < 15 | NA | < 15 | 122% | 60% | 140% | 95% | 60% | 140% | 96% | 30% | 130% |
| >C21-C32 Hydrocarbons | 1 | 9614973 | < 15 | < 15 | NA | < 15 | 127% | 60% | 140% | 95% | 60% | 140% | 96% | 30% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Lower | Upper | Recovery | Lower | Upper | Recovery | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved** | | | | | | | | | | | | | | | |
| Benzene | 1 | 9615862 | < 0.03 | < 0.03 | NA | < 0.03 | 100% | 60% | 140% | 103% | 60% | 140% | | | |
| Toluene | 1 | 9615862 | < 0.04 | < 0.04 | NA | < 0.04 | 110% | 60% | 140% | 108% | 60% | 140% | | | |
| Ethylbenzene | 1 | 9615862 | < 0.03 | < 0.03 | NA | < 0.03 | 108% | 60% | 140% | 105% | 60% | 140% | | | |
| Xylene (Total) | 1 | 9615862 | < 0.05 | < 0.05 | NA | < 0.05 | 119% | 60% | 140% | 107% | 60% | 140% | | | |
| C6-C10 (less BTEX) | 1 | 9615862 | < 3 | < 3 | NA | < 3 | 116% | 60% | 140% | 122% | 60% | 140% | NA | 30% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K395584
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Soil Analysis | | | |
| Aluminum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Antimony | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Arsenic | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Barium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Beryllium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Boron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cadmium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Chromium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cobalt | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Copper | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Iron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Lead | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Lithium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Manganese | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Molybdenum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Nickel | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Selenium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Silver | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Strontium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Thallium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Tin | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Uranium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Vanadium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Zinc | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Mercury | INOR-121-6101 & INOR-121-6107 | Based on EPA 245.5 & SM 3112B | CV/AA |

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K395584
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Trace Organics Analysis | | | |
| Benzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Toluene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Ethylbenzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Xylene (Total) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| C6-C10 (less BTEX) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| >C10-C16 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C16-C21 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C21-C32 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Modified TPH (Tier 1) | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | CALCULATION |
| Resemblance Comment | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| Return to Baseline at C32 | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - VPH | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| n-Dotriacontane - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| % Moisture | | Calculation | GRAVIMETRIC |

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B3B 1M2

# AGAT Laboratories

webearth.agatlabs.com ▪ www.agatlabscom

P: 902.468.8718 ▪ F: 902.468.8924



## Chain of Custody Record

### Report Information

Company: GHD Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone 1-709-364-5353 Fax: 1-709-364-5368
**Site # and/or Name:** MARYSTOWN SHIPYARD - MAEB
Project #: 11178792-02
**AGAT Quotation #:** GHD Standing Offer
**GHD PO #:** TO FOLLOW

### Invoice To

Same Yes ☑ / No ☐

Company:
Contact:
Address:
Phone: Fax:

### Report Information

1. Name: **James O'Neill**
Email: James.Oneill@ghd.com
2. Name: datanl
Email: datanl@ghd.oom

### Report Format

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

### Regulatory Requirements (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ **PIRI**
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☐ **CCME** ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

### Laboratory Use Only

Arrival Condition: ☑ Good ☐ Poor (see notes)
Arrival Temperature: 1.1, 3.2, 1.9°c
AGAT Job Number: ~~[illegible]~~
Notes: 18K395584

### Turnaround Time Required (TAT)

**Regular TAT** ☑ 5 to 7 working days
**Rush TAT** ☐ 1 day ☐ 2 days ☐ 3 days
Date Required:

**Drinking Water Sample:** ☐ Yes ☑ No
Reg. No.:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER 1 - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: MERCURY (Hg) | OTHER: | OTHER: | HOLD FOR POSS. LEAHATE | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAEB-MW1-2018-SS1 | 2018/02/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MAEB-MW1-2018-SS2 | 2018/02/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MAEB-BH1-2018-SS2 | 2018/02/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MAEB-BH1-2018-SS4 | 2018/02/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| JP ~~MAEB-BH1-2018-SS1~~ | ~~2018/02/10 00:00~~ | ~~Soil~~ | ~~VARIOUS~~ | ~~3~~ | ~~☑~~ | | | | | | | | | | | | | | | | | | | | | | |
| MAEB-BH2-2018-SS2 | 2018/02/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MAEB-BH2-2018-SS4 | 2018/02/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MAEB-MW2-2018-SS4 | 2018/02/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MAEB-MW2-2018-SS5 | 2018/02/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MAEB-MW2-2018-DUP01 | 2018/02/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MAEB-MW2-2018-SS1 | 2018/02/10 00:00 | Soil | 1 X 60 ML | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |

Samples Relinquished By (Print Name): Hubert Anderson
Date/Time: 2018/10/10
Samples Relinquished By (Sign): H. Anderson
Date/Time: 08:00
Samples Received By (Print Name): Emma Penney
Date/Time: Oct. 10/18
Samples Received By (Sign): [signature]
Date/Time: 2:32 pm

Page 1 of 2

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AGAT Laboratories

# Chain of Custody Record

**Laboratory Use Only**

Arrival Condition: ☑ Good ☐ Poor (see notes)
Arrival Temperature: 1.1, 3.2 1.9°c
AGAT Job Number: 18K395584
Notes:

## Report Information

Company: GHD Limited
Contact: James O'Neil
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone 1-709-364-5353 Fax: 1-709-364-5368
**Site # and/or Name:** MARYSTOWN SHIPYARD - MAEB
Project #: 11178792-02
**AGAT Quotation #:** GHD Standing Offer
**GHD PO #:** TO FOLLOW

**Report Information**

1. Name: **James O'Neill**
Email: James.Oneill@ghd.com
2. Name: datanl
Email: datanl@ghd.oom

**Report Format**

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

**Turnaround Time Required (TAT)**

**Regular TAT** ☑ 5 to 7 working days
**Rush TAT** ☐ 1 day ☐ 2 days ☐ 3 days
Date Required:

**Invoice To** Same Yes ☑ / No ☐

Company:
Contact:
Address:
Phone: Fax:

**Regulatory Requirements** (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ **PIRI**
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☐ **CCME** ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

**Drinking Water Sample:** ☐ Yes ☑ No
Reg. No.:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER 1 - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: MERCUREY (HG) | OTHER: | OTHER: | HOLD FOR POSS. LEACHATE | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAEB-MW2-2018-SS2 | 2018/02/10 00:00 | Soil | 1 X 60 ML | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |

| Samples Relinquished By (Print Name): | Date/Time | Samples Received By (Print Name): | Date/Time |
|---|---|---|---|
| Hubert Anderson | 2018/10/10 | Emma Penney | Oct 10/18 |
| Samples Relinquished By (Sign): H. Anderson | Date/Time 08:00 | Samples Received By (Sign): [signature] | Date/Time 2:32 pm |

Page 2 of 2

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| | |
|---|---|
| CLIENT NAME: | GHD LIMITED<br>1118 TOPSAIL ROAD<br>ST. JOHN'S , NL A1B3N7<br>(709) 364-5353 |
| ATTENTION TO: | JAMES O'NEILL |
| PROJECT: | 11178792-02 |
| AGAT WORK ORDER: | 18K395586 |
| SOIL ANALYSIS REVIEWED BY: | Jason Coughtrey, Inorganics Supervisor |
| TRACE ORGANICS REVIEWED BY: | Amy Hunter, Trace Organics Supervisor, B.Sc. |
| DATE REPORTED: | Oct 19, 2018 |
| PAGES (INCLUDING COVER): | 10 |
| VERSION*: | 1 |

Should you require any information regarding this analysis please contact your client services representative at (709)747-8573

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

AGAT Laboratories

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# Certificate of Analysis

AGAT WORK ORDER: 18K395586
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
SAMPLING SITE:
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Available Metals in Soil

DATE RECEIVED: 2018-10-10
DATE REPORTED: 2018-10-19

| Parameter | Unit | G / S | RDL | MDSA-MW1-2018-SS1 | MDSA-MW1-2018-SS2 |
|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Soil | Soil |
| DATE SAMPLED: | | | | 2018-10-02 | 2018-10-02 |
| | | | | 9614934 | 9614935 |
| Aluminum | mg/kg | | 10 | 23100 | 19900 |
| Antimony | mg/kg | | 1 | <1 | <1 |
| Arsenic | mg/kg | | 1 | 9 | 9 |
| Barium | mg/kg | | 5 | 53 | 63 |
| Beryllium | mg/kg | | 2 | <2 | <2 |
| Boron | mg/kg | | 2 | <2 | <2 |
| Cadmium | mg/kg | | 0.3 | <0.3 | <0.3 |
| Chromium | mg/kg | | 2 | 64 | 52 |
| Cobalt | mg/kg | | 1 | 25 | 20 |
| Copper | mg/kg | | 2 | 63 | 58 |
| Iron | mg/kg | | 50 | 26300 | 25600 |
| Lead | mg/kg | | 0.5 | 11.9 | 15.6 |
| Lithium | mg/kg | | 5 | 12 | 11 |
| Manganese | mg/kg | | 2 | 1110 | 1160 |
| Molybdenum | mg/kg | | 2 | <2 | <2 |
| Nickel | mg/kg | | 2 | 40 | 31 |
| Selenium | mg/kg | | 1 | <1 | <1 |
| Silver | mg/kg | | 0.5 | <0.5 | <0.5 |
| Strontium | mg/kg | | 5 | 78 | 49 |
| Thallium | mg/kg | | 0.1 | <0.1 | <0.1 |
| Tin | mg/kg | | 2 | 4 | 3 |
| Uranium | mg/kg | | 0.1 | 0.2 | 0.2 |
| Vanadium | mg/kg | | 2 | 87 | 77 |
| Zinc | mg/kg | | 5 | 116 | 121 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9614934-9614935 Results are based on the dry weight of the sample.
Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

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# Certificate of Analysis

AGAT WORK ORDER: 18K395586

PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Mercury Analysis in Soil

DATE RECEIVED: 2018-10-10

DATE REPORTED: 2018-10-19

| Parameter | Unit | G / S | RDL | MDSA-MW1-2018-SS1 | MDSA-MW1-2018-SS2 |
|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-02 | 2018-10-02 |
| | | | | 9614934 | 9614935 |
| Mercury | mg/kg | | 0.05 | <0.05 | <0.05 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9614934-9614935 Results are based on the dry weight of the soil.

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

AGAT Laboratories

# Certificate of Analysis

AGAT WORK ORDER: 18K395586

PROJECT: 11178792-02

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CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved

DATE RECEIVED: 2018-10-10

DATE REPORTED: 2018-10-19

| | | | SAMPLE DESCRIPTION: | MDSA-MW2-2018-SS4 | MDSA-MW2-2018-SS5 | MDSA-BH4-2018-SS4 | MDSA-BH4-2018-SS5 |
|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 |
| Parameter | Unit | G / S | RDL | 9614936 | 9614937 | 9614938 | 9614939 |
| Benzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | <3 | <3 | <3 | <3 |
| >C10-C16 Hydrocarbons | mg/kg | | 15 | <15 | <15 | <15 | <15 |
| >C16-C21 Hydrocarbons | mg/kg | | 15 | <15 | <15 | <15 | <15 |
| >C21-C32 Hydrocarbons | mg/kg | | 15 | 15 | 22 | 24 | 36 |
| Modified TPH (Tier 1) | mg/kg | | 20 | <20 | 22 | 24 | 36 |
| Resemblance Comment | | | | LR | LR | LR | LR |
| Return to Baseline at C32 | | | | Y | Y | Y | Y |
| Surrogate | Unit | Acceptable Limits | | | | | |
| Isobutylbenzene - EPH | % | 60-140 | | 94 | 90 | 92 | 91 |
| Isobutylbenzene - VPH | % | 60-140 | | 113 | 119 | 125 | 124 |
| n-Dotriacontane - EPH | % | 60-140 | | 91 | 92 | 91 | 94 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9614936-9614939 Results are based on the dry weight of the soil.

Resemblance Comment Key:
GF - Gasoline Fraction
WGF - Weathered Gasoline Fraction
GR - Product in Gasoline Range
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
FR - Product in Fuel Oil Range
LOF - Lube Oil Fraction
LR - Lube Range
UC - Unidentified Compounds
NR - No Resemblance
NA - Not Applicable

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

AGAT Laboratories

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# Certificate of Analysis

AGAT WORK ORDER: 18K395586
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Moisture

DATE RECEIVED: 2018-10-10
DATE REPORTED: 2018-10-19

| Parameter | Unit | G / S | RDL | MDSA-MW2-2018-SS4 | MDSA-MW2-2018-SS5 | MDSA-BH4-2018-SS4 | MDSA-BH4-2018-SS5 |
|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Soil | Soil | Soil | Soil |
| DATE SAMPLED: | | | | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 |
| | | | | 9614936 | 9614937 | 9614938 | 9614939 |
| % Moisture | % | | 0 | 18 | 17 | 10 | 15 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
Analysis performed at AGAT Halifax (unless marked by *)

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K395586
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Soil Analysis

| RPT Date: Oct 19, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Available Metals in Soil | | | | | | | | | | | | | | | |
| Aluminum | 9619456 | | 8860 | 8530 | 3.8% | < 10 | 107% | 80% | 120% | 100% | 80% | 120% | 126% | 70% | 130% |
| Antimony | 9619456 | | <1 | <1 | NA | < 1 | 91% | 80% | 120% | 107% | 80% | 120% | NA | 70% | 130% |
| Arsenic | 9619456 | | 167 | 156 | 6.8% | < 1 | 97% | 80% | 120% | 98% | 80% | 120% | 108% | 70% | 130% |
| Barium | 9619456 | | 127 | 118 | 7.1% | < 5 | 100% | 80% | 120% | 99% | 80% | 120% | 106% | 70% | 130% |
| Beryllium | 9619456 | | <2 | <2 | NA | < 2 | 105% | 80% | 120% | 100% | 80% | 120% | 109% | 70% | 130% |
| Boron | 9619456 | | 8 | 6 | NA | < 2 | 108% | 80% | 120% | 102% | 80% | 120% | 108% | 70% | 130% |
| Cadmium | 9619456 | | 0.5 | 0.4 | NA | < 0.3 | 99% | 80% | 120% | 94% | 80% | 120% | 101% | 70% | 130% |
| Chromium | 9619456 | | 16 | 16 | 3.6% | < 2 | 104% | 80% | 120% | 93% | 80% | 120% | 113% | 70% | 130% |
| Cobalt | 9619456 | | 10 | 9 | 9.8% | < 1 | 105% | 80% | 120% | 98% | 80% | 120% | 109% | 70% | 130% |
| Copper | 9619456 | | 54 | 51 | 5.0% | < 2 | 105% | 80% | 120% | 99% | 80% | 120% | 104% | 70% | 130% |
| Iron | 9619456 | | 23200 | 21400 | 8.2% | < 50 | 105% | 80% | 120% | 95% | 80% | 120% | 108% | 70% | 130% |
| Lead | 9619456 | | 97.9 | 93.4 | 4.6% | < 0.5 | 103% | 80% | 120% | 103% | 80% | 120% | 105% | 70% | 130% |
| Lithium | 9619456 | | 19 | 18 | NA | < 5 | 105% | 70% | 130% | 102% | 70% | 130% | 113% | 70% | 130% |
| Manganese | 9619456 | | 546 | 488 | 11.2% | < 2 | 105% | 80% | 120% | 97% | 80% | 120% | 111% | 70% | 130% |
| Molybdenum | 9619456 | | 5 | 4 | NA | < 2 | 101% | 80% | 120% | 97% | 80% | 120% | 105% | 70% | 130% |
| Nickel | 9619456 | | 20 | 20 | 2.3% | < 2 | 98% | 80% | 120% | 106% | 80% | 120% | 104% | 70% | 130% |
| Selenium | 9619456 | | 4 | 4 | NA | < 1 | 104% | 80% | 120% | 86% | 80% | 120% | 107% | 70% | 130% |
| Silver | 9619456 | | <0.5 | <0.5 | NA | < 0.5 | 96% | 80% | 120% | 97% | 80% | 120% | 102% | 70% | 130% |
| Strontium | 9619456 | | 57 | 43 | NA | < 5 | 94% | 80% | 120% | 87% | 80% | 120% | 99% | 70% | 130% |
| Thallium | 9619456 | | 1.0 | 0.9 | 11.1% | < 0.1 | 99% | 80% | 120% | 100% | 80% | 120% | 81% | 70% | 130% |
| Tin | 9619456 | | 4 | 4 | NA | < 2 | 98% | 80% | 120% | 95% | 80% | 120% | 95% | 70% | 130% |
| Uranium | 9619456 | | 0.6 | 0.6 | 3.1% | < 0.1 | 100% | 80% | 120% | 99% | 80% | 120% | 103% | 70% | 130% |
| Vanadium | 9619456 | | 33 | 31 | 6.1% | < 2 | 102% | 80% | 120% | 97% | 80% | 120% | 110% | 70% | 130% |
| Zinc | 9619456 | | 152 | 149 | 1.8% | < 5 | 103% | 80% | 120% | 99% | 80% | 120% | 104% | 70% | 130% |
| Mercury Analysis in Soil | | | | | | | | | | | | | | | |
| Mercury | 1 | 9615884 | <0.05 | <0.05 | NA | < 0.05 | 115% | 70% | 130% | | 70% | 130% | 105% | 70% | 130% |

Certified By:

AGAT Laboratories

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K395586
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Trace Organics Analysis

| RPT Date: Oct 19, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits | | Recovery | Acceptable Limits | | Recovery | Acceptable Limits | |
| | | | | | | | | Lower | Upper | | Lower | Upper | | Lower | Upper |
| Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved | | | | | | | | | | | | | | | |
| Benzene | 1 | 9584397 | < 0.03 | < 0.03 | NA | < 0.03 | 121% | 60% | 140% | 109% | 60% | 140% | | | |
| Toluene | 1 | 9584397 | < 0.04 | < 0.04 | NA | < 0.04 | 128% | 60% | 140% | 114% | 60% | 140% | | | |
| Ethylbenzene | 1 | 9584397 | < 0.03 | < 0.03 | NA | < 0.03 | 122% | 60% | 140% | 105% | 60% | 140% | | | |
| Xylene (Total) | 1 | 9584397 | < 0.05 | < 0.05 | NA | < 0.05 | 126% | 60% | 140% | 107% | 60% | 140% | | | |
| C6-C10 (less BTEX) | 1 | 9584397 | < 3 | < 3 | NA | < 3 | 127% | 60% | 140% | 101% | 60% | 140% | 115% | 30% | 130% |
| >C10-C16 Hydrocarbons | 1 | 9614973 | < 15 | < 15 | NA | < 15 | 126% | 60% | 140% | 95% | 60% | 140% | 96% | 30% | 130% |
| >C16-C21 Hydrocarbons | 1 | 9614973 | < 15 | < 15 | NA | < 15 | 122% | 60% | 140% | 95% | 60% | 140% | 96% | 30% | 130% |
| >C21-C32 Hydrocarbons | 1 | 9614973 | < 15 | < 15 | NA | < 15 | 127% | 60% | 140% | 95% | 60% | 140% | 96% | 30% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

Certified By:

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TEL (709)747-8573
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http://www.agatlabs.com

# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K395586
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Soil Analysis | | | |
| Aluminum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Antimony | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Arsenic | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Barium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Beryllium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Boron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cadmium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Chromium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cobalt | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Copper | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Iron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Lead | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Lithium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Manganese | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Molybdenum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Nickel | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Selenium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Silver | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Strontium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Thallium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Tin | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Uranium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Vanadium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Zinc | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Mercury | INOR-121-6101 & INOR-121-6107 | Based on EPA 245.5 & SM 3112B | CV/AA |

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TEL (709)747-8573
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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K395586
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Trace Organics Analysis | | | |
| Benzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Toluene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Ethylbenzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Xylene (Total) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| C6-C10 (less BTEX) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| >C10-C16 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C16-C21 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C21-C32 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Modified TPH (Tier 1) | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | CALCULATION |
| Resemblance Comment | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| Return to Baseline at C32 | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - VPH | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| n-Dotriacontane - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| % Moisture | | Calculation | GRAVIMETRIC |

Unit 122 ▪ 11 Morris Drive
Dartmouth, NS
B3B 1M2

AGAT Laboratories

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**Laboratory Use Only**

Arrival Condition: ☑ Good ☐ Poor (see notes)

Arrival Temperature: 2.0 | 1.4 | 3.3°C

AGAT Job Number: 18K395586

Notes:

# Chain of Custody Record

## Report Information

Company: GHD Limited

Contact: James O'Neill

Address: 1118 Topsail Road
St. John's NL A1B 3N7

Phone 1-709-364-5353 Fax: 1-709-364-5368

**Site # and/or Name:** MARYSTOWN SHIPYARD - MDSA

Project #: 11178792-02

**AGAT Quotation #:** GHD Standing Offer

**GHD PO #:** TO FOLLOW

## Report Information

1. Name: **James O'Neill**
   Email: James.Oneill@ghd.com
2. Name: datanl
   Email: datanl@ghd.oom

## Report Format

☐ Single Sample per page

☑ Multiple Samples per page

☑ Excel Format Included

## Turnaround Time Required (TAT)

**Regular TAT** ☑ 5 to 7 working days

**Rush TAT** ☐ 1 day ☐ 2 days ☐ 3 days

Date Required:

## Invoice To

Same Yes ☑ / No ☐

Company:

Contact:

Address:

Phone: Fax:

## Regulatory Requirements (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ **PIRI**

☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☐ **CCME** ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

**Drinking Water Sample:** ☐ Yes ☑ No

Reg. No.:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I – LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: MERCURY (Hg) | OTHER: | OTHER: | HOLD FOR POSS. LEAHATE | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MDSA-MW1-2018-SS1 | 2018/02/10 00:00 | Soil | 1 X 60 ML | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MDSA-MW1-2018-SS2 | 2018/02/10 00:00 | Soil | 1 X 60 ML | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MDSA-MW2-2018-SS4 | 2018/02/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MDSA-MW2-2018-SS5 | 2018/02/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MDSA-BH4-2018-SS4 | 2018/02/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MDSA-BH4-2018-SS5 | 2018/02/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| X | | X | X | | | | | | | | | | | | | | | | | | | | | | | | |
| X | | X | X | | | | | | | | | | | | | | | | | | | | | | | | |
| X | | X | X | | | | | | | | | | | | | | | | | | | | | | | | |
| X | | X | X | | | | | | | | | | | | | | | | | | | | | | | | |
| X | | X | X | | | | | | | | | | | | | | | | | | | | | | | | |

| Samples Relinquished By (Print Name): | Date/Time | Samples Received By (Print Name): | Date/Time |
|---|---|---|---|
| Hubert Anderson | 2018/10/10 | Emma Penney | Oct 10/18 |
| Samples Relinquished By (Sign): H. Anderson | Date/Time 08:00 | Samples Received By (Sign): | Date/Time 2:32pm |

Page 1 of 1

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CLIENT NAME: GHD LIMITED
1118 TOPSAIL ROAD
ST. JOHN'S , NL A1B3N7
(709) 364-5353

ATTENTION TO: JAMES O'NEILL

PROJECT: 11178792-02

AGAT WORK ORDER: 18K395595

TRACE ORGANICS REVIEWED BY: Amy Hunter, Trace Organics Supervisor, B.Sc.

DATE REPORTED: Oct 20, 2018

PAGES (INCLUDING COVER): 6

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (709)747-8573

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

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# Certificate of Analysis

AGAT WORK ORDER: 18K395595
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved

DATE RECEIVED: 2018-10-10
DATE REPORTED: 2018-10-20

| | | | SAMPLE DESCRIPTION: | MSGB-BH4-2018-SS4 | MSGB-BH4-2018-SS6 | MSGB-BH3-2018-SS1 | MSGB-BH3-2018-SS4 | MSGB-BH2-2018-SS3 | MSGB-BH2-2018-SS4 | MSGB-BH1-2018-SS4 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 |
| Parameter | Unit | G / S | RDL | 9614967 | 9614968 | 9614969 | 9614970 | 9614971 | 9614972 | 9614973 |
| Benzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | 22 | 22 | <3 | 29 | 4 | <3 | <3 |
| >C10-C16 Hydrocarbons | mg/kg | | 15 | 776 | 695 | <15 | 302 | <15 | 62 | <15 |
| >C16-C21 Hydrocarbons | mg/kg | | 15 | 514 | 447 | <15 | 228 | <15 | 69 | <15 |
| >C21-C32 Hydrocarbons | mg/kg | | 15 | 82 | 73 | <15 | 48 | <15 | 17 | <15 |
| Modified TPH (Tier 1) | mg/kg | | 20 | 1390 | 1240 | <20 | 607 | <20 | 148 | <20 |
| Resemblance Comment | | | | FOF | FOF | NR | FOF | GR | WFOF | NR |
| Return to Baseline at C32 | | | | Y | Y | Y | Y | Y | Y | Y |
| Surrogate | Unit | Acceptable Limits | | | | | | | | |
| Isobutylbenzene - EPH | % | 60-140 | | 92 | 89 | 88 | 97 | 88 | 100 | 88 |
| Isobutylbenzene - VPH | % | 60-140 | | 117 | 115 | 109 | 115 | 112 | 122 | 82 |
| n-Dotriacontane - EPH | % | 60-140 | | 92 | 89 | 86 | 95 | 86 | 97 | 83 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9614967-9614973 Results are based on the dry weight of the soil.

Resemblance Comment Key:
GF - Gasoline Fraction
WGF - Weathered Gasoline Fraction
GR - Product in Gasoline Range
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
FR - Product in Fuel Oil Range
LOF - Lube Oil Fraction
LR - Lube Range
UC - Unidentified Compounds
NR - No Resemblance
NA - Not Applicable

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

AGAT Laboratories

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St. John's, NL
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# Certificate of Analysis

AGAT WORK ORDER: 18K395595
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Moisture

DATE RECEIVED: 2018-10-10
DATE REPORTED: 2018-10-20

| Parameter | Unit | G / S | RDL | MSGB-BH4-2018-SS4 | MSGB-BH4-2018-SS6 | MSGB-BH3-2018-SS1 | MSGB-BH3-2018-SS4 | MSGB-BH2-2018-SS3 | MSGB-BH2-2018-SS4 | MSGB-BH1-2018-SS4 |
|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
| DATE SAMPLED: | | | | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 | 2018-10-02 |
| | | | | 9614967 | 9614968 | 9614969 | 9614970 | 9614971 | 9614972 | 9614973 |
| % Moisture | % | | 0 | 6 | 13 | 5 | 17 | 8 | 11 | 4 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

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AGAT Laboratories

# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K395595
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Trace Organics Analysis

| RPT Date: Oct 20, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| **Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved** | | | | | | | | | | | | | | | |
| Benzene | 1 | 9615862 | < 0.03 | < 0.03 | NA | < 0.03 | 100% | 60% | 140% | 103% | 60% | 140% | | | |
| Toluene | 1 | 9615862 | < 0.04 | < 0.04 | NA | < 0.04 | 110% | 60% | 140% | 108% | 60% | 140% | | | |
| Ethylbenzene | 1 | 9615862 | < 0.03 | < 0.03 | NA | < 0.03 | 108% | 60% | 140% | 105% | 60% | 140% | | | |
| Xylene (Total) | 1 | 9615862 | < 0.05 | < 0.05 | NA | < 0.05 | 119% | 60% | 140% | 107% | 60% | 140% | | | |
| C6-C10 (less BTEX) | 1 | 9615862 | < 3 | < 3 | NA | < 3 | 116% | 60% | 140% | 122% | 60% | 140% | NA | 30% | 130% |
| >C10-C16 Hydrocarbons | 1 | 9614973 | < 15 | < 15 | NA | < 15 | 126% | 60% | 140% | 95% | 60% | 140% | 96% | 30% | 130% |
| >C16-C21 Hydrocarbons | 1 | 9614973 | < 15 | < 15 | NA | < 15 | 122% | 60% | 140% | 95% | 60% | 140% | 96% | 30% | 130% |
| >C21-C32 Hydrocarbons | 1 | 9614973 | < 15 | < 15 | NA | < 15 | 127% | 60% | 140% | 95% | 60% | 140% | 96% | 30% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Lower | Upper | Recovery | Lower | Upper | Recovery | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved** | | | | | | | | | | | | | | | |
| Benzene | 1 | 9614973 | < 0.03 | < 0.03 | NA | < 0.03 | 87% | 60% | 140% | 81% | 60% | 140% | | | |
| Toluene | 1 | 9614973 | < 0.04 | < 0.04 | NA | < 0.04 | 90% | 60% | 140% | 70% | 60% | 140% | | | |
| Ethylbenzene | 1 | 9614973 | < 0.03 | < 0.03 | NA | < 0.03 | 93% | 60% | 140% | 73% | 60% | 140% | | | |
| Xylene (Total) | 1 | 9614973 | < 0.05 | < 0.05 | NA | < 0.05 | 96% | 60% | 140% | 75% | 60% | 140% | | | |
| C6-C10 (less BTEX) | 1 | 9614973 | < 3 | < 3 | NA | < 3 | 116% | 60% | 140% | 103% | 60% | 140% | 117% | 30% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

Certified By:

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K395595
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Trace Organics Analysis | | | |
| Benzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Toluene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Ethylbenzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Xylene (Total) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| C6-C10 (less BTEX) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| >C10-C16 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C16-C21 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C21-C32 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Modified TPH (Tier 1) | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | CALCULATION |
| Resemblance Comment | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| Return to Baseline at C32 | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - VPH | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| n-Dotriacontane - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| % Moisture | | Calculation | GRAVIMETRIC |

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# AGAT Laboratories

**Laboratory Use Only**
Arrival Condition: ☑ Good ☐ Poor (see notes)
Arrival Temperature: 2.0, 1.4, 3.3 °C
AGAT Job Number: 18K395595
Notes:

## Chain of Custody Record

**Report Information**
Company: GHD Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone: 1-709-364-5353 Fax: 1-709-364-5368
**Site # and/or Name:** MARYSTOWN SHIPYARD ~~-MSGB~~ MSGB 32
**Project #:** 11178792-02
**AGAT Quotation #:** GHD Standing Offer
**GHD PO #:** TO FOLLOW

**Report Information**
1. Name: **James O'Neill**
Email: James.Oneill@ghd.com
2. Name: datanl
Email: datanl@ghd.om

**Report Format**
☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

**Turnaround Time Required (TAT)**
**Regular TAT** ☑ 5 to 7 working days
**Rush TAT** ☐ 1 day ☐ 2 days ☐ 3 days
Date Required:

**Invoice To** Same Yes ☑ / No ☐
Company:
Contact:
Address:
Phone: Fax:

**Regulatory Requirements** (Check):
☐ List Guidelines on Report ☑ Do Not List Guidelines on Report
☐ **PIRI**
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube
☐ **CCME** ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

**Drinking Water Sample:** ☐ Yes ☑ No
Reg. No.:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OF CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: MERCURY (Hg) | OTHER: | OTHER: | HOLD FOR POSS. LEAHATE | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MSGB-BH4-2018-SS4 | 2018/02/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSGB-BH4-2018-SS6 | 2018/02/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSGB-BH3-2018-SS1 | 2018/03/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSGB-BH3-2018-SS4 | 2018/03/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSGB-BH2-2018-SS3 | 2018/03/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSGB-BH2-2018-SS4 | 2018/03/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSGB-BH1-2018-SS4 | 2018/03/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| X | | X | X | | | | | | | | | | | | | | | | | | | | | | | | |
| X | | X | X | | | | | | | | | | | | | | | | | | | | | | | | |
| X | | X | X | | | | | | | | | | | | | | | | | | | | | | | | |
| X | | X | X | | | | | | | | | | | | | | | | | | | | | | | | |

Samples Relinquished By (Print Name): Hubert Anderson
Date/Time: 2018/10/10
Samples Relinquished By (Sign): N. Anderson
Date/Time: 08:00
Samples Received By (Print Name): Emma Penney
Date/Time: Oct 10/18
Samples Received By (Sign): Em Penny
Date/Time: 2:32 pm

Page 1 of 1

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CLIENT NAME: GHD LIMITED
1118 TOPSAIL ROAD
ST. JOHN'S , NL A1B3N7
(709) 364-5353

ATTENTION TO: JAMES O'NEILL

PROJECT: 11178792-02

AGAT WORK ORDER: 18K395631

SOIL ANALYSIS REVIEWED BY: Jason Coughtrey, Inorganics Supervisor

TRACE ORGANICS REVIEWED BY: Amy Hunter, Trace Organics Supervisor, B.Sc.

DATE REPORTED: Oct 19, 2018

PAGES (INCLUDING COVER): 13

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (709)747-8573

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

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# Certificate of Analysis

AGAT WORK ORDER: 18K395631
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
SAMPLING SITE:

ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Available Metals in Soil

DATE RECEIVED: 2018-10-10

DATE REPORTED: 2018-10-19

| | | | SAMPLE DESCRIPTION: | MFPA-BH3-2018 -SS1 | MFPA-BH3-2018 -SS2 | MFPA-BH4-2018 -SS1 | MFPA-BH4-2018 -SS3 |
|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 |
| Parameter | Unit | G / S | RDL | 9615521 | 9615522 | 9615526 | 9615527 |
| Aluminum | mg/kg | | 10 | 32000 | 19600 | 11200 | 5400 |
| Antimony | mg/kg | | 1 | <1 | <1 | <1 | <1 |
| Arsenic | mg/kg | | 1 | 5 | 14 | 11 | 6 |
| Barium | mg/kg | | 5 | 20 | 79 | 238 | 35 |
| Beryllium | mg/kg | | 2 | <2 | <2 | <2 | <2 |
| Boron | mg/kg | | 2 | <2 | <2 | 2 | <2 |
| Cadmium | mg/kg | | 0.3 | <0.3 | <0.3 | 0.4 | <0.3 |
| Chromium | mg/kg | | 2 | 107 | 33 | 43 | 46 |
| Cobalt | mg/kg | | 1 | 34 | 23 | 18 | 6 |
| Copper | mg/kg | | 2 | 54 | 29 | 66 | 22 |
| Iron | mg/kg | | 50 | 22600 | 43400 | 32100 | 13300 |
| Lead | mg/kg | | 0.5 | 5.9 | 7.6 | 96.7 | 8.5 |
| Lithium | mg/kg | | 5 | 15 | 14 | 9 | 7 |
| Manganese | mg/kg | | 2 | 1240 | 1700 | 1840 | 642 |
| Molybdenum | mg/kg | | 2 | <2 | <2 | <2 | 7 |
| Nickel | mg/kg | | 2 | 69 | 24 | 23 | 11 |
| Selenium | mg/kg | | 1 | <1 | <1 | <1 | <1 |
| Silver | mg/kg | | 0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Strontium | mg/kg | | 5 | 67 | 26 | 29 | 22 |
| Thallium | mg/kg | | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | mg/kg | | 2 | <2 | <2 | <2 | <2 |
| Uranium | mg/kg | | 0.1 | 0.1 | 0.2 | 0.3 | 0.3 |
| Vanadium | mg/kg | | 2 | 84 | 79 | 60 | 28 |
| Zinc | mg/kg | | 5 | 101 | 96 | 152 | 43 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9615521-9615527 Results are based on the dry weight of the sample.
Analysis performed at AGAT Halifax (unless marked by *)

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AGAT WORK ORDER: 18K395631
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
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SAMPLED BY:

## Mercury Analysis in Soil

DATE RECEIVED: 2018-10-10
DATE REPORTED: 2018-10-19

| | | | SAMPLE DESCRIPTION: | MFPA-BH3-2018 -SS1 | MFPA-BH3-2018 -SS2 | MFPA-BH4-2018 -SS1 | MFPA-BH4-2018 -SS3 |
|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 |
| Parameter | Unit | G / S | RDL | 9615521 | 9615522 | 9615526 | 9615527 |
| Mercury | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9615521-9615527 Results are based on the dry weight of the soil.
Analysis performed at AGAT Halifax (unless marked by *)

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AGAT WORK ORDER: 18K395631
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved

DATE RECEIVED: 2018-10-10
DATE REPORTED: 2018-10-19

| Parameter | Unit | G / S | RDL | MFPA-BH3-2018-SS5 | MFPA-BH3-2018-SS6 | MFPA-BH4-2018-SS4 | MFPA-BH4-2018-SS6 | MFPA-BH2-2018-SS4 | MFPA-BH2-2018-SS6 | MFPA-BH1-2018-SS4 | MFPA-MW1-2018-SS5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-03 |
| | | | | 9615523 | 9615525 | 9615528 | 9615529 | 9615530 | 9615531 | 9615532 | 9615533 |
| Benzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | 49 | <3 | <3 | 12 | <3 | 62 | <3 | 44 |
| >C10-C16 Hydrocarbons | mg/kg | | 15 | <15 | <15 | <15 | 1320 | 64 | 109 | <15 | 3660 |
| >C16-C21 Hydrocarbons | mg/kg | | 15 | <15 | <15 | <15 | 912 | 39 | 87 | <15 | 2740 |
| >C21-C32 Hydrocarbons | mg/kg | | 15 | <15 | <15 | <15 | 176 | 53 | 102 | <15 | 1200 |
| Modified TPH (Tier 1) | mg/kg | | 20 | 49 | <20 | <20 | 2420 | 156 | 360 | <20 | 7640 |
| Resemblance Comment | | | | GR | NR | NR | FOF | LOF+LOF | FOF+LOF | NR | FOF |
| Return to Baseline at C32 | | | | Y | Y | Y | Y | Y | Y | Y | Y |
| Surrogate | Unit | Acceptable Limits | | | | | | | | | |
| Isobutylbenzene - EPH | % | 60-140 | | 91 | 94 | 93 | 97 | 89 | 92 | 95 | 103 |
| Isobutylbenzene - VPH | % | 60-140 | | 127 | 126 | 125 | 122 | 122 | 129 | 130 | 132 |
| n-Dotriacontane - EPH | % | 60-140 | | 98 | 99 | 97 | 92 | 94 | 97 | 100 | 106 |

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CLIENT NAME: GHD LIMITED
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ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved

DATE RECEIVED: 2018-10-10
DATE REPORTED: 2018-10-19

| | | | SAMPLE DESCRIPTION: | MFPA-MW1-2018-SS7 |
|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil |
| | | | DATE SAMPLED: | 2018-10-03 |
| Parameter | Unit | G / S | RDL | 9615534 |
| Benzene | mg/kg | | 0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | <3 |
| >C10-C16 Hydrocarbons | mg/kg | | 15 | 170 |
| >C16-C21 Hydrocarbons | mg/kg | | 15 | 141 |
| >C21-C32 Hydrocarbons | mg/kg | | 15 | 111 |
| Modified TPH (Tier 1) | mg/kg | | 20 | 422 |
| Resemblance Comment | | | | FOF+LOF |
| Return to Baseline at C32 | | | | Y |
| Surrogate | Unit | Acceptable Limits | | |
| Isobutylbenzene - EPH | % | 60-140 | | 93 |
| Isobutylbenzene - VPH | % | 60-140 | | 124 |
| n-Dotriacontane - EPH | % | 60-140 | | 99 |

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# Certificate of Analysis

AGAT WORK ORDER: 18K395631
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED | ATTENTION TO: JAMES O'NEILL
SAMPLING SITE: | SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved

DATE RECEIVED: 2018-10-10 | DATE REPORTED: 2018-10-19

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9615523 Discrepancy between results obtained for VPH and EPH. VPH vials tested and a fuel product is observed. EPH jar sampled in duplicate and no product seen.

Results are based on the dry weight of the soil.

Resemblance Comment Key:
GF - Gasoline Fraction
WGF - Weathered Gasoline Fraction
GR - Product in Gasoline Range
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
FR - Product in Fuel Oil Range
LOF - Lube Oil Fraction
LR - Lube Range
UC - Unidentified Compounds
NR - No Resemblance
NA - Not Applicable

9615525-9615534 Results are based on the dry weight of the soil.

Resemblance Comment Key:
GF - Gasoline Fraction
WGF - Weathered Gasoline Fraction
GR - Product in Gasoline Range
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
FR - Product in Fuel Oil Range
LOF - Lube Oil Fraction
LR - Lube Range
UC - Unidentified Compounds
NR - No Resemblance
NA - Not Applicable

Analysis performed at AGAT Halifax (unless marked by *)

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# Certificate of Analysis

AGAT WORK ORDER: 18K395631
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
SAMPLING SITE:

ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Moisture

DATE RECEIVED: 2018-10-10

DATE REPORTED: 2018-10-19

| | | | SAMPLE DESCRIPTION: | MFPA-BH3-2018-SS5 | MFPA-BH3-2018-SS6 | MFPA-BH4-2018-SS4 | MFPA-BH4-2018-SS6 | MFPA-BH2-2018-SS4 | MFPA-BH2-2018-SS6 | MFPA-BH1-2018-SS4 | MFPA-MW1-2018-SS5 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-04 | 2018-10-03 |
| Parameter | Unit | G / S | RDL | 9615523 | 9615525 | 9615528 | 9615529 | 9615530 | 9615531 | 9615532 | 9615533 |
| % Moisture | % | | 0 | 13 | 9 | 9 | 9 | 8 | 14 | 12 | 12 |

| | | | SAMPLE DESCRIPTION: | MFPA-MW1-2018-SS7 |
|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil |
| | | | DATE SAMPLED: | 2018-10-03 |
| Parameter | Unit | G / S | RDL | 9615534 |
| % Moisture | % | | 0 | 13 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
Analysis performed at AGAT Halifax (unless marked by *)

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K395631
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Soil Analysis

| RPT Date: Oct 19, 2018 | | | DUPLICATE | | | | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Available Metals in Soil | | | | | | | | | | | | | | | |
| Aluminum | 9615940 | | 3830 | 3410 | 11.7% | < 10 | 118% | 80% | 120% | 114% | 80% | 120% | NA | 70% | 130% |
| Antimony | 9615940 | | <1 | <1 | NA | < 1 | 102% | 80% | 120% | 116% | 80% | 120% | 70% | 70% | 130% |
| Arsenic | 9615940 | | 7 | 6 | 13.7% | < 1 | 101% | 80% | 120% | 102% | 80% | 120% | 98% | 70% | 130% |
| Barium | 9615940 | | 87 | 73 | 17.3% | < 5 | 99% | 80% | 120% | 101% | 80% | 120% | 111% | 70% | 130% |
| Beryllium | 9615940 | | <2 | <2 | NA | < 2 | 111% | 80% | 120% | 114% | 80% | 120% | 106% | 70% | 130% |
| Boron | 9615940 | | <2 | 6 | NA | < 2 | 116% | 80% | 120% | 115% | 80% | 120% | 101% | 70% | 130% |
| Cadmium | 9615940 | | <0.3 | <0.3 | NA | < 0.3 | 99% | 80% | 120% | 101% | 80% | 120% | 99% | 70% | 130% |
| Chromium | 9615940 | | 11 | 8 | NA | < 2 | 103% | 80% | 120% | 104% | 80% | 120% | 129% | 70% | 130% |
| Cobalt | 9615940 | | 6 | 5 | 8.2% | < 1 | 100% | 80% | 120% | 101% | 80% | 120% | 107% | 70% | 130% |
| Copper | 9615940 | | 18 | 15 | 19.0% | < 2 | 106% | 80% | 120% | 106% | 80% | 120% | 100% | 70% | 130% |
| Iron | 9615940 | | 8430 | 7110 | 17.0% | < 50 | 102% | 80% | 120% | 116% | 80% | 120% | 70% | 70% | 130% |
| Lead | 9615940 | | 15.3 | 11.2 | NA | < 0.5 | 106% | 80% | 120% | 107% | 80% | 120% | 93% | 70% | 130% |
| Lithium | 9615940 | | <5 | <5 | NA | < 5 | 111% | 70% | 130% | 115% | 70% | 130% | 115% | 70% | 130% |
| Manganese | 9615940 | | 1150 | 873 | NA | < 2 | 118% | 80% | 120% | 119% | 80% | 120% | 111% | 70% | 130% |
| Molybdenum | 9615940 | | <2 | <2 | NA | < 2 | 100% | 80% | 120% | 104% | 80% | 120% | 101% | 70% | 130% |
| Nickel | 9615940 | | 7 | 33 | NA | < 2 | 101% | 80% | 120% | 104% | 80% | 120% | NA | 70% | 130% |
| Selenium | 9615940 | | <1 | <1 | NA | < 1 | 100% | 80% | 120% | 103% | 80% | 120% | 87% | 70% | 130% |
| Silver | 9615940 | | <0.5 | <0.5 | NA | < 0.5 | 103% | 80% | 120% | 105% | 80% | 120% | 98% | 70% | 130% |
| Strontium | 9615940 | | 25 | 22 | NA | < 5 | 114% | 80% | 120% | 116% | 80% | 120% | 130% | 70% | 130% |
| Thallium | 9615940 | | <0.1 | <0.1 | NA | < 0.1 | 103% | 80% | 120% | 103% | 80% | 120% | NA | 70% | 130% |
| Tin | 9615940 | | <2 | <2 | NA | < 2 | 101% | 80% | 120% | 100% | 80% | 120% | 96% | 70% | 130% |
| Uranium | 9615940 | | 0.2 | 0.2 | NA | < 0.1 | 102% | 80% | 120% | 101% | 80% | 120% | 99% | 70% | 130% |
| Vanadium | 9615940 | | 21 | 18 | 17.9% | < 2 | 101% | 80% | 120% | 102% | 80% | 120% | 113% | 70% | 130% |
| Zinc | 9615940 | | 48 | 54 | 11.7% | < 5 | 101% | 80% | 120% | 101% | 80% | 120% | 95% | 70% | 130% |
| Mercury Analysis in Soil | | | | | | | | | | | | | | | |
| Mercury | 1 | 9615884 | <0.05 | <0.05 | NA | < 0.05 | 115% | 70% | 130% | | 70% | 130% | 105% | 70% | 130% |

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K395631
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Trace Organics Analysis

| RPT Date: Oct 19, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved | | | | | | | | | | | | | | | |
| Benzene | 1 | 9584397 | < 0.03 | < 0.03 | NA | < 0.03 | 121% | 60% | 140% | 109% | 60% | 140% | | | |
| Toluene | 1 | 9584397 | < 0.04 | < 0.04 | NA | < 0.04 | 128% | 60% | 140% | 114% | 60% | 140% | | | |
| Ethylbenzene | 1 | 9584397 | < 0.03 | < 0.03 | NA | < 0.03 | 122% | 60% | 140% | 105% | 60% | 140% | | | |
| Xylene (Total) | 1 | 9584397 | < 0.05 | < 0.05 | NA | < 0.05 | 126% | 60% | 140% | 107% | 60% | 140% | | | |
| C6-C10 (less BTEX) | 1 | 9584397 | < 3 | < 3 | NA | < 3 | 127% | 60% | 140% | 101% | 60% | 140% | 115% | 30% | 130% |
| >C10-C16 Hydrocarbons | 1 | 9616181 | < 15 | < 15 | NA | < 15 | 103% | 60% | 140% | 94% | 60% | 140% | 108% | 30% | 130% |
| >C16-C21 Hydrocarbons | 1 | 9616181 | < 15 | < 15 | NA | < 15 | 98% | 60% | 140% | 94% | 60% | 140% | 108% | 30% | 130% |
| >C21-C32 Hydrocarbons | 1 | 9616181 | 20 | 18 | NA | < 15 | 97% | 60% | 140% | 94% | 60% | 140% | 108% | 30% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K395631
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Soil Analysis | | | |
| Aluminum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Antimony | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Arsenic | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Barium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Beryllium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Boron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cadmium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Chromium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cobalt | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Copper | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Iron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Lead | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Lithium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Manganese | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Molybdenum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Nickel | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Selenium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Silver | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Strontium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Thallium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Tin | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Uranium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Vanadium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Zinc | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Mercury | INOR-121-6101 & INOR-121-6107 | Based on EPA 245.5 & SM 3112B | CV/AA |

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K395631
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Trace Organics Analysis | | | |
| Benzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Toluene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Ethylbenzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Xylene (Total) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| C6-C10 (less BTEX) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| >C10-C16 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C16-C21 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C21-C32 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Modified TPH (Tier 1) | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | CALCULATION |
| Resemblance Comment | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| Return to Baseline at C32 | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - VPH | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| n-Dotriacontane - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| % Moisture | | Calculation | GRAVIMETRIC |

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B3B 1M2
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AGAT Laboratories



# Chain of Custody Record

## Report Information

Company: GHD Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone 1-709-364-5353 Fax: 1-709-364-5368
Site # and/or Name: MARYSTOWN SHIPYARD - MFPA
Project #: 11178792-02
AGAT Quotation #: GHD Standing Offer
GHD PO #: TO FOLLOW

## Report Information

1. Name: **James O'Neill**
   Email: James.Oneill@ghd.com
2. Name: datanl
   Email: datanl@ghd.om

## Report Format

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

## Laboratory Use Only

Arrival Condition: ☑ Good ☐ Poor (see notes)
Arrival Temperature: 2.0, 1.4, 3.3 c
AGAT Job Number: 18K395631
Notes:

## Turnaround Time Required (TAT)

**Regular TAT** ☑ 5 to 7 working days
**Rush TAT** ☐ 1 day ☐ 2 days ☐ 3 days
Date Required:

## Invoice To

Same Yes ☑ / No ☐

Company:
Contact:
Address:
Phone: Fax:

## Regulatory Requirements (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ **PIRI**
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☐ **CCME** ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

Drinking Water Sample: ☐ Yes ☑ No
Reg. No.:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I – LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: MERCURY (Hg) | OTHER: | OTHER: | HOLD FOR POSS. LEAHATE | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MFPA-BH3-2018-SS1 | 2018/04/10 00:00 | Soil | 1 X 60 ML | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MFPA-BH3-2018-SS2 | 2018/04/10 00:00 | Soil | 1 X 60 ML | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MFPA-BH3-2018-SS5 | 2018/04/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MFPA-BH3-2018-SS6 | 2018/04/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MFPA-BH4-2018-SS1 | 2018/04/10 00:00 | Soil | 1 X 60 ML | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MFPA-BH4-2018-SS3 | 2018/04/10 00:00 | sOIL | 1 X 60 ML | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MFPA-BH4-2018-SS4 | 2018/04/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MFPA-BH4-2018-SS6 | 2018/04/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MFPA-BH2-2018-SS4 | 2018/04/10 00:00 | sOIL | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MFPA-BH2-2018-SS6 | 2018/04/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MFPA-BH1-2018-SS4 | 2018/04/10 00:00 | SoiL | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |

Samples Relinquished By (Print Name): Hubert Anderson
Date/Time: 2018/10/10
Samples Received By (Print Name): Emmes Kenny
Date/Time: Oct. 10/18

Samples Relinquished By (Sign): H. Anderson
Date/Time: 08:00
Samples Received By (Sign): [signature]
Date/Time: 2:32 pm

Page 1 of 2

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# Chain of Custody Record

**Laboratory Use Only**
Arrival Condition: ☑ Good ☐ Poor (see notes)
Arrival Temperature:
AGAT Job Number:
Notes:

## Report Information

Company: GHD Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone 1-709-364-5353 Fax: 1-709-364-5368
**Site # and/or Name:** MARYSTOWN SHIPYARD - MFPA
Project #: 11178792-02
**AGAT Quotation #:** GHD Standing Offer
**GHD PO #:** TO FOLLOW

## Report Information

1. Name: **James O'Neill**
   Email: James.Oneill@ghd.com
2. Name: datanl
   Email: datanl@ghd.com

## Report Format

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

## Turnaround Time Required (TAT)

**Regular TAT** ☑ 5 to 7 working days
**Rush TAT** ☐ 1 day ☐ 2 days ☐ 3 days
Date Required:

**Drinking Water Sample:** ☐ Yes ☑ No
Reg. No.:

## Invoice To

Same Yes ☑ / No ☐
Company:
Contact:
Address:
Phone: Fax:

## Regulatory Requirements (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ **PIRI**
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☐ **CCME** ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: MERCURY (Hg) | OTHER: | OTHER: | HOLD FOR POSS. LEAHATE | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MFPA-MW1-2018-SS5 | 2018/03/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MFPA-MW1-2018-SS7 | 2018/03/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |

Samples Relinquished By (Print Name): Hubert Anderson
Date/Time: 2018/10/10
Samples Relinquished By (Sign): H. Anderson
Date/Time: 08:00
Samples Received By (Print Name): Emma Kenney
Date/Time: Oct 10/18
Samples Received By (Sign): [illegible]
Date/Time: 2:32pm

Page 2 of 2

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| | |
|---|---|
| CLIENT NAME: | GHD LIMITED<br>1118 TOPSAIL ROAD<br>ST. JOHN'S , NL A1B3N7<br>(709) 364-5353 |
| ATTENTION TO: | JAMES O'NEILL |
| PROJECT: | 11178792-02 Marystown Shipyard - MDSA |
| AGAT WORK ORDER: | 18K397501 |
| SOIL ANALYSIS REVIEWED BY: | Jason Coughtrey, Inorganics Supervisor |
| TRACE ORGANICS REVIEWED BY: | Amy Hunter, Trace Organics Supervisor, B.Sc. |
| DATE REPORTED: | Oct 24, 2018 |
| PAGES (INCLUDING COVER): | 12 |
| VERSION*: | 1 |

Should you require any information regarding this analysis please contact your client services representative at (709)747-8573

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

AGAT Laboratories

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# Certificate of Analysis

AGAT WORK ORDER: 18K397501
PROJECT: 11178792-02 Marystown Shipyard - MDSA

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Available Metals in Soil

DATE RECEIVED: 2018-10-16
DATE REPORTED: 2018-10-24

| Parameter | Unit | G / S | RDL | MDSA-BH1-2018-SS1 | MDSA-BH1-2018-SS2 | MDSA-BH2-2018-SS1 | MDSA-BH2-2018-SS2 | MDSA-BH3-2018-SS1 | MDSA-BH3-2018-SS2 |
|---|---|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Soil | Soil | Soil | Soil | Soil | Soil |
| DATE SAMPLED: | | | | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-10 | 2018-10-10 |
| | | | | 9626499 | 9626518 | 9626519 | 9626520 | 9626534 | 9626535 |
| Aluminum | mg/kg | | 10 | 19600 | 9840 | 15900 | 8920 | 10000 | 7190 |
| Antimony | mg/kg | | 1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Arsenic | mg/kg | | 1 | 12 | 11 | 11 | 11 | 11 | 11 |
| Barium | mg/kg | | 5 | 48 | 37 | 39 | 52 | 37 | 56 |
| Beryllium | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Boron | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Cadmium | mg/kg | | 0.3 | <0.3 | <0.3 | <0.3 | <0.3 | 0.3 | <0.3 |
| Chromium | mg/kg | | 2 | 37 | 13 | 33 | 12 | 20 | 13 |
| Cobalt | mg/kg | | 1 | 17 | 9 | 15 | 7 | 11 | 7 |
| Copper | mg/kg | | 2 | 40 | 17 | 33 | 14 | 78 | 19 |
| Iron | mg/kg | | 50 | 23600 | 12700 | 18500 | 12900 | 12100 | 10000 |
| Lead | mg/kg | | 0.5 | 19.6 | 6.4 | 7.3 | 14.2 | 6.7 | 16.1 |
| Lithium | mg/kg | | 5 | 14 | 12 | 13 | 7 | 11 | 7 |
| Manganese | mg/kg | | 2 | 1060 | 671 | 865 | 812 | 721 | 752 |
| Molybdenum | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Nickel | mg/kg | | 2 | 23 | 11 | 22 | 9 | 27 | 9 |
| Selenium | mg/kg | | 1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Silver | mg/kg | | 0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Strontium | mg/kg | | 5 | 29 | 20 | 26 | 17 | 19 | 18 |
| Thallium | mg/kg | | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Uranium | mg/kg | | 0.1 | 0.3 | 0.4 | 0.4 | 0.4 | 0.3 | 0.4 |
| Vanadium | mg/kg | | 2 | 73 | 45 | 66 | 36 | 51 | 37 |
| Zinc | mg/kg | | 5 | 83 | 50 | 62 | 50 | 87 | 51 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9626499-9626535 Results are based on the dry weight of the sample.
Analysis performed at AGAT Halifax (unless marked by *)

Certified By: Jason Coughtrey

AGAT Laboratories
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# Certificate of Analysis

AGAT WORK ORDER: 18K397501

PROJECT: 11178792-02 Marystown Shipyard - MDSA

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Mercury Analysis in Soil

DATE RECEIVED: 2018-10-16

DATE REPORTED: 2018-10-24

| | | | SAMPLE DESCRIPTION: | MDSA-BH1-2018-SS1 | MDSA-BH1-2018-SS2 | MDSA-BH2-2018-SS1 | MDSA-BH2-2018-SS2 | MDSA-BH3-2018-SS1 | MDSA-BH3-2018-SS2 |
|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-10 | 2018-10-10 |
| Parameter | Unit | G / S | RDL | 9626499 | 9626518 | 9626519 | 9626520 | 9626534 | 9626535 |
| Mercury | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9626499-9626535 Results are based on the dry weight of the soil.

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

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CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved

DATE RECEIVED: 2018-10-16

DATE REPORTED: 2018-10-24

| | | | SAMPLE DESCRIPTION: | MDSA-BH2-2018-SS4 | MDSA-BH2-2018-SS5 | MDSA-BH3-2018-SS4 | MDSA-BH3-2018-SS5 | MDSA-BH5-2018-SS3 | MDSA-BH5-2018-SS4 | MDSA-BH6-2018-SS3 | MDSA-BH6-2018-SS4 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-09 | 2018-10-09 | 2018-10-10 | 2018-10-10 | 2018-10-10 | 2018-10-10 | 2018-10-10 | 2018-10-10 |
| Parameter | Unit | G / S | RDL | 9626522 | 9626526 | 9626537 | 9626538 | 9626539 | 9626540 | 9626541 | 9626542 |
| Benzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 |
| >C10-C16 Hydrocarbons | mg/kg | | 15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 |
| >C16-C21 Hydrocarbons | mg/kg | | 15 | <15 | <15 | <15 | 20 | <15 | <15 | <15 | <15 |
| >C21-C32 Hydrocarbons | mg/kg | | 15 | 25 | 27 | 26 | 163 | 21 | 25 | 17 | 73 |
| Modified TPH (Tier 1) | mg/kg | | 20 | 25 | 27 | 26 | 183 | 21 | 25 | <20 | 73 |
| Resemblance Comment | | | | LOF | LOF | LOF | LOF | LOF | LOF | LOF | LOF |
| Return to Baseline at C32 | | | | Y | Y | Y | Y | Y | Y | Y | Y |
| Surrogate | Unit | Acceptable Limits | | | | | | | | | |
| Isobutylbenzene - EPH | % | 60-140 | | 89 | 93 | 95 | 95 | 98 | 97 | 97 | 93 |
| Isobutylbenzene - VPH | % | 60-140 | | 80 | 81 | 88 | 84 | 86 | 86 | 101 | 98 |
| n-Dotriacontane - EPH | % | 60-140 | | 104 | 106 | 106 | 107 | 110 | 109 | 104 | 107 |

Certified By:

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TEL (709)747-8573
FAX (709 747-2139
http://www.agatlabs.com

AGAT Laboratories

# Certificate of Analysis

AGAT WORK ORDER: 18K397501

PROJECT: 11178792-02 Marystown Shipyard - MDSA

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved

DATE RECEIVED: 2018-10-16

DATE REPORTED: 2018-10-24

| | | | SAMPLE DESCRIPTION: | MDSA-MW3-2018-SS2 | MDSA-MW3-2018-SS4 |
|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-10 | 2018-10-10 |
| Parameter | Unit | G / S | RDL | 9626543 | 9626544 |
| Benzene | mg/kg | | 0.03 | <0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | <3 | <3 |
| >C10-C16 Hydrocarbons | mg/kg | | 15 | <15 | <15 |
| >C16-C21 Hydrocarbons | mg/kg | | 15 | <15 | <15 |
| >C21-C32 Hydrocarbons | mg/kg | | 15 | 106 | 79 |
| Modified TPH (Tier 1) | mg/kg | | 20 | 106 | 79 |
| Resemblance Comment | | | | LOF | LOF |
| Return to Baseline at C32 | | | | Y | Y |
| Surrogate | Unit | Acceptable Limits | | | |
| Isobutylbenzene - EPH | % | 60-140 | | 96 | 95 |
| Isobutylbenzene - VPH | % | 60-140 | | 95 | 97 |
| n-Dotriacontane - EPH | % | 60-140 | | 112 | 111 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9626522-9626544 Results are based on the dry weight of the soil.

Resemblance Comment Key:
GF - Gasoline Fraction
WGF - Weathered Gasoline Fraction
GR - Product in Gasoline Range
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
FR - Product in Fuel Oil Range
LOF - Lube Oil Fraction
LR - Lube Range
UC - Unidentified Compounds
NR - No Resemblance
NA - Not Applicable

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

57 Old Pennywell Road, Unit I
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CANADA A1E 6A8
TEL (709)747-8573
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AGAT Laboratories

# Certificate of Analysis

AGAT WORK ORDER: 18K397501
PROJECT: 11178792-02 Marystown Shipyard - MDSA

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Moisture

DATE RECEIVED: 2018-10-16
DATE REPORTED: 2018-10-24

| | | | SAMPLE DESCRIPTION: | MDSA-BH2-2018-SS4 | MDSA-BH2-2018-SS5 | MDSA-BH3-2018-SS4 | MDSA-BH3-2018-SS5 | MDSA-BH5-2018-SS3 | MDSA-BH5-2018-SS4 | MDSA-BH6-2018-SS3 | MDSA-BH6-2018-SS4 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-09 | 2018-10-09 | 2018-10-10 | 2018-10-10 | 2018-10-10 | 2018-10-10 | 2018-10-10 | 2018-10-10 |
| Parameter | Unit | G / S | RDL | 9626522 | 9626526 | 9626537 | 9626538 | 9626539 | 9626540 | 9626541 | 9626542 |
| % Moisture | % | | 0 | 5 | 6 | 9 | 10 | 6 | 8 | 5 | 8 |

| | | | SAMPLE DESCRIPTION: | MDSA-MW3-2018-SS2 | MDSA-MW3-2018-SS4 |
|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-10 | 2018-10-10 |
| Parameter | Unit | G / S | RDL | 9626543 | 9626544 |
| % Moisture | % | | 0 | 7 | 6 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

57 Old Pennywell Road, Unit I
St. John's, NL
CANADA A1E 6A8
TEL (709)747-8573
FAX (709 747-2139
http://www.agatlabs.com

AGAT Laboratories

# Quality Assurance

CLIENT NAME: GHD LIMITED | AGAT WORK ORDER: 18K397501

PROJECT: 11178792-02 Marystown Shipyard - MDSA | ATTENTION TO: JAMES O'NEILL

SAMPLING SITE: | SAMPLED BY:

## Soil Analysis

| RPT Date: Oct 24, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Available Metals in Soil | | | | | | | | | | | | | | | |
| Aluminum | 9641128 | | 6820 | 7420 | 8.3% | < 10 | 117% | 80% | 120% | 116% | 80% | 120% | 121% | 70% | 130% |
| Antimony | 9641128 | | 1 | 2 | NA | < 1 | 99% | 80% | 120% | 106% | 80% | 120% | 103% | 70% | 130% |
| Arsenic | 9641128 | | 7 | 8 | 12.2% | < 1 | 108% | 80% | 120% | 100% | 80% | 120% | 117% | 70% | 130% |
| Barium | 9641128 | | 62 | 65 | 6.0% | < 5 | 106% | 80% | 120% | 97% | 80% | 120% | 123% | 70% | 130% |
| Beryllium | 9641128 | | <2 | <2 | NA | < 2 | 110% | 80% | 120% | 101% | 80% | 120% | 122% | 70% | 130% |
| Boron | 9641128 | | <2 | 3 | NA | < 2 | 101% | 80% | 120% | 98% | 80% | 120% | 119% | 70% | 130% |
| Cadmium | 9641128 | | <0.3 | <0.3 | NA | < 0.3 | 111% | 80% | 120% | 99% | 80% | 120% | 117% | 70% | 130% |
| Chromium | 9641128 | | 16 | 18 | 7.9% | < 2 | 108% | 80% | 120% | 97% | 80% | 120% | 119% | 70% | 130% |
| Cobalt | 9641128 | | 4 | 5 | NA | < 1 | 109% | 80% | 120% | 102% | 80% | 120% | 125% | 70% | 130% |
| Copper | 9641128 | | 52 | 51 | 0.7% | < 2 | 111% | 80% | 120% | 101% | 80% | 120% | 106% | 70% | 130% |
| Iron | 9641128 | | 7530 | 9170 | 19.7% | < 50 | 110% | 80% | 120% | 96% | 80% | 120% | 119% | 70% | 130% |
| Lead | 9641128 | | 13.2 | 14.5 | 9.1% | < 0.5 | 115% | 80% | 120% | 102% | 80% | 120% | 114% | 70% | 130% |
| Lithium | 9641128 | | <5 | 6 | NA | < 5 | 110% | 70% | 130% | 103% | 70% | 130% | 122% | 70% | 130% |
| Manganese | 9641128 | | 149 | 154 | 3.3% | < 2 | 108% | 80% | 120% | 99% | 80% | 120% | 121% | 70% | 130% |
| Molybdenum | 9641128 | | <2 | <2 | NA | < 2 | 106% | 80% | 120% | 102% | 80% | 120% | 127% | 70% | 130% |
| Nickel | 9641128 | | 9 | 9 | NA | < 2 | 111% | 80% | 120% | 95% | 80% | 120% | 119% | 70% | 130% |
| Selenium | 9641128 | | <1 | <1 | NA | < 1 | 104% | 80% | 120% | 99% | 80% | 120% | 116% | 70% | 130% |
| Silver | 9641128 | | <0.5 | <0.5 | NA | < 0.5 | 109% | 80% | 120% | 105% | 80% | 120% | 130% | 70% | 130% |
| Strontium | 9641128 | | 13 | 14 | NA | < 5 | 120% | 80% | 120% | 109% | 80% | 120% | NA | 70% | 130% |
| Thallium | 9641128 | | <0.1 | <0.1 | NA | < 0.1 | 111% | 80% | 120% | 103% | 80% | 120% | 87% | 70% | 130% |
| Tin | 9641128 | | < 2 | < 2 | NA | < 2 | 105% | 80% | 120% | 97% | 80% | 120% | 118% | 70% | 130% |
| Uranium | 9641128 | | 0.6 | 0.5 | 10.4% | < 0.1 | 109% | 80% | 120% | 99% | 80% | 120% | 123% | 70% | 130% |
| Vanadium | 9641128 | | 31 | 35 | 11.4% | < 2 | 105% | 80% | 120% | 96% | 80% | 120% | 124% | 70% | 130% |
| Zinc | 9641128 | | 56 | 61 | 8.7% | < 5 | 107% | 80% | 120% | 94% | 80% | 120% | 123% | 70% | 130% |
| Mercury Analysis in Soil | | | | | | | | | | | | | | | |
| Mercury | 1 | 9634372 | <0.05 | <0.05 | NA | < 0.05 | 88% | 70% | 130% | | 70% | 130% | 72% | 70% | 130% |

Certified By: Jason Coughtrey

57 Old Pennywell Road, Unit I
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http://www.agatlabs.com

# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02 Marystown Shipyard - MDSA
SAMPLING SITE:

AGAT WORK ORDER: 18K397501
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Trace Organics Analysis

| RPT Date: Oct 24, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved | | | | | | | | | | | | | | | |
| Benzene | 1 | 9629306 | <0.005 | <0.005 | 0 | < 0.03 | 73% | 60% | 140% | 63% | 60% | 140% | | | |
| Toluene | 1 | 9629306 | <0.025 | <0.025 | 0 | < 0.04 | 77% | 60% | 140% | 66% | 60% | 140% | | | |
| Ethylbenzene | 1 | 9629306 | <0.01 | <0.01 | 0 | < 0.03 | 79% | 60% | 140% | 68% | 60% | 140% | | | |
| Xylene (Total) | 1 | 9629306 | <0.05 | <0.05 | 0 | < 0.05 | 82% | 60% | 140% | 70% | 60% | 140% | | | |
| C6-C10 (less BTEX) | 1 | 9629306 | <3 | <3 | 0 | < 3 | 114% | 60% | 140% | 116% | 60% | 140% | 117% | 30% | 130% |
| >C10-C16 Hydrocarbons | 1 | 9626743 | < 15 | < 15 | NA | < 15 | 129% | 60% | 140% | 94% | 60% | 140% | 125% | 30% | 130% |
| >C16-C21 Hydrocarbons | 1 | 9626743 | 35 | 42 | NA | < 15 | 123% | 60% | 140% | 94% | 60% | 140% | 125% | 30% | 130% |
| >C21-C32 Hydrocarbons | 1 | 9626743 | 20 | 25 | NA | < 15 | 133% | 60% | 140% | 94% | 60% | 140% | 125% | 30% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Lower | Upper | Recovery | Lower | Upper | Recovery | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved | | | | | | | | | | | | | | | |
| Benzene | 1 | 9626541 | < 0.03 | < 0.03 | NA | < 0.03 | 113% | 60% | 140% | 89% | 60% | 140% | | | |
| Toluene | 1 | 9626541 | < 0.04 | < 0.04 | NA | < 0.04 | 122% | 60% | 140% | 91% | 60% | 140% | | | |
| Ethylbenzene | 1 | 9626541 | < 0.03 | < 0.03 | NA | < 0.03 | 120% | 60% | 140% | 89% | 60% | 140% | | | |
| Xylene (Total) | 1 | 9626541 | < 0.05 | < 0.05 | NA | < 0.05 | 125% | 60% | 140% | 93% | 60% | 140% | | | |
| C6-C10 (less BTEX) | 1 | 9626541 | < 3 | < 3 | NA | < 3 | 118% | 60% | 140% | 113% | 60% | 140% | 120% | 30% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

Certified By:

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02 Marystown Shipyard - MDSA
SAMPLING SITE:

AGAT WORK ORDER: 18K397501
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Soil Analysis | | | |
| Aluminum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Antimony | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Arsenic | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Barium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Beryllium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Boron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cadmium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Chromium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cobalt | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Copper | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Iron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Lead | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Lithium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Manganese | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Molybdenum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Nickel | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Selenium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Silver | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Strontium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Thallium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Tin | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Uranium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Vanadium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Zinc | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Mercury | INOR-121-6101 & INOR-121-6107 | Based on EPA 245.5 & SM 3112B | CV/AA |

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# Method Summary

CLIENT NAME: GHD LIMITED
AGAT WORK ORDER: 18K397501
PROJECT: 11178792-02 Marystown Shipyard - MDSA
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Trace Organics Analysis | | | |
| Benzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Toluene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Ethylbenzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Xylene (Total) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| C6-C10 (less BTEX) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| >C10-C16 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C16-C21 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C21-C32 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Modified TPH (Tier 1) | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | CALCULATION |
| Resemblance Comment | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| Return to Baseline at C32 | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - VPH | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| n-Dotriacontane - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| % Moisture | | Calculation | GRAVIMETRIC |

Unit 122 • 11 Morris Drive
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B3B 1M2

# AGAT Laboratories

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**Laboratory Use Only**

Arrival Condition: ☑ Good ☐ Poor (see notes)
Arrival Temperature: 2.5 6.3 5.1
AGAT Job Number: 18K397501
Notes:

## Chain of Custody Record

**Report Information**

Company: GHD Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone 1-709-364-5353 Fax: 1-709-364-5368
Site # and/or Name: MARYSTOWN SHIPYARD - MDSA
Project #: 11178792-02
AGAT Quotation #: GHD Standing Offer
GHD PO #: TO FOLLOW

**Report Information**

1. Name: James O'Neill
   Email: James.Oneill@ghd.com
2. Name: datanl
   Email: datanl@ghd.com

**Report Format**

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

**Turnaround Time Required (TAT)**

Regular TAT ☑ 5 to 7 working days
Rush TAT ☐ 1 day ☐ 2 days ☐ 3 days
Date Required:

**Regulatory Requirements** (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ PIRI
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☐ CCME ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

Drinking Water Sample: ☐ Yes ☑ No
Reg. No.:

**Invoice To** Same Yes ☑ / No ☐

Company:
Contact:
Address:
Phone: Fax:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO. TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: MERCURY (Hg) | OTHER: | OTHER: | HOLD FOR POSS. LEAHATE | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MDSA-BH1-2018-SS1 | 2018/09/10 00:00 | Soil | VARIOUS | 2 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MDSA-BH1-2018-SS2 | 2018/09/10 00:00 | Soil | VARIOUS | 2 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MDSA-BH2-2018-SS1 | 2018/09/10 00:00 | Soil | VARIOUS | 2 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MDSA-BH2-2018-SS2 | 2018/09/10 00:00 | Soil | VARIOUS | 2 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MDSA-BH2-2018-SS4 | 2018/09/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MDSA-BH2-2018-SS5 | 2018/09/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MDSA-BH3-2018-SS1 | 2018/10/10 00:00 | Soil | VARIOUS | 2 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MDSA-BH3-2018-SS2 | 2018/10/10 00:00 | Soil | VARIOUS | 2 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MDSA-BH3-2018-SS4 | 2018/10/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MDSA-BH3-2018-SS5 | 2018/10/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MDSA-BH5-2018-SS3 | 2018/10/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |

Samples Relinquished By (Print Name): Robert Perry
Date/Time: 10/16/10
Samples Received By (Print Name):
Date/Time: 10/16/18

Samples Relinquished By (Sign): R. Perry
Date/Time:
Samples Received By (Sign):
Date/Time: @ 1:10

Page 1 of 2



Document ID: DIV-133-1502.001

Date revised: September 18, 2015

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AGAT Laboratories

**Laboratory Use Only**

Arrival Condition: ☑ Good ☐ Poor (see notes)
Arrival Temperature: 2.5, 6.3, 5.1
AGAT Job Number:
Notes:

# Chain of Custody Record

**Report Information**

Company: GHD Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone 1-709-364-5353 Fax: 1-709-364-5368
Site # and/or Name: MARYSTOWN SHIPYARD - MDSA
Project #: 11178792-02
AGAT Quotation #: GHD Standing Offer
GHD PO #: TO FOLLOW

**Report Information**

1. Name: James O'Neill
Email: James.Oneill@ghd.com
2. Name: datanl
Email: datanl@ghd.com

**Report Format**

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

**Turnaround Time Required (TAT)**

Regular TAT ☑ 5 to 7 working days
Rush TAT ☐ 1 day ☐ 2 days ☐ 3 days
Date Required:

**Invoice To** Same Yes ☑ / No ☐

Company:
Contact:
Address:
Phone: Fax:

**Regulatory Requirements** (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ PIRI
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☐ CCME ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

Drinking Water Sample: ☐ Yes ☑ No
Reg. No.:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I – LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: MERCURY (Hg) | OTHER: | OTHER: | HOLD FOR POSS. LEAHATE | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MDSA-BH5-2018-SS4 | 2018/10/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MDSA-BH6-2018-SS3 | 2018/10/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MDSA-BH6-2018-SS4 | 2018/10/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MDSA-MW3-2018-SS2 | 2018/10/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MDSA-MW3-2018-SS4 | 2018/10/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |

| Samples Relinquished By (Print Name): Robert Perry | Date/Time 10/16/2018 | Samples Received By (Print Name): | Date/Time 10/16/18 |
|---|---|---|---|
| Samples Relinquished By (Sign): R. Perry | Date/Time | Samples Received By (Sign): | Date/Time @ 1:10 |

Page 2 of 2

Document ID: DIV-100-1502.001

Date revised: September 18, 2015

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| | |
|---|---|
| CLIENT NAME: | GHD LIMITED<br>1118 TOPSAIL ROAD<br>ST. JOHN'S , NL A1B3N7<br>(709) 364-5353 |
| ATTENTION TO: | JAMES O'NEILL |
| PROJECT: | 11178792-02 Marystown Shipyard - MSBL |
| AGAT WORK ORDER: | 18K397519 |
| SOIL ANALYSIS REVIEWED BY: | Jason Coughtrey, Inorganics Supervisor |
| TRACE ORGANICS REVIEWED BY: | Amy Hunter, Trace Organics Supervisor, B.Sc. |
| DATE REPORTED: | Oct 24, 2018 |
| PAGES (INCLUDING COVER): | 10 |
| VERSION*: | 1 |

Should you require any information regarding this analysis please contact your client services representative at (709)747-8573

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

AGAT Laboratories

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http://www.agatlabs.com

# Certificate of Analysis

AGAT WORK ORDER: 18K397519

PROJECT: 11178792-02 Marystown Shipyard - MSBL

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Available Metals in Soil

DATE RECEIVED: 2018-10-16

DATE REPORTED: 2018-10-24

| Parameter | Unit | G / S | RDL | MSBL-MW2-2018-SS1 | MSBL-BH4-2018-SS1 |
|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Soil | Soil |
| DATE SAMPLED: | | | | 2018-10-04 | 2018-10-09 |
| | | | | 9626709 | 9626723 |
| Aluminum | mg/kg | | 10 | 10800 | 11400 |
| Antimony | mg/kg | | 1 | <1 | <1 |
| Arsenic | mg/kg | | 1 | 8 | 9 |
| Barium | mg/kg | | 5 | 40 | 35 |
| Beryllium | mg/kg | | 2 | <2 | <2 |
| Boron | mg/kg | | 2 | <2 | <2 |
| Cadmium | mg/kg | | 0.3 | <0.3 | <0.3 |
| Chromium | mg/kg | | 2 | 13 | 9 |
| Cobalt | mg/kg | | 1 | 7 | 6 |
| Copper | mg/kg | | 2 | 13 | 13 |
| Iron | mg/kg | | 50 | 8310 | 12100 |
| Lead | mg/kg | | 0.5 | 8.7 | 12.5 |
| Lithium | mg/kg | | 5 | 8 | 13 |
| Manganese | mg/kg | | 2 | 714 | 451 |
| Molybdenum | mg/kg | | 2 | <2 | <2 |
| Nickel | mg/kg | | 2 | 9 | 6 |
| Selenium | mg/kg | | 1 | <1 | <1 |
| Silver | mg/kg | | 0.5 | <0.5 | <0.5 |
| Strontium | mg/kg | | 5 | 14 | 9 |
| Thallium | mg/kg | | 0.1 | <0.1 | <0.1 |
| Tin | mg/kg | | 2 | <2 | <2 |
| Uranium | mg/kg | | 0.1 | 0.3 | 0.4 |
| Vanadium | mg/kg | | 2 | 26 | 26 |
| Zinc | mg/kg | | 5 | 39 | 101 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9626709-9626723 Results are based on the dry weight of the sample.

Analysis performed at AGAT Halifax (unless marked by *)

Certified By: Jason Coughtrey

AGAT Laboratories

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FAX (709 747-2139
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# Certificate of Analysis

AGAT WORK ORDER: 18K397519

PROJECT: 11178792-02 Marystown Shipyard - MSBL

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Mercury Analysis in Soil

DATE RECEIVED: 2018-10-16

DATE REPORTED: 2018-10-24

| | | | SAMPLE DESCRIPTION: | MSBL-MW2-2018-SS1 | MSBL-BH4-2018-SS1 |
|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-04 | 2018-10-09 |
| Parameter | Unit | G / S | RDL | 9626709 | 9626723 |
| Mercury | mg/kg | | 0.05 | <0.05 | <0.05 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9626709-9626723 Results are based on the dry weight of the soil.

Analysis performed at AGAT Halifax (unless marked by *)

Certified By: Jason Coughtrey

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AGAT Laboratories

# Certificate of Analysis

AGAT WORK ORDER: 18K397519
PROJECT: 11178792-02 Marystown Shipyard - MSBL

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved

DATE RECEIVED: 2018-10-16
DATE REPORTED: 2018-10-24

| Parameter | Unit | G / S | RDL | MSBL-MW2-2018-SS4 | MSBL-MW2-2018-SS6 | MSBL-BH4-2018-SS5 | MSBL-BH4-2018-SS6 |
|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Soil | Soil | Soil | Soil |
| DATE SAMPLED: | | | | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-09 |
| | | | | 9626713 | 9626717 | 9626742 | 9626743 |
| Benzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | 14 | <3 | 70 | <3 |
| >C10-C16 Hydrocarbons | mg/kg | | 15 | 380 | <15 | 1520 | <15 |
| >C16-C21 Hydrocarbons | mg/kg | | 15 | 374 | <15 | 1200 | 35 |
| >C21-C32 Hydrocarbons | mg/kg | | 15 | 337 | 17 | 190 | 20 |
| Modified TPH (Tier 1) | mg/kg | | 20 | 1110 | <20 | 2980 | 55 |
| Resemblance Comment | | | | WFOF+LOF | LOF | WFOF | WFOF |
| Return to Baseline at C32 | | | | Y | Y | Y | Y |

| Surrogate | Unit | Acceptable Limits | MSBL-MW2-2018-SS4 | MSBL-MW2-2018-SS6 | MSBL-BH4-2018-SS5 | MSBL-BH4-2018-SS6 |
|---|---|---|---|---|---|---|
| Isobutylbenzene - EPH | % | 60-140 | 93 | 96 | 90 | 98 |
| Isobutylbenzene - VPH | % | 60-140 | 107 | 78 | 95 | 100 |
| n-Dotriacontane - EPH | % | 60-140 | 119 | 106 | 96 | 102 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9626713-9626743 Results are based on the dry weight of the soil.

Resemblance Comment Key:
GF - Gasoline Fraction
WGF - Weathered Gasoline Fraction
GR - Product in Gasoline Range
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
FR - Product in Fuel Oil Range
LOF - Lube Oil Fraction
LR - Lube Range
UC - Unidentified Compounds
NR - No Resemblance
NA - Not Applicable

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

AGAT Laboratories

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# Certificate of Analysis

AGAT WORK ORDER: 18K397519

PROJECT: 11178792-02 Marystown Shipyard - MSBL

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Moisture

DATE RECEIVED: 2018-10-16

DATE REPORTED: 2018-10-24

| | | | SAMPLE DESCRIPTION: | MSBL-MW2-2018-SS4 | MSBL-MW2-2018-SS6 | MSBL-BH4-2018-SS5 | MSBL-BH4-2018-SS6 |
|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-09 |
| Parameter | Unit | G / S | RDL | 9626713 | 9626717 | 9626742 | 9626743 |
| % Moisture | % | | 0 | 12 | 11 | 9 | 10 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02 Marystown Shipyard - MSBL
SAMPLING SITE:

AGAT WORK ORDER: 18K397519
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Soil Analysis

| RPT Date: Oct 24, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Available Metals in Soil | | | | | | | | | | | | | | | |
| Aluminum | 9634372 | | 19600 | 20200 | 2.7% | < 10 | 120% | 80% | 120% | 119% | 80% | 120% | 107% | 70% | 130% |
| Antimony | 9634372 | | <1 | <1 | NA | < 1 | 111% | 80% | 120% | 115% | 80% | 120% | NA | 70% | 130% |
| Arsenic | 9634372 | | 15 | 16 | 10.6% | < 1 | 113% | 80% | 120% | 110% | 80% | 120% | 94% | 70% | 130% |
| Barium | 9634372 | | 45 | 51 | 13.0% | < 5 | 107% | 80% | 120% | 111% | 80% | 120% | 102% | 70% | 130% |
| Beryllium | 9634372 | | <2 | <2 | NA | < 2 | 119% | 80% | 120% | 113% | 80% | 120% | 94% | 70% | 130% |
| Boron | 9634372 | | <2 | <2 | NA | < 2 | 105% | 80% | 120% | 105% | 80% | 120% | 90% | 70% | 130% |
| Cadmium | 9634372 | | <0.3 | <0.3 | NA | < 0.3 | 114% | 80% | 120% | 108% | 80% | 120% | 91% | 70% | 130% |
| Chromium | 9634372 | | 14 | 17 | 15.4% | < 2 | 80% | 80% | 120% | 83% | 80% | 120% | 93% | 70% | 130% |
| Cobalt | 9634372 | | 8 | 10 | 14.7% | < 1 | 91% | 80% | 120% | 89% | 80% | 120% | 91% | 70% | 130% |
| Copper | 9634372 | | 13 | 15 | 13.1% | < 2 | 97% | 80% | 120% | 94% | 80% | 120% | 88% | 70% | 130% |
| Iron | 9634372 | | 20900 | 18600 | 11.4% | < 50 | 80% | 80% | 120% | 81% | 80% | 120% | 98% | 70% | 130% |
| Lead | 9634372 | | 14.4 | 16.0 | 10.8% | < 0.5 | 116% | 80% | 120% | 109% | 80% | 120% | 92% | 70% | 130% |
| Lithium | 9634372 | | 28 | 32 | 11.9% | < 5 | 120% | 70% | 130% | 114% | 70% | 130% | 99% | 70% | 130% |
| Manganese | 9634372 | | 550 | 539 | 2.0% | < 2 | 86% | 80% | 120% | 84% | 80% | 120% | 103% | 70% | 130% |
| Molybdenum | 9634372 | | <2 | <2 | NA | < 2 | 104% | 80% | 120% | 104% | 80% | 120% | 90% | 70% | 130% |
| Nickel | 9634372 | | 13 | 16 | 19.9% | < 2 | 93% | 80% | 120% | 85% | 80% | 120% | 87% | 70% | 130% |
| Selenium | 9634372 | | 1 | 1 | NA | < 1 | 107% | 80% | 120% | 110% | 80% | 120% | 79% | 70% | 130% |
| Silver | 9634372 | | <0.5 | <0.5 | NA | < 0.5 | 98% | 80% | 120% | 98% | 80% | 120% | 82% | 70% | 130% |
| Strontium | 9634372 | | 6 | 7 | NA | < 5 | 106% | 80% | 120% | 105% | 80% | 120% | 101% | 70% | 130% |
| Thallium | 9634372 | | <0.1 | <0.1 | NA | < 0.1 | 110% | 80% | 120% | 103% | 80% | 120% | NA | 70% | 130% |
| Tin | 9634372 | | < 2 | < 2 | NA | < 2 | 110% | 80% | 120% | 110% | 80% | 120% | 89% | 70% | 130% |
| Uranium | 9634372 | | 0.8 | 0.9 | 15.4% | < 0.1 | 107% | 80% | 120% | 102% | 80% | 120% | 92% | 70% | 130% |
| Vanadium | 9634372 | | 18 | 21 | 14.3% | < 2 | 83% | 80% | 120% | 81% | 80% | 120% | 95% | 70% | 130% |
| Zinc | 9634372 | | 46 | 52 | 13.0% | < 5 | 97% | 80% | 120% | 94% | 80% | 120% | 89% | 70% | 130% |
| Mercury Analysis in Soil | | | | | | | | | | | | | | | |
| Mercury | 1 | 9620020 | <0.05 | <0.05 | NA | < 0.05 | 93% | 70% | 130% | | 70% | 130% | 76% | 70% | 130% |

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02 Marystown Shipyard - MSBL
SAMPLING SITE:

AGAT WORK ORDER: 18K397519
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Trace Organics Analysis

| RPT Date: Oct 24, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved | | | | | | | | | | | | | | | |
| Benzene | 1 | 9626541 | < 0.03 | < 0.03 | NA | < 0.03 | 113% | 60% | 140% | 89% | 60% | 140% | | | |
| Toluene | 1 | 9626541 | < 0.04 | < 0.04 | NA | < 0.04 | 122% | 60% | 140% | 91% | 60% | 140% | | | |
| Ethylbenzene | 1 | 9626541 | < 0.03 | < 0.03 | NA | < 0.03 | 120% | 60% | 140% | 89% | 60% | 140% | | | |
| Xylene (Total) | 1 | 9626541 | < 0.05 | < 0.05 | NA | < 0.05 | 125% | 60% | 140% | 93% | 60% | 140% | | | |
| C6-C10 (less BTEX) | 1 | 9626541 | < 3 | < 3 | NA | < 3 | 118% | 60% | 140% | 113% | 60% | 140% | 120% | 30% | 130% |
| >C10-C16 Hydrocarbons | 1 | 9626743 | < 15 | < 15 | NA | < 15 | 129% | 60% | 140% | 94% | 60% | 140% | 125% | 30% | 130% |
| >C16-C21 Hydrocarbons | 1 | 9626743 | 35 | 42 | NA | < 15 | 123% | 60% | 140% | 94% | 60% | 140% | 125% | 30% | 130% |
| >C21-C32 Hydrocarbons | 1 | 9626743 | 20 | 25 | NA | < 15 | 133% | 60% | 140% | 94% | 60% | 140% | 125% | 30% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02 Marystown Shipyard - MSBL
SAMPLING SITE:

AGAT WORK ORDER: 18K397519
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Soil Analysis | | | |
| Aluminum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Antimony | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Arsenic | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Barium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Beryllium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Boron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cadmium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Chromium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cobalt | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Copper | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Iron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Lead | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Lithium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Manganese | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Molybdenum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Nickel | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Selenium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Silver | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Strontium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Thallium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Tin | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Uranium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Vanadium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Zinc | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Mercury | INOR-121-6101 & INOR-121-6107 | Based on EPA 245.5 & SM 3112B | CV/AA |

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02 Marystown Shipyard - MSBL
SAMPLING SITE:

AGAT WORK ORDER: 18K397519
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Trace Organics Analysis | | | |
| Benzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Toluene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Ethylbenzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Xylene (Total) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| C6-C10 (less BTEX) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| >C10-C16 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C16-C21 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C21-C32 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Modified TPH (Tier 1) | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | CALCULATION |
| Resemblance Comment | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| Return to Baseline at C32 | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - VPH | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| n-Dotriacontane - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| % Moisture | | Calculation | GRAVIMETRIC |

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**AGAT Laboratories**

**Laboratory Use Only**

Arrival Condition: ☑ Good ☐ Poor (see notes)

Arrival Temperature: 2.5 | 6.3 | 5.1

AGAT Job Number: 18K397519

Notes:

# Chain of Custody Record

## Report Information

Company: GHD Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone 1-709-364-5353 Fax: 1-709-364-5368
**Site # and/or Name:** MARYSTOWN SHIPYARD - MSBL
Project #: 11178792-02
**AGAT Quotation #:** GHD Standing Offer
**GHD PO #:** TO FOLLOW

## Report Information

1. Name: **James O'Neill**
Email: James.Oneill@ghd.com
2. Name: datanl
Email: datanl@ghd.om

## Report Format

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

## Turnaround Time Required (TAT)

**Regular TAT** ☑ 5 to 7 working days
**Rush TAT** ☐ 1 day ☐ 2 days ☐ 3 days
Date Required:

## Regulatory Requirements (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ **PIRI**
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☐ **CCME** ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

**Drinking Water Sample:** ☐ Yes ☑ No
Reg. No.:

## Invoice To

Same Yes ☑ / No ☐

Company:
Contact:
Address:
Phone: Fax:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: MERCURY (Hg) | OTHER: | OTHER: | HOLD FOR POSS. LEAHATE | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MSBL-MW2-2018-SS1 | 2018/04/10 00:00 | Soil | VARIOUS | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MSBL-MW2-2018-SS4 | 2018/09/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSBL-MW2-2018-SS6 | 2018/09/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSBL-BH4-2018-SS1 | 2018/09/10 00:00 | Soil | VARIOUS | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | | | | | | | |
| MSBL-BH4-2018-SS5 | 2018/09/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |
| MSBL-BH4-2018-SS6 | 2018/09/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | | | | | | | |

Samples Relinquished By (Print Name): Robert Perry
Date/Time: 10/16/2018
Samples Received By (Print Name):
Date/Time: 10/16/18
Samples Relinquished By (Sign): R. Perry
Date/Time
Samples Received By (Sign):
Date/Time: 11:10

Page 1 of 1

Document ID: DIV-133-1502.001

Date revised: September 16, 2015

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CLIENT NAME: GHD LIMITED
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ST. JOHN'S , NL A1B3N7
(709) 364-5353

ATTENTION TO: JAMES O'NEILL

PROJECT: 11178792-02 Marystown Shipyard - MAEB

AGAT WORK ORDER: 18K397528

SOIL ANALYSIS REVIEWED BY: Jason Coughtrey, Inorganics Supervisor

TRACE ORGANICS REVIEWED BY: Amy Hunter, Trace Organics Supervisor, B.Sc.

DATE REPORTED: Oct 24, 2018

PAGES (INCLUDING COVER): 10

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (709)747-8573

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

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# Certificate of Analysis

AGAT WORK ORDER: 18K397528

PROJECT: 11178792-02 Marystown Shipyard - MAEB

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Available Metals in Soil

DATE RECEIVED: 2018-10-16

DATE REPORTED: 2018-10-24

| Parameter | Unit | G / S | RDL | MAEB-BH3-2018-SS1 | MAEB-BH3-2018-SS2 | MAEB-BH4-2018-SS1 | MAEB-BH4-2018-SS2 | MAEB-BH5-2018-SS1 | MAEB-BH5-2018-SS2 |
|---|---|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Soil | Soil | Soil | Soil | Soil | Soil |
| DATE SAMPLED: | | | | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-09 |
| | | | | 9626852 | 9626862 | 9626902 | 9626904 | 9626925 | 9626926 |
| Aluminum | mg/kg | | 10 | 8940 | 8890 | 10500 | 12500 | 10700 | 8520 |
| Antimony | mg/kg | | 1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Arsenic | mg/kg | | 1 | 14 | 15 | 13 | 19 | 13 | 11 |
| Barium | mg/kg | | 5 | 38 | 75 | 44 | 111 | 44 | 36 |
| Beryllium | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Boron | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Cadmium | mg/kg | | 0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 | <0.3 |
| Chromium | mg/kg | | 2 | 11 | 17 | 15 | 19 | 13 | 14 |
| Cobalt | mg/kg | | 1 | 6 | 10 | 9 | 11 | 8 | 9 |
| Copper | mg/kg | | 2 | 18 | 18 | 20 | 25 | 18 | 18 |
| Iron | mg/kg | | 50 | 16800 | 13900 | 17700 | 23700 | 18200 | 13300 |
| Lead | mg/kg | | 0.5 | 23.8 | 12.1 | 18.3 | 22.5 | 16.1 | 8.6 |
| Lithium | mg/kg | | 5 | 11 | 9 | 12 | 10 | 11 | 8 |
| Manganese | mg/kg | | 2 | 1030 | 1060 | 1100 | 1810 | 828 | 553 |
| Molybdenum | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Nickel | mg/kg | | 2 | 6 | 12 | 10 | 14 | 8 | 10 |
| Selenium | mg/kg | | 1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Silver | mg/kg | | 0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Strontium | mg/kg | | 5 | 12 | 21 | 16 | 15 | 13 | 20 |
| Thallium | mg/kg | | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Uranium | mg/kg | | 0.1 | 0.5 | 0.3 | 0.6 | 0.4 | 0.5 | 0.3 |
| Vanadium | mg/kg | | 2 | 33 | 47 | 44 | 50 | 37 | 46 |
| Zinc | mg/kg | | 5 | 75 | 59 | 110 | 97 | 78 | 47 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9626852-9626926 Results are based on the dry weight of the sample.

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

AGAT Laboratories

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# Certificate of Analysis

AGAT WORK ORDER: 18K397528

PROJECT: 11178792-02 Marystown Shipyard - MAEB

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Mercury Analysis in Soil

DATE RECEIVED: 2018-10-16

DATE REPORTED: 2018-10-24

| | | | SAMPLE DESCRIPTION: | MAEB-BH3-2018-SS1 | MAEB-BH3-2018-SS2 | MAEB-BH4-2018-SS1 | MAEB-BH4-2018-SS2 | MAEB-BH5-2018-SS1 | MAEB-BH5-2018-SS2 |
|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-09 |
| Parameter | Unit | G / S | RDL | 9626852 | 9626862 | 9626902 | 9626904 | 9626925 | 9626926 |
| Mercury | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9626852-9626926 Results are based on the dry weight of the soil.

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

# Certificate of Analysis

AGAT WORK ORDER: 18K397528

PROJECT: 11178792-02 Marystown Shipyard - MAEB

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CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved

DATE RECEIVED: 2018-10-16

DATE REPORTED: 2018-10-24

| | | | SAMPLE DESCRIPTION: | MAEB-BH3-2018-SS2 | MAEB-BH3-2018-SS3 | MAEB-BH4-2018-SS2 | MAEB-BH4-2018-SS3 | MAEB-BH5-2018-SS2 | MAEB-BH5-2018-SS3 |
|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-09 |
| Parameter | Unit | G / S | RDL | 9626862 | 9626869 | 9626904 | 9626916 | 9626926 | 9626930 |
| Benzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | <3 | <3 | <3 | <3 | <3 | <3 |
| >C10-C16 Hydrocarbons | mg/kg | | 15 | 164 | <15 | <15 | <15 | <15 | <15 |
| >C16-C21 Hydrocarbons | mg/kg | | 15 | 248 | <15 | <15 | <15 | <15 | <15 |
| >C21-C32 Hydrocarbons | mg/kg | | 15 | 103 | <15 | <15 | <15 | <15 | 21 |
| Modified TPH (Tier 1) | mg/kg | | 20 | 515 | <20 | <20 | <20 | <20 | 21 |
| Resemblance Comment | | | | FOF | NR | NR | NR | NR | UC |
| Return to Baseline at C32 | | | | Y | Y | Y | Y | Y | Y |
| Surrogate | Unit | Acceptable Limits | | | | | | | |
| Isobutylbenzene - EPH | % | 60-140 | | 87 | 96 | 90 | 93 | 99 | 94 |
| Isobutylbenzene - VPH | % | 60-140 | | 100 | 99 | 98 | 95 | 96 | 96 |
| n-Dotriacontane - EPH | % | 60-140 | | 95 | 100 | 96 | 99 | 107 | 107 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9626862-9626930 Results are based on the dry weight of the soil.

Resemblance Comment Key:
GF - Gasoline Fraction
WGF - Weathered Gasoline Fraction
GR - Product in Gasoline Range
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
FR - Product in Fuel Oil Range
LOF - Lube Oil Fraction
LR - Lube Range
UC - Unidentified Compounds
NR - No Resemblance
NA - Not Applicable

Analysis performed at AGAT Halifax (unless marked by *)

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# Certificate of Analysis

AGAT WORK ORDER: 18K397528
PROJECT: 11178792-02 Marystown Shipyard - MAEB

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Moisture

DATE RECEIVED: 2018-10-16
DATE REPORTED: 2018-10-24

| | | | SAMPLE DESCRIPTION: | MAEB-BH3-2018-SS2 | MAEB-BH3-2018-SS3 | MAEB-BH4-2018-SS2 | MAEB-BH4-2018-SS3 | MAEB-BH5-2018-SS2 | MAEB-BH5-2018-SS3 |
|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-09 | 2018-10-09 |
| Parameter | Unit | G / S | RDL | 9626862 | 9626869 | 9626904 | 9626916 | 9626926 | 9626930 |
| % Moisture | % | | 0 | 7 | 9 | 9 | 9 | 8 | 11 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
Analysis performed at AGAT Halifax (unless marked by *)

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# Quality Assurance

CLIENT NAME: GHD LIMITED

PROJECT: 11178792-02 Marystown Shipyard - MAEB

SAMPLING SITE:

AGAT WORK ORDER: 18K397528

ATTENTION TO: JAMES O'NEILL

SAMPLED BY:

## Soil Analysis

| RPT Date: Oct 24, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| **Available Metals in Soil** | | | | | | | | | | | | | | | |
| Aluminum | 9641128 | | 6820 | 7420 | 8.3% | < 10 | 117% | 80% | 120% | 116% | 80% | 120% | 121% | 70% | 130% |
| Antimony | 9641128 | | 1 | 2 | NA | < 1 | 99% | 80% | 120% | 106% | 80% | 120% | 103% | 70% | 130% |
| Arsenic | 9641128 | | 7 | 8 | 12.2% | < 1 | 108% | 80% | 120% | 100% | 80% | 120% | 117% | 70% | 130% |
| Barium | 9641128 | | 62 | 65 | 6.0% | < 5 | 106% | 80% | 120% | 97% | 80% | 120% | 123% | 70% | 130% |
| Beryllium | 9641128 | | <2 | <2 | NA | < 2 | 110% | 80% | 120% | 101% | 80% | 120% | 122% | 70% | 130% |
| Boron | 9641128 | | <2 | 3 | NA | < 2 | 101% | 80% | 120% | 98% | 80% | 120% | 119% | 70% | 130% |
| Cadmium | 9641128 | | <0.3 | <0.3 | NA | < 0.3 | 111% | 80% | 120% | 99% | 80% | 120% | 117% | 70% | 130% |
| Chromium | 9641128 | | 16 | 18 | 7.9% | < 2 | 108% | 80% | 120% | 97% | 80% | 120% | 119% | 70% | 130% |
| Cobalt | 9641128 | | 4 | 5 | NA | < 1 | 109% | 80% | 120% | 102% | 80% | 120% | 125% | 70% | 130% |
| Copper | 9641128 | | 52 | 51 | 0.7% | < 2 | 111% | 80% | 120% | 101% | 80% | 120% | 106% | 70% | 130% |
| Iron | 9641128 | | 7530 | 9170 | 19.7% | < 50 | 110% | 80% | 120% | 96% | 80% | 120% | 119% | 70% | 130% |
| Lead | 9641128 | | 13.2 | 14.5 | 9.1% | < 0.5 | 115% | 80% | 120% | 102% | 80% | 120% | 114% | 70% | 130% |
| Lithium | 9641128 | | <5 | 6 | NA | < 5 | 110% | 70% | 130% | 103% | 70% | 130% | 122% | 70% | 130% |
| Manganese | 9641128 | | 149 | 154 | 3.3% | < 2 | 108% | 80% | 120% | 99% | 80% | 120% | 121% | 70% | 130% |
| Molybdenum | 9641128 | | <2 | <2 | NA | < 2 | 106% | 80% | 120% | 102% | 80% | 120% | 127% | 70% | 130% |
| Nickel | 9641128 | | 9 | 9 | NA | < 2 | 111% | 80% | 120% | 95% | 80% | 120% | 119% | 70% | 130% |
| Selenium | 9641128 | | <1 | <1 | NA | < 1 | 104% | 80% | 120% | 99% | 80% | 120% | 116% | 70% | 130% |
| Silver | 9641128 | | <0.5 | <0.5 | NA | < 0.5 | 109% | 80% | 120% | 105% | 80% | 120% | 130% | 70% | 130% |
| Strontium | 9641128 | | 13 | 14 | NA | < 5 | 120% | 80% | 120% | 109% | 80% | 120% | NA | 70% | 130% |
| Thallium | 9641128 | | <0.1 | <0.1 | NA | < 0.1 | 111% | 80% | 120% | 103% | 80% | 120% | 87% | 70% | 130% |
| Tin | 9641128 | | < 2 | < 2 | NA | < 2 | 105% | 80% | 120% | 97% | 80% | 120% | 118% | 70% | 130% |
| Uranium | 9641128 | | 0.6 | 0.5 | 10.4% | < 0.1 | 109% | 80% | 120% | 99% | 80% | 120% | 123% | 70% | 130% |
| Vanadium | 9641128 | | 31 | 35 | 11.4% | < 2 | 105% | 80% | 120% | 96% | 80% | 120% | 124% | 70% | 130% |
| Zinc | 9641128 | | 56 | 61 | 8.7% | < 5 | 107% | 80% | 120% | 94% | 80% | 120% | 123% | 70% | 130% |
| **Mercury Analysis in Soil** | | | | | | | | | | | | | | | |
| Mercury | 1 | 9620020 | <0.05 | <0.05 | NA | < 0.05 | 93% | 70% | 130% | | 70% | 130% | 76% | 70% | 130% |

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02 Marystown Shipyard - MAEB
SAMPLING SITE:

AGAT WORK ORDER: 18K397528
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Trace Organics Analysis

| RPT Date: Oct 24, 2018 | | | DUPLICATE | | | | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Acceptable Limits | | Recovery | Acceptable Limits | | Recovery | Acceptable Limits | |
| | | | | | | | | Lower | Upper | | Lower | Upper | | Lower | Upper |
| Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved | | | | | | | | | | | | | | | |
| Benzene | 1 | 9626541 | < 0.03 | < 0.03 | NA | < 0.03 | 113% | 60% | 140% | 89% | 60% | 140% | | | |
| Toluene | 1 | 9626541 | < 0.04 | < 0.04 | NA | < 0.04 | 122% | 60% | 140% | 91% | 60% | 140% | | | |
| Ethylbenzene | 1 | 9626541 | < 0.03 | < 0.03 | NA | < 0.03 | 120% | 60% | 140% | 89% | 60% | 140% | | | |
| Xylene (Total) | 1 | 9626541 | < 0.05 | < 0.05 | NA | < 0.05 | 125% | 60% | 140% | 93% | 60% | 140% | | | |
| C6-C10 (less BTEX) | 1 | 9626541 | < 3 | < 3 | NA | < 3 | 118% | 60% | 140% | 113% | 60% | 140% | 120% | 30% | 130% |
| >C10-C16 Hydrocarbons | 1 | 9615152 | < 15 | < 15 | NA | < 15 | 88% | 60% | 140% | 84% | 60% | 140% | NA | 30% | 130% |
| >C16-C21 Hydrocarbons | 1 | 9615152 | < 15 | < 15 | NA | < 15 | 80% | 60% | 140% | 84% | 60% | 140% | NA | 30% | 130% |
| >C21-C32 Hydrocarbons | 1 | 9615152 | < 15 | < 15 | NA | < 15 | 83% | 60% | 140% | 84% | 60% | 140% | NA | 30% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

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# Method Summary

CLIENT NAME: GHD LIMITED
AGAT WORK ORDER: 18K397528
PROJECT: 11178792-02 Marystown Shipyard - MAEB
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Soil Analysis | | | |
| Aluminum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Antimony | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Arsenic | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Barium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Beryllium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Boron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cadmium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Chromium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cobalt | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Copper | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Iron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Lead | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Lithium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Manganese | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Molybdenum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Nickel | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Selenium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Silver | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Strontium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Thallium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Tin | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Uranium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Vanadium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Zinc | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Mercury | INOR-121-6101 & INOR-121-6107 | Based on EPA 245.5 & SM 3112B | CV/AA |

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02 Marystown Shipyard - MAEB
SAMPLING SITE:
AGAT WORK ORDER: 18K397528
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Trace Organics Analysis | | | |
| Benzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Toluene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Ethylbenzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Xylene (Total) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| C6-C10 (less BTEX) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| >C10-C16 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C16-C21 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C21-C32 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Modified TPH (Tier 1) | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | CALCULATION |
| Resemblance Comment | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| Return to Baseline at C32 | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - VPH | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| n-Dotriacontane - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| % Moisture | | Calculation | GRAVIMETRIC |

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# AGAT Laboratories

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**Laboratory Use Only**

Arrival Condition: ☑ Good ☐ Poor (see notes)

Arrival Temperature: 2.5 6.3 5.1

AGAT Job Number: 18K397528

Notes:

## Chain of Custody Record

### Report Information

Company: GHD Limited

Contact: James O'Neill

Address: 1118 Topsail Road
St. John's NL A1B 3N7

Phone 1-709-364-5353 Fax: 1-709-364-5368

**Site # and/or Name:** MARYSTOWN SHIPYARD - MAEB

Project #: 11178792-02

**AGAT Quotation #:** GHD Standing Offer

**GHD PO #:** TO FOLLOW

### Report Information

1. Name: **James O'Neill**
   Email: James.Oneill@ghd.com
2. Name: datanl
   Email: datanl@ghd.oom

**Report Format**

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

**Turnaround Time Required (TAT)**

**Regular TAT** ☑ 5 to 7 working days

**Rush TAT** ☐ 1 day ☐ 2 days ☐ 3 days

Date Required:

**Invoice To** Same Yes ☑ / No ☐

Company:

Contact:

Address:

Phone: Fax:

**Regulatory Requirements** (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ **PIRI**

☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☐ **CCME** ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

**Drinking Water Sample:** ☐ Yes ☑ No

Reg. No.:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: MERCURY (Hg) | OTHER: | OTHER: | HOLD FOR POSS. LEAHATE | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MAEB-BH3-2018-SS1 | 2018/09/10 00:00 | Soil | VARIOUS | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | |
| MAEB-BH3-2018-SS2 | 2018/09/10 00:00 | Soil | VARIOUS | 4 | ☑ | | | | | ☑ | | | | | | ☑ | | | ☑ | | |
| MAEB-BH3-2018-SS3 | 2018/09/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | |
| MAEB-BH4-2018-SS1 | 2018/09/10 00:00 | Soil | VARIOUS | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | |
| MAEB-BH4-2018-SS2 | 2018/09/10 00:00 | Soil | VARIOUS | 4 | ☑ | | | | | ☑ | | | | | | ☑ | | | ☑ | | |
| MAEB-BH4-2018-SS3 | 2018/09/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | |
| MAEB-BH5-2018-SS1 | 2018/09/10 00:00 | Soil | VARIOUS | 1 | | | | | | ☑ | | | | | | ☑ | | | ☑ | | |
| MAEB-BH5-2018-SS2 | 2018/09/10 00:00 | Soil | VARIOUS | 4 | ☑ | | | | | ☑ | | | | | | ☑ | | | ☑ | | |
| MAEB-BH5-2018-SS3 | 2018/09/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | |

Samples Relinquished By (Print Name): Robert Perry

Date/Time: 10/16/2018

Samples Relinquished By (Sign):

Date/Time

Samples Received By (Print Name):

Date/Time: 10/16/18

Samples Received By (Sign):

Date/Time: 1:10

Page 1 of 1

Document ID: DIV-133-1502.001

Date revised: September 18, 2015

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CLIENT NAME: GHD LIMITED
1118 TOPSAIL ROAD
ST. JOHN'S , NL A1B3N7
(709) 364-5353

ATTENTION TO: JAMES O'NEILL

PROJECT: 11178792-02

AGAT WORK ORDER: 18K397507

TRACE ORGANICS REVIEWED BY: Amy Hunter, Trace Organics Supervisor, B.Sc.

DATE REPORTED: Oct 26, 2018

PAGES (INCLUDING COVER): 7

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (709)747-8573

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

Laboratories

# Certificate of Analysis

AGAT WORK ORDER: 18K397507

PROJECT: 11178792-02

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CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved

DATE RECEIVED: 2018-10-16

DATE REPORTED: 2018-10-26

| Parameter | Unit | G / S | RDL | MASO-BH2-2018-SS3 | MASO-BH2-2018-SS4 | MASO-BH3-2018-SS4 | MASO-BH3-2018-SS5 | MASO-BH1-2018-SS2 | MASO-BH1-2018-SS7 | MASO-BH1-2018-SS8 | MASO-MW1-2018-SS2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-10 | 2018-10-10 | 2018-10-10 | 2018-10-10 | 2018-10-10 | 2018-10-10 | 2018-10-10 | 2018-10-10 |
| | | | | 9626548 | 9626557 | 9626558 | 9626559 | 9626560 | 9626561 | 9626562 | 9626563 |
| Benzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 |
| >C10-C16 Hydrocarbons | mg/kg | | 15 | <15 | <15 | 92 | 21 | <15 | <15 | <15 | <15 |
| >C16-C21 Hydrocarbons | mg/kg | | 15 | <15 | <15 | 59 | <15 | <15 | <15 | <15 | <15 |
| >C21-C32 Hydrocarbons | mg/kg | | 15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 | 67 |
| Modified TPH (Tier 1) | mg/kg | | 20 | <20 | <20 | 151 | 21 | <20 | <20 | <20 | 67 |
| Resemblance Comment | | | | NR | NR | FOF | FOF | NR | NR | NR | LOF |
| Return to Baseline at C32 | | | | Y | Y | Y | Y | Y | Y | Y | Y |
| **Surrogate** | **Unit** | **Acceptable Limits** | | | | | | | | | |
| Isobutylbenzene - EPH | % | 60-140 | | 102 | 82 | 78 | 82 | 83 | 84 | 87 | 84 |
| Isobutylbenzene - VPH | % | 60-140 | | 99 | 83 | 79 | 77 | 77 | 77 | 75 | 75 |
| n-Dotriacontane - EPH | % | 60-140 | | 111 | 76 | 69 | 75 | 78 | 80 | 83 | 83 |

Certified By:

AGAT Laboratories

# Certificate of Analysis

AGAT WORK ORDER: 18K397507

PROJECT: 11178792-02

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St. John's, NL
CANADA A1E 6A8
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http://www.agatlabs.com

CLIENT NAME: GHD LIMITED | ATTENTION TO: JAMES O'NEILL

SAMPLING SITE: | SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved

DATE RECEIVED: 2018-10-16 | DATE REPORTED: 2018-10-26

| Parameter | Unit | G / S | RDL | SAMPLE DESCRIPTION: MASO-MW1-2018-SS3<br>SAMPLE TYPE: Soil<br>DATE SAMPLED: 2018-10-10<br>9626564 |
|---|---|---|---|---|
| Benzene | mg/kg | | 0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | <3 |
| >C10-C16 Hydrocarbons | mg/kg | | 15 | 27 |
| >C16-C21 Hydrocarbons | mg/kg | | 15 | <15 |
| >C21-C32 Hydrocarbons | mg/kg | | 15 | 90 |
| Modified TPH (Tier 1) | mg/kg | | 20 | 117 |
| Resemblance Comment | | | | FOF, LOF |
| Return to Baseline at C32 | | | | Y |
| **Surrogate** | **Unit** | **Acceptable Limits** | | |
| Isobutylbenzene - EPH | % | 60-140 | | 89 |
| Isobutylbenzene - VPH | % | 60-140 | | 81 |
| n-Dotriacontane - EPH | % | 60-140 | | 89 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9626548-9626564 Results are based on the dry weight of the soil.

Resemblance Comment Key:
GF - Gasoline Fraction
WGF - Weathered Gasoline Fraction
GR - Product in Gasoline Range
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
FR - Product in Fuel Oil Range
LOF - Lube Oil Fraction
LR - Lube Range
UC - Unidentified Compounds
NR - No Resemblance
NA - Not Applicable

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

# Certificate of Analysis

AGAT WORK ORDER: 18K397507

PROJECT: 11178792-02

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http://www.agatlabs.com

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Moisture

DATE RECEIVED: 2018-10-16

DATE REPORTED: 2018-10-26

| | | | SAMPLE DESCRIPTION: | MASO-BH2-2018-SS3 | MASO-BH2-2018-SS4 | MASO-BH3-2018-SS4 | MASO-BH3-2018-SS5 | MASO-BH1-2018-SS2 | MASO-BH1-2018-SS7 | MASO-BH1-2018-SS8 | MASO-MW1-2018-SS2 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-10 | 2018-10-10 | 2018-10-10 | 2018-10-10 | 2018-10-10 | 2018-10-10 | 2018-10-10 | 2018-10-10 |
| Parameter | Unit | G / S | RDL | 9626548 | 9626557 | 9626558 | 9626559 | 9626560 | 9626561 | 9626562 | 9626563 |
| % Moisture | % | | 0 | 10 | 11 | 7 | 11 | 8 | 13 | 9 | 10 |

| | | | SAMPLE DESCRIPTION: | MASO-MW1-2018-SS3 |
|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil |
| | | | DATE SAMPLED: | 2018-10-10 |
| Parameter | Unit | G / S | RDL | 9626564 |
| % Moisture | % | | 0 | 12 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K397507
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Trace Organics Analysis

| RPT Date: Oct 26, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved | | | | | | | | | | | | | | | |
| Benzene | 1 | 9635341 | < 0.03 | < 0.03 | NA | < 0.03 | 98% | 60% | 140% | 75% | 60% | 140% | | | |
| Toluene | 1 | 9635341 | < 0.04 | < 0.04 | NA | < 0.04 | 99% | 60% | 140% | 79% | 60% | 140% | | | |
| Ethylbenzene | 1 | 9635341 | < 0.03 | < 0.03 | NA | < 0.03 | 100% | 60% | 140% | 79% | 60% | 140% | | | |
| Xylene (Total) | 1 | 9635341 | < 0.05 | < 0.05 | NA | < 0.05 | 104% | 60% | 140% | 82% | 60% | 140% | | | |
| C6-C10 (less BTEX) | 1 | 9635341 | < 3 | < 3 | NA | < 3 | 124% | 60% | 140% | 115% | 60% | 140% | NA | 30% | 130% |
| >C10-C16 Hydrocarbons | 1 | 9615152 | < 15 | < 15 | NA | < 15 | 88% | 60% | 140% | 84% | 60% | 140% | NA | 30% | 130% |
| >C16-C21 Hydrocarbons | 1 | 9615152 | < 15 | < 15 | NA | < 15 | 80% | 60% | 140% | 84% | 60% | 140% | NA | 30% | 130% |
| >C21-C32 Hydrocarbons | 1 | 9615152 | < 15 | < 15 | NA | < 15 | 83% | 60% | 140% | 84% | 60% | 140% | NA | 30% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Lower | Upper | Recovery | Lower | Upper | Recovery | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved | | | | | | | | | | | | | | | |
| Benzene | 1 | 9626557 | < 0.03 | < 0.03 | NA | < 0.03 | 64% | 60% | 140% | 74% | 60% | 140% | | | |
| Toluene | 1 | 9626557 | < 0.04 | < 0.04 | NA | < 0.04 | 67% | 60% | 140% | 80% | 60% | 140% | | | |
| Ethylbenzene | 1 | 9626557 | < 0.03 | < 0.03 | NA | < 0.03 | 68% | 60% | 140% | 82% | 60% | 140% | | | |
| Xylene (Total) | 1 | 9626557 | < 0.05 | < 0.05 | NA | < 0.05 | 71% | 60% | 140% | 84% | 60% | 140% | | | |
| C6-C10 (less BTEX) | 1 | 9626557 | < 3 | < 3 | NA | < 3 | 105% | 60% | 140% | 113% | 60% | 140% | NA | 30% | 130% |
| >C10-C16 Hydrocarbons | 1 | 9615144 | <15 | <15 | 0 | < 15 | 90% | 60% | 140% | 69% | 60% | 140% | 56% | 30% | 130% |
| >C16-C21 Hydrocarbons | 1 | 9615144 | <15 | <15 | 0 | < 15 | 79% | 60% | 140% | 69% | 60% | 140% | 56% | 30% | 130% |
| >C21-C32 Hydrocarbons | 1 | 9615144 | <15 | <15 | 0 | < 15 | 84% | 60% | 140% | 69% | 60% | 140% | 56% | 30% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K397507
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Trace Organics Analysis | | | |
| Benzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Toluene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Ethylbenzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Xylene (Total) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| C6-C10 (less BTEX) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| >C10-C16 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C16-C21 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C21-C32 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Modified TPH (Tier 1) | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | CALCULATION |
| Resemblance Comment | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| Return to Baseline at C32 | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - VPH | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| n-Dotriacontane - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| % Moisture | | Calculation | GRAVIMETRIC |

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AGAT Laboratories

**Laboratory Use Only**

Arrival Condition: ☑ Good ☐ Poor (see notes)

Arrival Temperature: 2.5, 6.3, 5.1

AGAT Job Number: 18K397507

Notes:

# Chain of Custody Record

## Report Information

Company: GHD Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone 1-709-364-5353 Fax: 1-709-364-5368
**Site # and/or Name:** MARYSTOWN SHIPYARD - MASO
Project #: 11178792-02
**AGAT Quotation #:** GHD Standing Offer
**GHD PO #:** TO FOLLOW

## Report Information

1. Name: **James O'Neill**
   Email: James.Oneill@ghd.com
2. Name: datanl
   Email: datanl@ghd.oom

## Report Format

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

## Turnaround Time Required (TAT)

**Regular TAT** ☑ 5 to 7 working days
**Rush TAT** ☐ 1 day ☐ 2 days ☐ 3 days

Date Required:

## Invoice To

Same Yes ☑ / No ☐

Company:
Contact:
Address:
Phone: Fax:

## Regulatory Requirements (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ **PIRI**
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☐ **CCME** ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

**Drinking Water Sample:** ☐ Yes ☑ No
Reg. No.:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER 1 - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: MERCURY (Hg) | OTHER: | OTHER: | HOLD FOR POSS. LEAHATE | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MASO-BH2-2018-SS3 | 2018/10/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | |
| MASO-BH2-2018-SS4 | 2018/10/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | |
| MASO-BH3-2018-SS4 | 2018/10/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | |
| MASO-BH3-2018-SS5 | 2018/10/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | |
| MASO-BH1-2018-SS2 | 2018/10/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | |
| MASO-BH1-2018-SS7 | 2018/10/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | |
| MASO-BH1-2018-SS8 | 2018/10/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | |
| MASO-MW1-2018-SS2 | 2018/10/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | |
| MASO-MW1-2018-SS3 | 2018/10/10 00:00 | Soil | VARIOUS | 3 | ☑ | | | | | | | | | | | | | | | | |

| Samples Relinquished By (Print Name): | Date/Time | Samples Received By (Print Name): | Date/Time |
|---|---|---|---|
| Robert Perry | 10/16/2018 | | 10/16/18 |
| Samples Relinquished By (Sign): | Date/Time | Samples Received By (Sign): | Date/Time |
| | | | 21:10 |

Page 1 of 1

Document ID: DIV-133-1502.001

Date revised September 18, 2015

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CLIENT NAME: GHD LIMITED
1118 TOPSAIL ROAD
ST. JOHN'S , NL A1B3N7
(709) 364-5353

ATTENTION TO: JAMES O'NEILL

PROJECT:

AGAT WORK ORDER: 18K399949

SOIL ANALYSIS REVIEWED BY: Jason Coughtrey, Inorganics Supervisor

TRACE ORGANICS REVIEWED BY: Amy Hunter, Trace Organics Supervisor, B.Sc.

DATE REPORTED: Oct 29, 2018

PAGES (INCLUDING COVER): 27

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (709)747-8573

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

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CLIENT NAME: GHD LIMITED
SAMPLING SITE:

ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Available Metals in Soil

DATE RECEIVED: 2018-10-22

DATE REPORTED: 2018-10-29

| | | | SAMPLE DESCRIPTION: | 18-MNMA-S1 | 18-MNMA-S2 | 18-MNMA-S3 | 18-MNMA-S4 | 18-MNMA-S5 | 18-MNMA-S6 | 18-MNMA-S7 | 18-MNMA-S8 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642091 | 9642093 | 9642094 | 9642095 | 9642096 | 9642097 | 9642098 | 9642099 |
| Aluminum | mg/kg | | 10 | 10900 | 10500 | 11900 | 14300 | 11700 | 11900 | 9980 | 9140 |
| Antimony | mg/kg | | 1 | <1 | 28 | <1 | <1 | 1 | 2 | 1 | 1 |
| Arsenic | mg/kg | | 1 | 22 | 17 | 19 | 19 | 24 | 19 | 22 | 20 |
| Barium | mg/kg | | 5 | 250 | 83 | 79 | 97 | 148 | 92 | 73 | 58 |
| Beryllium | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Boron | mg/kg | | 2 | 38 | 30 | 32 | 38 | 53 | 40 | 32 | 45 |
| Cadmium | mg/kg | | 0.3 | 0.3 | <0.3 | <0.3 | 0.3 | 0.4 | <0.3 | <0.3 | 0.3 |
| Chromium | mg/kg | | 2 | 71 | 32 | 31 | 26 | 35 | 38 | 19 | 39 |
| Cobalt | mg/kg | | 1 | 13 | 13 | 13 | 13 | 14 | 12 | 10 | 10 |
| Copper | mg/kg | | 2 | 147 | 98 | 171 | 161 | 207 | 170 | 99 | 63 |
| Iron | mg/kg | | 50 | 27600 | 23800 | 30900 | 37900 | 31300 | 30900 | 36200 | 22400 |
| Lead | mg/kg | | 0.5 | 358 | 135 | 284 | 381 | 125 | 252 | 143 | 222 |
| Lithium | mg/kg | | 5 | 18 | 17 | 22 | 19 | 22 | 18 | 16 | 13 |
| Manganese | mg/kg | | 2 | 326 | 288 | 351 | 397 | 321 | 338 | 390 | 387 |
| Molybdenum | mg/kg | | 2 | 4 | 4 | 4 | 5 | 6 | 5 | 2 | 3 |
| Nickel | mg/kg | | 2 | 22 | 24 | 24 | 22 | 27 | 24 | 14 | 17 |
| Selenium | mg/kg | | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 1 |
| Silver | mg/kg | | 0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Strontium | mg/kg | | 5 | 92 | 77 | 47 | 38 | 70 | 40 | 30 | 50 |
| Thallium | mg/kg | | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | mg/kg | | 2 | 14 | 8 | 8 | 10 | 15 | 12 | 13 | 20 |
| Uranium | mg/kg | | 0.1 | 1.0 | 1.0 | 1.0 | 1.2 | 1.1 | 0.9 | 0.8 | 1.0 |
| Vanadium | mg/kg | | 2 | 47 | 42 | 46 | 42 | 53 | 47 | 25 | 40 |
| Zinc | mg/kg | | 5 | 799 | 267 | 282 | 329 | 397 | 297 | 629 | 868 |

Certified By: Jason Coughtrey

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# Certificate of Analysis

AGAT WORK ORDER: 18K399949
PROJECT:

CLIENT NAME: GHD LIMITED
SAMPLING SITE:

ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Available Metals in Soil

DATE RECEIVED: 2018-10-22

DATE REPORTED: 2018-10-29

| | | | SAMPLE DESCRIPTION: | 18-MNMA-S9 | 18-MNMA-S10 | 18-MNMA-S11 | 18-MNMA-S12 | 18-MNMA-S13 | 18-MNMA-S14 | 18-MNMA-S15 | 18-MNMA-DUP1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642100 | 9642101 | 9642102 | 9642103 | 9642104 | 9642105 | 9642106 | 9642107 |
| Aluminum | mg/kg | | 10 | 7190 | 9350 | 8010 | 11400 | 10900 | 12600 | 9940 | 10900 |
| Antimony | mg/kg | | 1 | 2 | 2 | <1 | <1 | <1 | 1 | <1 | <1 |
| Arsenic | mg/kg | | 1 | 22 | 34 | 28 | 29 | 31 | 78 | 65 | 25 |
| Barium | mg/kg | | 5 | 106 | 149 | 48 | 120 | 66 | 122 | 135 | 214 |
| Beryllium | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Boron | mg/kg | | 2 | 26 | 50 | 104 | 60 | 152 | 65 | 86 | 51 |
| Cadmium | mg/kg | | 0.3 | 0.3 | 0.5 | 0.5 | 0.4 | 1.0 | 0.4 | 0.5 | 0.4 |
| Chromium | mg/kg | | 2 | 15 | 24 | 26 | 20 | 27 | 11 | 12 | 31 |
| Cobalt | mg/kg | | 1 | 8 | 12 | 9 | 12 | 10 | 18 | 19 | 15 |
| Copper | mg/kg | | 2 | 98 | 122 | 77 | 144 | 111 | 159 | 158 | 260 |
| Iron | mg/kg | | 50 | 19400 | 28100 | 48700 | 29900 | 34600 | 50000 | 43100 | 27400 |
| Lead | mg/kg | | 0.5 | 343 | 332 | 54.4 | 252 | 67.0 | 728 | 236 | 135 |
| Lithium | mg/kg | | 5 | 13 | 16 | 15 | 20 | 17 | 17 | 16 | 20 |
| Manganese | mg/kg | | 2 | 316 | 343 | 274 | 559 | 283 | 115 | 116 | 332 |
| Molybdenum | mg/kg | | 2 | 2 | 4 | 9 | 5 | 9 | <2 | 2 | 6 |
| Nickel | mg/kg | | 2 | 9 | 17 | 16 | 14 | 17 | 14 | 23 | 25 |
| Selenium | mg/kg | | 1 | 1 | 2 | <1 | <1 | <1 | 2 | 1 | <1 |
| Silver | mg/kg | | 0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Strontium | mg/kg | | 5 | 31 | 73 | 345 | 61 | 200 | 15 | 24 | 48 |
| Thallium | mg/kg | | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | mg/kg | | 2 | 22 | 26 | 7 | 13 | 8 | 17 | 10 | 10 |
| Uranium | mg/kg | | 0.1 | 0.7 | 1.2 | 2.4 | 1.4 | 2.5 | 1.5 | 1.8 | 1.3 |
| Vanadium | mg/kg | | 2 | 22 | 39 | 45 | 39 | 63 | 14 | 16 | 50 |
| Zinc | mg/kg | | 5 | 1450 | 1660 | 334 | 585 | 379 | 5020 | 662 | 375 |

Certified By:

# Certificate of Analysis

AGAT Laboratories

AGAT WORK ORDER: 18K399949
PROJECT:

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CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Available Metals in Soil

DATE RECEIVED: 2018-10-22
DATE REPORTED: 2018-10-29

| Parameter | Unit | G / S | RDL | 18-MNMA-DUP2 | 18-MNMA-REF1 | 18-MNMA-REF2 | 18-MNMA-REF3 |
|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Sediment | Sediment | Sediment | Sediment |
| DATE SAMPLED: | | | | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| | | | | 9642108 | 9642109 | 9642110 | 9642111 |
| Aluminum | mg/kg | | 10 | 11900 | 8770 | 8780 | 9750 |
| Antimony | mg/kg | | 1 | 3 | <1 | <1 | <1 |
| Arsenic | mg/kg | | 1 | 41 | 9 | 11 | 13 |
| Barium | mg/kg | | 5 | 167 | 37 | 34 | 53 |
| Beryllium | mg/kg | | 2 | <2 | <2 | <2 | <2 |
| Boron | mg/kg | | 2 | 100 | 15 | 16 | 20 |
| Cadmium | mg/kg | | 0.3 | 0.6 | <0.3 | <0.3 | <0.3 |
| Chromium | mg/kg | | 2 | 98 | 11 | 16 | 22 |
| Cobalt | mg/kg | | 1 | 22 | 7 | 8 | 10 |
| Copper | mg/kg | | 2 | 145 | 6 | 8 | 14 |
| Iron | mg/kg | | 50 | 41200 | 6990 | 7390 | 9550 |
| Lead | mg/kg | | 0.5 | 466 | 5.9 | 6.5 | 7.4 |
| Lithium | mg/kg | | 5 | 17 | 13 | 17 | 17 |
| Manganese | mg/kg | | 2 | 279 | 197 | 211 | 183 |
| Molybdenum | mg/kg | | 2 | 9 | <2 | 3 | 2 |
| Nickel | mg/kg | | 2 | 45 | 11 | 13 | 18 |
| Selenium | mg/kg | | 1 | 3 | <1 | <1 | <1 |
| Silver | mg/kg | | 0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Strontium | mg/kg | | 5 | 120 | 17 | 22 | 27 |
| Thallium | mg/kg | | 0.1 | <0.1 | <0.1 | 0.1 | 0.1 |
| Tin | mg/kg | | 2 | 28 | 3 | 3 | 4 |
| Uranium | mg/kg | | 0.1 | 2.0 | 1.1 | 1.4 | 1.4 |
| Vanadium | mg/kg | | 2 | 48 | 26 | 33 | 40 |
| Zinc | mg/kg | | 5 | 1730 | 30 | 34 | 38 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9642091-9642111 Results are based on the dry weight of the sample.
Analysis performed at AGAT Halifax (unless marked by *)

Certified By: Jason Coughtrey

# Certificate of Analysis

AGAT WORK ORDER: 18K399949
PROJECT:

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http://www.agatlabs.com

CLIENT NAME: GHD LIMITED
SAMPLING SITE:

ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Fraction Organic Carbon

DATE RECEIVED: 2018-10-22

DATE REPORTED: 2018-10-29

| | | | SAMPLE DESCRIPTION: | 18-MNMA-S1 | 18-MNMA-S2 | 18-MNMA-S3 | 18-MNMA-S4 | 18-MNMA-S5 | 18-MNMA-S6 | 18-MNMA-S7 | 18-MNMA-S8 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642091 | 9642093 | 9642094 | 9642095 | 9642096 | 9642097 | 9642098 | 9642099 |
| Fraction Organic Carbon-1 | NA | | 0.003 | 0.018 | 0.062 | 0.058 | 0.054 | 0.049 | 0.079 | 0.082 | 0.112 |
| Fraction Organic Carbon-2 | NA | | 0.003 | 0.019 | 0.062 | 0.057 | 0.058 | 0.051 | 0.080 | 0.080 | 0.113 |
| Fraction Organic Carbon-3 | NA | | 0.003 | 0.019 | 0.062 | 0.055 | 0.059 | 0.049 | 0.082 | 0.083 | 0.113 |
| Fraction Organic Carbon-Avg | NA | | 0.003 | 0.019 | 0.062 | 0.057 | 0.057 | 0.049 | 0.080 | 0.083 | 0.113 |

| | | | SAMPLE DESCRIPTION: | 18-MNMA-S9 | 18-MNMA-S10 | 18-MNMA-S11 | 18-MNMA-S12 | 18-MNMA-S13 | 18-MNMA-S14 | | 18-MNMA-S15 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642100 | 9642101 | 9642102 | 9642103 | 9642104 | 9642105 | RDL | 9642106 |
| Fraction Organic Carbon-1 | NA | | 0.003 | 0.107 | 0.088 | 0.098 | 0.109 | 0.159 | 0.198 | 0.006 | 0.371 |
| Fraction Organic Carbon-2 | NA | | 0.003 | 0.106 | 0.088 | 0.099 | 0.108 | 0.160 | 0.198 | 0.006 | 0.371 |
| Fraction Organic Carbon-3 | NA | | 0.003 | 0.105 | 0.089 | 0.099 | 0.109 | 0.159 | 0.198 | 0.006 | 0.369 |
| Fraction Organic Carbon-Avg | NA | | 0.003 | 0.106 | 0.088 | 0.099 | 0.109 | 0.159 | 0.198 | 0.006 | 0.370 |

| | | | SAMPLE DESCRIPTION: | 18-MNMA-DUP1 | 18-MNMA-DUP2 | 18-MNMA-REF1 | 18-MNMA-REF2 | 18-MNMA-REF3 |
|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642107 | 9642108 | 9642109 | 9642110 | 9642111 |
| Fraction Organic Carbon-1 | NA | | 0.003 | 0.075 | 0.100 | 0.034 | 0.050 | 0.029 |
| Fraction Organic Carbon-2 | NA | | 0.003 | 0.075 | 0.102 | 0.034 | 0.052 | 0.029 |
| Fraction Organic Carbon-3 | NA | | 0.003 | 0.075 | 0.100 | 0.034 | 0.051 | 0.030 |
| Fraction Organic Carbon-Avg | NA | | 0.003 | 0.075 | 0.101 | 0.034 | 0.051 | 0.029 |

Certified By: Jason Coughtrey

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CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Fraction Organic Carbon

DATE RECEIVED: 2018-10-22

DATE REPORTED: 2018-10-29

| | |
|---|---|
| Comments: | RDL - Reported Detection Limit; G / S - Guideline / Standard |
| 9642091-9642105 | Samples were analyzed and are reported in triplicate.<br>FOC was calculated from the Total Organic Carbon determined by Walkley Black Wet oxidation procedure. |
| 9642106 | Samples were analyzed and are reported in triplicate.<br>FOC was calculated from the Total Organic Carbon determined by Walkley Black Wet oxidation procedure.<br><br>Elevated RDLs indicate the degree of sample dilutions prior to the analysis to keep analytes within the calibration range, reduce matrix interference and/or to avoid contaminating the instrument. |
| 9642107-9642111 | Samples were analyzed and are reported in triplicate.<br>FOC was calculated from the Total Organic Carbon determined by Walkley Black Wet oxidation procedure. |

Analysis performed at AGAT Toronto (unless marked by *)

Certified By:

# Certificate of Analysis

AGAT WORK ORDER: 18K399949
PROJECT:

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CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Mercury Analysis in Soil

DATE RECEIVED: 2018-10-22
DATE REPORTED: 2018-10-29

| | | | SAMPLE DESCRIPTION: | 18-MNMA-S1 | 18-MNMA-S2 | 18-MNMA-S3 | 18-MNMA-S4 | 18-MNMA-S5 | 18-MNMA-S6 | 18-MNMA-S7 | 18-MNMA-S8 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642091 | 9642093 | 9642094 | 9642095 | 9642096 | 9642097 | 9642098 | 9642099 |
| Mercury | mg/kg | | 0.05 | 0.14 | 0.08 | 0.10 | 0.64 | 0.09 | 0.11 | 0.06 | 0.06 |

| | | | SAMPLE DESCRIPTION: | 18-MNMA-S9 | 18-MNMA-S10 | 18-MNMA-S11 | 18-MNMA-S12 | 18-MNMA-S13 | 18-MNMA-S14 | 18-MNMA-S15 | 18-MNMA-DUP1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642100 | 9642101 | 9642102 | 9642103 | 9642104 | 9642105 | 9642106 | 9642107 |
| Mercury | mg/kg | | 0.05 | 0.07 | 0.07 | 0.05 | 0.05 | 0.05 | 0.05 | 0.07 | 0.14 |

| | | | SAMPLE DESCRIPTION: | 18-MNMA-DUP2 | 18-MNMA-REF1 | 18-MNMA-REF2 | 18-MNMA-REF3 |
|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642108 | 9642109 | 9642110 | 9642111 |
| Mercury | mg/kg | | 0.05 | 0.05 | <0.05 | 0.05 | 0.05 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9642091-9642111 Results are based on the dry weight of the soil.
Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

# Certificate of Analysis

AGAT WORK ORDER: 18K399949
PROJECT:

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CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved + 1X Silica Gel

DATE RECEIVED: 2018-10-22
DATE REPORTED: 2018-10-29

| | | | SAMPLE DESCRIPTION: | 18-MNMA-S1 | 18-MNMA-S2 | 18-MNMA-S3 | 18-MNMA-S4 | 18-MNMA-S5 | 18-MNMA-S6 | 18-MNMA-S7 | 18-MNMA-S8 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642091 | 9642093 | 9642094 | 9642095 | 9642096 | 9642097 | 9642098 | 9642099 |
| Benzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 |
| >C10-C16 Hydrocarbons - 1X silica gel | mg/kg | | 15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 | <15 |
| >C16-C21 Hydrocarbons - 1X silica gel | mg/kg | | 15 | 76 | 54 | 56 | 66 | 76 | 103 | 19 | <15 |
| >C21-C32 Hydrocarbons - 1X silica gel | mg/kg | | 15 | 203 | 139 | 179 | 187 | 226 | 316 | 81 | 63 |
| Modified TPH (Tier 1) - 1X silica gel | mg/kg | | 20 | 279 | 193 | 235 | 253 | 302 | 419 | 100 | 63 |
| Resemblance Comment | | | | FR, LR | FR, LR | FR, LR | FR, LR | FR, LR | FR, LR | FR, LR | FR, LR |
| Return to Baseline at C32 | | | | Y | Y | Y | Y | Y | Y | Y | Y |
| Silica Gel Cleanup | | | | Y | Y | Y | Y | Y | Y | Y | Y |
| Surrogate | Unit | Acceptable Limits | | | | | | | | | |
| Isobutylbenzene - EPH | % | 60-140 | | 71 | 78 | 96 | 89 | 78 | 97 | 87 | 98 |
| Isobutylbenzene - VPH | % | 60-140 | | 78 | 76 | 79 | 80 | 78 | 79 | 75 | 77 |
| n-Dotriacontane - EPH | % | 60-140 | | 83 | 87 | 103 | 93 | 84 | 105 | 89 | 101 |

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CLIENT NAME: GHD LIMITED
SAMPLING SITE:

ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved + 1X Silica Gel

DATE RECEIVED: 2018-10-22

DATE REPORTED: 2018-10-29

| | | | SAMPLE DESCRIPTION: | 18-MNMA-S9 | 18-MNMA-S10 | 18-MNMA-S11 | 18-MNMA-S12 | 18-MNMA-S13 | 18-MNMA-S14 | 18-MNMA-S15 | 18-MNMA-DUP1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642100 | 9642101 | 9642102 | 9642103 | 9642104 | 9642105 | 9642106 | 9642107 |
| Benzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 | <3 |
| >C10-C16 Hydrocarbons - 1X silica gel | mg/kg | | 15 | 19 | <15 | <15 | <15 | <15 | <15 | <15 | <15 |
| >C16-C21 Hydrocarbons - 1X silica gel | mg/kg | | 15 | 77 | 51 | 28 | <15 | 55 | <15 | 24 | 48 |
| >C21-C32 Hydrocarbons - 1X silica gel | mg/kg | | 15 | 178 | 149 | 70 | 38 | 51 | 54 | 41 | 129 |
| Modified TPH (Tier 1) - 1X silica gel | mg/kg | | 20 | 274 | 200 | 98 | 38 | 106 | 54 | 65 | 177 |
| Resemblance Comment | | | | FR, LR | FR, LR | FR, LR | LR | FR, LR | LR | FR, LR | FR, LR |
| Return to Baseline at C32 | | | | Y | Y | Y | Y | Y | Y | Y | Y |
| Silica Gel Cleanup | | | | Y | Y | Y | Y | Y | Y | Y | Y |
| Surrogate | Unit | Acceptable Limits | | | | | | | | | |
| Isobutylbenzene - EPH | % | 60-140 | | 94 | 89 | 89 | 99 | 99 | 100 | 69 | 63 |
| Isobutylbenzene - VPH | % | 60-140 | | 79 | 81 | 75 | 78 | 79 | 75 | 80 | 78 |
| n-Dotriacontane - EPH | % | 60-140 | | 95 | 89 | 97 | 107 | 102 | 104 | 77 | 69 |

Certified By:

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CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved + 1X Silica Gel

DATE RECEIVED: 2018-10-22

DATE REPORTED: 2018-10-29

| | | | SAMPLE DESCRIPTION: | 18-MNMA-DUP2 | 18-MNMA-REF1 | 18-MNMA-REF2 | 18-MNMA-REF3 |
|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642108 | 9642109 | 9642110 | 9642111 |
| Benzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | <3 | <3 | <3 | <3 |
| >C10-C16 Hydrocarbons - 1X silica gel | mg/kg | | 15 | <15 | <15 | <15 | <15 |
| >C16-C21 Hydrocarbons - 1X silica gel | mg/kg | | 15 | 75 | <15 | <15 | <15 |
| >C21-C32 Hydrocarbons - 1X silica gel | mg/kg | | 15 | 182 | 22 | <15 | <15 |
| Modified TPH (Tier 1) - 1X silica gel | mg/kg | | 20 | 257 | 22 | <20 | <20 |
| Resemblance Comment | | | | FR, LR | LR | NR | NR |
| Return to Baseline at C32 | | | | Y | Y | Y | Y |
| Silica Gel Cleanup | | | | Y | Y | Y | Y |
| Surrogate | Unit | Acceptable Limits | | | | | |
| Isobutylbenzene - EPH | % | 60-140 | | 97 | 93 | 105 | 98 |
| Isobutylbenzene - VPH | % | 60-140 | | 78 | 75 | 81 | 77 |
| n-Dotriacontane - EPH | % | 60-140 | | 98 | 97 | 110 | 102 |

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# Certificate of Analysis

AGAT WORK ORDER: 18K399949
PROJECT:

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved + 1X Silica Gel

DATE RECEIVED: 2018-10-22
DATE REPORTED: 2018-10-29

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9642091-9642111 Results are based on the dry weight of the soil.

Resemblance Comment Key:
GF - Gasoline Fraction
WGF - Weathered Gasoline Fraction
GR - Product in Gasoline Range
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
FR - Product in Fuel Oil Range
LOF - Lube Oil Fraction
LR - Lube Range
UC - Unidentified Compounds
NR - No Resemblance
NA - Not Applicable

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

AGAT Laboratories
57 Old Pennywell Road, Unit I
St. John's, NL
CANADA A1E 6A8
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FAX (709 747-2139
http://www.agatlabs.com

# Certificate of Analysis

AGAT WORK ORDER: 18K399949
PROJECT:

CLIENT NAME: GHD LIMITED
SAMPLING SITE:

ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Moisture

DATE RECEIVED: 2018-10-22

DATE REPORTED: 2018-10-29

| | | | SAMPLE DESCRIPTION: | 18-MNMA-S1 | 18-MNMA-S2 | 18-MNMA-S3 | 18-MNMA-S4 | 18-MNMA-S5 | 18-MNMA-S6 | 18-MNMA-S7 | 18-MNMA-S8 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642091 | 9642093 | 9642094 | 9642095 | 9642096 | 9642097 | 9642098 | 9642099 |
| % Moisture | % | | 0 | 47 | 39 | 33 | 46 | 57 | 60 | 34 | 36 |

| | | | SAMPLE DESCRIPTION: | 18-MNMA-S9 | 18-MNMA-S10 | 18-MNMA-S11 | 18-MNMA-S12 | 18-MNMA-S13 | 18-MNMA-S14 | 18-MNMA-S15 | 18-MNMA-DUP1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642100 | 9642101 | 9642102 | 9642103 | 9642104 | 9642105 | 9642106 | 9642107 |
| % Moisture | % | | 0 | 54 | 46 | 49 | 68 | 77 | 48 | 38 | 55 |

| | | | SAMPLE DESCRIPTION: | 18-MNMA-DUP2 | 18-MNMA-REF1 | 18-MNMA-REF2 | 18-MNMA-REF3 |
|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642108 | 9642109 | 9642110 | 9642111 |
| % Moisture | % | | 0 | 57 | 22 | 22 | 22 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
Analysis performed at AGAT Halifax (unless marked by *)

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# Certificate of Analysis

AGAT WORK ORDER: 18K399949

PROJECT:

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Polycyclic Aromatic Hydrocarbons in Soil

DATE RECEIVED: 2018-10-22

DATE REPORTED: 2018-10-29

| | | | SAMPLE DESCRIPTION: | 18-MNMA-S1 | 18-MNMA-S2 | 18-MNMA-S3 | 18-MNMA-S4 | 18-MNMA-S5 | 18-MNMA-S6 | 18-MNMA-S7 | 18-MNMA-S8 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642091 | 9642093 | 9642094 | 9642095 | 9642096 | 9642097 | 9642098 | 9642099 |
| 1-Methylnaphthalene | mg/kg | | 0.05 | <0.05 | 0.06 | 0.20 | 0.05 | 0.27 | 0.06 | <0.05 | <0.05 |
| 2-Methylnaphthalene | mg/kg | | 0.01 | 0.05 | 0.07 | 0.24 | 0.06 | 0.38 | 0.07 | 0.03 | <0.01 |
| Acenaphthene | mg/kg | | 0.00671 | 0.122 | 0.146 | 0.279 | 0.168 | 0.728 | 0.179 | 0.101 | <0.00671 |
| Acenaphthylene | mg/kg | | 0.004 | 0.039 | <0.004 | 0.045 | 0.043 | 0.076 | 0.063 | 0.034 | 0.020 |
| Acridine | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | 0.11 | <0.05 | <0.05 | <0.05 |
| Anthracene | mg/kg | | 0.03 | 0.19 | 0.22 | 0.31 | 0.24 | 1.01 | 0.27 | 0.17 | 0.05 |
| Benzo(a)anthracene | mg/kg | | 0.01 | 0.36 | 0.42 | 0.58 | 0.43 | 1.55 | 0.59 | 0.29 | 0.11 |
| Benzo(a)pyrene | mg/kg | | 0.01 | 0.37 | 0.42 | 0.60 | 0.44 | 1.34 | 0.57 | 0.29 | 0.10 |
| Benzo(b)fluoranthene | mg/kg | | 0.05 | 0.36 | 0.39 | 0.55 | 0.41 | 1.23 | 0.56 | 0.27 | 0.11 |
| Benzo(b+j)fluoranthene | mg/kg | | 0.1 | 0.57 | 0.60 | 0.90 | 0.64 | 1.96 | 0.80 | 0.39 | 0.17 |
| Benzo(e)pyrene | mg/kg | | 0.05 | 0.30 | 0.32 | 0.42 | 0.32 | 0.93 | 0.43 | 0.21 | 0.08 |
| Benzo(ghi)perylene | mg/kg | | 0.01 | <0.01 | 0.28 | 0.41 | 0.29 | 0.86 | 0.38 | <0.01 | <0.01 |
| Benzo(k)fluoranthene | mg/kg | | 0.01 | 0.19 | 0.23 | 0.31 | 0.26 | 0.72 | 0.29 | 0.19 | 0.05 |
| Chrysene | mg/kg | | 0.01 | 0.47 | 0.51 | 0.67 | 0.53 | 1.70 | 0.70 | 0.33 | 0.14 |
| Dibenzo(a,h)anthracene | mg/kg | | 0.006 | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 |
| Fluoranthene | mg/kg | | 0.05 | 0.92 | 0.99 | 1.59 | 1.16 | 3.62 | 1.37 | 0.80 | 0.30 |
| Fluorene | mg/kg | | 0.01 | 0.15 | 0.17 | 0.32 | 0.19 | 0.94 | 0.20 | 0.12 | 0.03 |
| Indeno(1,2,3)pyrene | mg/kg | | 0.01 | <0.01 | 0.29 | 0.51 | 0.38 | 1.09 | <0.01 | <0.01 | <0.01 |
| Naphthalene | mg/kg | | 0.01 | <0.01 | <0.01 | 0.32 | <0.01 | 0.62 | <0.01 | <0.01 | <0.01 |
| Perylene | mg/kg | | 0.05 | <0.05 | 0.11 | 0.15 | 0.12 | 0.33 | 0.15 | <0.05 | <0.05 |
| Phenanthrene | mg/kg | | 0.03 | 0.91 | 0.94 | 1.67 | 1.12 | 4.05 | 1.26 | 0.74 | 0.22 |
| Pyrene | mg/kg | | 0.05 | 0.87 | 0.80 | 1.19 | 0.90 | 2.61 | 1.13 | 0.57 | 0.24 |
| Quinoline | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Surrogate | Unit | Acceptable Limits | | | | | | | | | |
| Nitrobenzene-d5 | % | 50-140 | | 105 | 108 | 106 | 123 | 116 | 111 | 118 | 109 |
| 2-Fluorobiphenyl | % | 50-140 | | 95 | 93 | 92 | 105 | 103 | 92 | 101 | 90 |
| Terphenyl-d14 | % | 50-140 | | 107 | 107 | 107 | 118 | 118 | 107 | 117 | 102 |

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# Certificate of Analysis

AGAT WORK ORDER: 18K399949

PROJECT:

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Polycyclic Aromatic Hydrocarbons in Soil

DATE RECEIVED: 2018-10-22

DATE REPORTED: 2018-10-29

| | | | SAMPLE DESCRIPTION: | 18-MNMA-S9 | 18-MNMA-S10 | 18-MNMA-S11 | 18-MNMA-S12 | 18-MNMA-S13 | 18-MNMA-S14 | 18-MNMA-S15 | 18-MNMA-DUP1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642100 | 9642101 | 9642102 | 9642103 | 9642104 | 9642105 | 9642106 | 9642107 |
| 1-Methylnaphthalene | mg/kg | | 0.05 | <0.05 | 0.20 | 0.07 | <0.05 | <0.05 | <0.05 | <0.05 | 0.11 |
| 2-Methylnaphthalene | mg/kg | | 0.01 | 0.04 | 0.20 | 0.09 | 0.02 | 0.02 | 0.02 | 0.01 | 0.13 |
| Acenaphthene | mg/kg | | 0.00671 | 0.0831 | 0.226 | 0.269 | <0.00671 | <0.00671 | <0.00671 | 0.0478 | 0.480 |
| Acenaphthylene | mg/kg | | 0.004 | 0.058 | 0.060 | 0.095 | 0.049 | 0.465 | 0.030 | 0.039 | 0.084 |
| Acridine | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Anthracene | mg/kg | | 0.03 | 0.17 | 0.33 | 0.49 | 0.12 | 0.56 | 0.28 | 0.16 | 0.72 |
| Benzo(a)anthracene | mg/kg | | 0.01 | 0.35 | 0.59 | 1.26 | 0.28 | 1.45 | 0.34 | 0.30 | 1.08 |
| Benzo(a)pyrene | mg/kg | | 0.01 | 0.35 | 0.52 | 1.06 | 0.22 | 1.42 | 0.25 | 0.24 | 1.04 |
| Benzo(b)fluoranthene | mg/kg | | 0.05 | 0.35 | 0.49 | 1.00 | 0.23 | 1.20 | 0.26 | 0.24 | 1.00 |
| Benzo(b+j)fluoranthene | mg/kg | | 0.1 | 0.35 | 0.81 | 1.41 | 0.38 | 1.80 | 0.39 | 0.38 | 1.39 |
| Benzo(e)pyrene | mg/kg | | 0.05 | 0.35 | 0.37 | 0.74 | 0.18 | 0.89 | 0.18 | 0.19 | 0.74 |
| Benzo(ghi)perylene | mg/kg | | 0.01 | <0.01 | 0.32 | 0.64 | <0.01 | 0.76 | <0.01 | <0.01 | 0.68 |
| Benzo(k)fluoranthene | mg/kg | | 0.01 | 0.43 | 0.25 | 0.53 | 0.11 | 0.59 | 0.19 | 0.11 | 0.38 |
| Chrysene | mg/kg | | 0.01 | 0.41 | 0.66 | 1.63 | 0.33 | 1.37 | 0.39 | 0.33 | 1.19 |
| Dibenzo(a,h)anthracene | mg/kg | | 0.006 | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 | <0.006 |
| Fluoranthene | mg/kg | | 0.05 | 0.92 | 1.67 | 2.76 | 1.08 | 3.93 | 0.49 | 0.56 | 2.91 |
| Fluorene | mg/kg | | 0.01 | 0.11 | 0.26 | 0.35 | 0.04 | 0.13 | 0.06 | 0.07 | 0.52 |
| Indeno(1,2,3)pyrene | mg/kg | | 0.01 | <0.01 | 0.42 | 0.65 | <0.01 | 1.13 | <0.01 | <0.01 | 0.87 |
| Naphthalene | mg/kg | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | 0.02 | <0.01 | 0.32 |
| Perylene | mg/kg | | 0.05 | <0.05 | 0.13 | 0.25 | <0.05 | 0.41 | <0.05 | <0.05 | 0.29 |
| Phenanthrene | mg/kg | | 0.03 | 0.78 | 1.50 | 2.41 | 0.32 | 1.42 | 0.33 | 0.42 | 2.82 |
| Pyrene | mg/kg | | 0.05 | 0.76 | 1.27 | 2.13 | 0.83 | 2.98 | 0.41 | 0.50 | 2.27 |
| Quinoline | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Surrogate | Unit | Acceptable Limits | | | | | | | | | |
| Nitrobenzene-d5 | % | 50-140 | | 110 | 116 | 94 | 98 | 96 | 96 | 98 | 110 |
| 2-Fluorobiphenyl | % | 50-140 | | 89 | 95 | 82 | 85 | 82 | 83 | 79 | 91 |
| Terphenyl-d14 | % | 50-140 | | 103 | 109 | 85 | 85 | 85 | 84 | 79 | 94 |

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# Certificate of Analysis

AGAT WORK ORDER: 18K399949
PROJECT:

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Polycyclic Aromatic Hydrocarbons in Soil

DATE RECEIVED: 2018-10-22
DATE REPORTED: 2018-10-29

| Parameter | Unit | G / S | RDL | 18-MNMA-DUP2 | 18-MNMA-REF1 | 18-MNMA-REF2 | 18-MNMA-REF3 |
|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Sediment | Sediment | Sediment | Sediment |
| DATE SAMPLED: | | | | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| | | | | 9642108 | 9642109 | 9642110 | 9642111 |
| 1-Methylnaphthalene | mg/kg | | 0.05 | 0.08 | <0.05 | <0.05 | <0.05 |
| 2-Methylnaphthalene | mg/kg | | 0.01 | 0.09 | <0.01 | <0.01 | <0.01 |
| Acenaphthene | mg/kg | | 0.00671 | 0.209 | <0.00671 | <0.00671 | <0.00671 |
| Acenaphthylene | mg/kg | | 0.004 | 0.081 | <0.004 | <0.004 | <0.004 |
| Acridine | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Anthracene | mg/kg | | 0.03 | 0.44 | <0.03 | <0.03 | <0.03 |
| Benzo(a)anthracene | mg/kg | | 0.01 | 0.72 | 0.03 | 0.02 | <0.01 |
| Benzo(a)pyrene | mg/kg | | 0.01 | 0.66 | <0.01 | <0.01 | <0.01 |
| Benzo(b)fluoranthene | mg/kg | | 0.05 | 0.66 | <0.05 | <0.05 | <0.05 |
| Benzo(b+j)fluoranthene | mg/kg | | 0.1 | 0.94 | <0.1 | <0.1 | <0.1 |
| Benzo(e)pyrene | mg/kg | | 0.05 | 0.49 | <0.05 | <0.05 | <0.05 |
| Benzo(ghi)perylene | mg/kg | | 0.01 | 0.40 | <0.01 | <0.01 | <0.01 |
| Benzo(k)fluoranthene | mg/kg | | 0.01 | 0.35 | 0.02 | <0.01 | <0.01 |
| Chrysene | mg/kg | | 0.01 | 0.83 | 0.03 | 0.03 | <0.01 |
| Dibenzo(a,h)anthracene | mg/kg | | 0.006 | <0.006 | <0.006 | <0.006 | <0.006 |
| Fluoranthene | mg/kg | | 0.05 | 1.84 | 0.07 | 0.07 | <0.05 |
| Fluorene | mg/kg | | 0.01 | 0.26 | <0.01 | <0.01 | <0.01 |
| Indeno(1,2,3)pyrene | mg/kg | | 0.01 | 0.53 | <0.01 | <0.01 | <0.01 |
| Naphthalene | mg/kg | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Perylene | mg/kg | | 0.05 | 0.18 | <0.05 | <0.05 | <0.05 |
| Phenanthrene | mg/kg | | 0.03 | 1.51 | 0.06 | 0.04 | <0.03 |
| Pyrene | mg/kg | | 0.05 | 1.54 | 0.05 | 0.06 | <0.05 |
| Quinoline | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| **Surrogate** | **Unit** | **Acceptable Limits** | | | | | |
| Nitrobenzene-d5 | % | 50-140 | | 103 | 103 | 92 | 104 |
| 2-Fluorobiphenyl | % | 50-140 | | 87 | 86 | 76 | 90 |
| Terphenyl-d14 | % | 50-140 | | 90 | 88 | 81 | 89 |

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# Certificate of Analysis

AGAT WORK ORDER: 18K399949
PROJECT:

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Polycyclic Aromatic Hydrocarbons in Soil

DATE RECEIVED: 2018-10-22
DATE REPORTED: 2018-10-29

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9642091-9642111 Results are based on the dry weight of the soil.

Benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene, if also present in the sample.

Analysis performed at AGAT Halifax (unless marked by *)

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# Certificate of Analysis

AGAT WORK ORDER: 18K399949
PROJECT:

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Total Polychlorinated Biphenyls in Soil - (PCB)

DATE RECEIVED: 2018-10-22

DATE REPORTED: 2018-10-29

| | | | SAMPLE DESCRIPTION: | 18-MNMA-S1 | 18-MNMA-S2 | 18-MNMA-S3 | 18-MNMA-S4 | 18-MNMA-S5 | 18-MNMA-S6 | 18-MNMA-S7 | 18-MNMA-S8 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642091 | 9642093 | 9642094 | 9642095 | 9642096 | 9642097 | 9642098 | 9642099 |
| Total Polychlorinated Biphenyls | mg/kg | | 0.02 | 0.10 | 0.17 | 0.65 | 0.05 | 0.10 | 0.53 | <0.02 | <0.02 |
| Surrogate | Unit | Acceptable Limits | | | | | | | | | |
| Decachlorobiphenyl | % | 50-130 | | 121 | 128 | 107 | 110 | 111 | 120 | 118 | 104 |

| | | | SAMPLE DESCRIPTION: | 18-MNMA-S9 | 18-MNMA-S10 | 18-MNMA-S11 | 18-MNMA-S12 | 18-MNMA-S13 | 18-MNMA-S14 | 18-MNMA-S15 | 18-MNMA-DUP1 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642100 | 9642101 | 9642102 | 9642103 | 9642104 | 9642105 | 9642106 | 9642107 |
| Total Polychlorinated Biphenyls | mg/kg | | 0.02 | 0.13 | 0.03 | 0.08 | <0.02 | <0.02 | 0.27 | <0.02 | 0.07 |
| Surrogate | Unit | Acceptable Limits | | | | | | | | | |
| Decachlorobiphenyl | % | 50-130 | | 93 | 116 | 128 | 104 | 108 | 115 | 108 | 109 |

| | | | SAMPLE DESCRIPTION: | 18-MNMA-DUP2 | 18-MNMA-REF1 | 18-MNMA-REF2 | 18-MNMA-REF3 |
|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Sediment | Sediment | Sediment | Sediment |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9642108 | 9642109 | 9642110 | 9642111 |
| Total Polychlorinated Biphenyls | mg/kg | | 0.02 | 0.05 | <0.02 | <0.02 | <0.02 |
| Surrogate | Unit | Acceptable Limits | | | | | |
| Decachlorobiphenyl | % | 50-130 | | 116 | 83 | 95 | 96 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9642091-9642111 Results are based on the dry weight of the soil.
Analysis performed at AGAT Halifax (unless marked by *)

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT:
SAMPLING SITE:

AGAT WORK ORDER: 18K399949
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Soil Analysis

| RPT Date: Oct 29, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits | | Recovery | Acceptable Limits | | Recovery | Acceptable Limits | |
| | | | | | | | | Lower | Upper | | Lower | Upper | | Lower | Upper |
| Available Metals in Soil | | | | | | | | | | | | | | | |
| Aluminum | 9645716 | | 4040 | 3990 | 1.1% | < 10 | 119% | 80% | 120% | NA | 80% | 120% | 102% | 70% | 130% |
| Antimony | 9645716 | | <1 | <1 | NA | < 1 | 94% | 80% | 120% | 119% | 80% | 120% | 78% | 70% | 130% |
| Arsenic | 9645716 | | 2 | 2 | NA | < 1 | 110% | 80% | 120% | 110% | 80% | 120% | 92% | 70% | 130% |
| Barium | 9645716 | | 19 | 18 | NA | < 5 | 108% | 80% | 120% | 104% | 80% | 120% | 94% | 70% | 130% |
| Beryllium | 9645716 | | <2 | <2 | NA | < 2 | 119% | 80% | 120% | 112% | 80% | 120% | 93% | 70% | 130% |
| Boron | 9645716 | | 7 | 7 | NA | < 2 | 110% | 80% | 120% | 112% | 80% | 120% | 96% | 70% | 130% |
| Cadmium | 9645716 | | <0.3 | <0.3 | NA | < 0.3 | 109% | 80% | 120% | 108% | 80% | 120% | 91% | 70% | 130% |
| Chromium | 9645716 | | 8 | 8 | NA | < 2 | 100% | 80% | 120% | 104% | 80% | 120% | 100% | 70% | 130% |
| Cobalt | 9645716 | | 2 | 2 | NA | < 1 | 109% | 80% | 120% | 110% | 80% | 120% | 94% | 70% | 130% |
| Copper | 9645716 | | 3 | 3 | NA | < 2 | 109% | 80% | 120% | 110% | 80% | 120% | 92% | 70% | 130% |
| Iron | 9645716 | | 5100 | 5040 | 1.2% | < 50 | 106% | 80% | 120% | 108% | 80% | 120% | 99% | 70% | 130% |
| Lead | 9645716 | | 2.1 | 2.0 | NA | < 0.5 | 113% | 80% | 120% | 103% | 80% | 120% | 91% | 70% | 130% |
| Lithium | 9645716 | | 11 | 10 | NA | < 5 | 120% | 70% | 130% | 120% | 70% | 130% | 98% | 70% | 130% |
| Manganese | 9645716 | | 85 | 84 | 0.7% | < 2 | 108% | 80% | 120% | 108% | 80% | 120% | 102% | 70% | 130% |
| Molybdenum | 9645716 | | <2 | <2 | NA | < 2 | 105% | 80% | 120% | 111% | 80% | 120% | 88% | 70% | 130% |
| Nickel | 9645716 | | 5 | 5 | NA | < 2 | 111% | 80% | 120% | 111% | 80% | 120% | 95% | 70% | 130% |
| Selenium | 9645716 | | <1 | <1 | NA | < 1 | 103% | 80% | 120% | 113% | 80% | 120% | 95% | 70% | 130% |
| Silver | 9645716 | | <0.5 | <0.5 | NA | < 0.5 | 113% | 80% | 120% | 113% | 80% | 120% | 92% | 70% | 130% |
| Strontium | 9645716 | | 44 | 41 | 7.6% | < 5 | 102% | 80% | 120% | 101% | 80% | 120% | 85% | 70% | 130% |
| Thallium | 9645716 | | <0.1 | <0.1 | NA | < 0.1 | 109% | 80% | 120% | 105% | 80% | 120% | NA | 70% | 130% |
| Tin | 9645716 | | 3 | 3 | NA | < 2 | 108% | 80% | 120% | 113% | 80% | 120% | 88% | 70% | 130% |
| Uranium | 9645716 | | 0.5 | 0.5 | 3.2% | < 0.1 | 106% | 80% | 120% | 100% | 80% | 120% | 87% | 70% | 130% |
| Vanadium | 9645716 | | 11 | 11 | 0.5% | < 2 | 103% | 80% | 120% | 104% | 80% | 120% | 101% | 70% | 130% |
| Zinc | 9645716 | | 7 | 7 | NA | < 5 | 95% | 80% | 120% | 97% | 80% | 120% | 92% | 70% | 130% |
| Mercury Analysis in Soil | | | | | | | | | | | | | | | |
| Mercury | 1 | 9645117 | 0.10 | 0.11 | NA | < 0.05 | 94% | 70% | 130% | | 70% | 130% | 113% | 70% | 130% |
| Available Metals in Soil | | | | | | | | | | | | | | | |
| Aluminum | 9644818 | | 15300 | 17200 | 11.7% | < 10 | NA | 80% | 120% | 114% | 80% | 120% | 90% | 70% | 130% |
| Antimony | 9644818 | | <1 | <1 | NA | < 1 | 90% | 80% | 120% | 118% | 80% | 120% | 73% | 70% | 130% |
| Arsenic | 9644818 | | 31 | 30 | 0.4% | < 1 | 113% | 80% | 120% | 103% | 80% | 120% | 97% | 70% | 130% |
| Barium | 9644818 | | 63 | 63 | 0.0% | < 5 | 113% | 80% | 120% | 105% | 80% | 120% | 104% | 70% | 130% |
| Beryllium | 9644818 | | <2 | <2 | NA | < 2 | 119% | 80% | 120% | 106% | 80% | 120% | 104% | 70% | 130% |
| Boron | 9644818 | | 3 | 4 | NA | < 2 | 115% | 80% | 120% | 110% | 80% | 120% | 85% | 70% | 130% |
| Cadmium | 9644818 | | <0.3 | <0.3 | NA | < 0.3 | 110% | 80% | 120% | 106% | 80% | 120% | 101% | 70% | 130% |
| Chromium | 9644818 | | 33 | 32 | 3.0% | < 2 | 104% | 80% | 120% | 100% | 80% | 120% | 89% | 70% | 130% |
| Cobalt | 9644818 | | 14 | 14 | 3.3% | < 1 | 108% | 80% | 120% | 101% | 80% | 120% | 92% | 70% | 130% |
| Copper | 9644818 | | 30 | 29 | 1.7% | < 2 | 108% | 80% | 120% | 103% | 80% | 120% | 97% | 70% | 130% |
| Iron | 9644818 | | 23100 | 26800 | 15.1% | < 50 | 106% | 80% | 120% | 101% | 80% | 120% | 95% | 70% | 130% |

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT:
SAMPLING SITE:

AGAT WORK ORDER: 18K399949
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Soil Analysis (Continued)

| RPT Date: Oct 29, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Lead | 9644818 | | 30.5 | 22.3 | 31.1% | < 0.5 | 116% | 80% | 120% | 109% | 80% | 120% | 86% | 70% | 130% |
| Lithium | 9644818 | | 20 | 21 | NA | < 5 | 121% | 70% | 130% | 108% | 70% | 130% | 93% | 70% | 130% |
| Manganese | 9644818 | | 828 | 884 | 6.5% | < 2 | 109% | 80% | 120% | 103% | 80% | 120% | 95% | 70% | 130% |
| Molybdenum | 9644818 | | <2 | <2 | NA | < 2 | 102% | 80% | 120% | 96% | 80% | 120% | 80% | 70% | 130% |
| Nickel | 9644818 | | 31 | 31 | 1.2% | < 2 | 106% | 80% | 120% | 99% | 80% | 120% | 91% | 70% | 130% |
| Selenium | 9644818 | | <1 | <1 | NA | < 1 | 104% | 80% | 120% | 92% | 80% | 120% | 83% | 70% | 130% |
| Silver | 9644818 | | <0.5 | <0.5 | NA | < 0.5 | 90% | 80% | 120% | 99% | 80% | 120% | 93% | 70% | 130% |
| Strontium | 9644818 | | 15 | 15 | NA | < 5 | 107% | 80% | 120% | 101% | 80% | 120% | 103% | 70% | 130% |
| Thallium | 9644818 | | <0.1 | <0.1 | NA | < 0.1 | 118% | 80% | 120% | 107% | 80% | 120% | NA | 70% | 130% |
| Tin | 9644818 | | 4 | 4 | NA | < 2 | 110% | 80% | 120% | 102% | 80% | 120% | 93% | 70% | 130% |
| Uranium | 9644818 | | 1.2 | 1.0 | 12.6% | < 0.1 | 116% | 80% | 120% | 107% | 80% | 120% | 94% | 70% | 130% |
| Vanadium | 9644818 | | 51 | 54 | 4.3% | < 2 | 107% | 80% | 120% | 98% | 80% | 120% | 92% | 70% | 130% |
| Zinc | 9644818 | | 88 | 92 | 4.3% | < 5 | 106% | 80% | 120% | 98% | 80% | 120% | 92% | 70% | 130% |
| Fraction Organic Carbon | | | | | | | | | | | | | | | |
| Fraction Organic Carbon-1 | 9642091 | 9642091 | 0.018 | 0.019 | 5.4% | < 0.003 | 113% | 70% | 130% | | | | 102% | 70% | 130% |
| Fraction Organic Carbon | | | | | | | | | | | | | | | |
| Fraction Organic Carbon-1 | 9642108 | 9642108 | 0.100 | 0.102 | 2.0% | < 0.003 | 108% | 70% | 130% | | | | 102% | 70% | 130% |

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT:
SAMPLING SITE:

AGAT WORK ORDER: 18K399949
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Trace Organics Analysis

| RPT Date: Oct 29, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| **Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved + 1X Silica Gel** | | | | | | | | | | | | | | | |
| Benzene | 1 | 9642091 | < 0.03 | < 0.03 | NA | < 0.03 | 68% | 60% | 140% | 66% | 60% | 140% | | | |
| Toluene | 1 | 9642091 | < 0.04 | < 0.04 | NA | < 0.04 | 69% | 60% | 140% | 69% | 60% | 140% | | | |
| Ethylbenzene | 1 | 9642091 | < 0.03 | < 0.03 | NA | < 0.03 | 70% | 60% | 140% | 70% | 60% | 140% | | | |
| Xylene (Total) | 1 | 9642091 | < 0.05 | < 0.05 | NA | < 0.05 | 75% | 60% | 140% | 73% | 60% | 140% | | | |
| C6-C10 (less BTEX) | 1 | 9642091 | < 3 | < 3 | NA | < 3 | 105% | 60% | 140% | 113% | 60% | 140% | NA | 30% | 130% |
| >C10-C16 Hydrocarbons - 1X silica gel | 1 | 9642101 | < 15 | < 15 | NA | < 15 | 106% | 60% | 140% | 111% | 60% | 140% | 101% | 30% | 130% |
| >C16-C21 Hydrocarbons - 1X silica gel | 1 | 9642101 | 51 | 49 | NA | < 15 | 115% | 60% | 140% | 111% | 60% | 140% | 101% | 30% | 130% |
| >C21-C32 Hydrocarbons - 1X silica gel | 1 | 9642101 | 149 | 153 | 2.6% | < 15 | 131% | 60% | 140% | 111% | 60% | 140% | 101% | 30% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Lower | Upper | Recovery | Lower | Upper | Recovery | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Polycyclic Aromatic Hydrocarbons in Soil** | | | | | | | | | | | | | | | |
| 1-Methylnaphthalene | 1 | 9642101 | 0.20 | 0.15 | NA | < 0.05 | 131% | 50% | 140% | 103% | 50% | 140% | 71% | 50% | 140% |
| 2-Methylnaphthalene | 1 | 9642101 | 0.20 | 0.17 | 16.2% | < 0.01 | 131% | 50% | 140% | 104% | 50% | 140% | 76% | 50% | 140% |
| Acenaphthene | 1 | 9642101 | 0.226 | 0.177 | 24.3% | < 0.00671 | 135% | 50% | 140% | 109% | 50% | 140% | 86% | 50% | 140% |
| Acenaphthylene | 1 | 9642101 | 0.060 | 0.041 | 37.6% | < 0.004 | 130% | 50% | 140% | 97% | 50% | 140% | 98% | 50% | 140% |
| Acridine | 1 | 9642101 | < 0.05 | < 0.05 | NA | < 0.05 | 91% | 50% | 140% | 90% | 50% | 140% | 95% | 50% | 140% |
| Anthracene | 1 | 9642101 | 0.33 | 0.27 | 20.0% | < 0.03 | 121% | 50% | 140% | 100% | 50% | 140% | 99% | 50% | 140% |
| Benzo(a)anthracene | 1 | 9642101 | 0.59 | 0.56 | 5.2% | < 0.01 | 116% | 50% | 140% | 98% | 50% | 140% | 75% | 50% | 140% |
| Benzo(a)pyrene | 1 | 9642101 | 0.52 | 0.44 | 16.7% | < 0.01 | 123% | 50% | 140% | 103% | 50% | 140% | 78% | 50% | 140% |
| Benzo(b)fluoranthene | 1 | 9642101 | 0.49 | 0.47 | 4.2% | < 0.05 | 107% | 50% | 140% | 92% | 50% | 140% | 68% | 50% | 140% |
| Benzo(b+j)fluoranthene | 1 | 9642101 | 0.81 | 0.72 | 11.8% | < 0.1 | 119% | 50% | 140% | 116% | 50% | 140% | 59% | 50% | 140% |
| Benzo(e)pyrene | 1 | 9642101 | 0.37 | 0.33 | 11.4% | < 0.05 | 130% | 50% | 140% | 104% | 50% | 140% | 79% | 50% | 140% |
| Benzo(ghi)perylene | 1 | 9642101 | 0.32 | 0.27 | 16.9% | < 0.01 | 129% | 50% | 140% | 98% | 50% | 140% | 78% | 50% | 140% |
| Benzo(k)fluoranthene | 1 | 9642101 | 0.25 | 0.30 | 18.2% | < 0.01 | 103% | 50% | 140% | 90% | 50% | 140% | 68% | 50% | 140% |
| Chrysene | 1 | 9642101 | 0.66 | 0.66 | 0.0% | < 0.01 | 129% | 50% | 140% | 102% | 50% | 140% | 73% | 50% | 140% |
| Dibenzo(a,h)anthracene | 1 | 9642101 | < 0.006 | < 0.006 | NA | < 0.006 | 101% | 50% | 140% | 87% | 50% | 140% | 86% | 50% | 140% |
| Fluoranthene | 1 | 9642101 | 1.67 | 1.37 | 19.7% | < 0.05 | 124% | 50% | 140% | 102% | 50% | 140% | 99% | 50% | 140% |
| Fluorene | 1 | 9642101 | 0.26 | 0.20 | 26.1% | < 0.01 | 132% | 50% | 140% | 106% | 50% | 140% | 84% | 50% | 140% |
| Indeno(1,2,3)pyrene | 1 | 9642101 | 0.42 | 0.36 | 15.4% | < 0.01 | 98% | 50% | 140% | 83% | 50% | 140% | 55% | 50% | 140% |
| Naphthalene | 1 | 9642101 | < 0.01 | < 0.01 | NA | < 0.01 | 134% | 50% | 140% | 109% | 50% | 140% | 110% | 50% | 140% |
| Perylene | 1 | 9642101 | 0.13 | 0.12 | NA | < 0.05 | 123% | 50% | 140% | 101% | 50% | 140% | 85% | 50% | 140% |
| Phenanthrene | 1 | 9642101 | 1.50 | 1.17 | 24.7% | < 0.03 | 136% | 50% | 140% | 107% | 50% | 140% | 60% | 50% | 140% |
| Pyrene | 1 | 9642101 | 1.27 | 1.06 | 18.0% | < 0.05 | 121% | 50% | 140% | 99% | 50% | 140% | 91% | 50% | 140% |
| Quinoline | 1 | 9642101 | < 0.05 | < 0.05 | NA | < 0.05 | 117% | 50% | 140% | 100% | 50% | 140% | 97% | 50% | 140% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT:
SAMPLING SITE:

AGAT WORK ORDER: 18K399949
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Trace Organics Analysis (Continued)

| RPT Date: Oct 29, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Total Polychlorinated Biphenyls in Soil - (PCB) | | | | | | | | | | | | | | | |
| Total Polychlorinated Biphenyls | 1 | 9615144 | < 0.02 | < 0.02 | NA | < 0.02 | 124% | 60% | 130% | 91% | 60% | 130% | 103% | 60% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Lower | Upper | Recovery | Lower | Upper | Recovery | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Polychlorinated Biphenyls in Soil - (PCB) | | | | | | | | | | | | | | | |
| Total Polychlorinated Biphenyls | 1 | 9642102 | 0.08 | 0.10 | NA | < 0.02 | 121% | 60% | 130% | 96% | 60% | 130% | 125% | 60% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT:
SAMPLING SITE:

AGAT WORK ORDER: 18K399949
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Soil Analysis | | | |
| Aluminum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Antimony | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Arsenic | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Barium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Beryllium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Boron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cadmium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Chromium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cobalt | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Copper | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Iron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Lead | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Lithium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Manganese | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Molybdenum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Nickel | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Selenium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Silver | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Strontium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Thallium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Tin | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Uranium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Vanadium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Zinc | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Fraction Organic Carbon-1 | INOR-93-6062 | Skjemstad & Baldock, 2008 & Walkley & Balck 1934 | SPECTROPHOTOMETER |
| Fraction Organic Carbon-2 | INOR-93-6062 | Skjemstad & Baldock, 2008 & Walkley & Balck 1934 | SPECTROPHOTOMETER |
| Fraction Organic Carbon-3 | INOR-93-6062 | Skjemstad & Baldock, 2008 & Walkley & Balck 1934 | SPECTROPHOTOMETER |

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT:
SAMPLING SITE:

AGAT WORK ORDER: 18K399949
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SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Fraction Organic Carbon-Avg | INOR-93-6062 | Skjemstad & Baldock, 2008 & Walkley & Balck 1934 | SPECTROPHOTOMETER |
| Mercury | INOR-121-6101 & INOR-121-6107 | Based on EPA 245.5 & SM 3112B | CV/AA |

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| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Trace Organics Analysis | | | |
| Benzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Toluene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Ethylbenzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Xylene (Total) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| C6-C10 (less BTEX) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| >C10-C16 Hydrocarbons - 1X silica gel | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C16-C21 Hydrocarbons - 1X silica gel | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| >C21-C32 Hydrocarbons - 1X silica gel | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| Modified TPH (Tier 1) - 1X silica gel | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | CALCULATION |
| Resemblance Comment | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| Return to Baseline at C32 | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Silica Gel Cleanup | | | GC/FID |
| Isobutylbenzene - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - VPH | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| n-Dotriacontane - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| % Moisture | | Calculation | GRAVIMETRIC |
| 1-Methylnaphthalene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| 2-Methylnaphthalene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Acenaphthene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Acenaphthylene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Acridine | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Anthracene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Benzo(a)anthracene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Benzo(a)pyrene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Benzo(b)fluoranthene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Benzo(b+j)fluoranthene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Benzo(e)pyrene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Benzo(ghi)perylene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Benzo(k)fluoranthene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Chrysene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Dibenzo(a,h)anthracene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Fluoranthene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Fluorene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Indeno(1,2,3)pyrene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Naphthalene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Perylene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Phenanthrene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Pyrene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |

57 Old Pennywell Road, Unit I
St. John's, NL
CANADA A1E 6A8
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FAX (709 747-2139
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# Method Summary

CLIENT NAME: GHD LIMITED
AGAT WORK ORDER: 18K399949
PROJECT:
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Quinoline | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Nitrobenzene-d5 | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| 2-Fluorobiphenyl | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Terphenyl-d14 | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Total Polychlorinated Biphenyls | ORG-120-5106 | EPA SW846/8081/8080 | GC/ECD |
| Decachlorobiphenyl | ORG-120-5106 | EAP SW846 3510C/8080/8010 | GC/ECD |

Unit 122 ▪ 11 Morris Drive
Dartmouth, NS
B3B 1M2
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P: 902.468.8718 ▪ F: 902.468.8924

AGAT Laboratories

**Laboratory Use Only**

Arrival Condition: ☑ Good ☐ Poor (see notes)
Arrival Temperature: 8.1, 8.3, 8.6
AGAT Job Number: 18K399949
Notes:

# Chain of Custody Record

## Report Information

Company: GHD Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone: 1-709-364-5353 Fax: 1-709-364-5368
IOL Site # and Name: Marystown Shipyard Waterlot
Project #: 11178792-02
AGAT Quotation #: GHD 'Standing Offer"
GHD PO #: To Follow

## Invoice To

Same Yes ☑ / No ☐

Company:
Contact:
Address:
Phone: Fax:

## Report Information

1. Name: 
Email: James O'Neill
2. Name: James.O'Neill@ghd.com
Email: DataNL
datanl@ghd.com

## Report Format

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

## Turnaround Time Required (TAT)

**Regular TAT** ☐ 5 to 7 working days
**Rush TAT** ☐ 1 day ☑ 2 days ☐ 3 days

RUSH!

Date Required:

## Regulatory Requirements (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ PIRI
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☑ CCME ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☑ Sediment

**Drinking Water Sample:** ☐ Yes ☑ No
Reg. No.:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I – LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: Silica Gel Clean-up | OTHER: Mercury | OTHER: | | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18-MNMA-S1 | 2018/10/19 09:30 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-S2 | 2018/10/19 09:45 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-S3 | 2018/10/19 10:30 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-S4 | 2018/10/19 11:00 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-S5 | 2018/10/19 11:20 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-S6 | 2018/10/19 11:45 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-S7 | 2018/10/19 12:00 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-S8 | 2018/10/19 12:20 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-S9 | 2018/10/19 12:40 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-S10 | 2018/10/19 13:05 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-S11 | 2018/10/19 13:25 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |

| | | | |
|---|---|---|---|
| Samples Relinquished By (Print Name): Robert Percy | Date/Time 19/10/2018 | Samples Received By (Print Name): Sam Murphy | Date/Time 410pm |
| Samples Relinquished By (Sign): [signature] | Date/Time 15:00 | Samples Received By (Sign): [signature] | Date/Time 10/22/18 |

Page 1 of 2

Document ID: DIV-133-1502.001

Date revised: September 18, 2015

Unit 122 ▪ 11 Morris Drive
Dartmouth, NS
B3B 1M2

# AGAT Laboratories

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## Laboratory Use Only

Arrival Condition: ☑ Good ☐ Poor (see notes)
Arrival Temperature: 8.1 8.3 8.6
AGAT Job Number: 18K399949
Notes:

# Chain of Custody Record

## Report Information

Company: GHD Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone: 1-709-364-5353 Fax: 1-709-364-5368
IOL Site # and Name: Marystown Shipyard Waterlot
Project #: 11178792-02
AGAT Quotation #: GHD 'Standing Offer"
GHD PO #: To Follow

## Report Information

1. Name: James O'Neill
Email: James.O'Neill@ghd.com
2. Name: DataNL
Email: datanl@ghd.com

## Report Format

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

## Turnaround Time Required (TAT)

Regular TAT ☐ 5 to 7 working days
Rush TAT ☐ 1 day ☑ 2 days ☐ 3 days
Date Required:
RUSH!

## Regulatory Requirements (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ PIRI
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☑ CCME ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☑ Sediment

Drinking Water Sample: ☐ Yes ☑ No
Reg. No.:

## Invoice To

Same Yes ☑ / No ☐

Company:
Contact:
Address:
Phone: Fax:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: Silica Gel Clean-up | OTHER: Mercury | OTHER: | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18-MNMA-S12 | 2018/10/19 13:40 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-S13 | 2018/10/19 13:55 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-S14 | 2018/10/19 14:05 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-S15 | 2018/10/19 14:15 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-DUP1 | 2018/10/19 11:46 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-DUP2 | 2018/10/19 13:26 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-REF1 | 2018/10/19 14:30 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-REF2 | 2018/10/19 14:45 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-REF3 | 2018/10/19 15:00 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |

Samples Relinquished By (Print Name): Robert Perry
Date/Time: 10/22/2018
Samples Relinquished By (Sign):
Date/Time: 15:00
Samples Received By (Print Name):
Date/Time
Samples Received By (Sign):
Date/Time

Page 2 of 2

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CANADA A1E 6A8
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http://www.agatlabs.com

| | |
|---|---|
| CLIENT NAME: | GHD LIMITED<br>1118 TOPSAIL ROAD<br>ST. JOHN'S , NL A1B3N7<br>(709) 364-5353 |
| ATTENTION TO: | JAMES O'NEILL |
| PROJECT: | 11178792-02 |
| AGAT WORK ORDER: | 18K397661 |
| TRACE ORGANICS REVIEWED BY: | Amy Hunter, Trace Organics Supervisor, B.Sc. |
| WATER ANALYSIS REVIEWED BY: | Jason Coughtrey, Inorganics Supervisor |
| DATE REPORTED: | Nov 01, 2018 |
| PAGES (INCLUDING COVER): | 10 |
| VERSION*: | 1 |

Should you require any information regarding this analysis please contact your client services representative at (709)747-8573

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

AGAT Laboratories

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# Certificate of Analysis

AGAT WORK ORDER: 18K397661
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Water (Version 3.0)

DATE RECEIVED: 2018-10-16
DATE REPORTED: 2018-11-01

| Parameter | Unit | G / S | RDL | MASO-MW1-2018 | MLLA-MW1-2018 | MFPA-MW1-2018 | MSBL-MW6 | MSBL-MW2-2018 | MW0 | MAEB-MW1-2018 | MAEB-MW2-2018 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Water | Water | Water | Water | Water | Water | Water | Water |
| DATE SAMPLED: | | | | 2018-10-12 | 2018-10-12 | 2018-10-12 | 2018-10-12 | 2018-10-12 | 2018-10-12 | 2018-10-12 | 2018-10-12 |
| | | | | 9627307 | 9627322 | 9627336 | 9627337 | 9627338 | 9627339 | 9627340 | 9627341 |
| Benzene | mg/L | | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Toluene | mg/L | | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Ethylbenzene | mg/L | | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Xylene (Total) | mg/L | | 0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 |
| C6-C10 (less BTEX) | mg/L | | 0.01 | 0.04 | <0.01 | 0.24 | 0.04 | <0.01 | <0.01 | <0.01 | 0.22 |
| >C10-C16 Hydrocarbons | mg/L | | 0.05 | 1.28 | <0.05 | 0.40 | 1.99 | 0.16 | 0.44 | <0.05 | 6.51 |
| >C16-C21 Hydrocarbons | mg/L | | 0.10 | 0.64 | <0.10 | 0.46 | 2.72 | 0.15 | 0.51 | <0.10 | 4.88 |
| >C21-C32 Hydrocarbons | mg/L | | 0.1 | 1.29 | <0.1 | 0.32 | 0.76 | <0.1 | 0.20 | <0.1 | 0.68 |
| Modified TPH (Tier 1) | mg/L | | 0.1 | 3.3 | <0.1 | 1.4 | 5.5 | 0.3 | 1.2 | <0.1 | 12.3 |
| Resemblance Comment | | | | FOF, LOF | NR | WFOF | WFOF | WFOF | WFOF | NR | FOF |
| Return to Baseline at C32 | | | | Y | Y | Y | Y | Y | Y | Y | Y |
| **Surrogate** | **Unit** | **Acceptable Limits** | | | | | | | | | |
| Isobutylbenzene - EPH | % | 70-130 | | 70 | 88 | 109 | 92 | 87 | 117 | 92 | 103 |
| Isobutylbenzene - VPH | % | 70-130 | | 91 | 95 | 96 | 96 | 97 | 89 | 92 | 100 |
| n-Dotriacontane - EPH | % | 70-130 | | 71 | 87 | 111 | 94 | 84 | 124 | 93 | 88 |

Certified By:

57 Old Pennywell Road, Unit I
St. John's, NL
CANADA A1E 6A8
TEL (709)747-8573
FAX (709 747-2139
http://www.agatlabs.com

CLIENT NAME: GHD LIMITED
SAMPLING SITE:

ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Water (Version 3.0)

DATE RECEIVED: 2018-10-16

DATE REPORTED: 2018-11-01

| | | | SAMPLE DESCRIPTION: | MGSB-MW15 | MW00 | MDSA-MW3-2018 | MDSA-MW2-2018 | MDSA-MW9 | MGSB-MW17 |
|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Water | Water | Water | Water | Water | Water |
| | | | DATE SAMPLED: | 2018-10-12 | 2018-10-12 | 2018-10-12 | 2018-10-12 | 2018-10-12 | 2018-10-12 |
| Parameter | Unit | G / S | RDL | 9627342 | 9627343 | 9627344 | 9627347 | 9627348 | 9627349 |
| Benzene | mg/L | | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Toluene | mg/L | | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Ethylbenzene | mg/L | | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Xylene (Total) | mg/L | | 0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 |
| C6-C10 (less BTEX) | mg/L | | 0.01 | 1.08 | 1.09 | 0.01 | <0.01 | <0.01 | <0.01 |
| >C10-C16 Hydrocarbons | mg/L | | 0.05 | 230 | 88.6 | <0.05 | 0.12 | <0.05 | 1.87 |
| >C16-C21 Hydrocarbons | mg/L | | 0.10 | 190 | 71.2 | <0.10 | 0.17 | <0.10 | 3.23 |
| >C21-C32 Hydrocarbons | mg/L | | 0.1 | 26.0 | 10.9 | <0.1 | <0.1 | <0.1 | 0.92 |
| Modified TPH (Tier 1) | mg/L | | 0.1 | 447 | 172 | <0.1 | 0.3 | <0.1 | 6.0 |
| Resemblance Comment | | | | FOF | FOF | GR | WFOF | NR | WFOF |
| Return to Baseline at C32 | | | | Y | Y | Y | Y | Y | Y |
| Surrogate | Unit | Acceptable Limits | | | | | | | |
| Isobutylbenzene - EPH | % | 70-130 | | 72 | 124 | 101 | 109 | 109 | 107 |
| Isobutylbenzene - VPH | % | 70-130 | | 97 | 86 | 97 | 96 | 96 | 99 |
| n-Dotriacontane - EPH | % | 70-130 | | 105 | 93 | 103 | 115 | 115 | 113 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9627307-9627349 Resemblance Comment Key:
GF - Gasoline Fraction
WGF - Weathered Gasoline Fraction
GR - Product in Gasoline Range
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
FR - Product in Fuel Oil Range
LOF - Lube Oil Fraction
LR - Lube Range
UC - Unidentified Compounds
NR - No Resemblance
NA - Not Applicable

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

Laboratories

# Certificate of Analysis

AGAT WORK ORDER: 18K397661

PROJECT: 11178792-02

57 Old Pennywell Road, Unit I
St. John's, NL
CANADA A1E 6A8
TEL (709)747-8573
FAX (709 747-2139
http://www.agatlabs.com

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Dissolved Metals

DATE RECEIVED: 2018-10-16

DATE REPORTED: 2018-11-01

| Parameter | Unit | G / S | RDL | MLLA-MW3-2018 | MLLA-MW4-2018 | MLLA-MW2-2018 | MAEB-MW2-2018 | MDSA-MW1-2018 | MW000 |
|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Water | Water | Water | Water | Water | Water |
| | | | DATE SAMPLED: | 2018-10-12 | 2018-10-12 | 2018-10-12 | 2018-10-12 | 2018-10-12 | 2018-10-12 |
| | | | | 9627313 | 9627317 | 9627325 | 9627341 | 9627345 | 9627346 |
| Dissolved Aluminum | ug/L | | 5 | 14 | 14 | 110 | 39 | 13 | <5 |
| Dissolved Antimony | ug/L | | 2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Dissolved Arsenic | ug/L | | 2 | 240 | 362 | 87 | 19 | 27 | 36 |
| Dissolved Barium | ug/L | | 5 | 55 | 76 | 483 | 97 | 87 | 82 |
| Dissolved Beryllium | ug/L | | 2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Dissolved Bismuth | ug/L | | 2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Dissolved Boron | ug/L | | 5 | 2370 | 2960 | 387 | 20 | 1930 | 1720 |
| Dissolved Cadmium | ug/L | | 0.09 | 0.13 | 0.16 | <0.09 | <0.09 | 0.11 | 0.11 |
| Dissolved Chromium | ug/L | | 1 | 6 | 7 | 4 | 2 | 3 | 3 |
| Dissolved Cobalt | ug/L | | 1 | 1 | 2 | 1 | <1 | <1 | <1 |
| Dissolved Copper | ug/L | | 2 | 4 | 7 | 3 | 3 | 5 | 4 |
| Dissolved Iron | ug/L | | 50 | <50 | <50 | 2780 | 149 | <50 | <50 |
| Dissolved Lead | ug/L | | 0.5 | <0.5 | <0.5 | 0.5 | <0.5 | 0.5 | <0.5 |
| Dissolved Manganese | ug/L | | 2 | 176 | 33 | 4790 | 320 | 20 | 18 |
| Dissolved Molybdenum | ug/L | | 2 | 4 | 5 | <2 | 4 | 2 | 2 |
| Dissolved Nickel | ug/L | | 2 | 8 | 10 | 4 | <2 | 7 | 8 |
| Dissolved Selenium | ug/L | | 1 | 109 | 156 | 43 | 3 | 97 | 96 |
| Dissolved Silver | ug/L | | 0.1 | <0.1 | 0.2 | <0.1 | <0.1 | <0.1 | <0.1 |
| Dissolved Strontium | ug/L | | 5 | 4040 | 5290 | 969 | 139 | 3860 | 3630 |
| Dissolved Thallium | ug/L | | 0.1 | <0.1 | <0.1 | <0.1 | 0.1 | <0.1 | <0.1 |
| Dissolved Tin | ug/L | | 2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Dissolved Titanium | ug/L | | 2 | 4 | 6 | 6 | 4 | 2 | 2 |
| Dissolved Uranium | ug/L | | 0.1 | 1.5 | 1.9 | 0.4 | 0.1 | 0.8 | 0.8 |
| Dissolved Vanadium | ug/L | | 2 | 478 | 494 | 152 | 18 | 25 | 32 |
| Dissolved Zinc | ug/L | | 5 | 17 | 32 | 12 | 9 | 17 | 15 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9627313-9627346 Analysis completed on a filtered sample.

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

57 Old Pennywell Road, Unit I
St. John's, NL
CANADA A1E 6A8
TEL (709)747-8573
FAX (709 747-2139
http://www.agatlabs.com

AGAT Laboratories

# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K397661
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Trace Organics Analysis

| RPT Date: Nov 01, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits | | Recovery | Acceptable Limits | | Recovery | Acceptable Limits | |
| | | | | | | | | Lower | Upper | | Lower | Upper | | Lower | Upper |
| **Atlantic RBCA Tier 1 Hydrocarbons in Water (Version 3.0)** | | | | | | | | | | | | | | | |
| Benzene | 1 | 9640692 | < 0.001 | < 0.001 | NA | < 0.001 | 79% | 70% | 130% | 70% | 70% | 130% | | | |
| Toluene | 1 | 9640692 | < 0.001 | < 0.001 | NA | < 0.001 | 84% | 70% | 130% | 71% | 70% | 130% | | | |
| Ethylbenzene | 1 | 9640692 | < 0.001 | < 0.001 | NA | < 0.001 | 85% | 70% | 130% | 72% | 70% | 130% | | | |
| Xylene (Total) | 1 | 9640692 | < 0.002 | < 0.002 | NA | < 0.002 | 89% | 70% | 130% | 75% | 70% | 130% | | | |
| C6-C10 (less BTEX) | 1 | 9640692 | < 0.01 | < 0.01 | NA | < 0.01 | 120% | 70% | 130% | 111% | 70% | 130% | NA | 70% | 130% |
| >C10-C16 Hydrocarbons | 1 | 9627338 | 0.16 | 0.20 | NA | < 0.05 | 102% | 70% | 130% | 96% | 70% | 130% | 74% | 70% | 130% |
| >C16-C21 Hydrocarbons | 1 | 9627338 | 0.19 | 0.26 | NA | < 0.10 | 88% | 70% | 130% | 96% | 70% | 130% | 74% | 70% | 130% |
| >C21-C32 Hydrocarbons | 1 | 9627338 | <0.1 | <0.1 | NA | < 0.1 | 93% | 70% | 130% | 96% | 70% | 130% | 74% | 70% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

| RPT Date: Nov 01, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits | | Recovery | Acceptable Limits | | Recovery | Acceptable Limits | |
| | | | | | | | | Lower | Upper | | Lower | Upper | | Lower | Upper |
| **Atlantic RBCA Tier 1 Hydrocarbons in Water (Version 3.0)** | | | | | | | | | | | | | | | |
| Benzene | 1 | 9632900 | < 0.001 | < 0.001 | NA | < 0.001 | 84% | 70% | 130% | 70% | 70% | 130% | | | |
| Toluene | 1 | 9632900 | < 0.001 | < 0.001 | NA | < 0.001 | 92% | 70% | 130% | 77% | 70% | 130% | | | |
| Ethylbenzene | 1 | 9632900 | < 0.001 | < 0.001 | NA | < 0.001 | 96% | 70% | 130% | 82% | 70% | 130% | | | |
| Xylene (Total) | 1 | 9632900 | < 0.002 | < 0.002 | NA | < 0.002 | 99% | 70% | 130% | 84% | 70% | 130% | | | |
| C6-C10 (less BTEX) | 1 | 9632900 | < 0.01 | < 0.01 | NA | < 0.01 | 124% | 70% | 130% | 118% | 70% | 130% | NA | 70% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

| RPT Date: Nov 01, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits | | Recovery | Acceptable Limits | | Recovery | Acceptable Limits | |
| | | | | | | | | Lower | Upper | | Lower | Upper | | Lower | Upper |
| **Atlantic RBCA Tier 1 Hydrocarbons in Water (Version 3.0)** | | | | | | | | | | | | | | | |
| Benzene | 1 | 9654418 | <0.001 | <0.001 | 0 | < 0.001 | 87% | 70% | 130% | 75% | 70% | 130% | | | |
| Toluene | 1 | 9654418 | <0.001 | <0.001 | 0 | < 0.001 | 89% | 70% | 130% | 83% | 70% | 130% | | | |
| Ethylbenzene | 1 | 9654418 | <0.001 | <0.001 | 0 | < 0.001 | 90% | 70% | 130% | 86% | 70% | 130% | | | |
| Xylene (Total) | 1 | 9654418 | <0.002 | <0.002 | 0 | < 0.002 | 95% | 70% | 130% | 90% | 70% | 130% | | | |
| C6-C10 (less BTEX) | 1 | 9654418 | <0.01 | <0.01 | 0 | < 0.01 | 95% | 70% | 130% | 101% | 70% | 130% | 104% | 70% | 130% |
| >C10-C16 Hydrocarbons | 1 | 9643254 | <0.05 | <0.05 | 0 | < 0.05 | 98% | 70% | 130% | 82% | 70% | 130% | 87% | 70% | 130% |
| >C16-C21 Hydrocarbons | 1 | 9643254 | <0.05 | <0.05 | 0 | < 0.10 | 90% | 70% | 130% | 82% | 70% | 130% | 87% | 70% | 130% |
| >C21-C32 Hydrocarbons | 1 | 9643254 | <0.01 | <0.01 | 0 | < 0.1 | 97% | 70% | 130% | 82% | 70% | 130% | 87% | 70% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

Certified By:

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K397661
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Water Analysis

| RPT Date: Nov 01, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Dissolved Metals | | | | | | | | | | | | | | | |
| Dissolved Aluminum | 9643800 | | <5 | <5 | NA | < 5 | 115% | 80% | 120% | 109% | 80% | 120% | 116% | 70% | 130% |
| Dissolved Antimony | 9643800 | | <2 | <2 | NA | < 2 | 100% | 80% | 120% | 109% | 80% | 120% | 95% | 70% | 130% |
| Dissolved Arsenic | 9643800 | | <2 | <2 | NA | < 2 | 97% | 80% | 120% | 93% | 80% | 120% | NA | 70% | 130% |
| Dissolved Barium | 9643800 | | 199 | 233 | 15.7% | < 5 | 99% | 80% | 120% | 94% | 80% | 120% | NA | 70% | 130% |
| Dissolved Beryllium | 9643800 | | <2 | <2 | NA | < 2 | 92% | 80% | 120% | 89% | 80% | 120% | 124% | 70% | 130% |
| Dissolved Bismuth | 9643800 | | <2 | <2 | NA | < 2 | 99% | 80% | 120% | 95% | 80% | 120% | 103% | 70% | 130% |
| Dissolved Boron | 9643800 | | 28 | 36 | 25.4% | < 5 | 96% | 80% | 120% | 86% | 80% | 120% | 122% | 70% | 130% |
| Dissolved Cadmium | 9643800 | | <0.09 | <0.09 | NA | < 0.09 | 101% | 80% | 120% | 93% | 80% | 120% | 108% | 70% | 130% |
| Dissolved Chromium | 9643800 | | 4 | 5 | NA | < 1 | 103% | 80% | 120% | 93% | 80% | 120% | 83% | 70% | 130% |
| Dissolved Cobalt | 9643800 | | <1 | <1 | NA | < 1 | 103% | 80% | 120% | 93% | 80% | 120% | 82% | 70% | 130% |
| Dissolved Copper | 9643800 | | <2 | <2 | NA | < 2 | 102% | 80% | 120% | 93% | 80% | 120% | 90% | 70% | 130% |
| Dissolved Iron | 9643800 | | <50 | <50 | NA | < 50 | 101% | 80% | 120% | 91% | 80% | 120% | 73% | 70% | 130% |
| Dissolved Lead | 9643800 | | <0.5 | <0.5 | NA | < 0.5 | 99% | 80% | 120% | 94% | 80% | 120% | 105% | 70% | 130% |
| Dissolved Manganese | 9643800 | | 226 | 233 | 3.1% | < 2 | 102% | 80% | 120% | 92% | 80% | 120% | NA | 70% | 130% |
| Dissolved Molybdenum | 9643800 | | <2 | <2 | NA | < 2 | 99% | 80% | 120% | 90% | 80% | 120% | 121% | 70% | 130% |
| Dissolved Nickel | 9643800 | | <2 | <2 | NA | < 2 | 102% | 80% | 120% | 94% | 80% | 120% | 86% | 70% | 130% |
| Dissolved Selenium | 9643800 | | <1 | <1 | NA | < 1 | 97% | 80% | 120% | 95% | 80% | 120% | 113% | 70% | 130% |
| Dissolved Silver | 9643800 | | <0.1 | 0.3 | NA | < 0.1 | 103% | 80% | 120% | 95% | 80% | 120% | 98% | 70% | 130% |
| Dissolved Strontium | 9643800 | | 295 | 309 | 4.7% | < 5 | 112% | 80% | 120% | 103% | 80% | 120% | NA | 70% | 130% |
| Dissolved Thallium | 9643800 | | <0.1 | <0.1 | NA | < 0.1 | 100% | 80% | 120% | 95% | 80% | 120% | 104% | 70% | 130% |
| Dissolved Tin | 9643800 | | <2 | <2 | NA | < 2 | 98% | 80% | 120% | 93% | 80% | 120% | NA | 70% | 130% |
| Dissolved Titanium | 9643800 | | <2 | <2 | NA | < 2 | 107% | 80% | 120% | 101% | 80% | 120% | 122% | 70% | 130% |
| Dissolved Uranium | 9643800 | | 2.0 | 2.6 | 23.3% | < 0.1 | 95% | 80% | 120% | 91% | 80% | 120% | 118% | 70% | 130% |
| Dissolved Vanadium | 9643800 | | 2 | <2 | NA | < 2 | 99% | 80% | 120% | 90% | 80% | 120% | 76% | 70% | 130% |
| Dissolved Zinc | 9643800 | | <5 | <5 | NA | < 5 | 102% | 80% | 120% | 92% | 80% | 120% | 104% | 70% | 130% |

Comments: If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

Certified By:

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K397661
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Trace Organics Analysis | | | |
| Benzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Toluene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Ethylbenzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Xylene (Total) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| C6-C10 (less BTEX) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| >C10-C16 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C16-C21 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C21-C32 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Modified TPH (Tier 1) | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | CALCULATION |
| Resemblance Comment | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| Return to Baseline at C32 | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - VPH | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| n-Dotriacontane - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |

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# Method Summary

CLIENT NAME: GHD LIMITED

PROJECT: 11178792-02

SAMPLING SITE:

AGAT WORK ORDER: 18K397661

ATTENTION TO: JAMES O'NEILL

SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Water Analysis | | | |
| Dissolved Aluminum | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Antimony | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Arsenic | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Barium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Beryllium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Bismuth | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Boron | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Cadmium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Chromium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Cobalt | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Copper | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Iron | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Lead | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Manganese | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Molybdenum | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Nickel | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Selenium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Silver | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Strontium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Thallium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Tin | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Titanium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Uranium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Vanadium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Dissolved Zinc | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |

Unit 122 • 11 Morris Drive
Dartmouth, NS
B3B 1M2

AGAT Laboratories

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**Laboratory Use Only**

Arrival Condition: ☑ Good ☐ Poor (see notes)

Arrival Temperature: 6.1, 8.6, 6.4°C

AGAT Job Number: 18K397661

Notes:

# Chain of Custody Record

## Report Information

Company: GHD Contractors Limited

Contact: James O'Neill

Address: 1118 Topsail Road
St. John's NL

Phone: 1-709-364-5353 Fax: 1-709-364-5368

**IOL Site # and Name:** Marystown Shipyard

Project #: 11178792-02

**AGAT Quotation #:** 15-115798

**GHD PO #:** 73512762

## Report Information

1. Name:
   Email: James O'Neil
2. Name: James.Oneill@ghd.com
   Email: Robert Perry
   Robert.Perry@ghd.com

## Report Format

☐ Single Sample per page

☑ Multiple Samples per page

☑ Excel Format Included

## Turnaround Time Required (TAT)

**Regular TAT** ☑ 5 to 7 working days

**Rush TAT** ☐ 1 day ☐ 2 days ☐ 3 days

Date Required:

## Regulatory Requirements (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☑ **PIRI**

☑ Tier 1 ☐ Gas ☐ Pot ☑ Coarse

☐ Res ☐ Fuel ☑ N/Pot ☐ Fine

☑ Com ☐ Lube

☐ **CCME** ☐ CDWQ

☐ Industrial

☐ Commercial ☐ Other

☐ Res/Park

☐ Agricultural

☐ FWAL

☐ Sediment

**Drinking Water Sample:** ☐ Yes ☑ No

Reg. No.:

## Invoice To

Same Yes ☑ / No ☐

Company:

Contact:

Address:

Phone: Fax:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: | OTHER: | OTHER: | | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MASO-MW1-2018 | 2018/10/12 08:30 | Water | 3 x 40 mL & 2 x 250 mL | 5 | | ☑ | | | | | | | | | | | | | | | | | | | | | |
| MLLA-MW3-2018 | 2018/10/12 09:00 | Water | 1x120mL | 1 | | | | | | ☑ | | | | | | | | | | | | | | | | | |
| MLLA-MW4-2018 | 2018/10/12 09:10 | Water | 1x120mL | 1 | | | | | | ☑ | | | | | | | | | | | | | | | | | |
| MLLA-MW1-2018 | 2018/10/12 09:20 | Water | 3 x 40 mL & 2 x 250 mL | 5 | | ☑ | | | | | | | | | | | | | | | | | | | | | |
| MLLA-MW2-2018 | 2018/10/12 10:15 | Water | 1x120mL | 1 | | | | | | ☑ | | | | | | | | | | | | | | | | | |
| MFPA-MW1-2018 | 2018/10/12 09:30 | Water | 3 x 40 mL & 2 x 250 mL | 5 | | ☑ | | | | | | | | | | | | | | | | | | | | | |
| MSBL-MW1-2018 | 2018/10/12 09:50 | Water | 3 x 40 mL & 2 x 250 mL | 5 | | ☑ | | | | | | | | | | | | | | | | | | | | | |
| MSBL-MW2-2018 | 2018/10/12 10:05 | Water | 3 x 40 mL & 2 x 250 mL | 5 | | ☑ | | | | | | | | | | | | | | | | | | | | | |
| MW0 | 2018/10/12 10:06 | Water | 3 x 40 mL & 2 x 250 mL | 5 | | ☑ | | | | | | | | | | | | | | | | | | | | | |
| MAEB-MW1-2018 | 2018/10/12 10:30 | Water | 3 x 40 mL & 2 x 250 mL | 5 | | ☑ | | | | | | | | | | | | | | | | | | | | | |
| MAEB-MW2-2018 | 2018/10/12 11:15 | Water | 3x40mL,2x250mL,1x120mL | 6 | | ☑ | | | | ☑ | | | | | | | | | | | | | | | | | |

| | | | |
|---|---|---|---|
| Samples Relinquished By (Print Name): Robert Perry | Date/Time 10/16/2018 | Samples Received By (Print Name): Emma Penney | Date/Time Oct. 16/18 |
| Samples Relinquished By (Sign): [signature] | Date/Time | Samples Received By (Sign): [signature] | Date/Time 4:15pm |

Page 1 of 2

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# Chain of Custody Record

## Report Information

Company: GHD Contractors Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL
Phone: 1-709-364-5353 Fax: 1-709-364-5368
**IOL Site # and Name:** Marystown Shipyard
Project #: 11178792-02
**AGAT Quotation #:** 15-115798
**GHD PO #:** 73512762

## Report Information

1. Name: 
   Email: James O'Neil
2. Name: James.Oneill@ghd.com
   Email: Robert Perry
   Robert.Perry@ghd.com

## Report Format

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

## Laboratory Use Only

Arrival Condition: ☑ Good ☐ Poor (see notes)
Arrival Temperature: 6.1, 8.6, 6.4°C
AGAT Job Number:
Notes:

## Turnaround Time Required (TAT)

**Regular TAT** ☑ 5 to 7 working days
**Rush TAT** ☐ 1 day ☐ 2 days ☐ 3 days
Date Required:

## Invoice To

Same Yes ☑ / No ☐

Company:
Contact:
Address:
Phone: Fax:

## Regulatory Requirements (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☑ **PIRI**
☑ Tier 1 ☐ Gas ☐ Pot ☑ Coarse
☐ Res ☐ Fuel ☑ N/Pot ☐ Fine
☑ Com ☐ Lube

☐ **CCME** ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

**Drinking Water Sample:** ☐ Yes ☑ No
Reg. No.:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☐ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: | OTHER: | OTHER: | | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| MGSB-MW15 | 2018/10/12 10:40 | Water | 3 x 40 mL & 2 x 250 mL | 5 | | ☑ | | | | | | | | | | | | | | | | | | | | | |
| MW00 | 2018/10/12 10:41 | Water | 3 x 40 mL & 2 x 250 mL | 5 | | ☑ | | | | | | | | | | | | | | | | | | | | | |
| MDSA-MW3-2018 | 2018/10/12 10:50 | Water | 3 x 40 mL & 2 x 250 mL | 5 | | ☑ | | | | | | | | | | | | | | | | | | | | | |
| MDSA-MW1-2018 | 2018/10/12 12:00 | Water | 3 x 40 mL & 2 x 250 mL | 5 | | ☑ | | | | | | | | | | | | | | | | | | | | | |
| MW000 | 2018/10/12 12:01 | Water | 3 x 40 mL & 2 x 250 mL | 5 | | ☑ | | | | | | | | | | | | | | | | | | | | | |
| MDSA-MW2-2018 | 2018/10/12 12:12 | Water | 3 x 40 mL & 2 x 250 mL | 5 | | ☑ | | | | | | | | | | | | | | | | | | | | | |
| MDSA-MW9 | 2018/10/12 12:20 | Water | 3 x 40 mL & 2 x 250 mL | 5 | | ☑ | | | | | | | | | | | | | | | | | | | | | |
| MGSB-MW17 | 2018/10/12 11:00 | Water | 3 x 40 mL & 2 x 250 mL | 5 | | ☑ | | | | | | | | | | | | | | | | | | | | | |

Samples Relinquished By (Print Name): Robert Perry
Date/Time: 10/16/2018
Samples Relinquished By (Sign): R. Perry
Date/Time:
Samples Received By (Print Name): Emma Penney
Date/Time: Oct 16/18
Samples Received By (Sign): [signature]
Date/Time: 4:15pm

Page 2 of 2



Document ID: DIV-133-1502.001

Date revised: September 18, 2015

AGAT Laboratories

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St. John's, NL
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http://www.agatlabs.com

| | |
|---|---|
| CLIENT NAME: | GHD LIMITED<br>1118 TOPSAIL ROAD<br>ST. JOHN'S , NL A1B3N7<br>(709) 364-5353 |
| ATTENTION TO: | JAMES O'NEILL |
| PROJECT: | 11178792-02 |
| AGAT WORK ORDER: | 18K403228 |
| TRACE ORGANICS REVIEWED BY: | Kelly Hogue, B.Sc, P.Chem, Operations Manager |
| DATE REPORTED: | Nov 07, 2018 |
| PAGES (INCLUDING COVER): | 5 |
| VERSION*: | 1 |

Should you require any information regarding this analysis please contact your client services representative at (709)747-8573

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

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# Certificate of Analysis

AGAT WORK ORDER: 18K403228
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Water - Low Level

DATE RECEIVED: 2018-10-30
DATE REPORTED: 2018-11-07

| | | | SAMPLE DESCRIPTION: | RW1 | RW2 |
|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Water | Water |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9661466 | 9661478 |
| Benzene | mg/L | | 0.001 | <0.001 | <0.001 |
| Toluene | mg/L | | 0.001 | <0.001 | <0.001 |
| Ethylbenzene | mg/L | | 0.001 | <0.001 | <0.001 |
| Xylene (Total) | mg/L | | 0.001 | <0.001 | <0.001 |
| C6-C10 (less BTEX) | mg/L | | 0.01 | <0.01 | <0.01 |
| >C10-C16 Hydrocarbons | mg/L | | 0.05 | 0.16 | 0.06 |
| >C16-C21 Hydrocarbons | mg/L | | 0.05 | 0.27 | <0.05 |
| >C21-C32 Hydrocarbons | mg/L | | 0.01 | 0.03 | 0.02 |
| Modified TPH (Tier 1) | mg/L | | 0.1 | 0.5 | <0.1 |
| Resemblance Comment | | | | WFOF | FR, UC |
| Return to Baseline at C32 | | | | Y | Y |
| Surrogate | Unit | Acceptable Limits | | | |
| Isobutylbenzene - EPH | % | 70-130 | | 92 | 97 |
| Isobutylbenzene - VPH | % | 70-130 | | 92 | 88 |
| n-Dotriacontane - EPH | % | 70-130 | | 96 | 100 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9661466-9661478 Resemblance Comment Key:
GF - Gasoline Fraction
WGF - Weathered Gasoline Fraction
GR - Product in Gasoline Range
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
FR - Product in Fuel Oil Range
LOF - Lube Oil Fraction
LR - Lube Range
UC - Unidentified Compounds
NR - No Resemblance
NA - Not Applicable

Analysis performed at AGAT Halifax (unless marked by *)

Certified By: Kelly Hogue

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K403228
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Trace Organics Analysis

| RPT Date: Nov 07, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Atlantic RBCA Tier 1 Hydrocarbons in Water - Low Level | | | | | | | | | | | | | | | |
| Benzene | 1 | 9662095 | 0.008 | 0.006 | 28.6% | < 0.001 | 94% | 70% | 130% | 87% | 70% | 130% | | | |
| Toluene | 1 | 9662095 | < 0.001 | < 0.001 | NA | < 0.001 | 98% | 70% | 130% | 87% | 70% | 130% | | | |
| Ethylbenzene | 1 | 9662095 | < 0.001 | < 0.001 | NA | < 0.001 | 97% | 70% | 130% | 86% | 70% | 130% | | | |
| Xylene (Total) | 1 | 9662095 | < 0.001 | < 0.001 | NA | < 0.001 | 101% | 70% | 130% | 92% | 70% | 130% | | | |
| C6-C10 (less BTEX) | 1 | 9662095 | 0.13 | 0.14 | 7.4% | < 0.01 | 96% | 70% | 130% | 112% | 70% | 130% | 113% | 70% | 130% |
| >C10-C16 Hydrocarbons | 1 | 9665132 | < 0.05 | < 0.05 | NA | < 0.05 | 119% | 70% | 130% | 88% | 70% | 130% | 95% | 70% | 130% |
| >C16-C21 Hydrocarbons | 1 | 9665132 | < 0.05 | < 0.05 | NA | < 0.05 | 122% | 70% | 130% | 88% | 70% | 130% | 95% | 70% | 130% |
| >C21-C32 Hydrocarbons | 1 | 9665132 | 0.02 | <0.01 | NA | < 0.01 | 125% | 70% | 130% | 88% | 70% | 130% | 95% | 70% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

Certified By: Kelly Hogue

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K403228
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Trace Organics Analysis | | | |
| Benzene | VOL-120-5010 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Toluene | VOL-120-5010 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Ethylbenzene | VOL-120-5010 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Xylene (Total) | VOL-120-5010 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| C6-C10 (less BTEX) | VOL-120-5010 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| >C10-C16 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C16-C21 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C21-C32 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Modified TPH (Tier 1) | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | CALCULATION |
| Resemblance Comment | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| Return to Baseline at C32 | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - VPH | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| n-Dotriacontane - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |

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# AGAT Laboratories

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**Laboratory Use Only**

Arrival Condition: ☑ Good ☐ Poor (see notes)

Arrival Temperature: 4.4, 4.5

AGAT Job Number: 18K403228

Notes:

## Chain of Custody Record

**Report Information**

Company: GHD Contractors Limited

Contact: James O'Neill

Address: 1118 Topsail Road
St. John's NL

Phone: 1-709-364-5353 Fax: 1-709-364-5368

[redacted] Site [redacted] Name: Marystown Shipyard

Project #: 11178792-02

**AGAT Quotation #:** GHD "SO"

**GHD PO #:** To Follow

**Report Information**

1. Name:
   Email: James O'Neil
2. Name: James.Oneill@ghd.com
   Email: Robert Perry
   Robert.Perry@ghd.com

**Report Format**

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

**Turnaround Time Required (TAT)**

**Regular TAT** ☑ 5 to 7 working days

**Rush TAT** ☐ 1 day ☐ 2 days ☐ 3 days

Date Required:

**Invoice To** Same Yes ☑ / No ☐

Company:

Contact:

Address:

Phone: Fax:

**Regulatory Requirements** (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☑ **PIRI**
☑ Tier 1 ☐ Gas ☐ Pot ☐ Coarse
☐ Res ☐ Fuel ☑ N/Pot ☐ Fine
☑ Com ☐ Lube

☐ **CCME** ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

**Drinking Water Sample:** ☐ Yes ☑ No

Reg. No.:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS - SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☐ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: | OTHER: | OTHER: | | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| RW1 | 2018/10/19 16:45 | Soil | 3 x 40 mL & 2 x 250 mL | 5 | | ☑ | | | | | | | | | | | | | | | | | | | | | |
| RW2 | 2018/10/19 16:40 | Soil | 3 x 40 mL & 2 x 250 mL | 5 | | ☑ | | | | | | | | | | | | | | | | | | | | | |

| Samples Relinquished By (Print Name): | Date/Time | Samples Received By (Print Name): | Date/Time |
|---|---|---|---|
| Robert Perry | | Sam Murphy | 1:05PM |
| Samples Relinquished By (Sign): | Date/Time | Samples Received By (Sign): | Date/Time |
| [signature] | | [signature] | 10/30/18 |

Page 1 of 1

Document ID: DIV-133-1502.001

Date revised: September 18, 2015

AGAT Laboratories

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| | |
|---|---|
| CLIENT NAME: | GHD LIMITED<br>1118 TOPSAIL ROAD<br>ST. JOHN'S , NL A1B3N7<br>(709) 364-5353 |
| ATTENTION TO: | JAMES O'NEILL |
| PROJECT: | 11178792-02 |
| AGAT WORK ORDER: | 18K421242 |
| SOIL ANALYSIS REVIEWED BY: | Jason Coughtrey, Inorganics Supervisor |
| TRACE ORGANICS REVIEWED BY: | Amy Hunter, Trace Organics Supervisor, B.Sc. |
| WATER ANALYSIS REVIEWED BY: | Jason Coughtrey, Inorganics Supervisor |
| DATE REPORTED: | Jan 09, 2019 |
| PAGES (INCLUDING COVER): | 32 |
| VERSION*: | 1 |

Should you require any information regarding this analysis please contact your client services representative at (709)747-8573

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

# Certificate of Analysis

AGAT WORK ORDER: 18K421242

PROJECT: 11178792-02

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CLIENT NAME: GHD LIMITED

SAMPLING SITE:

ATTENTION TO: JAMES O'NEILL

SAMPLED BY:

## Available Metals in Soil

DATE RECEIVED: 2018-12-17

DATE REPORTED: 2019-01-09

| | | | SAMPLE DESCRIPTION: | 18-MNMA-STEP1 | 18-MNMA-STEP2 | 18-MNMA-STEP3 | 18-MNMA-DUP3 |
|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-12-13 | 2018-12-13 | 2018-12-13 | 2018-12-13 |
| Parameter | Unit | G / S | RDL | 9791888 | 9791898 | 9791899 | 9791900 |
| Aluminum | mg/kg | | 10 | 4060 | 7550 | 8330 | 9800 |
| Antimony | mg/kg | | 1 | <1 | <1 | <1 | <1 |
| Arsenic | mg/kg | | 1 | 26 | 13 | 19 | 22 |
| Barium | mg/kg | | 5 | 14 | 139 | 68 | 74 |
| Beryllium | mg/kg | | 2 | <2 | <2 | <2 | <2 |
| Boron | mg/kg | | 2 | 14 | 12 | 61 | 82 |
| Cadmium | mg/kg | | 0.3 | <0.3 | <0.3 | <0.3 | 0.4 |
| Chromium | mg/kg | | 2 | 11 | 23 | 24 | 30 |
| Cobalt | mg/kg | | 1 | 7 | 12 | 11 | 13 |
| Copper | mg/kg | | 2 | 7 | 13 | 62 | 77 |
| Iron | mg/kg | | 50 | 21000 | 17600 | 21400 | 24600 |
| Lead | mg/kg | | 0.5 | 7.8 | 12.6 | 38.1 | 48.3 |
| Lithium | mg/kg | | 5 | 10 | 19 | 19 | 22 |
| Manganese | mg/kg | | 2 | 320 | 350 | 242 | 300 |
| Molybdenum | mg/kg | | 2 | <2 | <2 | 5 | 7 |
| Nickel | mg/kg | | 2 | 10 | 19 | 22 | 24 |
| Selenium | mg/kg | | 1 | <1 | <1 | <1 | <1 |
| Silver | mg/kg | | 0.5 | <0.5 | <0.5 | <0.5 | 0.7 |
| Strontium | mg/kg | | 5 | 55 | 187 | 71 | 76 |
| Thallium | mg/kg | | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | mg/kg | | 2 | 3 | 4 | 11 | 7 |
| Uranium | mg/kg | | 0.1 | 0.2 | 0.2 | 1.6 | 1.9 |
| Vanadium | mg/kg | | 2 | 34 | 41 | 56 | 76 |
| Zinc | mg/kg | | 5 | 45 | 51 | 179 | 190 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9791888-9791900 Results are based on the dry weight of the sample.

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

AGAT Laboratories
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# Certificate of Analysis

AGAT WORK ORDER: 18K421242
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
SAMPLING SITE:
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Grain Size Analysis (Sieve & Pipette)

DATE RECEIVED: 2018-12-17
DATE REPORTED: 2019-01-09

| Parameter | Unit | G / S | RDL | 18-MNMA-STEP1 | 18-MNMA-STEP2 | 18-MNMA-STEP3 | 18-MNMA-DUP3 |
|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Soil | Soil | Soil | Soil |
| DATE SAMPLED: | | | | 2018-12-13 | 2018-12-13 | 2018-12-13 | 2018-12-13 |
| | | | | 9791888 | 9791898 | 9791899 | 9791900 |
| Particle Size Distribution (<12.5mm, -4 PHI) | % | | 0.1 | 100 | 100 | 86.7 | 100 |
| Particle Size Distribution (<9.5mm, -3 PHI) | % | | 0.1 | 100 | 100 | 81.4 | 100 |
| Particle Size Distribution (<4.75mm, -2 PHI | % | | 0.1 | 78.4 | 70.9 | 63.9 | 84.5 |
| Particle Size Distribution (<2mm, -1 PHI) | % | | 0.1 | 18.5 | 31.9 | 34.9 | 51.1 |
| Particle Size Distribution (<1mm, 0 PHI) | % | | 0.1 | 10.0 | 17.6 | 26.5 | 39.0 |
| Particle Size Distribution (<1/2mm, 1 PHI) | % | | 0.1 | 9.0 | 9.8 | 23.7 | 34.4 |
| Particle Size Distribution (<1/4mm, 2 PHI) | % | | 0.1 | 8.7 | 8.0 | 21.1 | 29.8 |
| Particle Size Distribution (<1/8mm, 3 PHI) | % | | 0.1 | 8.5 | 7.9 | 17.7 | 25.2 |
| Particle Size Distribution (<1/16mm, 4 PHI) | % | | 0.1 | 8.3 | 7.8 | 14.3 | 20.2 |
| Particle Size Distribution (<1/32mm, 5 PHI) | % | | 0.1 | 8.3 | 7.7 | 13.6 | 19.1 |
| Particle Size Distribution (<1/64mm, 6 PHI) | % | | 0.1 | 8.3 | 7.7 | 12.9 | 17.8 |
| Particle Size Distribution (<1/128mm, 7 PHI) | % | | 0.1 | 8.3 | 7.7 | 12.1 | 16.3 |
| Particle Size Distribution (<1/256mm, 8 PHI) | % | | 0.1 | 8.1 | 7.6 | 11.3 | 15.1 |
| Particle Size Distribution (<1/512mm, 9 PHI) | % | | 0.1 | 7.9 | 7.6 | 11.1 | 14.4 |
| Particle Size Distribution (Gravel) | % | | 1 | 82 | 68 | 65 | 49 |
| Particle Size Distribution (Sand) | % | | 1 | 10 | 24 | 21 | 31 |
| Particle Size Distribution (Silt) | % | | 1 | <2 | <1 | 3 | 5 |
| Particle Size Distribution (Clay) | % | | 1 | 8 | 8 | 11 | 15 |
| Particles >75um | % | | 1 | 92 | 92 | 85 | 79 |

Certified By:

AGAT Laboratories

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# Certificate of Analysis

AGAT WORK ORDER: 18K421242
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Grain Size Analysis (Sieve & Pipette)

DATE RECEIVED: 2018-12-17
DATE REPORTED: 2019-01-09

| | | | SAMPLE DESCRIPTION: | 18-MNMA-STEP1 | 18-MNMA-STEP2 | 18-MNMA-STEP3 | 18-MNMA-DUP3 |
|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-12-13 | 2018-12-13 | 2018-12-13 | 2018-12-13 |
| Parameter | Unit | G / S | RDL | 9791888 | 9791898 | 9791899 | 9791900 |
| Classification | Coarse/Fine | | | Coarse | Coarse | Coarse | Coarse |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

AGAT Laboratories

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# Certificate of Analysis

AGAT WORK ORDER: 18K421242
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Mercury Analysis in Soil

DATE RECEIVED: 2018-12-17
DATE REPORTED: 2019-01-09

| | | | SAMPLE DESCRIPTION: | 18-MNMA-STEP1 | 18-MNMA-STEP2 | 18-MNMA-STEP3 | 18-MNMA-DUP3 |
|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-12-13 | 2018-12-13 | 2018-12-13 | 2018-12-13 |
| Parameter | Unit | G / S | RDL | 9791888 | 9791898 | 9791899 | 9791900 |
| Mercury | mg/kg | | 0.05 | <0.05 | <0.05 | 0.09 | 0.22 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9791888-9791900 Results are based on the dry weight of the soil.
Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

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# Certificate of Analysis

AGAT WORK ORDER: 18K421242
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved + 1X Silica Gel

DATE RECEIVED: 2018-12-17
DATE REPORTED: 2019-01-09

| | | | SAMPLE DESCRIPTION: | 18-MNMA-STEP1 | 18-MNMA-STEP2 | 18-MNMA-STEP3 | 18-MNMA-DUP3 |
|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-12-13 | 2018-12-13 | 2018-12-13 | 2018-12-13 |
| Parameter | Unit | G / S | RDL | 9791888 | 9791898 | 9791899 | 9791900 |
| Benzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Toluene | mg/kg | | 0.04 | <0.04 | <0.04 | <0.04 | <0.04 |
| Ethylbenzene | mg/kg | | 0.03 | <0.03 | <0.03 | <0.03 | <0.03 |
| Xylene (Total) | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| C6-C10 (less BTEX) | mg/kg | | 3 | <3 | <3 | <3 | <3 |
| >C10-C16 Hydrocarbons - 1X silica gel | mg/kg | | 15 | <15 | <15 | <15 | <15 |
| >C16-C21 Hydrocarbons - 1X silica gel | mg/kg | | 15 | <15 | <15 | <15 | 40 |
| >C21-C32 Hydrocarbons - 1X silica gel | mg/kg | | 15 | <15 | <15 | 25 | 33 |
| Modified TPH (Tier 1) - 1X silica gel | mg/kg | | 20 | <20 | <20 | 25 | 73 |
| Resemblance Comment | | | | NR | NR | LR | FR, LR |
| Return to Baseline at C32 | | | | Y | Y | Y | Y |
| Silica Gel Cleanup | | | | Y | Y | Y | Y |
| Surrogate | Unit | Acceptable Limits | | | | | |
| Isobutylbenzene - EPH | % | 60-140 | | 72 | 80 | 90 | 106 |
| Isobutylbenzene - VPH | % | 60-140 | | 84 | 89 | 84 | 85 |
| n-Dotriacontane - EPH | % | 60-140 | | 77 | 86 | 96 | 112 |

Certified By:

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CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved + 1X Silica Gel

DATE RECEIVED: 2018-12-17
DATE REPORTED: 2019-01-09

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9791888-9791900 Results are based on the dry weight of the soil.

Resemblance Comment Key:
GF - Gasoline Fraction
WGF - Weathered Gasoline Fraction
GR - Product in Gasoline Range
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
FR - Product in Fuel Oil Range
LOF - Lube Oil Fraction
LR - Lube Range
UC - Unidentified Compounds
NR - No Resemblance
NA - Not Applicable

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

# Certificate of Analysis

AGAT Laboratories

AGAT WORK ORDER: 18K421242

PROJECT: 11178792-02

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FAX (709 747-2139
http://www.agatlabs.com

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Atlantic RBCA Tier 1 Hydrocarbons in Water (Version 3.0)

DATE RECEIVED: 2018-12-17

DATE REPORTED: 2019-01-09

| | | SAMPLE DESCRIPTION: | | 18-MNMA-W2 | 18-MNMA-W6 | 18-MNMA-W9 | 18-MNMA-W12 | 18-MNMA-W14 | 18-MNMA-W-DUP1 | 18-MNMA-W-REF2 | 18-MNMA-W-REF3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | SAMPLE TYPE: | | Water | Water | Water | Water | Water | Water | Water | Water |
| | | DATE SAMPLED: | | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-14 | 2018-12-14 | 2018-12-13 | 2018-12-13 | 2018-12-13 |
| Parameter | Unit | G / S | RDL | 9791495 | 9791865 | 9791866 | 9791867 | 9791868 | 9791869 | 9791870 | 9791871 |
| Benzene | mg/L | | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Toluene | mg/L | | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Ethylbenzene | mg/L | | 0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| Xylene (Total) | mg/L | | 0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 | <0.002 |
| C6-C10 (less BTEX) | mg/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| >C10-C16 Hydrocarbons | mg/L | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| >C16-C21 Hydrocarbons | mg/L | | 0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 | <0.10 |
| >C21-C32 Hydrocarbons | mg/L | | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Modified TPH (Tier 1) | mg/L | | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Resemblance Comment | | | | NR | NR | NR | NR | NR | NR | NR | NR |
| Return to Baseline at C32 | | | | Y | Y | Y | Y | Y | Y | Y | Y |
| Surrogate | Unit | Acceptable Limits | | | | | | | | | |
| Isobutylbenzene - EPH | % | 70-130 | | 89 | 115 | 80 | 98 | 86 | 99 | 110 | 87 |
| Isobutylbenzene - VPH | % | 70-130 | | 87 | 81 | 88 | 85 | 90 | 90 | 87 | 87 |
| n-Dotriacontane - EPH | % | 70-130 | | 89 | 108 | 73 | 96 | 80 | 92 | 105 | 81 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9791495-9791871 Resemblance Comment Key:
GF - Gasoline Fraction
WGF - Weathered Gasoline Fraction
GR - Product in Gasoline Range
FOF - Fuel Oil Fraction
WFOF - Weathered Fuel Oil Fraction
FR - Product in Fuel Oil Range
LOF - Lube Oil Fraction
LR - Lube Range
UC - Unidentified Compounds
NR - No Resemblance
NA - Not Applicable

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

AGAT Laboratories

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# Certificate of Analysis

AGAT WORK ORDER: 18K421242

PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Moisture

DATE RECEIVED: 2018-12-17

DATE REPORTED: 2019-01-09

| | | | SAMPLE DESCRIPTION: | 18-MNMA-STEP1 | 18-MNMA-STEP2 | 18-MNMA-STEP3 | 18-MNMA-DUP3 |
|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-12-13 | 2018-12-13 | 2018-12-13 | 2018-12-13 |
| Parameter | Unit | G / S | RDL | 9791888 | 9791898 | 9791899 | 9791900 |
| % Moisture | % | | 0 | 20 | 10 | 39 | 37 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

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# Certificate of Analysis

AGAT WORK ORDER: 18K421242
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Polycyclic Aromatic Hydrocarbons in Soil

DATE RECEIVED: 2018-12-17
DATE REPORTED: 2019-01-09

| Parameter | Unit | G / S | RDL | 18-MNMA-STEP1 | 18-MNMA-STEP2 | 18-MNMA-STEP3 | 18-MNMA-DUP3 |
|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Soil | Soil | Soil | Soil |
| DATE SAMPLED: | | | | 2018-12-13 | 2018-12-13 | 2018-12-13 | 2018-12-13 |
| | | | | 9791888 | 9791898 | 9791899 | 9791900 |
| 1-Methylnaphthalene | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| 2-Methylnaphthalene | mg/kg | | 0.01 | <0.01 | <0.01 | 0.01 | 0.01 |
| Acenaphthene | mg/kg | | 0.00671 | <0.00671 | <0.00671 | 0.0176 | 0.0469 |
| Acenaphthylene | mg/kg | | 0.004 | <0.004 | <0.004 | 0.025 | 0.024 |
| Acridine | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| Anthracene | mg/kg | | 0.03 | <0.03 | <0.03 | 0.05 | 0.13 |
| Benzo(a)anthracene | mg/kg | | 0.01 | <0.01 | <0.01 | 0.13 | 0.33 |
| Benzo(a)pyrene | mg/kg | | 0.01 | <0.01 | <0.01 | 0.13 | 0.31 |
| Benzo(b)fluoranthene | mg/kg | | 0.05 | <0.05 | <0.05 | 0.14 | 0.36 |
| Benzo(b+j)fluoranthene | mg/kg | | 0.1 | <0.1 | <0.1 | 0.20 | 0.56 |
| Benzo(e)pyrene | mg/kg | | 0.05 | <0.05 | <0.05 | 0.11 | 0.26 |
| Benzo(ghi)perylene | mg/kg | | 0.01 | <0.01 | <0.01 | 0.08 | 0.20 |
| Benzo(k)fluoranthene | mg/kg | | 0.01 | <0.01 | <0.01 | 0.09 | 0.24 |
| Chrysene | mg/kg | | 0.01 | <0.01 | <0.01 | 0.14 | 0.38 |
| Dibenzo(a,h)anthracene | mg/kg | | 0.006 | <0.006 | <0.006 | <0.006 | <0.006 |
| Fluoranthene | mg/kg | | 0.05 | <0.05 | <0.05 | 0.31 | 0.84 |
| Fluorene | mg/kg | | 0.01 | <0.01 | <0.01 | 0.03 | 0.01 |
| Indeno(1,2,3)pyrene | mg/kg | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Naphthalene | mg/kg | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Perylene | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | 0.09 |
| Phenanthrene | mg/kg | | 0.03 | <0.03 | <0.03 | 0.21 | 0.57 |
| Pyrene | mg/kg | | 0.05 | <0.05 | <0.05 | 0.28 | 0.61 |
| Quinoline | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 |
| **Surrogate** | **Unit** | **Acceptable Limits** | | | | | |
| Nitrobenzene-d5 | % | 50-140 | | 125 | 108 | 110 | 111 |
| 2-Fluorobiphenyl | % | 50-140 | | 108 | 101 | 106 | 99 |
| Terphenyl-d14 | % | 50-140 | | 94 | 91 | 94 | 71 |

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# Certificate of Analysis

AGAT WORK ORDER: 18K421242
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
SAMPLING SITE:

ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Polycyclic Aromatic Hydrocarbons in Soil

DATE RECEIVED: 2018-12-17

DATE REPORTED: 2019-01-09

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9791888-9791900 Results are based on the dry weight of the soil.

Benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene, if also present in the sample.

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

# Certificate of Analysis

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PROJECT: 11178792-02

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CLIENT NAME: GHD LIMITED
SAMPLING SITE:
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Polycyclic Aromatic Hydrocarbons in Water - (PAH)

DATE RECEIVED: 2018-12-17
DATE REPORTED: 2019-01-09

| Parameter | Unit | G / S | RDL | 18-MNMA-W2 | 18-MNMA-W6 | 18-MNMA-W9 | 18-MNMA-W12 | 18-MNMA-W14 | 18-MNMA-W-DUP1 | 18-MNMA-W-REF2 | 18-MNMA-W-REF3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Water | Water | Water | Water | Water | Water | Water | Water |
| | | | DATE SAMPLED: | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-14 | 2018-12-14 | 2018-12-13 | 2018-12-13 | 2018-12-13 |
| | | | | 9791495 | 9791865 | 9791866 | 9791867 | 9791868 | 9791869 | 9791870 | 9791871 |
| 1-Methylnaphthalene | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| 2-Methylnaphthalene | ug/L | | 0.01 | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Acenaphthene | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Acenaphthylene | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Acridine | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Anthracene | ug/L | | 0.012 | <0.012 | <0.012 | <0.012 | <0.012 | <0.012 | <0.012 | <0.012 | <0.012 |
| Benzo(a)anthracene | ug/L | | 0.018 | <0.018 | <0.018 | <0.018 | <0.018 | <0.018 | <0.018 | <0.018 | <0.018 |
| Benzo(a)pyrene | ug/L | | 0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 | <0.010 |
| Benzo(b)fluoranthene | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Benzo(e)pyrene | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Benzo(ghi)perylene | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Benzo(k)fluoranthene | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Chrysene | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Dibenzo(a,h)anthracene | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Fluoranthene | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Fluorene | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Indeno(1,2,3-cd)pyrene | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Naphthalene | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Perylene | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Phenanthrene | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Pyrene | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| Quinoline | ug/L | | 0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| **Surrogate** | **Unit** | **Acceptable Limits** | | | | | | | | | |
| Nitrobenzene-d5 | % | 50-140 | | 82 | 64 | 76 | 80 | 105 | 77 | 76 | 73 |
| 2-Fluorobiphenyl | % | 50-140 | | 89 | 66 | 79 | 85 | 106 | 81 | 75 | 80 |
| Terphenyl-d14 | % | 50-140 | | 78 | 51 | 62 | 76 | 87 | 60 | 55 | 53 |

Certified By:

# Certificate of Analysis

AGAT WORK ORDER: 18K421242
PROJECT: 11178792-02

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CLIENT NAME: GHD LIMITED | ATTENTION TO: JAMES O'NEILL
SAMPLING SITE: | SAMPLED BY:

## Polycyclic Aromatic Hydrocarbons in Water - (PAH)

DATE RECEIVED: 2018-12-17 | DATE REPORTED: 2019-01-09

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9791495-9791871 Benzo(b)fluoranthene may include contributions from benzo(j)fluoranthene, if also present in the sample.

Analysis performed at AGAT Halifax (unless marked by *)

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SAMPLING SITE:

ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Total Polychlorinated Biphenyls in Soil - (PCB)

DATE RECEIVED: 2018-12-17

DATE REPORTED: 2019-01-09

| Parameter | Unit | G / S | RDL | 18-MNMA-STEP1 | 18-MNMA-STEP2 | 18-MNMA-STEP3 | 18-MNMA-DUP3 |
|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Soil | Soil | Soil | Soil |
| DATE SAMPLED: | | | | 2018-12-13 | 2018-12-13 | 2018-12-13 | 2018-12-13 |
| | | | | 9791888 | 9791898 | 9791899 | 9791900 |
| Total Polychlorinated Biphenyls | mg/kg | | 0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| **Surrogate** | **Unit** | **Acceptable Limits** | | | | | |
| Decachlorobiphenyl | % | 50-130 | | 127 | 119 | 130 | 127 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9791888-9791900 Results are based on the dry weight of the soil.
Analysis performed at AGAT Halifax (unless marked by *)

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AGAT WORK ORDER: 18K421242
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Mercury Analysis in Water (Total)

DATE RECEIVED: 2018-12-17
DATE REPORTED: 2019-01-09

| | | | SAMPLE DESCRIPTION: | 18-MNMA-W2 | 18-MNMA-W6 | 18-MNMA-W9 | 18-MNMA-W12 | 18-MNMA-W14 | 18-MNMA-W-DUP1 | 18-MNMA-W-REF2 | 18-MNMA-W-REF3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Water | Water | Water | Water | Water | Water | Water | Water |
| | | | DATE SAMPLED: | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-14 | 2018-12-14 | 2018-12-13 | 2018-12-13 | 2018-12-13 |
| Parameter | Unit | G / S | RDL | 9791495 | 9791865 | 9791866 | 9791867 | 9791868 | 9791869 | 9791870 | 9791871 |
| Total Mercury | ug/L | | 0.026 | <0.026 | <0.026 | <0.026 | <0.026 | <0.026 | <0.026 | <0.026 | <0.026 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

# Certificate of Analysis

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AGAT WORK ORDER: 18K421242
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
SAMPLING SITE:

ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Standard Water Analysis + Total Metals

DATE RECEIVED: 2018-12-17

DATE REPORTED: 2019-01-09

| Parameter | Unit | G / S | RDL | 18-MNMA-W2 | 18-MNMA-W6 | 18-MNMA-W9 | 18-MNMA-W12 | 18-MNMA-W14 | 18-MNMA-W-DUP1 | 18-MNMA-W-REF2 | 18-MNMA-W-REF3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Water | Water | Water | Water | Water | Water | Water | Water |
| DATE SAMPLED: | | | | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-14 | 2018-12-14 | 2018-12-13 | 2018-12-13 | 2018-12-13 |
| | | | | 9791495 | 9791865 | 9791866 | 9791867 | 9791868 | 9791869 | 9791870 | 9791871 |
| pH | | | | 7.79 | 7.87 | 7.89 | 7.90 | 7.91 | 7.93 | 7.92 | 7.96 |
| Reactive Silica as SiO2 | mg/L | | 0.5 | 1.1 | 0.5 | 0.8 | 0.8 | 0.7 | 0.6 | 0.6 | <0.5 |
| Chloride | mg/L | | 200 | 9390 | 11200 | 9540 | 9520 | 9940 | 11600 | 11400 | 12900 |
| Fluoride | mg/L | | 24 | <24 | <24 | <24 | <24 | <24 | <24 | <24 | <24 |
| Sulphate | mg/L | | 400 | 1230 | 1460 | 1250 | 1240 | 1290 | 1500 | 1480 | 1690 |
| Alkalinity | mg/L | | 5 | 77 | 89 | 75 | 79 | 79 | 91 | 88 | 103 |
| True Color | TCU | | 5 | 22 | 13 | 22 | 8 | 10 | 12 | 10 | <5 |
| Turbidity | NTU | | 0.1 | 0.8 | 0.7 | 1.3 | 0.6 | 0.9 | 1.5 | 0.8 | 1.4 |
| Electrical Conductivity | umho/cm | | 1 | 34100 | 38800 | 32700 | 33700 | 33900 | 38300 | 37900 | 43500 |
| Nitrate + Nitrite as N | mg/L | | 10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| Nitrate as N | mg/L | | 10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| Nitrite as N | mg/L | | 10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| Ammonia as N | mg/L | | 0.03 | 0.31 | 0.11 | 0.10 | 0.11 | 0.13 | 0.09 | 0.09 | 0.10 |
| Total Organic Carbon | mg/L | | 0.5 | 3.2 | 2.2 | 3.0 | 2.8 | 2.9 | 2.2 | 2.2 | 1.4 |
| Ortho-Phosphate as P | mg/L | | 0.01 | 0.06 | 0.06 | 0.05 | 0.06 | 0.05 | 0.06 | 0.05 | 0.07 |
| Total Sodium | mg/L | | 0.1 | 6820 | 7930 | 6530 | 6900 | 6570 | 7630 | 7140 | 8350 |
| Total Potassium | mg/L | | 0.1 | 257 | 295 | 247 | 259 | 245 | 282 | 267 | 324 |
| Total Calcium | mg/L | | 0.1 | 247 | 303 | 228 | 243 | 244 | 275 | 274 | 330 |
| Total Magnesium | mg/L | | 0.1 | 789 | 955 | 800 | 806 | 773 | 897 | 855 | 1040 |
| Bicarb. Alkalinity (as CaCO3) | mg/L | | 5 | 77 | 89 | 75 | 79 | 79 | 91 | 88 | 103 |
| Carb. Alkalinity (as CaCO3) | mg/L | | 10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 | <10 |
| Hydroxide | mg/L | | 5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
| Calculated TDS | mg/L | | 1 | 18800 | 22200 | 18600 | 19000 | 19100 | 22200 | 21500 | 24700 |
| Hardness | mg/L | | | 3870 | 4690 | 3860 | 3930 | 3790 | 4380 | 4210 | 5110 |
| Langelier Index (@20C) | NA | | | 0.25 | 0.48 | 0.31 | 0.37 | 0.38 | 0.51 | 0.48 | 0.66 |
| Langelier Index (@ 4C) | NA | | | -0.07 | 0.16 | -0.01 | 0.05 | 0.06 | 0.19 | 0.16 | 0.34 |
| Saturation pH (@ 20C) | NA | | | 7.54 | 7.39 | 7.58 | 7.53 | 7.53 | 7.42 | 7.44 | 7.30 |
| Saturation pH (@ 4C) | NA | | | 7.86 | 7.71 | 7.90 | 7.85 | 7.85 | 7.74 | 7.76 | 7.62 |
| Anion Sum | me/L | | | 292 | 348 | 297 | 296 | 309 | 360 | 354 | 401 |

Certified By:

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# Certificate of Analysis

AGAT WORK ORDER: 18K421242
PROJECT: 11178792-02

CLIENT NAME: GHD LIMITED
SAMPLING SITE:

ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Standard Water Analysis + Total Metals

DATE RECEIVED: 2018-12-17

DATE REPORTED: 2019-01-09

| Parameter | Unit | G / S | RDL | 18-MNMA-W2 | 18-MNMA-W6 | 18-MNMA-W9 | 18-MNMA-W12 | 18-MNMA-W14 | 18-MNMA-W-DUP1 | 18-MNMA-W-REF2 | 18-MNMA-W-REF3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Water | Water | Water | Water | Water | Water | Water | Water |
| DATE SAMPLED: | | | | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-14 | 2018-12-14 | 2018-12-13 | 2018-12-13 | 2018-12-13 |
| | | | | 9791495 | 9791865 | 9791866 | 9791867 | 9791868 | 9791869 | 9791870 | 9791871 |
| Cation sum | me/L | | | 380 | 446 | 367 | 385 | 367 | 426 | 401 | 473 |
| % Difference/ Ion Balance | % | | | 13.1 | 12.3 | 10.6 | 13.1 | 8.7 | 8.4 | 6.2 | 8.2 |
| Total Aluminum | ug/L | | 5 | 23 | 21 | 30 | 31 | 27 | 22 | 21 | 12 |
| Total Antimony | ug/L | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Total Arsenic | ug/L | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Total Barium | ug/L | | 5 | 9 | 8 | 9 | 9 | 8 | 8 | 7 | 7 |
| Total Beryllium | ug/L | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Total Bismuth | ug/L | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Total Boron | ug/L | | 5 | 3020 | 3570 | 2970 | 3050 | 3210 | 3470 | 3410 | 3950 |
| Total Cadmium | ug/L | | 0.09 | <0.09 | <0.09 | <0.09 | <0.09 | <0.09 | <0.09 | <0.09 | <0.09 |
| Total Chromium | ug/L | | 1 | 6 | 8 | 8 | 9 | 8 | 8 | 8 | 8 |
| Total Cobalt | ug/L | | 1 | 3 | 3 | 3 | 3 | 3 | 3 | 3 | 3 |
| Total Copper | ug/L | | 1 | 6 | 8 | 8 | 8 | 11 | 11 | 11 | 13 |
| Total Iron | ug/L | | 50 | 179 | 180 | 200 | 202 | 210 | 174 | 177 | 157 |
| Total Lead | ug/L | | 0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Total Manganese | ug/L | | 2 | 13 | 9 | 15 | 14 | 13 | 9 | 9 | 5 |
| Total Molybdenum | ug/L | | 2 | 7 | 8 | 6 | 7 | 7 | 8 | 7 | 9 |
| Total Nickel | ug/L | | 2 | 17 | 18 | 15 | 16 | 16 | 19 | 20 | 24 |
| Total Phosphorous | mg/L | | 0.02 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 | 0.03 |
| Total Selenium | ug/L | | 1 | <1 | 1 | <1 | <1 | 2 | 1 | <1 | <1 |
| Total Silver | ug/L | | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Total Strontium | ug/L | | 5 | 4210 | 5080 | 4200 | 4410 | 4270 | 5040 | 4620 | 5690 |
| Total Thallium | ug/L | | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Total Tin | ug/L | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Total Titanium | ug/L | | 2 | 4 | 5 | 4 | 6 | 6 | 10 | 14 | 25 |
| Total Uranium | ug/L | | 0.1 | 1.8 | 2.0 | 1.7 | 1.9 | 1.8 | 2.1 | 2.0 | 2.4 |
| Total Vanadium | ug/L | | 2 | 1140 | 1180 | 1120 | 1120 | 1060 | 1040 | 944 | 930 |
| Total Zinc | ug/L | | 5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 |

Certified By:

# Certificate of Analysis

AGAT WORK ORDER: 18K421242
PROJECT: 11178792-02

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CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Standard Water Analysis + Total Metals

DATE RECEIVED: 2018-12-17
DATE REPORTED: 2019-01-09

| | |
|---|---|
| Comments: | RDL - Reported Detection Limit; G / S - Guideline / Standard |
| 9791495-9791865 | RDL's for Fluoride, Chloride, Nitrate, Nitrite and Sulphate are raised due to sample matrix. Ion Balance is biased high, contributing parameters have been confirmed. |
| 9791866 | RDL's for Fluoride, Chloride, Nitrate, Nitrite and Sulphate are raised due to sample matrix. |
| 9791867 | RDL's for Fluoride, Chloride, Nitrate, Nitrite and Sulphate are raised due to sample matrix. Ion Balance is biased high, contributing parameters have been confirmed. |
| 9791868-9791871 | RDL's for Fluoride, Chloride, Nitrate, Nitrite and Sulphate are raised due to sample matrix. |

Analysis performed at AGAT Halifax (unless marked by *)

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K421242
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Soil Analysis

| RPT Date: Jan 09, 2019 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Available Metals in Soil | | | | | | | | | | | | | | | |
| Aluminum | 9791954 | | 3980 | 3700 | 7.4% | < 10 | 90% | 80% | 120% | 104% | 80% | 120% | 130% | 70% | 130% |
| Antimony | 9791954 | | <1 | <1 | NA | < 1 | 80% | 80% | 120% | 110% | 80% | 120% | 76% | 70% | 130% |
| Arsenic | 9791954 | | 3 | 4 | NA | < 1 | 88% | 80% | 120% | 101% | 80% | 120% | 105% | 70% | 130% |
| Barium | 9791954 | | 17 | 20 | NA | < 5 | 101% | 80% | 120% | 101% | 80% | 120% | 130% | 70% | 130% |
| Beryllium | 9791954 | | <2 | <2 | NA | < 2 | 105% | 80% | 120% | 107% | 80% | 120% | 110% | 70% | 130% |
| Boron | 9791954 | | <2 | 2 | NA | < 2 | 96% | 80% | 120% | 108% | 80% | 120% | 112% | 70% | 130% |
| Cadmium | 9791954 | | <0.3 | <0.3 | NA | < 0.3 | 86% | 80% | 120% | 98% | 80% | 120% | 101% | 70% | 130% |
| Chromium | 9791954 | | 5 | 6 | NA | < 2 | 81% | 80% | 120% | 98% | 80% | 120% | 119% | 70% | 130% |
| Cobalt | 9791954 | | 2 | 3 | NA | < 1 | 87% | 80% | 120% | 99% | 80% | 120% | 112% | 70% | 130% |
| Copper | 9791954 | | 4 | 5 | NA | < 2 | 89% | 80% | 120% | 99% | 80% | 120% | 110% | 70% | 130% |
| Iron | 9791954 | | 5500 | 5710 | 3.7% | < 50 | 82% | 80% | 120% | 95% | 80% | 120% | 110% | 70% | 130% |
| Lead | 9791954 | | 2.2 | 2.6 | NA | < 0.5 | 90% | 80% | 120% | 102% | 80% | 120% | 108% | 70% | 130% |
| Lithium | 9791954 | | 8 | 9 | NA | < 5 | 94% | 70% | 130% | 109% | 70% | 130% | 115% | 70% | 130% |
| Manganese | 9791954 | | 185 | 218 | 16.4% | < 2 | 87% | 80% | 120% | 99% | 80% | 120% | 130% | 70% | 130% |
| Molybdenum | 9791954 | | <2 | <2 | NA | < 2 | 89% | 80% | 120% | 101% | 80% | 120% | 105% | 70% | 130% |
| Nickel | 9791954 | | 5 | 6 | NA | < 2 | 87% | 80% | 120% | 101% | 80% | 120% | 112% | 70% | 130% |
| Selenium | 9791954 | | <1 | <1 | NA | < 1 | 87% | 80% | 120% | 101% | 80% | 120% | 91% | 70% | 130% |
| Silver | 9791954 | | <0.5 | <0.5 | NA | < 0.5 | 91% | 80% | 120% | 104% | 80% | 120% | 107% | 70% | 130% |
| Strontium | 9791954 | | <5 | <5 | NA | < 5 | 86% | 80% | 120% | 96% | 80% | 120% | 107% | 70% | 130% |
| Thallium | 9791954 | | <0.1 | <0.1 | NA | < 0.1 | 89% | 80% | 120% | 102% | 80% | 120% | NA | 70% | 130% |
| Tin | 9791954 | | 3 | 3 | NA | < 2 | 90% | 80% | 120% | 101% | 80% | 120% | 101% | 70% | 130% |
| Uranium | 9791954 | | 0.3 | 0.4 | NA | < 0.1 | 85% | 80% | 120% | 101% | 80% | 120% | 99% | 70% | 130% |
| Vanadium | 9791954 | | 9 | 12 | 24.7% | < 2 | 89% | 80% | 120% | 100% | 80% | 120% | 116% | 70% | 130% |
| Zinc | 9791954 | | 11 | 13 | NA | < 5 | 87% | 80% | 120% | 96% | 80% | 120% | 103% | 70% | 130% |
| Mercury Analysis in Soil | | | | | | | | | | | | | | | |
| Mercury | 1 | 9791900 | 0.22 | 0.23 | NA | < 0.05 | 79% | 70% | 130% | | 70% | 130% | 86% | 70% | 130% |

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AGAT Laboratories

# Quality Assurance

CLIENT NAME: GHD LIMITED | AGAT WORK ORDER: 18K421242
PROJECT: 11178792-02 | ATTENTION TO: JAMES O'NEILL
SAMPLING SITE: | SAMPLED BY:

## Trace Organics Analysis

| RPT Date: Jan 09, 2019 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| **Atlantic RBCA Tier 1 Hydrocarbons in Water (Version 3.0)** | | | | | | | | | | | | | | | |
| Benzene | 1 | 9791495 | < 0.001 | < 0.001 | NA | < 0.001 | 105% | 70% | 130% | 103% | 70% | 130% | | | |
| Toluene | 1 | 9791495 | < 0.001 | < 0.001 | NA | < 0.001 | 106% | 70% | 130% | 92% | 70% | 130% | | | |
| Ethylbenzene | 1 | 9791495 | < 0.001 | < 0.001 | NA | < 0.001 | 105% | 70% | 130% | 86% | 70% | 130% | | | |
| Xylene (Total) | 1 | 9791495 | < 0.002 | < 0.002 | NA | < 0.002 | 103% | 70% | 130% | 86% | 70% | 130% | | | |
| C6-C10 (less BTEX) | 1 | 9791495 | < 0.01 | < 0.01 | NA | < 0.01 | 111% | 70% | 130% | 113% | 70% | 130% | 108% | 70% | 130% |
| >C10-C16 Hydrocarbons | 1 | 9791871 | < 0.05 | < 0.05 | NA | < 0.05 | 101% | 70% | 130% | 94% | 70% | 130% | 90% | 70% | 130% |
| >C16-C21 Hydrocarbons | 1 | 9791871 | < 0.10 | < 0.10 | NA | < 0.10 | 100% | 70% | 130% | 94% | 70% | 130% | 90% | 70% | 130% |
| >C21-C32 Hydrocarbons | 1 | 9791871 | < 0.1 | < 0.1 | NA | < 0.1 | 78% | 70% | 130% | 94% | 70% | 130% | 90% | 70% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Lower | Upper | Recovery | Lower | Upper | Recovery | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Atlantic RBCA Tier 1 Hydrocarbons in Water (Version 3.0)** | | | | | | | | | | | | | | | |
| >C10-C16 Hydrocarbons | 1 | 9791871 | < 0.05 | < 0.05 | NA | < 0.05 | 101% | 70% | 130% | 94% | 70% | 130% | 90% | 70% | 130% |
| >C16-C21 Hydrocarbons | 1 | 9791871 | < 0.10 | < 0.10 | NA | < 0.10 | 100% | 70% | 130% | 94% | 70% | 130% | 90% | 70% | 130% |
| >C21-C32 Hydrocarbons | 1 | 9791871 | < 0.1 | < 0.1 | NA | < 0.1 | 78% | 70% | 130% | 94% | 70% | 130% | 90% | 70% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Lower | Upper | Recovery | Lower | Upper | Recovery | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Atlantic RBCA Tier 1 Hydrocarbons in Soil (Version 3.1) - Field Preserved + 1X Silica Gel** | | | | | | | | | | | | | | | |
| Benzene | 1 | 9791947 | < 0.03 | < 0.03 | NA | < 0.03 | 85% | 60% | 140% | 117% | 60% | 140% | | | |
| Toluene | 1 | 9791947 | < 0.04 | < 0.04 | NA | < 0.04 | 101% | 60% | 140% | 102% | 60% | 140% | | | |
| Ethylbenzene | 1 | 9791947 | < 0.03 | < 0.03 | NA | < 0.03 | 110% | 60% | 140% | 103% | 60% | 140% | | | |
| Xylene (Total) | 1 | 9791947 | < 0.05 | < 0.05 | NA | < 0.05 | 118% | 60% | 140% | 108% | 60% | 140% | | | |
| C6-C10 (less BTEX) | 1 | 9791947 | < 3 | < 3 | NA | < 3 | 114% | 60% | 140% | 115% | 60% | 140% | 116% | 30% | 130% |
| >C10-C16 Hydrocarbons - 1X silica gel | 1 | 9784540 | < 15 | < 15 | NA | < 15 | 96% | 60% | 140% | 81% | 60% | 140% | 111% | 30% | 130% |
| >C16-C21 Hydrocarbons - 1X silica gel | 1 | 9784540 | < 15 | < 15 | NA | < 15 | 96% | 60% | 140% | 81% | 60% | 140% | 111% | 30% | 130% |
| >C21-C32 Hydrocarbons - 1X silica gel | 1 | 9784540 | 64 | 69 | NA | < 15 | 75% | 60% | 140% | 81% | 60% | 140% | 111% | 30% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Lower | Upper | Recovery | Lower | Upper | Recovery | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Total Polychlorinated Biphenyls in Soil - (PCB)** | | | | | | | | | | | | | | | |
| Total Polychlorinated Biphenyls | 1 | 9784768 | < 0.02 | < 0.02 | NA | < 0.02 | 116% | 60% | 130% | 94% | 60% | 130% | 102% | 60% | 130% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Lower | Upper | Recovery | Lower | Upper | Recovery | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Polycyclic Aromatic Hydrocarbons in Soil** | | | | | | | | | | | | | | | |
| 1-Methylnaphthalene | 1 | 9784768 | < 0.05 | < 0.05 | NA | < 0.05 | 123% | 50% | 140% | 100% | 50% | 140% | NA | 50% | 140% |
| 2-Methylnaphthalene | 1 | 9784768 | 0.03 | 0.03 | NA | < 0.01 | 120% | 50% | 140% | 96% | 50% | 140% | NA | 50% | 140% |
| Acenaphthene | 1 | 9784768 | < 0.00671 | < 0.00671 | NA | < 0.00671 | 137% | 50% | 140% | 102% | 50% | 140% | NA | 50% | 140% |
| Acenaphthylene | 1 | 9784768 | < 0.004 | < 0.004 | NA | < 0.004 | 125% | 50% | 140% | 95% | 50% | 140% | NA | 50% | 140% |

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K421242
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Trace Organics Analysis (Continued)

| RPT Date: Jan 09, 2019 | | | DUPLICATE | | | | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Acceptable Limits | | Recovery | Acceptable Limits | | Recovery | Acceptable Limits | |
| | | | | | | | | Lower | Upper | | Lower | Upper | | Lower | Upper |
| Acridine | 1 | 9784768 | < 0.05 | < 0.05 | NA | < 0.05 | 94% | 50% | 140% | 88% | 50% | 140% | NA | 50% | 140% |
| Anthracene | 1 | 9784768 | < 0.03 | < 0.03 | NA | < 0.03 | 120% | 50% | 140% | 90% | 50% | 140% | NA | 50% | 140% |
| Benzo(a)anthracene | 1 | 9784768 | < 0.01 | < 0.01 | NA | < 0.01 | 117% | 50% | 140% | 93% | 50% | 140% | NA | 50% | 140% |
| Benzo(a)pyrene | 1 | 9784768 | < 0.01 | < 0.01 | NA | < 0.01 | 126% | 50% | 140% | 93% | 50% | 140% | NA | 50% | 140% |
| Benzo(b)fluoranthene | 1 | 9784768 | < 0.05 | < 0.05 | NA | < 0.05 | 137% | 50% | 140% | 96% | 50% | 140% | NA | 50% | 140% |
| Benzo(b+j)fluoranthene | 1 | 9784768 | < 0.1 | < 0.1 | NA | < 0.1 | 138% | 50% | 140% | 102% | 50% | 140% | NA | 50% | 140% |
| Benzo(e)pyrene | 1 | 9784768 | < 0.05 | < 0.05 | NA | < 0.05 | 135% | 50% | 140% | 97% | 50% | 140% | NA | 50% | 140% |
| Benzo(ghi)perylene | 1 | 9784768 | < 0.01 | < 0.01 | NA | < 0.01 | 136% | 50% | 140% | 95% | 50% | 140% | NA | 50% | 140% |
| Benzo(k)fluoranthene | 1 | 9784768 | < 0.01 | < 0.01 | NA | < 0.01 | 131% | 50% | 140% | 87% | 50% | 140% | NA | 50% | 140% |
| Chrysene | 1 | 9784768 | < 0.01 | < 0.01 | NA | < 0.01 | 119% | 50% | 140% | 96% | 50% | 140% | NA | 50% | 140% |
| Dibenzo(a,h)anthracene | 1 | 9784768 | < 0.006 | < 0.006 | NA | < 0.006 | 128% | 50% | 140% | 93% | 50% | 140% | NA | 50% | 140% |
| Fluoranthene | 1 | 9784768 | < 0.05 | < 0.05 | NA | < 0.05 | 116% | 50% | 140% | 95% | 50% | 140% | NA | 50% | 140% |
| Fluorene | 1 | 9784768 | < 0.01 | < 0.01 | NA | < 0.01 | 121% | 50% | 140% | 99% | 50% | 140% | NA | 50% | 140% |
| Indeno(1,2,3)pyrene | 1 | 9784768 | < 0.01 | < 0.01 | NA | < 0.01 | 120% | 50% | 140% | 94% | 50% | 140% | NA | 50% | 140% |
| Naphthalene | 1 | 9784768 | < 0.01 | < 0.01 | NA | < 0.01 | 121% | 50% | 140% | 103% | 50% | 140% | NA | 50% | 140% |
| Perylene | 1 | 9784768 | < 0.05 | < 0.05 | NA | < 0.05 | 121% | 50% | 140% | 99% | 50% | 140% | NA | 50% | 140% |
| Phenanthrene | 1 | 9784768 | < 0.03 | < 0.03 | NA | < 0.03 | 130% | 50% | 140% | 98% | 50% | 140% | NA | 50% | 140% |
| Pyrene | 1 | 9784768 | < 0.05 | < 0.05 | NA | < 0.05 | 112% | 50% | 140% | 94% | 50% | 140% | NA | 50% | 140% |
| Quinoline | 1 | 9784768 | < 0.05 | < 0.05 | NA | < 0.05 | 104% | 50% | 140% | 95% | 50% | 140% | NA | 50% | 140% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

Polycyclic Aromatic Hydrocarbons in Water - (PAH)

| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Lower | Upper | Recovery | Lower | Upper | Recovery | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-Methylnaphthalene | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 129% | 50% | 140% | 78% | 50% | 140% | NA | 50% | 140% |
| 2-Methylnaphthalene | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 128% | 50% | 140% | 78% | 50% | 140% | NA | 50% | 140% |
| Acenaphthene | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 125% | 50% | 140% | 78% | 50% | 140% | NA | 50% | 140% |
| Acenaphthylene | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 121% | 50% | 140% | 77% | 50% | 140% | NA | 50% | 140% |
| Acridine | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 79% | 50% | 140% | 81% | 50% | 140% | NA | 50% | 140% |
| Anthracene | 1 | 9791867 | < 0.012 | < 0.012 | NA | < 0.012 | 113% | 50% | 140% | 74% | 50% | 140% | NA | 50% | 140% |
| Benzo(a)anthracene | 1 | 9791867 | < 0.018 | < 0.018 | NA | < 0.018 | 112% | 50% | 140% | 77% | 50% | 140% | NA | 50% | 140% |
| Benzo(a)pyrene | 1 | 9791867 | < 0.010 | < 0.010 | NA | < 0.010 | 98% | 50% | 140% | 83% | 50% | 140% | NA | 50% | 140% |
| Benzo(b)fluoranthene | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 127% | 50% | 140% | 88% | 50% | 140% | NA | 50% | 140% |
| Benzo(e)pyrene | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 122% | 50% | 140% | 82% | 50% | 140% | NA | 50% | 140% |
| Benzo(ghi)perylene | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 68% | 50% | 140% | 82% | 50% | 140% | NA | 50% | 140% |
| Benzo(k)fluoranthene | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 113% | 50% | 140% | 76% | 50% | 140% | NA | 50% | 140% |
| Chrysene | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 116% | 50% | 140% | 77% | 50% | 140% | NA | 50% | 140% |
| Dibenzo(a,h)anthracene | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 60% | 50% | 140% | 82% | 50% | 140% | NA | 50% | 140% |
| Fluoranthene | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 118% | 50% | 140% | 79% | 50% | 140% | NA | 50% | 140% |
| Fluorene | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 114% | 50% | 140% | 81% | 50% | 140% | NA | 50% | 140% |
| Indeno(1,2,3-cd)pyrene | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 69% | 50% | 140% | 81% | 50% | 140% | NA | 50% | 140% |

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K421242
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Trace Organics Analysis (Continued)

| RPT Date: Jan 09, 2019 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Naphthalene | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 120% | 50% | 140% | 76% | 50% | 140% | NA | 50% | 140% |
| Perylene | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 108% | 50% | 140% | 81% | 50% | 140% | NA | 50% | 140% |
| Phenanthrene | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 127% | 50% | 140% | 77% | 50% | 140% | NA | 50% | 140% |
| Pyrene | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 115% | 50% | 140% | 79% | 50% | 140% | NA | 50% | 140% |
| Quinoline | 1 | 9791867 | < 0.01 | < 0.01 | NA | < 0.01 | 107% | 50% | 140% | 74% | 50% | 140% | NA | 50% | 140% |

Comments: If Matrix spike value is NA, the spiked analyte concentration was lower than that of the matrix contribution.
If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

Certified By:

AGAT Laboratories

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# Quality Assurance

CLIENT NAME: GHD LIMITED | AGAT WORK ORDER: 18K421242
PROJECT: 11178792-02 | ATTENTION TO: JAMES O'NEILL
SAMPLING SITE: | SAMPLED BY:

## Water Analysis

| RPT Date: Jan 09, 2019 | | | DUPLICATE | | | | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Standard Water Analysis + Total Metals | | | | | | | | | | | | | | | |
| pH | 9794608 | | 8.37 | 8.02 | 4.3% | < | 102% | 80% | 120% | NA | 80% | 120% | NA | 80% | 120% |
| Reactive Silica as SiO2 | 1 | 9787172 | 12.7 | 12.7 | 0.0% | < 0.5 | 103% | 80% | 120% | NA | 80% | 120% | 96% | 80% | 120% |
| Chloride | 9794608 | | 17 | 13 | 23.1% | < 1 | 90% | 80% | 120% | NA | 80% | 120% | NA | 80% | 120% |
| Fluoride | 9794608 | | <0.12 | <0.12 | NA | < 0.12 | 114% | 80% | 120% | NA | 80% | 120% | 96% | 80% | 120% |
| Sulphate | 9794608 | | 4 | 4 | NA | < 2 | 106% | 80% | 120% | NA | 80% | 120% | 92% | 80% | 120% |
| Alkalinity | 9794608 | | 26 | 25 | 5.5% | < 5 | 94% | 80% | 120% | NA | 80% | 120% | NA | 80% | 120% |
| True Color | 9788296 | | <5 | 5 | NA | < 5 | 85% | 80% | 120% | NA | | | NA | | |
| Turbidity | 9788296 | | 18.1 | 17.1 | 5.7% | < 0.1 | 99% | 80% | 120% | NA | | | NA | | |
| Electrical Conductivity | 9794608 | | 95 | 90 | 5.1% | < 1 | 101% | 80% | 120% | NA | 80% | 120% | NA | 80% | 120% |
| Nitrate as N | 9794608 | | 0.08 | <0.05 | NA | < 0.05 | 97% | 80% | 120% | NA | 80% | 120% | 111% | 80% | 120% |
| Nitrite as N | 9794608 | | <0.05 | <0.05 | NA | < 0.05 | 102% | 80% | 120% | NA | 80% | 120% | 83% | 80% | 120% |
| Ammonia as N | 1 | | 0.41 | 0.20 | NA | < 0.03 | 95% | 80% | 120% | NA | 80% | 120% | 93% | 80% | 120% |
| Total Organic Carbon | 9792549 | | 2.0 | 2.0 | NA | < 0.5 | 98% | 80% | 120% | NA | 80% | 120% | 90% | 80% | 120% |
| Ortho-Phosphate as P | 1 | 9787172 | 0.02 | 0.01 | NA | < 0.01 | 97% | 80% | 120% | | 80% | 120% | 94% | 80% | 120% |
| Total Sodium | 9793739 | | 179 | 175 | 2.7% | < 0.1 | 104% | 80% | 120% | 108% | 80% | 120% | NA | 70% | 130% |
| Total Potassium | 9793739 | | 0.1 | 0.1 | NA | < 0.1 | 107% | 80% | 120% | 111% | 80% | 120% | 92% | 70% | 130% |
| Total Calcium | 9793739 | | 0.3 | 0.4 | NA | < 0.1 | 109% | 80% | 120% | 109% | 80% | 120% | 101% | 70% | 130% |
| Total Magnesium | 9793739 | | 0.9 | 0.9 | 1.6% | < 0.1 | 102% | 80% | 120% | 105% | 80% | 120% | 102% | 80% | 120% |
| Bicarb. Alkalinity (as CaCO3) | 9794608 | | 26 | 25 | 4.3% | < 5 | NA | 80% | 120% | NA | 80% | 120% | NA | 80% | 120% |
| Carb. Alkalinity (as CaCO3) | 9794608 | | <10 | <10 | NA | < 10 | NA | 80% | 120% | NA | 80% | 120% | NA | 80% | 120% |
| Hydroxide | 9794608 | | <5 | <5 | NA | < 5 | NA | 80% | 120% | NA | 80% | 120% | NA | 80% | 120% |
| Total Aluminum | 9793739 | | 8 | 8 | NA | < 5 | 101% | 80% | 120% | 104% | 80% | 120% | 85% | 70% | 130% |
| Total Antimony | 9793739 | | <2 | <2 | NA | < 2 | 104% | 80% | 120% | 120% | 80% | 120% | 111% | 70% | 130% |
| Total Arsenic | 9793739 | | <2 | <2 | NA | < 2 | 96% | 80% | 120% | 96% | 80% | 120% | NA | 70% | 130% |
| Total Barium | 9793739 | | <5 | <5 | NA | < 5 | 95% | 80% | 120% | 101% | 80% | 120% | 111% | 70% | 130% |
| Total Beryllium | 9793739 | | <2 | <2 | NA | < 2 | 107% | 80% | 120% | 107% | 80% | 120% | 112% | 70% | 130% |
| Total Bismuth | 9793739 | | <2 | <2 | NA | < 2 | 92% | 80% | 120% | 103% | 80% | 120% | 96% | 70% | 130% |
| Total Boron | 9793739 | | 74 | 65 | 13.5% | < 5 | 100% | 80% | 120% | 107% | 80% | 120% | NA | 70% | 130% |
| Total Cadmium | 9793739 | | <0.09 | <0.09 | NA | < 0.09 | 96% | 80% | 120% | 101% | 80% | 120% | 100% | 70% | 130% |
| Total Chromium | 9793739 | | 2 | 1 | NA | < 1 | 95% | 80% | 120% | 98% | 80% | 120% | 93% | 70% | 130% |
| Total Cobalt | 9793739 | | <1 | <1 | NA | < 1 | 95% | 80% | 120% | 99% | 80% | 120% | 99% | 70% | 130% |
| Total Copper | 9793739 | | 18 | 18 | 0.3% | < 1 | 97% | 80% | 120% | 100% | 80% | 120% | NA | 70% | 130% |
| Total Iron | 9793739 | | 85 | 81 | NA | < 50 | 95% | 80% | 120% | 97% | 80% | 120% | 96% | 70% | 130% |
| Total Lead | 9793739 | | 0.5 | 0.5 | NA | < 0.5 | 94% | 80% | 120% | 101% | 80% | 120% | 97% | 70% | 130% |
| Total Manganese | 9793739 | | 4 | 4 | NA | < 2 | 95% | 80% | 120% | 98% | 80% | 120% | 96% | 70% | 130% |
| Total Molybdenum | 9793739 | | <2 | <2 | NA | < 2 | 96% | 80% | 120% | 100% | 80% | 120% | 86% | 70% | 130% |
| Total Nickel | 9793739 | | 7 | 7 | NA | < 2 | 98% | 80% | 120% | 101% | 80% | 120% | 102% | 70% | 130% |
| Total Phosphorous | 9793739 | | <0.02 | <0.02 | NA | < 0.02 | 108% | 80% | 120% | 115% | 80% | 120% | 90% | 70% | 130% |
| Total Selenium | 9793739 | | <1 | <1 | NA | < 1 | 101% | 80% | 120% | 100% | 80% | 120% | 75% | 70% | 130% |

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K421242
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Water Analysis (Continued)

| RPT Date: Jan 09, 2019 | | | DUPLICATE | | | | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Total Silver | 9793739 | | <0.1 | <0.1 | NA | < 0.1 | 93% | 80% | 120% | 100% | 80% | 120% | 70% | 70% | 130% |
| Total Strontium | 9793739 | | <5 | <5 | NA | < 5 | 94% | 80% | 120% | 96% | 80% | 120% | 93% | 70% | 130% |
| Total Thallium | 9793739 | | <0.1 | <0.1 | NA | < 0.1 | 95% | 80% | 120% | 101% | 80% | 120% | 95% | 70% | 130% |
| Total Tin | 9793739 | | <2 | <2 | NA | < 2 | 92% | 80% | 120% | 101% | 80% | 120% | 99% | 70% | 130% |
| Total Titanium | 9793739 | | 3 | 3 | NA | < 2 | 102% | 80% | 120% | 107% | 80% | 120% | 110% | 70% | 130% |
| Total Uranium | 9793739 | | <0.1 | <0.1 | NA | < 0.1 | 94% | 80% | 120% | 101% | 80% | 120% | 94% | 70% | 130% |
| Total Vanadium | 9793739 | | 29 | 27 | 7.5% | < 2 | 92% | 80% | 120% | 98% | 80% | 120% | NA | 70% | 130% |
| Total Zinc | 9793739 | | 20 | 20 | NA | < 5 | 97% | 80% | 120% | 99% | 80% | 120% | 103% | 70% | 130% |

Comments: If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

Mercury Analysis in Water (Total)

| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Lower | Upper | Recovery | Lower | Upper | Recovery | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Mercury | 1 | 9791865 | <0.026 | <0.026 | NA | < 0.026 | 96% | 80% | 120% | | 80% | 120% | 90% | 80% | 120% |

Comments: If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

Standard Water Analysis + Total Metals

| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Lower | Upper | Recovery | Lower | Upper | Recovery | Lower | Upper |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Total Organic Carbon | 9791865 | 9791865 | 2.2 | 2.4 | NA | < 0.5 | 88% | 80% | 120% | NA | 80% | 120% | 89% | 80% | 120% |

Comments: If RPD value is NA, the results of the duplicates are less than 5x the RDL and the RPD will not be calculated.

Certified By: Jason Coughtrey

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K421242
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Soil Analysis | | | |
| Aluminum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Antimony | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Arsenic | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Barium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Beryllium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Boron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cadmium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Chromium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Cobalt | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Copper | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Iron | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Lead | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Lithium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP-MS |
| Manganese | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Molybdenum | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Nickel | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Selenium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Silver | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Strontium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Thallium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Tin | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Uranium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Vanadium | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Zinc | MET-121-6105 & MET-121-6103 | EPA SW 846 6020A/3050B & SM 3125 | ICP/MS |
| Particle Size Distribution (<12.5mm, -4 PHI) | INOR-121-6034 | ASTM D-422-63 | SIEVE & PIPETTE |
| Particle Size Distribution (<9.5mm, -3 PHI) | INOR-121-6034 | ASTM D-422-63 | SIEVE & PIPETTE |
| Particle Size Distribution (<4.75mm, -2 PHI | INOR-121-6034 | ASTM D-422-63 | SIEVE & PIPETTE |
| Particle Size Distribution (<2mm, -1 PHI) | INOR-121-6034 | ASTM D-422-63 | SIEVE & PIPETTE |
| Particle Size Distribution (<1mm, 0 PHI) | INOR-121-6034 | ASTM D-422-63 | SIEVE & PIPETTE |
| Particle Size Distribution (<1/2mm, 1 PHI) | INOR-121-6034 | ASTM D-422-63 | SIEVE & PIPETTE |

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K421242
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Particle Size Distribution (<1/4mm, 2 PHI) | INOR-121-6034 | ASTM D-422-63 | SIEVE & PIPETTE |
| Particle Size Distribution (<1/8mm, 3 PHI) | INOR-121-6034 | ASTM D-422-63 | SIEVE & PIPETTE |
| Particle Size Distribution (<1/16mm, 4 PHI) | INOR-121-6034 | ASTM D-422-63 | SIEVE & PIPETTE |
| Particle Size Distribution (<1/32mm, 5 PHI) | INOR-121-6034 | ASTM D-422-63 | SIEVE & PIPETTE |
| Particle Size Distribution (<1/64mm, 6 PHI) | INOR-121-6034 | ASTM D-422-63 | SIEVE & PIPETTE |
| Particle Size Distribution (<1/128mm, 7 PHI) | INOR-121-6034 | ASTM D-422-63 | SIEVE & PIPETTE |
| Particle Size Distribution (<1/256mm, 8 PHI) | INOR-121-6034 | ASTM D-422-63 | SIEVE & PIPETTE |
| Particle Size Distribution (<1/512mm, 9 PHI) | INOR-121-6034 | ASTM D-422-63 | SIEVE & PIPETTE |
| Particle Size Distribution (Gravel) | INOR-121-6031 | ASTM D-422-63 | SIEVE & PIPETTE |
| Particle Size Distribution (Sand) | INOR-121-6031 | ASTM D-422-63 | SIEVE & PIPETTE |
| Particle Size Distribution (Silt) | INOR-121-6031 | ASTM D-422-63 | SIEVE & PIPETTE |
| Particle Size Distribution (Clay) | INOR-121-6031 | ASTM D-422-63 | SIEVE & PIPETTE |
| Particles >75um | INOR-121-6031, INOR-121-6034 | ASTM D-422-63 | CALCULATED |
| Classification | INOR-121-6031, INOR-121-6031 | Atlantic RBCA | CALCULATED |
| Mercury | INOR-121-6101 & INOR-121-6107 | Based on EPA 245.5 & SM 3112B | CV/AA |

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CLIENT NAME: GHD LIMITED
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SAMPLING SITE:
AGAT WORK ORDER: 18K421242
ATTENTION TO: JAMES O'NEILL
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| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Trace Organics Analysis | | | |
| Benzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Toluene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Ethylbenzene | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| Xylene (Total) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| C6-C10 (less BTEX) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| >C10-C16 Hydrocarbons - 1X silica gel | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C16-C21 Hydrocarbons - 1X silica gel | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| >C21-C32 Hydrocarbons - 1X silica gel | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| Modified TPH (Tier 1) - 1X silica gel | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | CALCULATION |
| Resemblance Comment | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS/FID |
| Return to Baseline at C32 | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Silica Gel Cleanup | | | GC/FID |
| Isobutylbenzene - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Isobutylbenzene - VPH | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| n-Dotriacontane - EPH | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| C6-C10 (less BTEX) | VOL-120-5013 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/MS |
| >C10-C16 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C16-C21 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| >C21-C32 Hydrocarbons | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | GC/FID |
| Modified TPH (Tier 1) | ORG-120-5101 | Atlantic RBCA Guidelines for Laboratories Tier 1 | CALCULATION |
| % Moisture | | Calculation | GRAVIMETRIC |
| 1-Methylnaphthalene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| 2-Methylnaphthalene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Acenaphthene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Acenaphthylene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Acridine | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Anthracene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Benzo(a)anthracene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Benzo(a)pyrene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Benzo(b)fluoranthene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Benzo(b+j)fluoranthene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Benzo(e)pyrene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Benzo(ghi)perylene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Benzo(k)fluoranthene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K421242
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Chrysene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Dibenzo(a,h)anthracene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Fluoranthene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Fluorene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Indeno(1,2,3)pyrene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Naphthalene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Perylene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Phenanthrene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Pyrene | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Quinoline | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Nitrobenzene-d5 | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| 2-Fluorobiphenyl | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| Terphenyl-d14 | ORG-120-5104 | EPA SW846/3541/3510/8270C | GC/MS |
| 1-Methylnaphthalene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| 2-Methylnaphthalene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Acenaphthene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Acenaphthylene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Acridine | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Anthracene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Benzo(a)anthracene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Benzo(a)pyrene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Benzo(b)fluoranthene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Benzo(e)pyrene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Benzo(ghi)perylene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Benzo(k)fluoranthene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Chrysene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Dibenzo(a,h)anthracene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Fluoranthene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Fluorene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Indeno(1,2,3-cd)pyrene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Naphthalene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Perylene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Phenanthrene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Pyrene | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Quinoline | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Nitrobenzene-d5 | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| 2-Fluorobiphenyl | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Terphenyl-d14 | ORG-120-5104 | EPA SW846/3510/8270C | GC/MS |
| Total Polychlorinated Biphenyls | ORG-120-5106 | EPA SW846/8081/8080 | GC/ECD |
| Decachlorobiphenyl | ORG-120-5106 | EAP SW846 3510C/8080/8010 | GC/ECD |

AGAT Laboratories

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CANADA A1E 6A8
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FAX (709 747-2139
http://www.agatlabs.com

# Method Summary

CLIENT NAME: GHD LIMITED
AGAT WORK ORDER: 18K421242
PROJECT: 11178792-02
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Water Analysis | | | |
| Total Mercury | MET-121-6100 & MET-121-6107 | SM 3112 B | CV/AA |
| pH | INOR-121-6001 | SM 4500 H+B | PC TITRATE |
| Reactive Silica as SiO2 | INOR-121-6027 | SM 4110 B | COLORIMETER |
| Chloride | INORG-121-6005 | SM 4110 B | ION CHROMATOGRAPH |
| Fluoride | INORG-121-6005 | SM 4110 B | ION CHROMATOGRAPH |
| Sulphate | INORG-121-6005 | SM 4110 B | ION CHROMATOGRAPH |
| Alkalinity | INOR-121-6001 | SM 2320 B | |
| True Color | INOR-121-6014 | SM 2120 C | NEPHELOMETER |
| Turbidity | INOR-121-6022 | SM 2130 B | NEPHELOMETER |
| Electrical Conductivity | INOR-121-6001 | SM 2510 B | PC TITRATE |
| Nitrate + Nitrite as N | INORG-121-6005 | SM 4110 B | CALCULATION |
| Nitrate as N | INORG-121-6005 | SM 4110 B | ION CHROMATOGRAPH |
| Nitrite as N | INORG-121-6005 | SM 4110 B | ION CHROMATOGRAPH |
| Ammonia as N | INOR-121-6047 | SM 4500-NH3 G | COLORIMETER |
| Total Organic Carbon | INOR-121-6026 | SM 5310 B | TOC ANALYZER |
| Ortho-Phosphate as P | INOR-121-6012 | SM 4110 B | COLORIMETER |
| Total Sodium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Potassium | MET121-6104 & MET-121-6105 | SM 3125 | ICP-MS |
| Total Calcium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Magnesium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Bicarb. Alkalinity (as CaCO3) | INORG-121-6001 | SM 2320 B | PC TITRATE |
| Carb. Alkalinity (as CaCO3) | INORG-121-6001 | SM 2320 B | PC TITRATE |
| Hydroxide | INORG-121-6001 | SM 2320 B | PC-TITRATE |
| Calculated TDS | CALCULATION | SM 1030E | CALCULATION |
| Hardness | CALCULATION | SM 2340B | CALCULATION |
| Langelier Index (@20C) | CALCULATION | CALCULATION | CALCULATION |
| Langelier Index (@ 4C) | CALCULATION | CALCULATION | CALCULATION |
| Saturation pH (@ 20C) | CALCULATION | CALCULATION | CALCULATION |
| Saturation pH (@ 4C) | CALCULATION | CALCULATION | CALCULATION |
| Anion Sum | CALCULATION | SM 1030E | CALCULATION |
| Cation sum | CALCULATION | SM 1030E | CALCULATION |
| % Difference/ Ion Balance | CALCULATION | SM 1030E | CALCULATION |
| Total Aluminum | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Antimony | MET121-6104 & MET-121-6105 | SM 3125 | ICP-MS |
| Total Arsenic | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Barium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Beryllium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Bismuth | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Boron | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |

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# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02
SAMPLING SITE:

AGAT WORK ORDER: 18K421242
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Total Cadmium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Chromium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Cobalt | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Copper | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Iron | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Lead | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Manganese | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Molybdenum | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Nickel | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Phosphorous | MET-121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Selenium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Silver | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Strontium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Thallium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Tin | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Titanium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Uranium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Vanadium | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |
| Total Zinc | MET121-6104 & MET-121-6105 | modified from SM 3125/SM 3030 B/SM 3030 D | ICP-MS |

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AGAT Laboratories

# Chain of Custody Record

**Laboratory Use Only**

Arrival Condition: ☑ Good ☐ Poor (see notes)
Arrival Temperature: 1.5, 1.4
AGAT Job Number: 18K421242
Notes:

## Report Information

Company: GHD Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone: 1-709-364-5353 Fax: 1-709-364-5368
IOL Site # and Name: Marystown Shipyard Waterlot
Project #: 11178792-02
AGAT Quotation #: GHD 'Standing Offer'
GHD PO #: To Follow

## Report Information

1. Name:
Email: James O'Neill
2. Name: James.O'Neill@ghd.com
Email: DataNL
datanl@ghd.com

**Report Format**

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

**Turnaround Time Required (TAT)**

Regular TAT ☑ 5 to 7 working days
Rush TAT ☐ 1 day ☐ 2 days ☐ 3 days
Date Required:

**Invoice To** Same Yes ☑ / No ☐

Company:
Contact:
Address:
Phone: Fax:

**Regulatory Requirements** (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ PIRI
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☑ CCME ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☑ Sediment

**Drinking Water Sample:** ☐ Yes ☑ No
Reg. No.:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: Silica Gel Clean-up | OTHER: Mercury | OTHER: | | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18-MNMA-STEP1 | 2018/12/13 14:38 | Sediment | 1 x250ml& 2 x40ml &1x120ml | 6 | ☑ | | | | | ☑ | | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-STEP2 | 2018/12/13 15:02 | Sediment | 1 x250ml& 2 x40ml &1x120ml | 6 | ☑ | | | | | ☑ | | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-STEP3 | 2018/12/13 15:25 | Sediment | 1 x250ml& 2 x40ml &1x120ml | 6 | ☑ | | | | | ☑ | | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-DUP3 | 2018/12/13 15:28 | Sediment | 1 x250ml& 2 x40ml &1x120ml | 6 | ☑ | | | | | ☑ | | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18-MNMA-S4 | 2018/10/19 11:00 | Sediment | Prev. submitted 18K399949 | | | | | | | | | ☑ | | | | | | | | | | | | | | | |
| 18-MNMA-S8 | 2018/10/19 12:20 | Sediment | Prev. submitted 18K399949 | | | | | | | | | ☑ | | | | | | | | | | | | | | | |
| 18-MNMA-S13 | 2018/10/19 13:55 | Sediment | Prev. submitted 18K399949 | | | | | | | | | ☑ | | | | | | | | | | | | | | | |
| 18-MNMA-REF2 | 2018/10/19 14:45 | Sediment | Prev. submitted 18K399949 | | | | | | | | | ☑ | | | | | | | | | | | | | | | |

Samples Relinquished By (Print Name): INGRID LAWLOR
Samples Relinquished By (Sign): Ingrid Lawlor
Date/Time: Dec 17/18
Date/Time: 9.20
Samples Received By (Print Name): Melissa Harrison
Samples Received By (Sign): M Harrison
Date/Time: Dec 17/18
Date/Time: 1045 am

Page 1 of 2

Document ID: DIV-133-1502.001

Date revised: September 18, 2015

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# AGAT Laboratories

## Chain of Custody Record

**Laboratory Use Only**

Arrival Condition: ☑ Good ☐ Poor (see notes)
Arrival Temperature: 1.5, 1.4
AGAT Job Number: 18K421242
Notes:

### Report Information

Company: GHD Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone: 1-709-364-5353 Fax: 1-709-364-5368
**IOL Site # and Name:** Marystown Shipyard Waterlot
Project #: 11178792-02
**AGAT Quotation #:** GHD 'Standing Offer'
**GHD PO #:** To Follow

### Report Information

1. Name:
Email: James O'Neill
2. Name: James.O'Neill@ghd.com
Email: DataNL
datanl@ghd.com

### Report Format

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

### Turnaround Time Required (TAT)

**Regular TAT** ☑ 5 to 7 working days
**Rush TAT** ☐ 1 day ☐ 2 days ☐ 3 days
Date Required:

### Invoice To

Same Yes ☑ / No ☐

Company:
Contact:
Address:
Phone: Fax:

### Regulatory Requirements (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ PIRI
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☑ CCME ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

**Drinking Water Sample:** ☐ Yes ☑ No
Reg. No.:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: Silica Gel Clean-up | OTHER: Mercury | OTHER: PAHs (Low Level) | General Chemistry | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18-MNMA-W2 | 2018/12/13 09:08 | SW | 18-MNMA-S1 | 10 | ☑ | | | | | ☑ | | | | | | | ☑ | ☑ | ☑ | | | | | | | | |
| 18-MNMA-W6 | 2018/12/13 10:16 | SW | 18-MNMA-S6 | 10 | ☑ | | | | | ☑ | | | | | | | ☑ | ☑ | ☑ | | | | | | | | |
| 18-MNMA-W9 | 2018/12/14 10:20 | SW | 18-MNMA-S9 | 10 | ☑ | | | | | ☑ | | | | | | | ☑ | ☑ | ☑ | | | | | | | | |
| 18-MNMA-W12 | 2018/12/14 08:50 | SW | 18-MNMA-S12 | 10 | ☑ | | | | | ☑ | | | | | | | ☑ | ☑ | ☑ | | | | | | | | |
| 18-MNMA-W14 | 2018/12/14 09:28 | SW | 18-MNMA-S14 | 10 | ☑ | | | | | ☑ | | | | | | | ☑ | ☑ | ☑ | | | | | | | | |
| 18-MNMA-W-DUP1 | 2018/12/13 10:18 | SW | Field Dup | 10 | ☑ | | | | | ☑ | | | | | | | ☑ | ☑ | ☑ | | | | | | | | |
| 18-MNMA-W-REF2 | 2018/12/13 13:12 | SW | 18-MNMA-REF2 | 10 | ☑ | | | | | ☑ | | | | | | | ☑ | ☑ | ☑ | | | | | | | | |
| 18-MNMA-W-REF3 | 2018/12/13 13:51 | SW | 18-MNMA-REF3 | 10 | ☑ | | | | | ☑ | | | | | | | ☑ | ☑ | ☑ | | | | | | | | |

| Samples Relinquished By (Print Name): | Date/Time | Samples Received By (Print Name): | Date/Time |
|---|---|---|---|
| INGRID LAWLOR | Dec 17/18 | Melissa Harrison | Dec 17/18 |
| **Samples Relinquished By (Sign):** Ingrid Lawlor | 9:20 | **Samples Received By (Sign):** M Harrison | 1045 am |

Page 2 of 2

Document ID: DIV-133-1502.001

Date revised, September 18, 2015

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| | |
|---|---|
| CLIENT NAME: | GHD LIMITED<br>1118 TOPSAIL ROAD<br>ST. JOHN'S , NL A1B3N7<br>(709) 364-5353 |
| ATTENTION TO: | JAMES O'NEILL |
| PROJECT: | 11178792-02 Marystown Shipyard MSSP |
| AGAT WORK ORDER: | 18K421824 |
| SOIL ANALYSIS REVIEWED BY: | Jason Coughtrey, Inorganics Supervisor |
| TRACE ORGANICS REVIEWED BY: | Kelly Hogue, B.Sc, P.Chem, Operations Manager |
| ULTRA TRACE REVIEWED BY: | Anastasia Kazakova, chimiste |
| DATE REPORTED: | Dec 31, 2018 |
| PAGES (INCLUDING COVER): | 21 |
| VERSION*: | 2 |

Should you require any information regarding this analysis please contact your client services representative at (709)747-8573

*NOTES
VERSION 2:This report supersedes all previous reports and had been updated to include the complete list of metals.

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

# Certificate of Analysis

AGAT WORK ORDER: 18K421824

PROJECT: 11178792-02 Marystown Shipyard MSSP

AGAT Laboratories
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CANADA A1E 6A8
TEL (709)747-8573
FAX (709 747-2139
http://www.agatlabs.com

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Mercury Analysis in Tissue

DATE RECEIVED: 2018-12-18

DATE REPORTED: 2018-12-31

| | | | SAMPLE DESCRIPTION: | 18-MNMA-TIS-COMP1 | 18-MNMA-TIS-COMP2 | 18-MNMA-TIS-COMP3 | 18-MNMA-TIS-COMP4 | 18-MNMA-TIS-REF1B | 18-MNMA-TIS-REF3B | 18-MNMA-TIS1A | 18-MNMA-TIS3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue |
| | | | DATE SAMPLED: | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-13 | 2018-12-13 |
| Parameter | Unit | G / S | RDL | 9796093 | 9796104 | 9796105 | 9796108 | 9796109 | 9796110 | 9796111 | 9796115 |
| Mercury in Tissue | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |

| | | | SAMPLE DESCRIPTION: | 18-MNMA-TIS5A | 18-MNMA-TIS6A | 18-MNMA-TIS10A | 18-MNMA-TIS11 | 18-MNMA-TIS12A | 18-MNMA-TIS14A | 18-MNMA-TIS-REF3A |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue |
| | | | DATE SAMPLED: | 2018-12-13 | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-14 | 2018-12-14 | 2018-12-13 |
| Parameter | Unit | G / S | RDL | 9796116 | 9796117 | 9796118 | 9796119 | 9796120 | 9796121 | 9796122 |
| Mercury in Tissue | mg/kg | | 0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 | <0.05 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9796093-9796122 Results are based on the wet weight of the sample.

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

# Certificate of Analysis

AGAT WORK ORDER: 18K421824

PROJECT: 11178792-02 Marystown Shipyard MSSP

57 Old Pennywell Road, Unit I
St. John's, NL
CANADA A1E 6A8
TEL (709)747-8573
FAX (709 747-2139
http://www.agatlabs.com

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Metals in Tissue

DATE RECEIVED: 2018-12-18

DATE REPORTED: 2018-12-31

| Parameter | Unit | G / S | RDL | 18-MNMA-TIS-COMP1 | 18-MNMA-TIS-COMP2 | 18-MNMA-TIS-COMP3 | 18-MNMA-TIS-COMP4 | 18-MNMA-TIS-REF1B | 18-MNMA-TIS-REF3B | 18-MNMA-TIS1A | 18-MNMA-TIS3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue |
| DATE SAMPLED: | | | | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-13 | 2018-12-13 |
| | | | | 9796093 | 9796104 | 9796105 | 9796108 | 9796109 | 9796110 | 9796111 | 9796115 |
| Aluminum | mg/kg | | 10 | 15 | <10 | <10 | <10 | <10 | 29 | <10 | <10 |
| Antimony | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Arsenic | mg/kg | | 2 | 3 | 4 | 4 | 3 | 5 | 4 | 2 | 3 |
| Barium | mg/kg | | 5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
| Beryllium | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Bismuth | mg/kg | | 5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
| Boron | mg/kg | | 2 | <2 | <2 | <2 | 6 | 2 | 6 | 4 | 5 |
| Cadmium | mg/kg | | 0.3 | 2.9 | 1.3 | 2.3 | 4.8 | <0.3 | 3.5 | 2.7 | 6.0 |
| Chromium | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Cobalt | mg/kg | | 1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Copper | mg/kg | | 2 | 20 | 14 | 18 | 9 | 19 | <2 | <2 | <2 |
| Iron | mg/kg | | 50 | 125 | 63 | 132 | <50 | 52 | 95 | <50 | 146 |
| Lead | mg/kg | | 0.4 | <0.4 | <0.4 | <0.4 | 0.7 | <0.4 | 1.1 | <0.4 | <0.4 |
| Manganese | mg/kg | | 2 | 4 | <2 | <2 | 43 | 2 | 23 | <2 | <2 |
| Molybdenum | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Nickel | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Selenium | mg/kg | | 1 | <1 | <1 | <1 | <1 | 1 | <1 | <1 | <1 |
| Silver | mg/kg | | 0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Strontium | mg/kg | | 5 | 113 | 49 | 36 | 33 | 210 | 8 | 5 | 5 |
| Thallium | mg/kg | | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Uranium | mg/kg | | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Vanadium | mg/kg | | 2 | 2 | 4 | 3 | 5 | 4 | 6 | 4 | 6 |
| Zinc | mg/kg | | 5 | 25 | 28 | 27 | 108 | 27 | 74 | 10 | 10 |

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# Certificate of Analysis

AGAT WORK ORDER: 18K421824
PROJECT: 11178792-02 Marystown Shipyard MSSP

CLIENT NAME: GHD LIMITED
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Metals in Tissue

DATE RECEIVED: 2018-12-18
DATE REPORTED: 2018-12-31

| Parameter | Unit | G / S | RDL | 18-MNMA-TIS5A | 18-MNMA-TIS6A | 18-MNMA-TIS10A | 18-MNMA-TIS11 | 18-MNMA-TIS12A | 18-MNMA-TIS14A | 18-MNMA-TIS-REF3A |
|---|---|---|---|---|---|---|---|---|---|---|
| SAMPLE TYPE: | | | | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue |
| DATE SAMPLED: | | | | 2018-12-13 | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-14 | 2018-12-14 | 2018-12-13 |
| | | | | 9796116 | 9796117 | 9796118 | 9796119 | 9796120 | 9796121 | 9796122 |
| Aluminum | mg/kg | | 10 | <10 | <10 | <10 | <10 | <10 | 14 | <10 |
| Antimony | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Arsenic | mg/kg | | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 2 |
| Barium | mg/kg | | 5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
| Beryllium | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Bismuth | mg/kg | | 5 | <5 | <5 | <5 | <5 | <5 | <5 | <5 |
| Boron | mg/kg | | 2 | 5 | 4 | 5 | 5 | 5 | 5 | 4 |
| Cadmium | mg/kg | | 0.3 | 5.6 | 6.3 | 17.8 | 6.6 | 10.2 | 8.7 | 4.9 |
| Chromium | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Cobalt | mg/kg | | 1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Copper | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Iron | mg/kg | | 50 | 70 | 115 | 142 | 66 | 58 | 74 | <50 |
| Lead | mg/kg | | 0.4 | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 |
| Manganese | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Molybdenum | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Nickel | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Selenium | mg/kg | | 1 | <1 | <1 | <1 | <1 | <1 | <1 | <1 |
| Silver | mg/kg | | 0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Strontium | mg/kg | | 5 | 6 | <5 | 5 | <5 | 5 | 6 | 5 |
| Thallium | mg/kg | | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Tin | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Uranium | mg/kg | | 0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 | <0.1 |
| Vanadium | mg/kg | | 2 | 5 | 3 | 6 | 4 | 4 | 5 | 4 |
| Zinc | mg/kg | | 5 | 12 | 7 | 12 | 10 | 9 | 10 | 9 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard
9796093-9796122 Results are based on the wet weight of the sample.
Analysis performed at AGAT Halifax (unless marked by *)

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# Certificate of Analysis

AGAT WORK ORDER: 18K421824

PROJECT: 11178792-02 Marystown Shipyard MSSP

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Metals in Tissue - As,Pb,Cu,Zn

DATE RECEIVED: 2018-12-18

DATE REPORTED: 2018-12-31

| | | | SAMPLE DESCRIPTION: | 18-MNMA-TIS-COMP1 | 18-MNMA-TIS-COMP2 | 18-MNMA-TIS-COMP3 | 18-MNMA-TIS-COMP4 | 18-MNMA-TIS-REF1B | 18-MNMA-TIS-REF3B | 18-MNMA-TIS1A | 18-MNMA-TIS3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue |
| | | | DATE SAMPLED: | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-13 | 2018-12-13 |
| Parameter | Unit | G / S | RDL | 9796093 | 9796104 | 9796105 | 9796108 | 9796109 | 9796110 | 9796111 | 9796115 |
| Arsenic | mg/kg | | 2 | 3 | 4 | 4 | 3 | 5 | 4 | 2 | 3 |
| Copper | mg/kg | | 2 | 20 | 14 | 18 | 9 | 19 | <2 | <2 | <2 |
| Lead | mg/kg | | 0.4 | <0.4 | <0.4 | <0.4 | 0.7 | <0.4 | 1.1 | <0.4 | <0.4 |
| Zinc | mg/kg | | 5 | 25 | 28 | 27 | 108 | 27 | 74 | 10 | 10 |

| | | | SAMPLE DESCRIPTION: | 18-MNMA-TIS5A | 18-MNMA-TIS6A | 18-MNMA-TIS10A | 18-MNMA-TIS11 | 18-MNMA-TIS12A | 18-MNMA-TIS14A | 18-MNMA-TIS-REF3A |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue |
| | | | DATE SAMPLED: | 2018-12-13 | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-14 | 2018-12-14 | 2018-12-13 |
| Parameter | Unit | G / S | RDL | 9796116 | 9796117 | 9796118 | 9796119 | 9796120 | 9796121 | 9796122 |
| Arsenic | mg/kg | | 2 | 3 | 2 | 3 | 3 | 3 | 3 | 2 |
| Copper | mg/kg | | 2 | <2 | <2 | <2 | <2 | <2 | <2 | <2 |
| Lead | mg/kg | | 0.4 | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 | <0.4 |
| Zinc | mg/kg | | 5 | 12 | 7 | 12 | 10 | 9 | 10 | 9 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9796093-9796122 Results are based on the wet weight of the sample.

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

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# Certificate of Analysis

AGAT WORK ORDER: 18K421824

PROJECT: 11178792-02 Marystown Shipyard MSSP

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## Total Polychlorinated Biphenyls in Tissue

DATE RECEIVED: 2018-12-18

DATE REPORTED: 2018-12-31

| | | | SAMPLE DESCRIPTION: | 18-MNMA-TIS-COMP1 | 18-MNMA-TIS-COMP2 | 18-MNMA-TIS-COMP3 | 18-MNMA-TIS-COMP4 | 18-MNMA-TIS-REF1B | 18-MNMA-TIS-REF3B | 18-MNMA-TIS1A | 18-MNMA-TIS3 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue |
| | | | DATE SAMPLED: | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-13 | 2018-12-13 |
| Parameter | Unit | G / S | RDL | 9796093 | 9796104 | 9796105 | 9796108 | 9796109 | 9796110 | 9796111 | 9796115 |
| PCB in Tissue, Total | mg/Kg | | 0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Surrogate | Unit | Acceptable Limits | | | | | | | | | |
| Decachlorobiphenyl | % | 50-130 | | 111 | 116 | 95 | 76 | 108 | 111 | 105 | 90 |

| | | | SAMPLE DESCRIPTION: | 18-MNMA-TIS5A | 18-MNMA-TIS6A | 18-MNMA-TIS10A | 18-MNMA-TIS11 | 18-MNMA-TIS12A | 18-MNMA-TIS14A | 18-MNMA-TIS-REF3A |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue | Tissue |
| | | | DATE SAMPLED: | 2018-12-13 | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-14 | 2018-12-14 | 2018-12-13 |
| Parameter | Unit | G / S | RDL | 9796116 | 9796117 | 9796118 | 9796119 | 9796120 | 9796121 | 9796122 |
| PCB in Tissue, Total | mg/Kg | | 0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 | <0.5 |
| Surrogate | Unit | Acceptable Limits | | | | | | | | |
| Decachlorobiphenyl | % | 50-130 | | 108 | 114 | 100 | 108 | 95 | 91 | 78 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9796093 Results are based on the wet weight of the tissue.MS not available due to limited sample availability.

9796104-9796122 Results are based on the wet weight of the tissue.

Analysis performed at AGAT Halifax (unless marked by *)

Certified By: Kelly Hogue

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CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## PAHs in Tissue by HRMS (ng/g)

DATE RECEIVED: 2018-12-18

DATE REPORTED: 2018-12-31

| Parameter | Unit | G / S | RDL | 9796093 | RDL | 9796104 | RDL | 9796105 | RDL | 9796108 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | SAMPLE DESCRIPTION: | | 18-MNMA-TIS-COMP1 | | 18-MNMA-TIS-COMP2 | | 18-MNMA-TIS-COMP3 | | 18-MNMA-TIS-COMP4 |
| | | SAMPLE TYPE: | | Tissue | | Tissue | | Tissue | | Tissue |
| | | DATE SAMPLED: | | 2018-12-13 | | 2018-12-13 | | 2018-12-14 | | 2018-12-13 |
| 1,3-Dimethylnaphthalene | ng/g | | 0.6 | 36.9 | 0.4 | 25.4 | 0.4 | 27.5 | 0.3 | 22.3 |
| 1-Chloronaphthalene | ng/g | | 1 | <1 | 0.7 | <0.7 | 0.5 | <0.5 | 0.6 | <0.6 |
| 1-Methylnaphthalene | ng/g | | 1 | 20 | 0.9 | 13.3 | 0.9 | 12.9 | 0.8 | 14.1 |
| 2,3,5-Trimethylnaphthalene | ng/g | | 0.9 | 2.3 | 0.3 | 1.0 | 0.3 | 1.1 | 0.7 | 1.7 |
| 2,6-Dimethylnaphthalene | ng/g | | 0.6 | 47.5 | 0.4 | 32.7 | 0.4 | 22.3 | 0.3 | 36.1 |
| 2-Chloronaphthalene | ng/g | | 0.8 | <0.8 | 0.6 | <0.6 | 0.5 | <0.5 | 0.5 | <0.5 |
| 2-Methylnaphthalene | ng/g | | 1 | 34 | 0.9 | 23.7 | 0.9 | 25.0 | 0.8 | 26.5 |
| Acenaphthylene | ng/g | | 0.1 | 1.6 | 0.1 | 1.6 | 0.1 | 0.9 | 0.1 | 1.3 |
| Acenaphthene | ng/g | | 0.1 | 5.3 | 0.1 | 12.7 | 0.1 | 6.3 | 0.1 | 10.7 |
| Acridine | ng/g | | 0.3 | <0.3 | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 |
| Anthracene | ng/g | | 0.4 | 1.3 | 0.1 | 0.3 | 0.2 | 0.3 | 0.3 | 1.8 |
| Benzo[a]Anthracene | ng/g | | 0.1 | 4.3 | 0.1 | 0.2 | 0.1 | 0.1 | 0.1 | 0.4 |
| Benzo[a]Pyrene | ng/g | | 0.1 | 1.2 | 0.1 | 0.6 | 0.1 | 0.8 | 0.1 | 0.8 |
| Benzo(b+j)fluoranthene | ng/g | | 0.2 | 0.9 | 0.1 | 0.2 | 0.1 | 0.2 | 0.2 | 0.6 |
| Benzo(e)pyrene | ng/g | | 0.1 | 3.6 | 0.1 | 1.4 | 0.1 | 1.6 | 0.1 | 2.7 |
| Benzo[g,h,i]Perylene | ng/g | | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 |
| Benzo[k]Fluoranthene | ng/g | | 0.1 | 0.8 | 0.1 | <0.1 | 0.1 | 0.2 | 0.1 | 0.7 |
| Chrysene | ng/g | | 0.1 | 4.9 | 0.1 | 0.3 | 0.1 | 0.3 | 0.1 | 0.4 |
| Dibenzo[a,h]Anthracene | ng/g | | 0.1 | <0.1 | 01 | <01 | 0.1 | <0.1 | 0.1 | <0.1 |
| Fluoroanthene | ng/g | | 0.1 | 22.0 | 0.1 | 1.3 | 0.1 | 1.2 | 0.1 | 10.7 |
| Fluorene | ng/g | | 0.5 | 3.5 | 0.2 | 1.8 | 0.2 | 1.3 | 0.5 | 1.8 |
| Indeno[1,2,3,c-d]Pyrene | ng/g | | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 |
| Naphthalene | ng/g | | 0.6 | 22.1 | 0.3 | 15.3 | 0.3 | 14.0 | 0.3 | 16.4 |
| Perylene | ng/g | | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 |
| Phenanthrene | ng/g | | 0.3 | 17.8 | 0.1 | 2.3 | 0.1 | 2.4 | 0.2 | 4.1 |
| Pyrene | ng/g | | 0.1 | 43.3 | 0.1 | 1.3 | 0.1 | 1.1 | 0.1 | 7.4 |
| Quinoline | ng/g | | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 |
| Lipid Content | % | | | 0.55 | | 1.23 | | 0.58 | | 0.46 |

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CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## PAHs in Tissue by HRMS (ng/g)

DATE RECEIVED: 2018-12-18

DATE REPORTED: 2018-12-31

| | | SAMPLE DESCRIPTION: | 18-MNMA-TIS-COMP1 | 18-MNMA-TIS-COMP2 | 18-MNMA-TIS-COMP3 | 18-MNMA-TIS-COMP4 |
|---|---|---|---|---|---|---|
| | | SAMPLE TYPE: | Tissue | Tissue | Tissue | Tissue |
| | | DATE SAMPLED: | 2018-12-13 | 2018-12-13 | 2018-12-14 | 2018-12-13 |
| Surrogate | Unit | Acceptable Limits | 9796093 | 9796104 | 9796105 | 9796108 |
| 13C Naphthalene | % | 30-140 | 32 | 37 | 38 | 31 |
| 13C Acenaphthtylene | % | 30-140 | 102 | 103 | 111 | 111 |
| 13C Acenaphthene | % | 30-140 | 103 | 65 | 123 | 71 |
| 13C Fluorene | % | 30-140 | 35 | 41 | 49 | 51 |
| 13C Phenanthrene | % | 30-140 | 70 | 88 | 90 | 126 |
| 13C Anthracene | % | 30-140 | 66 | 79 | 85 | 127 |
| 13C Fluoroanthene | % | 30-140 | 32 | 30 | 30 | 45 |
| 13C Pyrene | % | 30-140 | 49 | 60 | 57 | 106 |
| 13C Benzo[a]Anthracene | % | 30-140 | 50 | 79 | 78 | 96 |
| 13C Chrysene | % | 30-140 | 74 | 110 | 102 | 123 |
| 13C Benzo[b]Fluoranthene | % | 30-140 | 32 | 41 | 46 | 52 |
| 13C Benzo[k]Fluoranthene | % | 30-140 | 52 | 60 | 62 | 84 |
| 13C Benzo[a]Pyrene | % | 30-140 | 48 | 84 | 80 | 55 |
| 13C Indeno[1,2,3,c-d]Pyrene | % | 30-140 | 68 | 67 | 75 | 93 |
| 13C Benzo[g,h,i]Perylene | % | 30-140 | 68 | 108 | 106 | 98 |
| 13C Dibenzo[a,h]Anthracene | % | 30-140 | 48 | 54 | 67 | 69 |

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CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## PAHs in Tissue by HRMS (ng/g)

DATE RECEIVED: 2018-12-18

DATE REPORTED: 2018-12-31

| | | SAMPLE DESCRIPTION: | | 18-MNMA-TIS-REF1B | | 18-MNMA-TIS-REF3B | | 18-MNMA-TIS1A | | 18-MNMA-TIS3 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | SAMPLE TYPE: | | Tissue | | Tissue | | Tissue | | Tissue |
| | | DATE SAMPLED: | | 2018-12-13 | | 2018-12-14 | | 2018-12-13 | | 2018-12-13 |
| Parameter | Unit | G / S | RDL | 9796109 | RDL | 9796110 | RDL | 9796111 | RDL | 9796115 |
| 1,3-Dimethylnaphthalene | ng/g | | 0.3 | 22.9 | 0.4 | 22.4 | 0.4 | 48.0 | 0.4 | 36.0 |
| 1-Chloronaphthalene | ng/g | | 0.5 | <0.5 | 0.7 | <0.7 | 0.7 | <0.7 | 0.5 | <0.5 |
| 1-Methylnaphthalene | ng/g | | 0.7 | 12.2 | 1 | 15 | 1 | 28 | 0.9 | 16.4 |
| 2,3,5-Trimethylnaphthalene | ng/g | | 3 | <3 | 0.6 | 1.5 | 0.4 | 3.1 | 0.7 | 2.2 |
| 2,6-Dimethylnaphthalene | ng/g | | 0.3 | 19.0 | 0.4 | 34.3 | 0.4 | 73.0 | 0.4 | 34.5 |
| 2-Chloronaphthalene | ng/g | | 0.4 | <0.4 | 0.6 | <0.6 | 0.6 | <0.6 | 0.4 | <0.4 |
| 2-Methylnaphthalene | ng/g | | 0.7 | 21.4 | 1 | 27 | 1 | 51 | 0.9 | 30.2 |
| Acenaphthylene | ng/g | | 0.1 | 1.8 | 0.1 | 1.7 | 0.1 | 2.1 | 0.1 | 1.2 |
| Acenaphthene | ng/g | | 0.1 | 18.4 | 0.1 | 12.1 | 0.1 | 16.4 | 0.1 | 10.5 |
| Acridine | ng/g | | 0.3 | <0.3 | 0.2 | <0.2 | 0.1 | <0.1 | 0.2 | <0.2 |
| Anthracene | ng/g | | 0.6 | 0.9 | 0.2 | 0.5 | 0.2 | 1.1 | 0.3 | 1.1 |
| Benzo[a]Anthracene | ng/g | | 0.1 | 15.6 | 0.1 | 0.6 | 0.1 | 5.0 | 0.1 | 5.6 |
| Benzo[a]Pyrene | ng/g | | 0.1 | 3.4 | 0.1 | 0.3 | 0.1 | 2.9 | 0.1 | 1.1 |
| Benzo(b+j)fluoranthene | ng/g | | 0.1 | 2.3 | 0.1 | 0.4 | 0.1 | 2.6 | 0.1 | 1.7 |
| Benzo(e)pyrene | ng/g | | 0.1 | 10.6 | 0.1 | 1.9 | 0.1 | 7.1 | 0.1 | 2.5 |
| Benzo[g,h,i]Perylene | ng/g | | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | 4.0 | 0.5 | <0.5 |
| Benzo[k]Fluoranthene | ng/g | | 0.1 | 3.9 | 0.1 | 0.4 | 0.1 | 3.1 | 0.1 | 1.7 |
| Chrysene | ng/g | | 0.1 | 37.8 | 0.1 | 1.5 | 0.1 | 5.3 | 0.5 | 3.8 |
| Dibenzo[a,h]Anthracene | ng/g | | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 |
| Fluoroanthene | ng/g | | 0.3 | 14.6 | 0.1 | 5.8 | 0.1 | 14.9 | 0.1 | 12.3 |
| Fluorene | ng/g | | 0.8 | 2.9 | 0.3 | 2.1 | 0.4 | 2.3 | 0.3 | 1.8 |
| Indeno[1,2,3,c-d]Pyrene | ng/g | | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | 0.9 | 0.1 | <0.1 |
| Naphthalene | ng/g | | 0.2 | 14.0 | 0.4 | 17.4 | 0.4 | 31.6 | 0.3 | 19.3 |
| Perylene | ng/g | | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | 1.7 | 0.1 | <0.1 |
| Phenanthrene | ng/g | | 0.5 | 7.7 | 0.1 | 5.2 | 0.2 | 6.1 | 0.2 | 5.1 |
| Pyrene | ng/g | | 0.1 | 11.7 | 0.1 | 7.2 | 0.1 | 8.0 | 0.1 | 6.8 |
| Quinoline | ng/g | | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 |
| Lipid Content | % | | | 0.22 | | 0.42 | | 0.37 | | 1.31 |

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# Certificate of Analysis

AGAT WORK ORDER: 18K421824

PROJECT: 11178792-02 Marystown Shipyard MSSP

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## PAHs in Tissue by HRMS (ng/g)

DATE RECEIVED: 2018-12-18

DATE REPORTED: 2018-12-31

| Surrogate | Unit | Acceptable Limits | 18-MNMA-TIS-REF1B | 18-MNMA-TIS-REF3B | 18-MNMA-TIS1A | 18-MNMA-TIS3 |
|---|---|---|---|---|---|---|
| | | SAMPLE DESCRIPTION: | 18-MNMA-TIS-REF1B | 18-MNMA-TIS-REF3B | 18-MNMA-TIS1A | 18-MNMA-TIS3 |
| | | SAMPLE TYPE: | Tissue | Tissue | Tissue | Tissue |
| | | DATE SAMPLED: | 2018-12-13 | 2018-12-14 | 2018-12-13 | 2018-12-13 |
| | | | 9796109 | 9796110 | 9796111 | 9796115 |
| 13C Naphthalene | % | 30-140 | 53 | 45 | 31 | 41 |
| 13C Acenaphthtylene | % | 30-140 | 98 | 104 | 112 | 116 |
| 13C Acenaphthene | % | 30-140 | 62 | 75 | 62 | 79 |
| 13C Fluorene | % | 30-140 | 48 | 47 | 44 | 47 |
| 13C Phenanthrene | % | 30-140 | 124 | 102 | 108 | 98 |
| 13C Anthracene | % | 30-140 | 127 | 95 | 97 | 84 |
| 13C Fluoroanthene | % | 30-140 | 36 | 34 | 38 | 37 |
| 13C Pyrene | % | 30-140 | 95 | 66 | 67 | 67 |
| 13C Benzo[a]Anthracene | % | 30-140 | 110 | 74 | 73 | 74 |
| 13C Chrysene | % | 30-140 | 126 | 115 | 117 | 119 |
| 13C Benzo[b]Fluoranthene | % | 30-140 | 109 | 53 | 46 | 47 |
| 13C Benzo[k]Fluoranthene | % | 30-140 | 119 | 92 | 73 | 75 |
| 13C Benzo[a]Pyrene | % | 30-140 | 119 | 88 | 53 | 97 |
| 13C Indeno[1,2,3,c-d]Pyrene | % | 30-140 | 96 | 91 | 111 | 80 |
| 13C Benzo[g,h,i]Perylene | % | 30-140 | 96 | 127 | 112 | 119 |
| 13C Dibenzo[a,h]Anthracene | % | 30-140 | 128 | 62 | 70 | 69 |

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# Certificate of Analysis

AGAT WORK ORDER: 18K421824

PROJECT: 11178792-02 Marystown Shipyard MSSP

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## PAHs in Tissue by HRMS (ng/g)

DATE RECEIVED: 2018-12-18

DATE REPORTED: 2018-12-31

| | | SAMPLE DESCRIPTION: | | 18-MNMA-TIS5A | | 18-MNMA-TIS6A | | 18-MNMA-TIS10A | | 18-MNMA-TIS11 |
|---|---|---|---|---|---|---|---|---|---|---|
| | | SAMPLE TYPE: | | Tissue | | Tissue | | Tissue | | Tissue |
| | | DATE SAMPLED: | | 2018-12-13 | | 2018-12-13 | | 2018-12-13 | | 2018-12-14 |
| Parameter | Unit | G / S | RDL | 9796116 | RDL | 9796117 | RDL | 9796118 | RDL | 9796119 |
| 1,3-Dimethylnaphthalene | ng/g | | 0.5 | 21.5 | 0.5 | 28.5 | 0.4 | 16.8 | 0.4 | 16.5 |
| 1-Chloronaphthalene | ng/g | | 0.8 | <0.8 | 0.7 | <0.7 | 0.7 | <0.7 | 0.7 | <0.7 |
| 1-Methylnaphthalene | ng/g | | 1 | 20 | 1 | 17 | 0.8 | 12.2 | 1 | 12 |
| 2,3,5-Trimethylnaphthalene | ng/g | | 0.4 | 1.5 | 0.4 | 1.7 | 0.4 | 0.6 | 0.4 | 1.5 |
| 2,6-Dimethylnaphthalene | ng/g | | 0.6 | 36.5 | 0.5 | 42.9 | 0.4 | 25.3 | 0.4 | 29.9 |
| 2-Chloronaphthalene | ng/g | | 0.7 | <0.7 | 0.6 | <0.6 | 0.6 | <0.6 | 0.6 | <0.6 |
| 2-Methylnaphthalene | ng/g | | 1 | 35 | 1 | 32 | 0.8 | 23.3 | 1 | 23 |
| Acenaphthylene | ng/g | | 0.1 | 1.3 | 0.1 | 1.3 | 0.1 | 1.1 | 0.1 | 1.5 |
| Acenaphthene | ng/g | | 0.1 | 16.3 | 0.1 | 14.7 | 0.1 | 14.6 | 0.1 | 9.8 |
| Acridine | ng/g | | 0.1 | <0.1 | 0.2 | <0.2 | 0.2 | <0.2 | 0.2 | <0.2 |
| Anthracene | ng/g | | 0.2 | 0.5 | 0.2 | 0.9 | 0.3 | 0.5 | 0.2 | 0.7 |
| Benzo[a]Anthracene | ng/g | | 0.1 | 1.7 | 0.1 | 3.3 | 0.1 | 6.2 | 0.1 | 3.4 |
| Benzo[a]Pyrene | ng/g | | 0.1 | 1.2 | 0.1 | 2.2 | 0.1 | 1.2 | 0.1 | 1.2 |
| Benzo(b+j)fluoranthene | ng/g | | 0.1 | 0.8 | 0.1 | 1.6 | 0.1 | 1.2 | 0.2 | 1.5 |
| Benzo(e)pyrene | ng/g | | 0.1 | 2.9 | 0.1 | 4.1 | 0.1 | 4.4 | 0.1 | 3.7 |
| Benzo[g,h,i]Perylene | ng/g | | 0.1 | <0.1 | 0.1 | 2.6 | 0.1 | <0.1 | 0.1 | <0.1 |
| Benzo[k]Fluoranthene | ng/g | | 0.1 | 1.2 | 0.1 | 1.8 | 0.1 | 1.4 | 0.1 | 1.4 |
| Chrysene | ng/g | | 0.1 | 0.9 | 0.1 | 2.4 | 0.1 | 3.9 | 0.1 | 2.6 |
| Dibenzo[a,h]Anthracene | ng/g | | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 |
| Fluoroanthene | ng/g | | 0.1 | 5.3 | 0.1 | 12.0 | 0.1 | 7.6 | 0.1 | 11.3 |
| Fluorene | ng/g | | 0.3 | 1.7 | 0.2 | 1.9 | 0.3 | 1.6 | 0.3 | 2.2 |
| Indeno[1,2,3,c-d]Pyrene | ng/g | | 0.1 | <0.1 | 0.1 | 0.5 | 0.1 | <0.1 | 0.1 | <0.1 |
| Naphthalene | ng/g | | 0.4 | 26.1 | 0.4 | 19.5 | 0.3 | 17.1 | 0.4 | 13.0 |
| Perylene | ng/g | | 0.1 | 0.7 | 0.1 | 2.1 | 0.1 | 1.4 | 0.1 | <0.1 |
| Phenanthrene | ng/g | | 0.2 | 3.8 | 0.1 | 4.8 | 0.2 | 4.2 | 0.2 | 6.0 |
| Pyrene | ng/g | | 0.1 | 3.0 | 0.1 | 8.0 | 0.1 | 4.5 | 0.1 | 10.7 |
| Quinoline | ng/g | | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 |
| Lipid Content | % | | | 0.27 | | 0.32 | | 0.36 | | 0.47 |

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CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## PAHs in Tissue by HRMS (ng/g)

DATE RECEIVED: 2018-12-18

DATE REPORTED: 2018-12-31

| | | SAMPLE DESCRIPTION: | 18-MNMA-TIS5A | 18-MNMA-TIS6A | 18-MNMA-TIS10A | 18-MNMA-TIS11 |
|---|---|---|---|---|---|---|
| | | SAMPLE TYPE: | Tissue | Tissue | Tissue | Tissue |
| | | DATE SAMPLED: | 2018-12-13 | 2018-12-13 | 2018-12-13 | 2018-12-14 |
| Surrogate | Unit | Acceptable Limits | 9796116 | 9796117 | 9796118 | 9796119 |
| 13C Naphthalene | % | 30-140 | 34 | 39 | 43 | 43 |
| 13C Acenaphthtylene | % | 30-140 | 105 | 109 | 99 | 94 |
| 13C Acenaphthene | % | 30-140 | 56 | 56 | 58 | 87 |
| 13C Fluorene | % | 30-140 | 50 | 49 | 47 | 42 |
| 13C Phenanthrene | % | 30-140 | 105 | 100 | 97 | 89 |
| 13C Anthracene | % | 30-140 | 95 | 90 | 87 | 78 |
| 13C Fluoroanthene | % | 30-140 | 34 | 33 | 36 | 30 |
| 13C Pyrene | % | 30-140 | 60 | 60 | 63 | 56 |
| 13C Benzo[a]Anthracene | % | 30-140 | 66 | 93 | 64 | 64 |
| 13C Chrysene | % | 30-140 | 98 | 118 | 108 | 83 |
| 13C Benzo[b]Fluoranthene | % | 30-140 | 45 | 42 | 50 | 34 |
| 13C Benzo[k]Fluoranthene | % | 30-140 | 73 | 72 | 71 | 58 |
| 13C Benzo[a]Pyrene | % | 30-140 | 75 | 55 | 69 | 55 |
| 13C Indeno[1,2,3,c-d]Pyrene | % | 30-140 | 66 | 88 | 96 | 68 |
| 13C Benzo[g,h,i]Perylene | % | 30-140 | 66 | 106 | 85 | 90 |
| 13C Dibenzo[a,h]Anthracene | % | 30-140 | 44 | 67 | 46 | 44 |

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# Certificate of Analysis

AGAT WORK ORDER: 18K421824

PROJECT: 11178792-02 Marystown Shipyard MSSP

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## PAHs in Tissue by HRMS (ng/g)

DATE RECEIVED: 2018-12-18

DATE REPORTED: 2018-12-31

| Parameter | Unit | G / S | RDL | 9796120 | RDL | 9796121 | RDL | 9796122 |
|---|---|---|---|---|---|---|---|---|
| SAMPLE DESCRIPTION: | | | | 18-MNMA-TIS12A | | 18-MNMA-TIS14A | | 18-MNMA-TIS-REF3A |
| SAMPLE TYPE: | | | | Tissue | | Tissue | | Tissue |
| DATE SAMPLED: | | | | 2018-12-14 | | 2018-12-14 | | 2018-12-13 |
| 1,3-Dimethylnaphthalene | ng/g | | 0.4 | 19.6 | 0.4 | 21.5 | 0.4 | 11.1 |
| 1-Chloronaphthalene | ng/g | | 0.8 | <0.8 | 0.6 | <0.6 | 0.6 | <0.6 |
| 1-Methylnaphthalene | ng/g | | 1 | 12 | 0.9 | 19.7 | 1 | 8 |
| 2,3,5-Trimethylnaphthalene | ng/g | | 0.4 | 1.2 | 0.9 | 1.3 | 0.5 | 1.0 |
| 2,6-Dimethylnaphthalene | ng/g | | 0.4 | 33.4 | 0.4 | 40.1 | 0.4 | 15.3 |
| 2-Chloronaphthalene | ng/g | | 0.7 | <0.7 | 0.5 | <0.5 | 0.5 | <0.5 |
| 2-Methylnaphthalene | ng/g | | 1 | 22 | 0.9 | 35.4 | 1 | 15 |
| Acenaphthylene | ng/g | | 0.1 | 1.3 | 0.1 | 1.4 | 0.1 | 0.9 |
| Acenaphthene | ng/g | | 0.1 | 8.7 | 0.1 | 6.1 | 0.1 | 13.7 |
| Acridine | ng/g | | 0.2 | <0.2 | 0.2 | <0.2 | 0.1 | <0.1 |
| Anthracene | ng/g | | 0.2 | 0.4 | 0.7 | 1.3 | 0.2 | 0.4 |
| Benzo[a]Anthracene | ng/g | | 0.1 | 2.0 | 0.4 | 5.1 | 0.1 | 1.6 |
| Benzo[a]Pyrene | ng/g | | 0.1 | 1.0 | 0.1 | 1.2 | 0.1 | 1.4 |
| Benzo(b+j)fluoranthene | ng/g | | 0.1 | 1.4 | 0.1 | 2.1 | 0.1 | 0.7 |
| Benzo(e)pyrene | ng/g | | 0.1 | 4.2 | 0.1 | 4.1 | 0.1 | 3.5 |
| Benzo[g,h,i]Perylene | ng/g | | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 |
| Benzo[k]Fluoranthene | ng/g | | 0.1 | 1.0 | 0.1 | 1.9 | 0.1 | 0.5 |
| Chrysene | ng/g | | 0.1 | 1.8 | 0.3 | 20.4 | 0.1 | 1.1 |
| Dibenzo[a,h]Anthracene | ng/g | | 0.6 | <0.6 | 0.1 | <0.1 | 0.1 | <0.1 |
| Fluoroanthene | ng/g | | 0.1 | 7.0 | 0.1 | 9.1 | 0.1 | 3.2 |
| Fluorene | ng/g | | 0.4 | 1.5 | 0.6 | 1.9 | 0.3 | 1.6 |
| Indeno[1,2,3,c-d]Pyrene | ng/g | | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 |
| Naphthalene | ng/g | | 0.3 | 13.3 | 0.3 | 24.6 | 0.3 | 10.2 |
| Perylene | ng/g | | 0.1 | 1.0 | 0.1 | 1.1 | 0.1 | 1.4 |
| Phenanthrene | ng/g | | 0.2 | 3.3 | 0.5 | 6.2 | 0.1 | 3.1 |
| Pyrene | ng/g | | 0.1 | 4.0 | 0.1 | 3.8 | 0.1 | 2.1 |
| Quinoline | ng/g | | 0.1 | <0.1 | 0.1 | <0.1 | 0.1 | <0.1 |
| Lipid Content | % | | | 1.97 | | 0.35 | | 0.38 |

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# Certificate of Analysis

AGAT WORK ORDER: 18K421824

PROJECT: 11178792-02 Marystown Shipyard MSSP

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## PAHs in Tissue by HRMS (ng/g)

DATE RECEIVED: 2018-12-18

DATE REPORTED: 2018-12-31

| | | SAMPLE DESCRIPTION: | 18-MNMA-TIS12A | 18-MNMA-TIS14A | 18-MNMA-TIS-REF3A |
|---|---|---|---|---|---|
| | | SAMPLE TYPE: | Tissue | Tissue | Tissue |
| | | DATE SAMPLED: | 2018-12-14 | 2018-12-14 | 2018-12-13 |
| Surrogate | Unit | Acceptable Limits | 9796120 | 9796121 | 9796122 |
| 13C Naphthalene | % | 30-140 | 42 | 32 | 48 |
| 13C Acenaphthtylene | % | 30-140 | 94 | 117 | 85 |
| 13C Acenaphthene | % | 30-140 | 80 | 112 | 42 |
| 13C Fluorene | % | 30-140 | 45 | 48 | 39 |
| 13C Phenanthrene | % | 30-140 | 88 | 94 | 83 |
| 13C Anthracene | % | 30-140 | 79 | 87 | 75 |
| 13C Fluoroanthene | % | 30-140 | 31 | 41 | 35 |
| 13C Pyrene | % | 30-140 | 50 | 129 | 57 |
| 13C Benzo[a]Anthracene | % | 30-140 | 66 | 86 | 63 |
| 13C Chrysene | % | 30-140 | 100 | 110 | 89 |
| 13C Benzo[b]Fluoranthene | % | 30-140 | 36 | 43 | 41 |
| 13C Benzo[k]Fluoranthene | % | 30-140 | 63 | 77 | 63 |
| 13C Benzo[a]Pyrene | % | 30-140 | 63 | 88 | 48 |
| 13C Indeno[1,2,3,c-d]Pyrene | % | 30-140 | 41 | 78 | 58 |
| 13C Benzo[g,h,i]Perylene | % | 30-140 | 64 | 63 | 83 |
| 13C Dibenzo[a,h]Anthracene | % | 30-140 | 55 | 52 | 43 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

9796093-9796122 The results were corrected based on the surrogate percent recoveries.

Analysis performed at AGAT Montreal (unless marked by *)

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AGAT Laboratories

# Quality Assurance

CLIENT NAME: GHD LIMITED
AGAT WORK ORDER: 18K421824
PROJECT: 11178792-02 Marystown Shipyard MSSP
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

## Soil Analysis

| RPT Date: Dec 31, 2018 | | | DUPLICATE | | | | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | Method Blank | Measured Value | Acceptable Limits | | Recovery | Acceptable Limits | | Recovery | Acceptable Limits | |
| | | | | | | | | Lower | Upper | | Lower | Upper | | Lower | Upper |
| Metals in Tissue - As,Pb,Cu,Zn | | | | | | | | | | | | | | | |
| Arsenic | 9796122 | 9796122 | 2 | 3 | NA | < 2 | 90% | 70% | 130% | 106% | 70% | 130% | NA | 70% | 130% |
| Copper | 9796122 | 9796122 | <2 | <2 | NA | < 2 | 94% | 70% | 130% | 111% | 70% | 130% | NA | 70% | 130% |
| Lead | 9796122 | 9796122 | <0.4 | <0.4 | NA | < 0.4 | 94% | 70% | 130% | 113% | 70% | 130% | NA | 70% | 130% |
| Zinc | 9796122 | 9796122 | 9 | 11 | NA | < 5 | 90% | 70% | 130% | 112% | 70% | 130% | NA | 70% | 130% |
| Metals in Tissue | | | | | | | | | | | | | | | |
| Aluminum | 9796122 | 9796122 | <10 | <10 | NA | < 10 | 92% | 70% | 130% | 109% | 70% | 130% | NA | 70% | 130% |
| Antimony | 9796122 | 9796122 | <2 | <2 | NA | < 2 | 81% | 70% | 130% | 111% | 70% | 130% | NA | 70% | 130% |
| Arsenic | 9796122 | 9796122 | 2 | 3 | NA | < 2 | 90% | 70% | 130% | 106% | 70% | 130% | NA | 70% | 130% |
| Barium | 9796122 | 9796122 | <5 | <5 | NA | < 5 | 92% | 70% | 130% | 111% | 70% | 130% | NA | 70% | 130% |
| Beryllium | 9796122 | 9796122 | <2 | <2 | NA | < 2 | 100% | 70% | 130% | 113% | 70% | 130% | NA | 70% | 130% |
| Bismuth | 9796122 | 9796122 | <5 | <5 | NA | < 5 | 93% | 70% | 130% | 114% | 70% | 130% | NA | 70% | 130% |
| Boron | 9796122 | 9796122 | 4 | 6 | NA | < 2 | 93% | 70% | 130% | 114% | 70% | 130% | NA | 70% | 130% |
| Cadmium | 9796122 | 9796122 | 4.9 | 6.3 | 23.8% | < 0.3 | 90% | 70% | 130% | 110% | 70% | 130% | NA | 70% | 130% |
| Chromium | 9796122 | 9796122 | <2 | <2 | NA | < 2 | 82% | 70% | 130% | 102% | 70% | 130% | NA | 70% | 130% |
| Cobalt | 9796122 | 9796122 | <1 | <1 | NA | < 1 | 92% | 70% | 130% | 111% | 70% | 130% | NA | 70% | 130% |
| Copper | 9796122 | 9796122 | <2 | <2 | NA | < 2 | 94% | 70% | 130% | 115% | 70% | 130% | NA | 70% | 130% |
| Iron | 9796122 | 9796122 | <50 | 56 | NA | < 50 | 86% | 70% | 130% | 110% | 70% | 130% | NA | 70% | 130% |
| Lead | 9796122 | 9796122 | <0.4 | <0.4 | NA | < 0.4 | 94% | 70% | 130% | 113% | 70% | 130% | NA | 70% | 130% |
| Manganese | 9796122 | 9796122 | <2 | <2 | NA | < 2 | 89% | 70% | 130% | 111% | 70% | 130% | NA | 70% | 130% |
| Molybdenum | 9796122 | 9796122 | <2 | <2 | NA | < 2 | 89% | 70% | 130% | 112% | 70% | 130% | NA | 70% | 130% |
| Nickel | 9796122 | 9796122 | <2 | <2 | NA | < 2 | 91% | 70% | 130% | 114% | 70% | 130% | NA | 70% | 130% |
| Selenium | 9796122 | 9796122 | <1 | <1 | NA | < 1 | 89% | 70% | 130% | 113% | 70% | 130% | NA | 70% | 130% |
| Silver | 9796122 | 9796122 | <0.5 | <0.5 | NA | < 0.5 | 91% | 70% | 130% | 116% | 70% | 130% | NA | 70% | 130% |
| Strontium | 9796122 | 9796122 | 5 | 6 | NA | < 5 | 91% | 70% | 130% | 109% | 70% | 130% | NA | 70% | 130% |
| Thallium | 9796122 | 9796122 | <0.1 | <0.1 | NA | < 0.1 | 93% | 70% | 130% | 112% | 70% | 130% | NA | 70% | 130% |
| Tin | 9796122 | 9796122 | <2 | <2 | NA | < 2 | 91% | 70% | 130% | 107% | 70% | 130% | NA | 70% | 130% |
| Uranium | 9796122 | 9796122 | <0.1 | <0.1 | NA | < 0.1 | 91% | 70% | 130% | 113% | 70% | 130% | NA | 70% | 130% |
| Vanadium | 9796122 | 9796122 | 4 | 6 | NA | < 2 | 85% | 70% | 130% | 104% | 70% | 130% | NA | 70% | 130% |
| Zinc | 9796122 | 9796122 | 9 | 11 | NA | < 5 | 91% | 70% | 130% | 112% | 70% | 130% | NA | 70% | 130% |

Certified By: Jason Coughtrey

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02 Marystown Shipyard MSSP
SAMPLING SITE:

AGAT WORK ORDER: 18K421824
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Trace Organics Analysis

| RPT Date: Dec 31, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| Total Polychlorinated Biphenyls in Tissue | | | | | | | | | | | | | | | |
| PCB in Tissue, Total | 1 | 9796999 | < 0.5 | < 0.5 | NA | < 0.5 | 109% | 70% | 130% | 88% | 60% | 140% | NA | 60% | 140% |

Certified By: Kelly Hogue

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# Quality Assurance

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02 Marystown Shipyard MSSP
SAMPLING SITE:

AGAT WORK ORDER: 18K421824
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

## Ultra Trace Analysis

| RPT Date: Dec 31, 2018 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| PAHs in Tissue by HRMS (ng/g) | | | | | | | | | | | | | | | |
| 1,3-Dimethylnaphthalene | 1 | 9796108 | 22.3 | 24.7 | 10.2% | < 0.1 | 124% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| 1-Chloronaphthalene | 1 | 9796108 | < 0.6 | < 0.6 | NA | < 0.1 | 111% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| 1-Methylnaphthalene | 1 | 9796108 | 14.1 | 13.4 | 5.1% | < 0.1 | 92% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| 2,3,5-Trimethylnaphthalene | 1 | 9796108 | 1.7 | 1.5 | 12.5% | < 0.1 | 76% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| 2,6-Dimethylnaphthalene | 1 | 9796108 | 36.1 | 35.6 | 1.4% | < 0.1 | 86% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| 2-Chloronaphthalene | 1 | 9796108 | < 0.5 | < 0.5 | NA | < 0.1 | 123% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| 2-Methylnaphthalene | 1 | 9796108 | 26.5 | 24.1 | 9.5% | < 0.1 | 105% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Acenaphthylene | 1 | 9796108 | 1.3 | 1.5 | 14.3% | < 0.1 | 107% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Acenaphthene | 1 | 9796108 | 10.7 | 13.0 | 19.4% | < 0.1 | 100% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Acridine | 1 | 9796108 | < 0.1 | < 0.1 | NA | < 0.1 | 99% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Anthracene | 1 | 9796108 | 1.8 | 1.6 | 11.8% | < 0.1 | 89% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Benzo[a]Anthracene | 1 | 9796108 | 0.4 | 0.4 | 0.0% | < 0.1 | 110% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Benzo[a]Pyrene | 1 | 9796108 | 0.8 | 0.9 | 11.8% | < 0.1 | 85% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Benzo(b+j)fluoranthene | 1 | 9796108 | 0.6 | 0.6 | 0.0% | < 0.1 | 105% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Benzo(e)pyrene | 1 | 9796108 | 2.7 | 2.7 | 0.0% | < 0.1 | 91% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Benzo[g,h,i]Perylene | 1 | 9796108 | < 0.1 | < 0.1 | NA | < 0.1 | 92% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Benzo[k]Fluoranthene | 1 | 9796108 | 0.7 | 0.7 | 0.0% | < 0.1 | 103% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Chrysene | 1 | 9796108 | 0.4 | 0.4 | 0.0% | < 0.1 | 112% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Dibenzo[a,h]Anthracene | 1 | 9796108 | < 0.1 | < 0.1 | NA | < 0.1 | 97% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Fluoroanthene | 1 | 9796108 | 10.7 | 11.0 | 2.8% | < 0.1 | 124% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Fluorene | 1 | 9796108 | 1.8 | 1.9 | 5.4% | < 0.1 | 80% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Indeno[1,2,3,c-d]Pyrene | 1 | 9796108 | < 0.1 | < 0.1 | NA | < 0.1 | 116% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Naphthalene | 1 | 9796108 | 16.4 | 16.7 | 1.8% | < 0.1 | 81% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Perylene | 1 | 9796108 | < 0.1 | < 0.1 | NA | < 0.1 | 104% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Phenanthrene | 1 | 9796108 | 4.1 | 4.6 | 11.5% | < 0.1 | 88% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Pyrene | 1 | 9796108 | 7.4 | 7.1 | 4.1% | < 0.1 | 104% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |
| Quinoline | 1 | 9796108 | < 0.1 | < 0.1 | NA | < 0.1 | 104% | 70% | 130% | NA | 70% | 130% | NA | 70% | 130% |

Certified By:

57 Old Pennywell Road, Unit I
St. John's, NL
CANADA A1E 6A8
TEL (709)747-8573
FAX (709 747-2139
http://www.agatlabs.com

# Method Summary

CLIENT NAME: GHD LIMITED
PROJECT: 11178792-02 Marystown Shipyard MSSP
SAMPLING SITE:

AGAT WORK ORDER: 18K421824
ATTENTION TO: JAMES O'NEILL
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Soil Analysis | | | |
| Mercury in Tissue | MET-121-6101, MET-121-6107 | modified from EPA 245.6 | CV/AA |
| Aluminum | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Antimony | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Arsenic | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Barium | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Beryllium | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Bismuth | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP-MS |
| Boron | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Cadmium | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Chromium | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Cobalt | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Copper | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Iron | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Lead | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP-MS |
| Manganese | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Molybdenum | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Nickel | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Selenium | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Silver | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Strontium | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Thallium | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Tin | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Uranium | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Vanadium | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Zinc | MET-121-6105 & MET-121-6103 | modified from EPA 200.8 and EPA 3050 | ICP/MS |
| Trace Organics Analysis | | | |
| PCB in Tissue, Total | ORG-120-5117 | EPA SW-846 3510C & 8082A | GC/ECD |
| Decachlorobiphenyl | ORG-120-5106, ORG-120-5108 | EPA SW846 3510C/8080/8010, 8081A | GC/ECD |

AGAT Laboratories

57 Old Pennywell Road, Unit I
St. John's, NL
CANADA A1E 6A8
TEL (709)747-8573
FAX (709 747-2139
http://www.agatlabs.com

# Method Summary

CLIENT NAME: GHD LIMITED
AGAT WORK ORDER: 18K421824
PROJECT: 11178792-02 Marystown Shipyard MSSP
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Ultra Trace Analysis | | | |
| 1,3-Dimethylnaphthalene | HR-151-5403 | EPA 8270 | HRMS |
| 1-Chloronaphthalene | HR-151-5403 | EPA 8270 | HRMS |
| 1-Methylnaphthalene | HR-151-5403 | EPA 8270 | HRMS |
| 2,3,5-Trimethylnaphthalene | HR-151-5403 | EPA 8270 | HRMS |
| 2,6-Dimethylnaphthalene | HR-151-5403 | EPA 8270 | HRMS |
| 2-Chloronaphthalene | HR-151-5403 | EPA 8270 | HRMS |
| 2-Methylnaphthalene | HR-151-5403 | EPA 8270 | HRMS |
| Acenaphthylene | HR-151-5403 | EPA 8270 | HRMS |
| Acenaphthene | HR-151-5403 | /EPA 8270 | HRMS |
| Acridine | HR-151-5403 | EPA 8270 | HRMS |
| Anthracene | HR-151-5403 | EPA 8270 | HRMS |
| Benzo[a]Anthracene | HR-151-5403 | EPA 8270 | HRMS |
| Benzo[a]Pyrene | HR-151-5403 | EPA 8270 | HRMS |
| Benzo(b+j)fluoranthene | HR-151-5403 | EPA 8270 | HRMS |
| Benzo(e)pyrene | HR-151-5403 | EPA 8270 | HRMS |
| Benzo[g,h,i]Perylene | HR-151-5403 | EPA 8270 | HRMS |
| Benzo[k]Fluoranthene | HR-151-5403 | EPA 8270 | HRMS |
| Chrysene | HR-151-5403 | EPA 8270 | HRMS |
| Dibenzo[a,h]Anthracene | HR-151-5403 | EPA 8270 | HRMS |
| Fluoroanthene | HR-151-5403 | EPA 8270 | HRMS |
| Fluorene | HR-151-5403 | EPA 8270 | HRMS |
| Indeno[1,2,3,c-d]Pyrene | HR-151-5403 | EPA 8270 | HRMS |
| Naphthalene | HR-151-5403 | EPA 8270 | HRMS |
| Perylene | HR-151-5403 | EPA 8270 | HRMS |
| Phenanthrene | HR-151-5403 | EPA 8270 | HRMS |
| Pyrene | HR-151-5403 | EPA 8270 | HRMS |
| Quinoline | HR-151-5403 | EPA 8270 | HRMS |
| 13C Naphthalene | HR-151-5403 | EPA 8270 | HRMS |
| 13C Acenaphthtylene | HR-151-5403 | EPA 8270 | HRMS |
| 13C Acenaphthene | HR-151-5403 | EPA 8270 | HRMS |
| 13C Fluorene | HR-151-5403 | EPA 8270 | HRMS |
| 13C Phenanthrene | HR-151-5403 | EPA 8270 | HRMS |
| 13C Anthracene | HR-151-5403 | EPA 8270 | HRMS |
| 13C Fluoroanthene | HR-151-5403 | EPA 8270 | HRMS |
| 13C Pyrene | HR-151-5403 | EPA 8270 | HRMS |
| 13C Benzo[a]Anthracene | HR-151-5403 | EPA 8270 | HRMS |
| 13C Chrysene | HR-151-5403 | EPA 8270 | HRMS |
| 13C Benzo[b]Fluoranthene | HR-151-5403 | EPA 8270 | HRMS |
| 13C Benzo[k]Fluoranthene | HR-151-5403 | EPA 8270 | HRMS |
| 13C Benzo[a]Pyrene | HR-151-5403 | EPA 8270 | HRMS |
| 13C Indeno[1,2,3,c-d]Pyrene | HR-151-5403 | EPA 8270 | HRMS |
| 13C Benzo[g,h,i]Perylene | HR-151-5403 | EPA 8270 | HRMS |
| 13C Dibenzo[a,h]Anthracene | HR-151-5403 | EPA 8270 | HRMS |
| Lipid Content | HR-151-5400 | | HRMS |

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AGAT Laboratories

# Chain of Custody Record

**Laboratory Use Only**

Arrival Condition: ☐ Good ☐ Poor (see notes)

Arrival Temperature:

AGAT Job Number: 18K421824

Notes:

## Report Information

Company: GHD Limited

Contact: James O'Neill

Address: 1118 Topsail Road, St. John's NL A1B 3N7

Phone: 1-709-364-5353 Fax: 1-709-364-5368

IOL Site # and Name: Marystown Shipyard MSSP

Project #: 11178792-02

AGAT Quotation #: GHD 'Standing Offer'

GHD PO #: To Follow

## Report Information

1. Name: 
   Email: James O'Neill
2. Name: James.O'Neill@ghd.com
   Email: Troy Small & DataNL
   troy.small@ghd.com & datanl@ghd.com

## Report Format

☐ Single Sample per page

☑ Multiple Samples per page

☑ Excel Format Included

## Turnaround Time Required (TAT)

Regular TAT ☐ 5 to 7 working days

Rush TAT ☐ 1 day ☐ 2 days ☐ 3 days Rush 5 to 6 days

Date Required:

## Regulatory Requirements (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ PIRI

☐ Tier 1 ☐ Gas ☐ Pot ☐ Coarse

☐ Res ☐ Fuel ☐ N/Pot ☐ Fine

☐ Com ☐ Lube

☑ CCME ☐ CDWQ

☐ Industrial

☐ Commercial ☑ Other Tissue

☐ Res/Park

☐ Agricultural

☐ FWAL

☐ Sediment

Drinking Water Sample: ☐ Yes ☑ No

Reg. No.:

## Invoice To

Same Yes ☑ / No ☐

Company:

Contact:

Address:

Phone: Fax:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☑ Total ☐ Diss ☐ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: Arsenic, Copper, Lead, Zinc & | OTHER: Mercury | OTHER: Low Level PAHs (HRMS) | OTHER: Lipids | Remove/analyze tissue portion | Composite Samples | | HOLD for potential methyl mercury | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18-MNMA-TIS-COMP1 | 2018/12/13 08:45 | Tissue | Ziplok bag - Rock Crabs from S1, S2 and S4 | 3 | | | | | | | | | | ☑ | | ☑ | ☑ | ☑ | ☑ | ☑ | ☑ | | ☑ | | | | |
| 18-MNMA-TIS-COMP2 | 2018/12/13 10:04 | Tissue | Ziplok bag - Rock Crabs from S5, S6, S7, S8, S9 and S10 | 6 | | | | | | | | | | ☑ | | ☑ | ☑ | ☑ | ☑ | ☑ | ☑ | | ☑ | | | | |
| 18-MNMA-TIS-COMP3 | 2018/12/14 08:53 | Tissue | Ziplok bag - Rock Crabs from S12, S13, S14 and S15 | 4 | | | | | | | | | | ☑ | | ☑ | ☑ | ☑ | ☑ | ☑ | ☑ | | ☑ | | | | |
| 18-MNMA-TIS-COMP4 | 2018/12/13 11:03 | Tissue | Ziplok bag - Mussels from S8 and S9 | 2 | | | | | | | | | | ☑ | | ☑ | ☑ | ☑ | ☑ | | ☑ | | ☑ | | | | |
| 18-MNMA-TIS-REF1B | 2018/12/13 13:02 | Tissue | Ziplok bag - Rock Crab | 1 | | | | | | | | | | ☑ | | ☑ | ☑ | ☑ | ☑ | ☑ | | | ☑ | | | | |
| 18-MNMA-TIS-REF3B | 2018/12/13 14:00 | Tissue | Ziplok bag - Mussels | 1 | | | | | | | | | | ☑ | | ☑ | ☑ | ☑ | ☑ | | | | ☑ | | | | |

Samples Relinquished By (Print Name): INGRID LAWLOR Date/Time: Dec 18/18

Samples Relinquished By (Sign): [signature] Date/Time: 9:50

Samples Received By (Print Name): Date/Time:

Samples Received By (Sign): Date/Time:

Page 1 of 2

Unit 122 • 11 Morris Drive
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# AGAT Laboratories



## Chain of Custody Record

**Laboratory Use Only**

Arrival Condition: ☐ Good ☐ Poor (see notes)
Arrival Temperature: ______
AGAT Job Number: ______
Notes:

### Report Information

Company: GHD Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone: 1-709-364-5353 Fax: 1-709-364-5368
IOL Site # and Name: Marystown Shipyard MSSP
Project #: 11178792-02
AGAT Quotation #: GHD 'Standing Offer'
GHD PO #: To Follow

### Report Information

1. Name:
   Email: James O'Neill
2. Name: James.O'Neill@ghd.com
   Email: Troy Small & DataNL
   troy.small@ghd.com & datanl@ghd.com

### Report Format

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

### Turnaround Time Required (TAT)

Regular TAT ☐ 5 to 7 working days
Rush TAT ☐ 1 day ☐ 2 days ☐ 3 days
Rush 5 to 6 days
Date Required: ______

### Invoice To

Same Yes ☑ / No ☐
Company:
Contact:
Address:
Phone: Fax:

### Regulatory Requirements (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ PIRI
☐ Tier 1 ☐ Gas ☐ Pot ☐ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☐ Com ☐ Lube

☑ CCME ☐ CDWQ
☐ Industrial
☐ Commercial ☑ Other Tissue
☐ Res/Park
☐ Agricultural
☐ FWAL
☐ Sediment

Drinking Water Sample: ☐ Yes ☑ No
Reg. No.: ______

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☑ Total ☐ Diss ☐ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: Arsenic, Copper, Lead, Zinc & | OTHER: Mercury | OTHER: Low Level PAHs (HRMS) | OTHER: Lipids | | | | HOLD for potential methyl mercury | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18-MNMA-TIS1A | 2018/12/13 08:45 | Tissue | Ziplok bag - Scallops | 1 | | | | | | | | | | ☑ | | ☑ | ☑ | ☑ | ☑ | | | | ☑ | | | | |
| 18-MNMA-TIS3 | 2018/12/13 09:23 | Tissue | Ziplok bag - Scallops | 1 | | | | | | | | | | ☑ | | ☑ | ☑ | ☑ | ☑ | | | | ☑ | | | | |
| 18-MNMA-TIS5A | 2018/12/13 10:04 | Tissue | Ziplok bag - Scallops | 1 | | | | | | | | | | ☑ | | ☑ | ☑ | ☑ | ☑ | | | | ☑ | | | | |
| 18-MNMA-TIS6A | 2018/12/13 10:32 | Tissue | Ziplok bag - Scallops | 1 | | | | | | | | | | ☑ | | ☑ | ☑ | ☑ | ☑ | | | | ☑ | | | | |
| 18-MNMA-TIS10A | 2018/12/13 11:43 | Tissue | Ziplok bag - Scallops | 1 | | | | | | | | | | ☑ | | ☑ | ☑ | ☑ | ☑ | | | | ☑ | | | | |
| 18-MNMA-TIS11 | 2018/12/14 08:35 | Tissue | Ziplok bag - Scallops | 1 | | | | | | | | | | ☑ | | ☑ | ☑ | ☑ | ☑ | | | | ☑ | | | | |
| 18-MNMA-TIS12A | 2018/12/14 08:53 | Tissue | Ziplok bag - Scallops | 1 | | | | | | | | | | ☑ | | ☑ | ☑ | ☑ | ☑ | | | | ☑ | | | | |
| 18-MNMA-TIS14A | 2018/12/14 09:31 | Tissue | Ziplok bag - Scallops | 1 | | | | | | | | | | ☑ | | ☑ | ☑ | ☑ | ☑ | | | | ☑ | | | | |
| 18-MNMA-TIS-REF3A | 2018/12/13 14:00 | Tissue | Ziplok bag - Scallops | 1 | | | | | | | | | | ☑ | | ☑ | ☑ | ☑ | ☑ | | | | ☑ | | | | |

| Samples Relinquished By (Print Name): | Date/Time | Samples Received By (Print Name): | Date/Time |
|---|---|---|---|
| Ingrid Lawlor | Dec 18/18 | | |
| **Samples Relinquished By (Sign):** | **Date/Time** | **Samples Received By (Sign):** | **Date/Time** |
| [signature] | 9:50 | | |

Page 2 of 2

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
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FAX (902)468-8924
http://www.agatlabs.com

CLIENT NAME: GHD LIMITED
1118 TOPSAIL ROAD
ST. JOHN'S , NL A1B3N7
(709) 364-5353

ATTENTION TO: JAMES O'NEILL

PROJECT: Marystown Shipyard Waterlot 11178792-02

AGAT WORK ORDER: 19X426031

SOIL ANALYSIS REVIEWED BY: Jason Coughtrey, Inorganics Supervisor

DATE REPORTED: Jan 15, 2019

PAGES (INCLUDING COVER): 6

VERSION*: 1

Should you require any information regarding this analysis please contact your client services representative at (902) 468-8718

*NOTES

All samples will be disposed of within 30 days following analysis. Please contact the lab if you require additional sample storage time.

# Certificate of Analysis

AGAT WORK ORDER: 19X426031

PROJECT: Marystown Shipyard Waterlot 11178792-02

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
http://www.agatlabs.com

CLIENT NAME: GHD LIMITED

ATTENTION TO: JAMES O'NEILL

SAMPLING SITE:

SAMPLED BY:

## TCLP Leachable Metals - As,Cu,Pb,Se,Zn

DATE RECEIVED: 2019-01-08

DATE REPORTED: 2019-01-15

| | | | SAMPLE DESCRIPTION: | 18-MNMA-S1 | 18-MNMA-S9 | 18-MNMA-S12 | 18-MNMA-S14 | 18-MNMA-S15 |
|---|---|---|---|---|---|---|---|---|
| | | | SAMPLE TYPE: | Soil | Soil | Soil | Soil | Soil |
| | | | DATE SAMPLED: | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 | 2018-10-19 |
| Parameter | Unit | G / S | RDL | 9821580 | 9821594 | 9821595 | 9821596 | 9821597 |
| Arsenic Leachate | mg/L | | 0.02 | <0.02 | 0.03 | 0.02 | 0.02 | <0.02 |
| Copper Leachate | mg/L | | 0.02 | <0.02 | <0.02 | <0.02 | <0.02 | 0.03 |
| Lead Leachate | mg/L | | 0.005 | 0.085 | <0.005 | <0.005 | 0.026 | 0.122 |
| Selenium Leachate | mg/L | | 0.02 | <0.02 | <0.02 | <0.02 | <0.02 | <0.02 |
| Zinc Leachate | mg/L | | 0.02 | 1.76 | 0.61 | 0.05 | 6.25 | 7.38 |

Comments: RDL - Reported Detection Limit; G / S - Guideline / Standard

Analysis performed at AGAT Halifax (unless marked by *)

Certified By:

AGAT Laboratories

11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
http://www.agatlabs.com

# Quality Assurance

CLIENT NAME: GHD LIMITED

PROJECT: Marystown Shipyard Waterlot 11178792-02

SAMPLING SITE:

AGAT WORK ORDER: 19X426031

ATTENTION TO: JAMES O'NEILL

SAMPLED BY:

## Soil Analysis

| RPT Date: Jan 15, 2019 | | | DUPLICATE | | | Method Blank | REFERENCE MATERIAL | | | METHOD BLANK SPIKE | | | MATRIX SPIKE | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| PARAMETER | Batch | Sample Id | Dup #1 | Dup #2 | RPD | | Measured Value | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper | Recovery | Acceptable Limits Lower | Acceptable Limits Upper |
| TCLP Leachable Metals - As,Cu,Pb,Se,Zn | | | | | | | | | | | | | | | |
| Arsenic Leachate | 9821597 | 9821597 | <0.02 | <0.02 | NA | < 0.02 | 107% | 80% | 120% | 111% | 80% | 120% | 96% | 70% | 130% |
| Copper Leachate | 9821597 | 9821597 | 0.03 | 0.03 | NA | < 0.02 | 110% | 80% | 120% | 120% | 80% | 120% | 96% | 70% | 130% |
| Lead Leachate | 9821597 | 9821597 | 0.122 | 0.121 | 0.4% | < 0.005 | 113% | 80% | 120% | 115% | 80% | 120% | 95% | 70% | 130% |
| Selenium Leachate | 9821597 | 9821597 | <0.02 | <0.02 | NA | < 0.02 | 105% | 80% | 120% | 120% | 80% | 120% | 85% | 70% | 130% |
| Zinc Leachate | 9821597 | 9821597 | 7.38 | 6.74 | 9.1% | < 0.02 | 109% | 80% | 120% | 116% | 80% | 120% | 89% | 70% | 130% |

Certified By:

AGAT Laboratories
11 Morris Drive, Unit 122
Dartmouth, Nova Scotia
CANADA B3B 1M2
TEL (902)468-8718
FAX (902)468-8924
http://www.agatlabs.com

# Method Summary

CLIENT NAME: GHD LIMITED
AGAT WORK ORDER: 19X426031
PROJECT: Marystown Shipyard Waterlot 11178792-02
ATTENTION TO: JAMES O'NEILL
SAMPLING SITE:
SAMPLED BY:

| PARAMETER | AGAT S.O.P | LITERATURE REFERENCE | ANALYTICAL TECHNIQUE |
|---|---|---|---|
| Soil Analysis | | | |
| Arsenic Leachate | MET-121-6108, MET-121-6105 | EPA SW-846 6020A/SM1325 In-house leachate | ICP-MS |
| Copper Leachate | MET-121-6108, MET-121-6105 | EPA SW-846 6020A/SM1325 In-house leachate | ICP-MS |
| Lead Leachate | MET-121-6108, MET-121-6105 | EPA SW-846 6020A/SM1325 In-house leachate | ICP-MS |
| Selenium Leachate | MET-121-6108, MET-121-6105 | EPA SW-846 6020A/SM1325 In-house leachate | ICP-MS |
| Zinc Leachate | MET-121-6108, MET-121-6105 | EPA SW-846 6020A/SM1325 In-house leachate | ICP-MS |

Unit 122 • 11 Morris Drive
Dartmouth, NS
B3B 1M2
webearth.agatlabs.com • www.agatlabscom
P: 902.468.8718 • F: 902.468.8924

AGAT Laboratories

**Laboratory Use Only** 19X426031

Arrival Condition: ☑ Good ☐ Poor (see notes)

Arrival Temperature: 8.1 8.3 8.6

AGAT Job Number: 18K399949

Notes:

# Chain of Custody Record

## Report Information

Company: GHD Limited
Contact: James O'Neill
Address: 1118 Topsail Road
St. John's NL A1B 3N7
Phone: 1-709-364-5353 Fax: 1-709-364-5368
IOL Site # and Name: Marystown Shipyard Waterlot
Project #: 11178792-02
AGAT Quotation #: GHD 'Standing Offer"
GHD PO #: To Follow

## Report Information

1. Name:
Email: James O'Neill
2. Name: James.O'Neill@ghd.com
Email: DataNL
datanl@ghd.com

## Report Format

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

## Turnaround Time Required (TAT)

Regular TAT ☐ 5 to 7 working days
Rush TAT ☐ 1 day ☑ 2 days ☐ 3 days
Date Required:

CO RUSH!

## Invoice To

Same Yes ☑ / No ☐
Company:
Contact:
Address:
Phone: Fax:

## Regulatory Requirements (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ PIRI
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☑ CCME ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☑ Sediment

Drinking Water Sample: ☐ Yes ☑ No
Reg. No.:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS - SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OR CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: Silica Gel Clean-up | OTHER: Mercury | OTHER: | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18-MNMA-S1 | 2018/10/19 09:30 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-S2 | 2018/10/19 09:45 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-S3 | 2018/10/19 10:30 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-S4 | 2018/10/19 11:00 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-S5 | 2018/10/19 11:20 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-S6 | 2018/10/19 11:45 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-S7 | 2018/10/19 12:00 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-S8 | 2018/10/19 12:20 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-S9 | 2018/10/19 12:40 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-S10 | 2018/10/19 13:05 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |
| 18-MNMA-S11 | 2018/10/19 13:25 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | |

Samples Relinquished By (Print Name): Robert Perry
Date/Time: [illegible]/2018
Samples Relinquished By (Sign):
Date/Time: 15:00
Samples Received By (Print Name): Sam Murphy
Date/Time: 410pm
Samples Received By (Sign):
Date/Time: 10/22/18

Page 1 of 2

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**Laboratory Use Only** 19x426031
Arrival Condition: ☑ Good ☐ Poor (see notes)
Arrival Temperature: 8.1 8.3 8.6
AGAT Job Number: 18K399949
Notes:

# Chain of Custody Record

## Report Information

Company: GHD Limited
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Project #: 11178792-02
AGAT Quotation #: GHD 'Standing Offer"
GHD PO #: To Follow

## Report Information

1. Name:
Email: James O'Neill
2. Name: James.O'Neill@ghd.com
Email: DataNL
datanl@ghd.com

## Report Format

☐ Single Sample per page
☑ Multiple Samples per page
☑ Excel Format Included

## Turnaround Time Required (TAT)

Regular TAT ☐ 5 to 7 working days
Rush TAT ☐ 1 day ☑ 2 days
☐ 3 days
CO
RUSH!
Date Required:

## Invoice To

Same Yes ☑ / No ☐
Company:
Contact:
Address:
Phone: Fax:

## Regulatory Requirements (Check):

☐ List Guidelines on Report ☑ Do Not List Guidelines on Report

☐ PIRI
☑ Tier 1 ☐ Gas ☑ Pot ☑ Coarse
☐ Res ☐ Fuel ☐ N/Pot ☐ Fine
☑ Com ☐ Lube

☑ CCME ☐ CDWQ
☐ Industrial
☐ Commercial ☐ Other
☐ Res/Park
☐ Agricultural
☐ FWAL
☑ Sediment

Drinking Water Sample: ☐ Yes ☑ No
Reg. No.:

| SAMPLE IDENTIFICATION | DATE/TIME SAMPLED | SAMPLE MATRIX | COMMENTS – SITE/SAMPLE INFO, TYPE OF CONTAMINANT | NUMBER OF CONTAINERS | TPH/BTEX - ATLANTIC RBCA TIER 1 | TPH/BTEX - ATLANTIC RBCA TIER I - LOW LEVEL (POTABLE) | TPH/BTEX FRACTIONATION | MTBE (ADDED TO TPH/BTEX) | MTBE ONLY | METALS: ☐ Total ☐ Diss ☑ Available | FOC | PARTICLE SIZE (Sieve and Pipette) | PAHs | PCBs | TPH FRACTIONATION (Summa Canister) | OTHER: Silica Gel Clean-up | OTHER: Mercury | OTHER: | | | | | | | | HOLD FOR 1 YEAR (Y/N) | HAZARDOUS (Y/N) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18-MNMA-S12 | 2018/10/19 13:40 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-S13 | 2018/10/19 13:55 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-S14 | 2018/10/19 14:05 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-S15 | 2018/10/19 14:15 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-DUP1 | 2018/10/19 11:46 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-DUP2 | 2018/10/19 13:26 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-REF1 | 2018/10/19 14:30 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-REF2 | 2018/10/19 14:45 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |
| 18-MNMA-REF3 | 2018/10/19 15:00 | Sediment | 2 x250ml& 2 x40ml &2x120ml | 6 | ☑ | | | | | ☑ | ☑ | | ☑ | ☑ | | ☑ | ☑ | | | | | | | | | | |

Samples Relinquished By (Print Name): Robert Perry
Date/Time: 10/22/2018
Samples Received By (Print Name):
Date/Time
Samples Relinquished By (Sign):
Date/Time: 15:00
Samples Received By (Sign):
Date/Time

Page 2 of 2

# Appendix D
# Statistical Analyses and Supporting Data

| | | | |
|---|---|---|---|
| UCL Statistics for Data Sets with Non-Detects | | | |
| | | | |
| User Selected Options | | | |
| Date/Time of Computation | ProUCL 5.111/14/2018 3:06:31 PM | | |
| From File | WorkSheet_a.xls | | |
| Full Precision | OFF | | |
| Confidence Coefficient | 95% | | |
| Number of Bootstrap Operations | 2000 | | |
| | | | |
| F1 | | | |
| | | | |
| **General Statistics** | | | |
| Total Number of Observations | 37 | Number of Distinct Observations | 20 |
| Number of Detects | 19 | Number of Non-Detects | 18 |
| Number of Distinct Detects | 19 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | 27 | Minimum Non-Detect | 15 |
| Maximum Detect | 3910 | Maximum Non-Detect | 15 |
| Variance Detects | 1807141 | Percent Non-Detects | 48.65% |
| Mean Detects | 1065 | SD Detects | 1344 |
| Median Detects | 302 | CV Detects | 1.262 |
| Skewness Detects | 1.175 | Kurtosis Detects | -0.0337 |
| Mean of Logged Detects | 5.888 | SD of Logged Detects | 1.67 |
| | | | |
| **Normal GOF Test on Detects Only** | | | |
| Shapiro Wilk Test Statistic | 0.764 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.901 | Detected Data Not Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.274 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.197 | Detected Data Not Normal at 5% Significance Level | |
| **Detected Data Not Normal at 5% Significance Level** | | | |
| | | | |
| **Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs** | | | |
| KM Mean | 554.4 | KM Standard Error of Mean | 181.5 |
| KM SD | 1075 | 95% KM (BCA) UCL | 838.9 |
| 95% KM (t) UCL | 860.9 | 95% KM (Percentile Bootstrap) UCL | 871.4 |
| 95% KM (z) UCL | 853 | 95% KM Bootstrap t UCL | 991.5 |
| 90% KM Chebyshev UCL | 1099 | 95% KM Chebyshev UCL | 1346 |
| 97.5% KM Chebyshev UCL | 1688 | 99% KM Chebyshev UCL | 2360 |
| | | | |
| **Gamma GOF Tests on Detected Observations Only** | | | |
| A-D Test Statistic | 0.878 | **Anderson-Darling GOF Test** | |
| 5% A-D Critical Value | 0.796 | Detected Data Not Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.204 | **Kolmogorov-Smirnov GOF** | |
| 5% K-S Critical Value | 0.209 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data follow Appr. Gamma Distribution at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics on Detected Data Only** | | | |
| k hat (MLE) | 0.574 | k star (bias corrected MLE) | 0.518 |
| Theta hat (MLE) | 1856 | Theta star (bias corrected MLE) | 2055 |
| nu hat (MLE) | 21.81 | nu star (bias corrected) | 19.7 |
| Mean (detects) | 1065 | | |
| | | | |

| | | | |
|---|---|---|---|
| **Gamma ROS Statistics using Imputed Non-Detects** | | | |
| GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| This is especially true when the sample size is small. | | | |
| For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| Minimum | 0.01 | Mean | 547.1 |
| Maximum | 3910 | Median | 27 |
| SD | 1093 | CV | 1.998 |
| k hat (MLE) | 0.141 | k star (bias corrected MLE) | 0.147 |
| Theta hat (MLE) | 3894 | Theta star (bias corrected MLE) | 3719 |
| nu hat (MLE) | 10.4 | nu star (bias corrected) | 10.89 |
| Adjusted Level of Significance (β) | 0.0431 | | |
| Approximate Chi Square Value (10.89, α) | 4.504 | Adjusted Chi Square Value (10.89, β) | 4.326 |
| 95% Gamma Approximate UCL (use when n>=50) | 1323 | 95% Gamma Adjusted UCL (use when n<50) | 1377 |
| | | | |
| **Estimates of Gamma Parameters using KM Estimates** | | | |
| Mean (KM) | 554.4 | SD (KM) | 1075 |
| Variance (KM) | 1154822 | SE of Mean (KM) | 181.5 |
| k hat (KM) | 0.266 | k star (KM) | 0.263 |
| nu hat (KM) | 19.7 | nu star (KM) | 19.43 |
| theta hat (KM) | 2083 | theta star (KM) | 2111 |
| 80% gamma percentile (KM) | 818.8 | 90% gamma percentile (KM) | 1658 |
| 95% gamma percentile (KM) | 2644 | 99% gamma percentile (KM) | 5252 |
| | | | |
| **Gamma Kaplan-Meier (KM) Statistics** | | | |
| Approximate Chi Square Value (19.43, α) | 10.43 | Adjusted Chi Square Value (19.43, β) | 10.15 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 1033 | 95% Gamma Adjusted KM-UCL (use when n<50) | 1062 |
| | | | |
| **Lognormal GOF Test on Detected Observations Only** | | | |
| Shapiro Wilk Test Statistic | 0.91 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.901 | Detected Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.163 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.197 | Detected Data appear Lognormal at 5% Significance Level | |
| **Detected Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal ROS Statistics Using Imputed Non-Detects** | | | |
| Mean in Original Scale | 551.3 | Mean in Log Scale | 3.677 |
| SD in Original Scale | 1091 | SD in Log Scale | 2.802 |
| 95% t UCL (assumes normality of ROS data) | 854.1 | 95% Percentile Bootstrap UCL | 856.3 |
| 95% BCA Bootstrap UCL | 915.2 | 95% Bootstrap t UCL | 973.1 |
| 95% H-UCL (Log ROS) | 20173 | | |
| | | | |
| **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | |
| KM Mean (logged) | 4.341 | KM Geo Mean | 76.77 |
| KM SD (logged) | 1.97 | 95% Critical H Value (KM-Log) | 3.686 |
| KM Standard Error of Mean (logged) | 0.333 | 95% H-UCL (KM -Log) | 1795 |
| KM SD (logged) | 1.97 | 95% Critical H Value (KM-Log) | 3.686 |
| KM Standard Error of Mean (logged) | 0.333 | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 102 | DL/2 Statistics | | | | | | | | | | | |
| 103 | DL/2 Normal | | | | | | DL/2 Log-Transformed | | | | | |
| 104 | Mean in Original Scale | | | | | 550.8 | Mean in Log Scale | | | | | 4.004 |
| 105 | SD in Original Scale | | | | | 1091 | SD in Log Scale | | | | | 2.29 |
| 106 | 95% t UCL (Assumes normality) | | | | | 853.7 | 95% H-Stat UCL | | | | | 3696 |
| 107 | **DL/2 is not a recommended method, provided for comparisons and historical reasons** | | | | | | | | | | | |
| 108 | | | | | | | | | | | | |
| 109 | **Nonparametric Distribution Free UCL Statistics** | | | | | | | | | | | |
| 110 | **Detected Data appear Approximate Gamma Distributed at 5% Significance Level** | | | | | | | | | | | |
| 111 | | | | | | | | | | | | |
| 112 | **Suggested UCL to Use** | | | | | | | | | | | |
| 113 | Adjusted KM-UCL (use when k<=1 and 15 < n < 50 but k<=1) | | | | | 1062 | | | | | | |
| 114 | | | | | | | | | | | | |
| 115 | When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test | | | | | | | | | | | |
| 116 | When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL | | | | | | | | | | | |
| 117 | | | | | | | | | | | | |
| 118 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | | | | | | | | | |
| 119 | Recommendations are based upon data size, data distribution, and skewness. | | | | | | | | | | | |
| 120 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | | | | | | | | | |
| 121 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | | | | | | | | | |
| 122 | | | | | | | | | | | | |
| 123 | F2 | | | | | | | | | | | |
| 124 | | | | | | | | | | | | |
| 125 | **General Statistics** | | | | | | | | | | | |
| 126 | Total Number of Observations | | | | | 37 | Number of Distinct Observations | | | | | 30 |
| 127 | Number of Detects | | | | | 29 | Number of Non-Detects | | | | | 8 |
| 128 | Number of Distinct Detects | | | | | 29 | Number of Distinct Non-Detects | | | | | 1 |
| 129 | Minimum Detect | | | | | 21 | Minimum Non-Detect | | | | | 15 |
| 130 | Maximum Detect | | | | | 3940 | Maximum Non-Detect | | | | | 15 |
| 131 | Variance Detects | | | | | 1124905 | Percent Non-Detects | | | | | 21.62% |
| 132 | Mean Detects | | | | | 699.4 | SD Detects | | | | | 1061 |
| 133 | Median Detects | | | | | 183 | CV Detects | | | | | 1.516 |
| 134 | Skewness Detects | | | | | 1.947 | Kurtosis Detects | | | | | 3.225 |
| 135 | Mean of Logged Detects | | | | | 5.354 | SD of Logged Detects | | | | | 1.664 |
| 136 | | | | | | | | | | | | |
| 137 | **Normal GOF Test on Detects Only** | | | | | | | | | | | |
| 138 | Shapiro Wilk Test Statistic | | | | | 0.685 | **Shapiro Wilk GOF Test** | | | | | |
| 139 | 5% Shapiro Wilk Critical Value | | | | | 0.926 | Detected Data Not Normal at 5% Significance Level | | | | | |
| 140 | Lilliefors Test Statistic | | | | | 0.284 | **Lilliefors GOF Test** | | | | | |
| 141 | 5% Lilliefors Critical Value | | | | | 0.161 | Detected Data Not Normal at 5% Significance Level | | | | | |
| 142 | **Detected Data Not Normal at 5% Significance Level** | | | | | | | | | | | |
| 143 | | | | | | | | | | | | |
| 144 | **Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs** | | | | | | | | | | | |
| 145 | KM Mean | | | | | 551.5 | KM Standard Error of Mean | | | | | 161.4 |
| 146 | KM SD | | | | | 964.7 | 95% KM (BCA) UCL | | | | | 842.4 |
| 147 | 95% KM (t) UCL | | | | | 824 | 95% KM (Percentile Bootstrap) UCL | | | | | 828.9 |
| 148 | 95% KM (z) UCL | | | | | 816.9 | 95% KM Bootstrap t UCL | | | | | 933.1 |
| 149 | 90% KM Chebyshev UCL | | | | | 1036 | 95% KM Chebyshev UCL | | | | | 1255 |
| 150 | 97.5% KM Chebyshev UCL | | | | | 1559 | 99% KM Chebyshev UCL | | | | | 2157 |
| 151 | | | | | | | | | | | | |

| | | | | |
|---|---|---|---|---|
| 152 | **Gamma GOF Tests on Detected Observations Only** | | | |
| 153 | A-D Test Statistic | 1.146 | **Anderson-Darling GOF Test** | |
| 154 | 5% A-D Critical Value | 0.809 | Detected Data Not Gamma Distributed at 5% Significance Level | |
| 155 | K-S Test Statistic | 0.195 | **Kolmogorov-Smirnov GOF** | |
| 156 | 5% K-S Critical Value | 0.172 | Detected Data Not Gamma Distributed at 5% Significance Level | |
| 157 | **Detected Data Not Gamma Distributed at 5% Significance Level** | | | |
| 158 | | | | |
| 159 | **Gamma Statistics on Detected Data Only** | | | |
| 160 | k hat (MLE) | 0.527 | k star (bias corrected MLE) | 0.495 |
| 161 | Theta hat (MLE) | 1328 | Theta star (bias corrected MLE) | 1413 |
| 162 | nu hat (MLE) | 30.55 | nu star (bias corrected) | 28.72 |
| 163 | Mean (detects) | 699.4 | | |
| 164 | | | | |
| 165 | **Gamma ROS Statistics using Imputed Non-Detects** | | | |
| 166 | GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| 167 | GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| 168 | For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| 169 | This is especially true when the sample size is small. | | | |
| 170 | For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| 171 | Minimum | 0.01 | Mean | 548.2 |
| 172 | Maximum | 3940 | Median | 86 |
| 173 | SD | 979.9 | CV | 1.787 |
| 174 | k hat (MLE) | 0.232 | k star (bias corrected MLE) | 0.231 |
| 175 | Theta hat (MLE) | 2368 | Theta star (bias corrected MLE) | 2376 |
| 176 | nu hat (MLE) | 17.13 | nu star (bias corrected) | 17.08 |
| 177 | Adjusted Level of Significance (β) | 0.0431 | | |
| 178 | Approximate Chi Square Value (17.08, α) | 8.727 | Adjusted Chi Square Value (17.08, β) | 8.467 |
| 179 | 95% Gamma Approximate UCL (use when n>=50) | 1073 | 95% Gamma Adjusted UCL (use when n<50) | 1106 |
| 180 | | | | |
| 181 | **Estimates of Gamma Parameters using KM Estimates** | | | |
| 182 | Mean (KM) | 551.5 | SD (KM) | 964.7 |
| 183 | Variance (KM) | 930669 | SE of Mean (KM) | 161.4 |
| 184 | k hat (KM) | 0.327 | k star (KM) | 0.318 |
| 185 | nu hat (KM) | 24.18 | nu star (KM) | 23.55 |
| 186 | theta hat (KM) | 1688 | theta star (KM) | 1733 |
| 187 | 80% gamma percentile (KM) | 857.3 | 90% gamma percentile (KM) | 1614 |
| 188 | 95% gamma percentile (KM) | 2475 | 99% gamma percentile (KM) | 4695 |
| 189 | | | | |
| 190 | **Gamma Kaplan-Meier (KM) Statistics** | | | |
| 191 | Approximate Chi Square Value (23.55, α) | 13.51 | Adjusted Chi Square Value (23.55, β) | 13.18 |
| 192 | 95% Gamma Approximate KM-UCL (use when n>=50) | 961.5 | 95% Gamma Adjusted KM-UCL (use when n<50) | 985.6 |
| 193 | | | | |
| 194 | **Lognormal GOF Test on Detected Observations Only** | | | |
| 195 | Shapiro Wilk Test Statistic | 0.931 | **Shapiro Wilk GOF Test** | |
| 196 | 5% Shapiro Wilk Critical Value | 0.926 | Detected Data appear Lognormal at 5% Significance Level | |
| 197 | Lilliefors Test Statistic | 0.11 | **Lilliefors GOF Test** | |
| 198 | 5% Lilliefors Critical Value | 0.161 | Detected Data appear Lognormal at 5% Significance Level | |
| 199 | **Detected Data appear Lognormal at 5% Significance Level** | | | |
| 200 | | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 201 | **Lognormal ROS Statistics Using Imputed Non-Detects** | | | | | | | | | | | |
| 202 | | | | | Mean in Original Scale | 549.4 | | | | | Mean in Log Scale | 4.509 |
| 203 | | | | | SD in Original Scale | 979.2 | | | | | SD in Log Scale | 2.228 |
| 204 | | | | | 95% t UCL (assumes normality of ROS data) | 821.2 | | | | | 95% Percentile Bootstrap UCL | 832 |
| 205 | | | | | 95% BCA Bootstrap UCL | 865.4 | | | | | 95% Bootstrap t UCL | 937.4 |
| 206 | | | | | 95% H-UCL (Log ROS) | 4924 | | | | | | |
| 207 | | | | | | | | | | | | |
| 208 | **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | | | | | | | | | |
| 209 | | | | | KM Mean (logged) | 4.782 | | | | | KM Geo Mean | 119.3 |
| 210 | | | | | KM SD (logged) | 1.812 | | | | | 95% Critical H Value (KM-Log) | 3.456 |
| 211 | | | | | KM Standard Error of Mean (logged) | 0.303 | | | | | 95% H-UCL (KM -Log) | 1748 |
| 212 | | | | | KM SD (logged) | 1.812 | | | | | 95% Critical H Value (KM-Log) | 3.456 |
| 213 | | | | | KM Standard Error of Mean (logged) | 0.303 | | | | | | |
| 214 | | | | | | | | | | | | |
| 215 | **DL/2 Statistics** | | | | | | | | | | | |
| 216 | **DL/2 Normal** | | | | | | **DL/2 Log-Transformed** | | | | | |
| 217 | | | | | Mean in Original Scale | 549.8 | | | | | Mean in Log Scale | 4.632 |
| 218 | | | | | SD in Original Scale | 978.9 | | | | | SD in Log Scale | 2.024 |
| 219 | | | | | 95% t UCL (Assumes normality) | 821.5 | | | | | 95% H-Stat UCL | 2836 |
| 220 | **DL/2 is not a recommended method, provided for comparisons and historical reasons** | | | | | | | | | | | |
| 221 | | | | | | | | | | | | |
| 222 | **Nonparametric Distribution Free UCL Statistics** | | | | | | | | | | | |
| 223 | **Detected Data appear Lognormal Distributed at 5% Significance Level** | | | | | | | | | | | |
| 224 | | | | | | | | | | | | |
| 225 | **Suggested UCL to Use** | | | | | | | | | | | |
| 226 | | | | | 95% KM (Chebyshev) UCL | 1255 | | | | | | |
| 227 | | | | | | | | | | | | |
| 228 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | | | | | | | | | |
| 229 | Recommendations are based upon data size, data distribution, and skewness. | | | | | | | | | | | |
| 230 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | | | | | | | | | |
| 231 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | | | | | | | | | |
| 232 | | | | | | | | | | | | |

| Row | | | | |
|---|---|---|---|---|
| 1 | **UCL Statistics for Data Sets with Non-Detects** | | | |
| 2 | | | | |
| 3 | User Selected Options | | | |
| 4 | Date/Time of Computation | ProUCL 5.111/14/2018 2:36:06 PM | | |
| 5 | From File | WorkSheet.xls | | |
| 6 | Full Precision | OFF | | |
| 7 | Confidence Coefficient | 95% | | |
| 8 | Number of Bootstrap Operations | 2000 | | |
| 9 | | | | |
| 10 | | | | |
| 11 | **Aluminum** | | | |
| 12 | | | | |
| 13 | **General Statistics** | | | |
| 14 | Total Number of Observations | 17 | Number of Distinct Observations | 17 |
| 15 | | | Number of Missing Observations | 0 |
| 16 | Minimum | 4900 | Mean | 13460 |
| 17 | Maximum | 32000 | Median | 10800 |
| 18 | SD | 8416 | Std. Error of Mean | 2041 |
| 19 | Coefficient of Variation | 0.625 | Skewness | 1.342 |
| 20 | | | | |
| 21 | **Normal GOF Test** | | | |
| 22 | Shapiro Wilk Test Statistic | 0.825 | **Shapiro Wilk GOF Test** | |
| 23 | 5% Shapiro Wilk Critical Value | 0.892 | Data Not Normal at 5% Significance Level | |
| 24 | Lilliefors Test Statistic | 0.251 | **Lilliefors GOF Test** | |
| 25 | 5% Lilliefors Critical Value | 0.207 | Data Not Normal at 5% Significance Level | |
| 26 | **Data Not Normal at 5% Significance Level** | | | |
| 27 | | | | |
| 28 | **Assuming Normal Distribution** | | | |
| 29 | **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 30 | 95% Student's-t UCL | 17024 | 95% Adjusted-CLT UCL (Chen-1995) | 17528 |
| 31 | | | 95% Modified-t UCL (Johnson-1978) | 17134 |
| 32 | | | | |
| 33 | **Gamma GOF Test** | | | |
| 34 | A-D Test Statistic | 0.552 | **Anderson-Darling Gamma GOF Test** | |
| 35 | 5% A-D Critical Value | 0.745 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 36 | K-S Test Statistic | 0.19 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 37 | 5% K-S Critical Value | 0.21 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 38 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| 39 | | | | |
| 40 | **Gamma Statistics** | | | |
| 41 | k hat (MLE) | 3.309 | k star (bias corrected MLE) | 2.764 |
| 42 | Theta hat (MLE) | 4068 | Theta star (bias corrected MLE) | 4869 |
| 43 | nu hat (MLE) | 112.5 | nu star (bias corrected) | 93.99 |
| 44 | MLE Mean (bias corrected) | 13460 | MLE Sd (bias corrected) | 8096 |
| 45 | | | Approximate Chi Square Value (0.05) | 72.63 |
| 46 | Adjusted Level of Significance | 0.0346 | Adjusted Chi Square Value | 70.66 |
| 47 | | | | |
| 48 | **Assuming Gamma Distribution** | | | |
| 49 | 95% Approximate Gamma UCL (use when n>=50) | 17418 | 95% Adjusted Gamma UCL (use when n<50) | 17903 |
| 50 | | | | |

| | | | |
|---|---|---|---|
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.948 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.892 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.152 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.207 | Data appear Lognormal at 5% Significance Level | |
| **Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | 8.497 | Mean of logged Data | 9.349 |
| Maximum of Logged Data | 10.37 | SD of logged Data | 0.566 |
| | | | |
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 18149 | 90% Chebyshev (MVUE) UCL | 19053 |
| 95% Chebyshev (MVUE) UCL | 21642 | 97.5% Chebyshev (MVUE) UCL | 25237 |
| 99% Chebyshev (MVUE) UCL | 32297 | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| | | | |
| **Nonparametric Distribution Free UCLs** | | | |
| 95% CLT UCL | 16817 | 95% Jackknife UCL | 17024 |
| 95% Standard Bootstrap UCL | 16743 | 95% Bootstrap-t UCL | 18268 |
| 95% Hall's Bootstrap UCL | 18470 | 95% Percentile Bootstrap UCL | 16954 |
| 95% BCA Bootstrap UCL | 17377 | | |
| 90% Chebyshev(Mean, Sd) UCL | 19583 | 95% Chebyshev(Mean, Sd) UCL | 22357 |
| 97.5% Chebyshev(Mean, Sd) UCL | 26207 | 99% Chebyshev(Mean, Sd) UCL | 33769 |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% Adjusted Gamma UCL | 17903 | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| | | | |
| | | | |
| **Arsenic** | | | |
| | | | |
| **General Statistics** | | | |
| Total Number of Observations | 17 | Number of Distinct Observations | 11 |
| | | Number of Missing Observations | 0 |
| Minimum | 8 | Mean | 12.94 |
| Maximum | 23 | Median | 12 |
| SD | 4.145 | Std. Error of Mean | 1.005 |
| Coefficient of Variation | 0.32 | Skewness | 1.008 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.914 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.892 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.178 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.207 | Data appear Normal at 5% Significance Level | |
| **Data appear Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 14.7 | 95% Adjusted-CLT UCL (Chen-1995) | 14.86 |
| | | 95% Modified-t UCL (Johnson-1978) | 14.74 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.348 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.739 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.149 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.209 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 116 | **Gamma Statistics** | | | | | | | | | | | |
| 117 | | | | | k hat (MLE) | 11.39 | | | | | k star (bias corrected MLE) | 9.417 |
| 118 | | | | | Theta hat (MLE) | 1.136 | | | | | Theta star (bias corrected MLE) | 1.374 |
| 119 | | | | | nu hat (MLE) | 387.2 | | | | | nu star (bias corrected) | 320.2 |
| 120 | | | | | MLE Mean (bias corrected) | 12.94 | | | | | MLE Sd (bias corrected) | 4.217 |
| 121 | | | | | | | | | | | Approximate Chi Square Value (0.05) | 279.7 |
| 122 | | | | | Adjusted Level of Significance | 0.0346 | | | | | Adjusted Chi Square Value | 275.8 |
| 123 | | | | | | | | | | | | |
| 124 | **Assuming Gamma Distribution** | | | | | | | | | | | |
| 125 | | | | | 95% Approximate Gamma UCL (use when n>=50)) | 14.81 | | | | | 95% Adjusted Gamma UCL (use when n<50) | 15.03 |
| 126 | | | | | | | | | | | | |
| 127 | **Lognormal GOF Test** | | | | | | | | | | | |
| 128 | | | | | Shapiro Wilk Test Statistic | 0.959 | **Shapiro Wilk Lognormal GOF Test** | | | | | |
| 129 | | | | | 5% Shapiro Wilk Critical Value | 0.892 | Data appear Lognormal at 5% Significance Level | | | | | |
| 130 | | | | | Lilliefors Test Statistic | 0.129 | **Lilliefors Lognormal GOF Test** | | | | | |
| 131 | | | | | 5% Lilliefors Critical Value | 0.207 | Data appear Lognormal at 5% Significance Level | | | | | |
| 132 | **Data appear Lognormal at 5% Significance Level** | | | | | | | | | | | |
| 133 | | | | | | | | | | | | |
| 134 | **Lognormal Statistics** | | | | | | | | | | | |
| 135 | | | | | Minimum of Logged Data | 2.079 | | | | | Mean of logged Data | 2.516 |
| 136 | | | | | Maximum of Logged Data | 3.135 | | | | | SD of logged Data | 0.303 |
| 137 | | | | | | | | | | | | |
| 138 | **Assuming Lognormal Distribution** | | | | | | | | | | | |
| 139 | | | | | 95% H-UCL | 14.92 | | | | | 90% Chebyshev (MVUE) UCL | 15.81 |
| 140 | | | | | 95% Chebyshev (MVUE) UCL | 17.12 | | | | | 97.5% Chebyshev (MVUE) UCL | 18.93 |
| 141 | | | | | 99% Chebyshev (MVUE) UCL | 22.5 | | | | | | |
| 142 | | | | | | | | | | | | |
| 143 | **Nonparametric Distribution Free UCL Statistics** | | | | | | | | | | | |
| 144 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | | | | | | | | | |
| 145 | | | | | | | | | | | | |
| 146 | **Nonparametric Distribution Free UCLs** | | | | | | | | | | | |
| 147 | | | | | 95% CLT UCL | 14.59 | | | | | 95% Jackknife UCL | 14.7 |
| 148 | | | | | 95% Standard Bootstrap UCL | 14.53 | | | | | 95% Bootstrap-t UCL | 15.11 |
| 149 | | | | | 95% Hall's Bootstrap UCL | 15.16 | | | | | 95% Percentile Bootstrap UCL | 14.53 |
| 150 | | | | | 95% BCA Bootstrap UCL | 14.88 | | | | | | |
| 151 | | | | | 90% Chebyshev(Mean, Sd) UCL | 15.96 | | | | | 95% Chebyshev(Mean, Sd) UCL | 17.32 |
| 152 | | | | | 97.5% Chebyshev(Mean, Sd) UCL | 19.22 | | | | | 99% Chebyshev(Mean, Sd) UCL | 22.94 |
| 153 | | | | | | | | | | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 154 | **Suggested UCL to Use** | | | | | | | | | | | |
| 155 | | | | | 95% Student's-t UCL | 14.7 | | | | | | |
| 156 | | | | | | | | | | | | |
| 157 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | | | | | | | | | |
| 158 | Recommendations are based upon data size, data distribution, and skewness. | | | | | | | | | | | |
| 159 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | | | | | | | | | |
| 160 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | | | | | | | | | |
| 161 | | | | | | | | | | | | |
| 162 | | | | | | | | | | | | |
| 163 | **Barium** | | | | | | | | | | | |
| 164 | | | | | | | | | | | | |
| 165 | **General Statistics** | | | | | | | | | | | |
| 166 | | | | | Total Number of Observations | 17 | | | | | Number of Distinct Observations | 17 |
| 167 | | | | | | | | | | | Number of Missing Observations | 0 |
| 168 | | | | | Minimum | 34 | | | | | Mean | 105.2 |
| 169 | | | | | Maximum | 343 | | | | | Median | 75 |
| 170 | | | | | SD | 86.77 | | | | | Std. Error of Mean | 21.04 |
| 171 | | | | | Coefficient of Variation | 0.825 | | | | | Skewness | 1.685 |
| 172 | | | | | | | | | | | | |
| 173 | **Normal GOF Test** | | | | | | | | | | | |
| 174 | | | | | Shapiro Wilk Test Statistic | 0.783 | **Shapiro Wilk GOF Test** | | | | | |
| 175 | | | | | 5% Shapiro Wilk Critical Value | 0.892 | Data Not Normal at 5% Significance Level | | | | | |
| 176 | | | | | Lilliefors Test Statistic | 0.266 | **Lilliefors GOF Test** | | | | | |
| 177 | | | | | 5% Lilliefors Critical Value | 0.207 | Data Not Normal at 5% Significance Level | | | | | |
| 178 | **Data Not Normal at 5% Significance Level** | | | | | | | | | | | |
| 179 | | | | | | | | | | | | |
| 180 | **Assuming Normal Distribution** | | | | | | | | | | | |
| 181 | **95% Normal UCL** | | | | | | **95% UCLs (Adjusted for Skewness)** | | | | | |
| 182 | | | | | 95% Student's-t UCL | 142 | | | | | 95% Adjusted-CLT UCL (Chen-1995) | 149 |
| 183 | | | | | | | | | | | 95% Modified-t UCL (Johnson-1978) | 143.4 |
| 184 | | | | | | | | | | | | |
| 185 | **Gamma GOF Test** | | | | | | | | | | | |
| 186 | | | | | A-D Test Statistic | 0.715 | **Anderson-Darling Gamma GOF Test** | | | | | |
| 187 | | | | | 5% A-D Critical Value | 0.749 | Detected data appear Gamma Distributed at 5% Significance Level | | | | | |
| 188 | | | | | K-S Test Statistic | 0.211 | **Kolmogorov-Smirnov Gamma GOF Test** | | | | | |
| 189 | | | | | 5% K-S Critical Value | 0.212 | Detected data appear Gamma Distributed at 5% Significance Level | | | | | |
| 190 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | | | | | | | | | |
| 191 | | | | | | | | | | | | |
| 192 | **Gamma Statistics** | | | | | | | | | | | |
| 193 | | | | | k hat (MLE) | 2.11 | | | | | k star (bias corrected MLE) | 1.777 |
| 194 | | | | | Theta hat (MLE) | 49.87 | | | | | Theta star (bias corrected MLE) | 59.21 |
| 195 | | | | | nu hat (MLE) | 71.75 | | | | | nu star (bias corrected) | 60.42 |
| 196 | | | | | MLE Mean (bias corrected) | 105.2 | | | | | MLE Sd (bias corrected) | 78.94 |
| 197 | | | | | | | | | | | Approximate Chi Square Value (0.05) | 43.55 |
| 198 | | | | | Adjusted Level of Significance | 0.0346 | | | | | Adjusted Chi Square Value | 42.05 |
| 199 | | | | | | | | | | | | |
| 200 | **Assuming Gamma Distribution** | | | | | | | | | | | |
| 201 | | | | | 95% Approximate Gamma UCL (use when n>=50) | 146 | | | | | 95% Adjusted Gamma UCL (use when n<50) | 151.2 |
| 202 | | | | | | | | | | | | |

| | | | |
|---|---|---|---|
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.931 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.892 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.165 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.207 | Data appear Lognormal at 5% Significance Level | |
| **Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | 3.526 | Mean of logged Data | 4.401 |
| Maximum of Logged Data | 5.838 | SD of logged Data | 0.703 |
| | | | |
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 155.4 | 90% Chebyshev (MVUE) UCL | 158.3 |
| 95% Chebyshev (MVUE) UCL | 183.5 | 97.5% Chebyshev (MVUE) UCL | 218.5 |
| 99% Chebyshev (MVUE) UCL | 287.3 | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| | | | |
| **Nonparametric Distribution Free UCLs** | | | |
| 95% CLT UCL | 139.9 | 95% Jackknife UCL | 142 |
| 95% Standard Bootstrap UCL | 138.5 | 95% Bootstrap-t UCL | 166.7 |
| 95% Hall's Bootstrap UCL | 154.9 | 95% Percentile Bootstrap UCL | 140.2 |
| 95% BCA Bootstrap UCL | 146.9 | | |
| 90% Chebyshev(Mean, Sd) UCL | 168.4 | 95% Chebyshev(Mean, Sd) UCL | 197 |
| 97.5% Chebyshev(Mean, Sd) UCL | 236.7 | 99% Chebyshev(Mean, Sd) UCL | 314.6 |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% Adjusted Gamma UCL | 151.2 | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| | | | |
| | | | |
| **Chromium** | | | |
| | | | |
| **General Statistics** | | | |
| Total Number of Observations | 17 | Number of Distinct Observations | 15 |
| | | Number of Missing Observations | 0 |
| Minimum | 9 | Mean | 34.47 |
| Maximum | 107 | Median | 21 |
| SD | 27.96 | Std. Error of Mean | 6.782 |
| Coefficient of Variation | 0.811 | Skewness | 1.637 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.791 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.892 | Data Not Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.229 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.207 | Data Not Normal at 5% Significance Level | |
| **Data Not Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 46.31 | 95% Adjusted-CLT UCL (Chen-1995) | 48.5 |
| | | 95% Modified-t UCL (Johnson-1978) | 46.76 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.64 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.749 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.195 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.212 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 268 | Gamma Statistics | | | | | | | | | | | |
| 269 | | | | | k hat (MLE) | 2.125 | | | | | k star (bias corrected MLE) | 1.789 |
| 270 | | | | | Theta hat (MLE) | 16.22 | | | | | Theta star (bias corrected MLE) | 19.27 |
| 271 | | | | | nu hat (MLE) | 72.25 | | | | | nu star (bias corrected) | 60.83 |
| 272 | | | | | MLE Mean (bias corrected) | 34.47 | | | | | MLE Sd (bias corrected) | 25.77 |
| 273 | | | | | | | | | | | Approximate Chi Square Value (0.05) | 43.9 |
| 274 | | | | | Adjusted Level of Significance | 0.0346 | | | | | Adjusted Chi Square Value | 42.39 |
| 275 | | | | | | | | | | | | |
| 276 | Assuming Gamma Distribution | | | | | | | | | | | |
| 277 | | | | | 95% Approximate Gamma UCL (use when n>=50) | 47.77 | | | | | 95% Adjusted Gamma UCL (use when n<50) | 49.47 |
| 278 | | | | | | | | | | | | |
| 279 | Lognormal GOF Test | | | | | | | | | | | |
| 280 | | | | | Shapiro Wilk Test Statistic | 0.947 | Shapiro Wilk Lognormal GOF Test | | | | | |
| 281 | | | | | 5% Shapiro Wilk Critical Value | 0.892 | Data appear Lognormal at 5% Significance Level | | | | | |
| 282 | | | | | Lilliefors Test Statistic | 0.163 | Lilliefors Lognormal GOF Test | | | | | |
| 283 | | | | | 5% Lilliefors Critical Value | 0.207 | Data appear Lognormal at 5% Significance Level | | | | | |
| 284 | Data appear Lognormal at 5% Significance Level | | | | | | | | | | | |
| 285 | | | | | | | | | | | | |
| 286 | Lognormal Statistics | | | | | | | | | | | |
| 287 | | | | | Minimum of Logged Data | 2.197 | | | | | Mean of logged Data | 3.287 |
| 288 | | | | | Maximum of Logged Data | 4.673 | | | | | SD of logged Data | 0.709 |
| 289 | | | | | | | | | | | | |
| 290 | Assuming Lognormal Distribution | | | | | | | | | | | |
| 291 | | | | | 95% H-UCL | 51.39 | | | | | 90% Chebyshev (MVUE) UCL | 52.27 |
| 292 | | | | | 95% Chebyshev (MVUE) UCL | 60.64 | | | | | 97.5% Chebyshev (MVUE) UCL | 72.26 |
| 293 | | | | | 99% Chebyshev (MVUE) UCL | 95.09 | | | | | | |
| 294 | | | | | | | | | | | | |
| 295 | Nonparametric Distribution Free UCL Statistics | | | | | | | | | | | |
| 296 | Data appear to follow a Discernible Distribution at 5% Significance Level | | | | | | | | | | | |
| 297 | | | | | | | | | | | | |
| 298 | Nonparametric Distribution Free UCLs | | | | | | | | | | | |
| 299 | | | | | 95% CLT UCL | 45.63 | | | | | 95% Jackknife UCL | 46.31 |
| 300 | | | | | 95% Standard Bootstrap UCL | 45.67 | | | | | 95% Bootstrap-t UCL | 51 |
| 301 | | | | | 95% Hall's Bootstrap UCL | 53.36 | | | | | 95% Percentile Bootstrap UCL | 46 |
| 302 | | | | | 95% BCA Bootstrap UCL | 48.71 | | | | | | |
| 303 | | | | | 90% Chebyshev(Mean, Sd) UCL | 54.82 | | | | | 95% Chebyshev(Mean, Sd) UCL | 64.03 |
| 304 | | | | | 97.5% Chebyshev(Mean, Sd) UCL | 76.83 | | | | | 99% Chebyshev(Mean, Sd) UCL | 102 |
| 305 | | | | | | | | | | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 306 | Suggested UCL to Use | | | |
| 307 | 95% Adjusted Gamma UCL | 49.47 | | |
| 308 | | | | |
| 309 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 310 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 311 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 312 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 313 | | | | |
| 314 | | | | |
| 315 | **Cobalt** | | | |
| 316 | | | | |
| 317 | **General Statistics** | | | |
| 318 | Total Number of Observations | 17 | Number of Distinct Observations | 13 |
| 319 | | | Number of Missing Observations | 0 |
| 320 | Minimum | 6 | Mean | 16.29 |
| 321 | Maximum | 34 | Median | 15 |
| 322 | SD | 8.571 | Std. Error of Mean | 2.079 |
| 323 | Coefficient of Variation | 0.526 | Skewness | 0.912 |
| 324 | | | | |
| 325 | **Normal GOF Test** | | | |
| 326 | Shapiro Wilk Test Statistic | 0.888 | **Shapiro Wilk GOF Test** | |
| 327 | 5% Shapiro Wilk Critical Value | 0.892 | Data Not Normal at 5% Significance Level | |
| 328 | Lilliefors Test Statistic | 0.186 | **Lilliefors GOF Test** | |
| 329 | 5% Lilliefors Critical Value | 0.207 | Data appear Normal at 5% Significance Level | |
| 330 | **Data appear Approximate Normal at 5% Significance Level** | | | |
| 331 | | | | |
| 332 | **Assuming Normal Distribution** | | | |
| 333 | **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 334 | 95% Student's-t UCL | 19.92 | 95% Adjusted-CLT UCL (Chen-1995) | 20.21 |
| 335 | | | 95% Modified-t UCL (Johnson-1978) | 20 |
| 336 | | | | |
| 337 | **Gamma GOF Test** | | | |
| 338 | A-D Test Statistic | 0.38 | **Anderson-Darling Gamma GOF Test** | |
| 339 | 5% A-D Critical Value | 0.743 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 340 | K-S Test Statistic | 0.132 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 341 | 5% K-S Critical Value | 0.21 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 342 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| 343 | | | | |
| 344 | **Gamma Statistics** | | | |
| 345 | k hat (MLE) | 4.162 | k star (bias corrected MLE) | 3.466 |
| 346 | Theta hat (MLE) | 3.915 | Theta star (bias corrected MLE) | 4.7 |
| 347 | nu hat (MLE) | 141.5 | nu star (bias corrected) | 117.9 |
| 348 | MLE Mean (bias corrected) | 16.29 | MLE Sd (bias corrected) | 8.752 |
| 349 | | | Approximate Chi Square Value (0.05) | 93.79 |
| 350 | Adjusted Level of Significance | 0.0346 | Adjusted Chi Square Value | 91.54 |
| 351 | | | | |
| 352 | **Assuming Gamma Distribution** | | | |
| 353 | 95% Approximate Gamma UCL (use when n>=50)) | 20.48 | 95% Adjusted Gamma UCL (use when n<50) | 20.98 |
| 354 | | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 355 | **Lognormal GOF Test** | | | |
| 356 | Shapiro Wilk Test Statistic | 0.962 | **Shapiro Wilk Lognormal GOF Test** | |
| 357 | 5% Shapiro Wilk Critical Value | 0.892 | Data appear Lognormal at 5% Significance Level | |
| 358 | Lilliefors Test Statistic | 0.11 | **Lilliefors Lognormal GOF Test** | |
| 359 | 5% Lilliefors Critical Value | 0.207 | Data appear Lognormal at 5% Significance Level | |
| 360 | **Data appear Lognormal at 5% Significance Level** | | | |
| 361 | | | | |
| 362 | **Lognormal Statistics** | | | |
| 363 | Minimum of Logged Data | 1.792 | Mean of logged Data | 2.666 |
| 364 | Maximum of Logged Data | 3.526 | SD of logged Data | 0.515 |
| 365 | | | | |
| 366 | **Assuming Lognormal Distribution** | | | |
| 367 | 95% H-UCL | 21.37 | 90% Chebyshev (MVUE) UCL | 22.58 |
| 368 | 95% Chebyshev (MVUE) UCL | 25.44 | 97.5% Chebyshev (MVUE) UCL | 29.41 |
| 369 | 99% Chebyshev (MVUE) UCL | 37.19 | | |
| 370 | | | | |
| 371 | **Nonparametric Distribution Free UCL Statistics** | | | |
| 372 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| 373 | | | | |
| 374 | **Nonparametric Distribution Free UCLs** | | | |
| 375 | 95% CLT UCL | 19.71 | 95% Jackknife UCL | 19.92 |
| 376 | 95% Standard Bootstrap UCL | 19.63 | 95% Bootstrap-t UCL | 20.84 |
| 377 | 95% Hall's Bootstrap UCL | 19.81 | 95% Percentile Bootstrap UCL | 19.88 |
| 378 | 95% BCA Bootstrap UCL | 20.06 | | |
| 379 | 90% Chebyshev(Mean, Sd) UCL | 22.53 | 95% Chebyshev(Mean, Sd) UCL | 25.36 |
| 380 | 97.5% Chebyshev(Mean, Sd) UCL | 29.28 | 99% Chebyshev(Mean, Sd) UCL | 36.98 |
| 381 | | | | |
| 382 | **Suggested UCL to Use** | | | |
| 383 | 95% Student's-t UCL | 19.92 | | |
| 384 | | | | |
| 385 | When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test | | | |
| 386 | When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL | | | |
| 387 | | | | |
| 388 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 389 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 390 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 391 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 392 | | | | |
| 393 | | | | |
| 394 | **Copper** | | | |
| 395 | | | | |
| 396 | **General Statistics** | | | |
| 397 | Total Number of Observations | 17 | Number of Distinct Observations | 15 |
| 398 | | | Number of Missing Observations | 0 |
| 399 | Minimum | 13 | Mean | 44.71 |
| 400 | Maximum | 87 | Median | 40 |
| 401 | SD | 26.51 | Std. Error of Mean | 6.429 |
| 402 | Coefficient of Variation | 0.593 | Skewness | 0.156 |
| 403 | | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 404 | **Normal GOF Test** | | | | | | | | | | | |
| 405 | | | | | Shapiro Wilk Test Statistic | 0.881 | **Shapiro Wilk GOF Test** | | | | | |
| 406 | | | | | 5% Shapiro Wilk Critical Value | 0.892 | Data Not Normal at 5% Significance Level | | | | | |
| 407 | | | | | Lilliefors Test Statistic | 0.183 | **Lilliefors GOF Test** | | | | | |
| 408 | | | | | 5% Lilliefors Critical Value | 0.207 | Data appear Normal at 5% Significance Level | | | | | |
| 409 | **Data appear Approximate Normal at 5% Significance Level** | | | | | | | | | | | |
| 410 | | | | | | | | | | | | |
| 411 | **Assuming Normal Distribution** | | | | | | | | | | | |
| 412 | **95% Normal UCL** | | | | | | **95% UCLs (Adjusted for Skewness)** | | | | | |
| 413 | | | | | 95% Student's-t UCL | 55.93 | | | | | 95% Adjusted-CLT UCL (Chen-1995) | 55.54 |
| 414 | | | | | | | | | | | 95% Modified-t UCL (Johnson-1978) | 55.97 |
| 415 | | | | | | | | | | | | |
| 416 | **Gamma GOF Test** | | | | | | | | | | | |
| 417 | | | | | A-D Test Statistic | 0.821 | **Anderson-Darling Gamma GOF Test** | | | | | |
| 418 | | | | | 5% A-D Critical Value | 0.747 | Data Not Gamma Distributed at 5% Significance Level | | | | | |
| 419 | | | | | K-S Test Statistic | 0.197 | **Kolmogorov-Smirnov Gamma GOF Test** | | | | | |
| 420 | | | | | 5% K-S Critical Value | 0.211 | Detected data appear Gamma Distributed at 5% Significance Level | | | | | |
| 421 | **Detected data follow Appr. Gamma Distribution at 5% Significance Level** | | | | | | | | | | | |
| 422 | | | | | | | | | | | | |
| 423 | **Gamma Statistics** | | | | | | | | | | | |
| 424 | | | | | k hat (MLE) | 2.598 | | | | | k star (bias corrected MLE) | 2.179 |
| 425 | | | | | Theta hat (MLE) | 17.21 | | | | | Theta star (bias corrected MLE) | 20.52 |
| 426 | | | | | nu hat (MLE) | 88.33 | | | | | nu star (bias corrected) | 74.08 |
| 427 | | | | | MLE Mean (bias corrected) | 44.71 | | | | | MLE Sd (bias corrected) | 30.29 |
| 428 | | | | | | | | | | | Approximate Chi Square Value (0.05) | 55.26 |
| 429 | | | | | Adjusted Level of Significance | 0.0346 | | | | | Adjusted Chi Square Value | 53.55 |
| 430 | | | | | | | | | | | | |
| 431 | **Assuming Gamma Distribution** | | | | | | | | | | | |
| 432 | | | | | 95% Approximate Gamma UCL (use when n>=50)) | 59.93 | | | | | 95% Adjusted Gamma UCL (use when n<50) | 61.84 |
| 433 | | | | | | | | | | | | |
| 434 | **Lognormal GOF Test** | | | | | | | | | | | |
| 435 | | | | | Shapiro Wilk Test Statistic | 0.88 | **Shapiro Wilk Lognormal GOF Test** | | | | | |
| 436 | | | | | 5% Shapiro Wilk Critical Value | 0.892 | Data Not Lognormal at 5% Significance Level | | | | | |
| 437 | | | | | Lilliefors Test Statistic | 0.197 | **Lilliefors Lognormal GOF Test** | | | | | |
| 438 | | | | | 5% Lilliefors Critical Value | 0.207 | Data appear Lognormal at 5% Significance Level | | | | | |
| 439 | **Data appear Approximate Lognormal at 5% Significance Level** | | | | | | | | | | | |
| 440 | | | | | | | | | | | | |
| 441 | **Lognormal Statistics** | | | | | | | | | | | |
| 442 | | | | | Minimum of Logged Data | 2.565 | | | | | Mean of logged Data | 3.595 |
| 443 | | | | | Maximum of Logged Data | 4.466 | | | | | SD of logged Data | 0.694 |
| 444 | | | | | | | | | | | | |
| 445 | **Assuming Lognormal Distribution** | | | | | | | | | | | |
| 446 | | | | | 95% H-UCL | 68.52 | | | | | 90% Chebyshev (MVUE) UCL | 69.96 |
| 447 | | | | | 95% Chebyshev (MVUE) UCL | 81.01 | | | | | 97.5% Chebyshev (MVUE) UCL | 96.34 |
| 448 | | | | | 99% Chebyshev (MVUE) UCL | 126.5 | | | | | | |
| 449 | | | | | | | | | | | | |
| 450 | **Nonparametric Distribution Free UCL Statistics** | | | | | | | | | | | |
| 451 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | | | | | | | | | |
| 452 | | | | | | | | | | | | |

| | | | |
|---|---|---|---|
| **Nonparametric Distribution Free UCLs** | | | |
| 95% CLT UCL | 55.28 | 95% Jackknife UCL | 55.93 |
| 95% Standard Bootstrap UCL | 54.75 | 95% Bootstrap-t UCL | 56.48 |
| 95% Hall's Bootstrap UCL | 55.05 | 95% Percentile Bootstrap UCL | 55.06 |
| 95% BCA Bootstrap UCL | 55.35 | | |
| 90% Chebyshev(Mean, Sd) UCL | 63.99 | 95% Chebyshev(Mean, Sd) UCL | 72.73 |
| 97.5% Chebyshev(Mean, Sd) UCL | 84.86 | 99% Chebyshev(Mean, Sd) UCL | 108.7 |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% Student's-t UCL | 55.93 | | |
| | | | |
| When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test | | | |
| When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL | | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| | | | |
| | | | |
| Iron | | | |
| | | | |
| **General Statistics** | | | |
| Total Number of Observations | 17 | Number of Distinct Observations | 16 |
| | | Number of Missing Observations | 0 |
| Minimum | 8310 | Mean | 23859 |
| Maximum | 43400 | Median | 23600 |
| SD | 9818 | Std. Error of Mean | 2381 |
| Coefficient of Variation | 0.411 | Skewness | 0.424 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.968 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.892 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.119 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.207 | Data appear Normal at 5% Significance Level | |
| **Data appear Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 28017 | 95% Adjusted-CLT UCL (Chen-1995) | 28038 |
| | | 95% Modified-t UCL (Johnson-1978) | 28058 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.173 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.741 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.0863 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.21 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 502 | **Gamma Statistics** | | | | | | | | | | | |
| 503 | | | | | k hat (MLE) | 5.903 | | | | | k star (bias corrected MLE) | 4.901 |
| 504 | | | | | Theta hat (MLE) | 4042 | | | | | Theta star (bias corrected MLE) | 4868 |
| 505 | | | | | nu hat (MLE) | 200.7 | | | | | nu star (bias corrected) | 166.6 |
| 506 | | | | | MLE Mean (bias corrected) | 23859 | | | | | MLE Sd (bias corrected) | 10778 |
| 507 | | | | | | | | | | | Approximate Chi Square Value (0.05) | 137.8 |
| 508 | | | | | Adjusted Level of Significance | 0.0346 | | | | | Adjusted Chi Square Value | 135 |
| 509 | | | | | | | | | | | | |
| 510 | **Assuming Gamma Distribution** | | | | | | | | | | | |
| 511 | | | | | 95% Approximate Gamma UCL (use when n>=50)) | 28855 | | | | | 95% Adjusted Gamma UCL (use when n<50) | 29442 |
| 512 | | | | | | | | | | | | |
| 513 | **Lognormal GOF Test** | | | | | | | | | | | |
| 514 | | | | | Shapiro Wilk Test Statistic | 0.968 | **Shapiro Wilk Lognormal GOF Test** | | | | | |
| 515 | | | | | 5% Shapiro Wilk Critical Value | 0.892 | Data appear Lognormal at 5% Significance Level | | | | | |
| 516 | | | | | Lilliefors Test Statistic | 0.11 | **Lilliefors Lognormal GOF Test** | | | | | |
| 517 | | | | | 5% Lilliefors Critical Value | 0.207 | Data appear Lognormal at 5% Significance Level | | | | | |
| 518 | **Data appear Lognormal at 5% Significance Level** | | | | | | | | | | | |
| 519 | | | | | | | | | | | | |
| 520 | **Lognormal Statistics** | | | | | | | | | | | |
| 521 | | | | | Minimum of Logged Data | 9.025 | | | | | Mean of logged Data | 9.993 |
| 522 | | | | | Maximum of Logged Data | 10.68 | | | | | SD of logged Data | 0.446 |
| 523 | | | | | | | | | | | | |
| 524 | **Assuming Lognormal Distribution** | | | | | | | | | | | |
| 525 | | | | | 95% H-UCL | 30127 | | | | | 90% Chebyshev (MVUE) UCL | 31993 |
| 526 | | | | | 95% Chebyshev (MVUE) UCL | 35613 | | | | | 97.5% Chebyshev (MVUE) UCL | 40638 |
| 527 | | | | | 99% Chebyshev (MVUE) UCL | 50508 | | | | | | |
| 528 | | | | | | | | | | | | |
| 529 | **Nonparametric Distribution Free UCL Statistics** | | | | | | | | | | | |
| 530 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | | | | | | | | | |
| 531 | | | | | | | | | | | | |
| 532 | **Nonparametric Distribution Free UCLs** | | | | | | | | | | | |
| 533 | | | | | 95% CLT UCL | 27776 | | | | | 95% Jackknife UCL | 28017 |
| 534 | | | | | 95% Standard Bootstrap UCL | 27656 | | | | | 95% Bootstrap-t UCL | 28323 |
| 535 | | | | | 95% Hall's Bootstrap UCL | 28075 | | | | | 95% Percentile Bootstrap UCL | 27759 |
| 536 | | | | | 95% BCA Bootstrap UCL | 27801 | | | | | | |
| 537 | | | | | 90% Chebyshev(Mean, Sd) UCL | 31003 | | | | | 95% Chebyshev(Mean, Sd) UCL | 34239 |
| 538 | | | | | 97.5% Chebyshev(Mean, Sd) UCL | 38730 | | | | | 99% Chebyshev(Mean, Sd) UCL | 47553 |
| 539 | | | | | | | | | | | | |
| 540 | **Suggested UCL to Use** | | | | | | | | | | | |
| 541 | | | | | 95% Student's-t UCL | 28017 | | | | | | |
| 542 | | | | | | | | | | | | |
| 543 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | | | | | | | | | |
| 544 | Recommendations are based upon data size, data distribution, and skewness. | | | | | | | | | | | |
| 545 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | | | | | | | | | |
| 546 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | | | | | | | | | |
| 547 | | | | | | | | | | | | |
| 548 | | | | | | | | | | | | |

Lead

| | | | |
|---|---|---|---|
| **General Statistics** | | | |
| Total Number of Observations | 17 | Number of Distinct Observations | 16 |
| | | Number of Missing Observations | 0 |
| Minimum | 7.6 | Mean | 29.15 |
| Maximum | 96.7 | Median | 16.1 |
| SD | 26.81 | Std. Error of Mean | 6.502 |
| Coefficient of Variation | 0.92 | Skewness | 1.681 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.73 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.892 | Data Not Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.285 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.207 | Data Not Normal at 5% Significance Level | |
| **Data Not Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 40.5 | 95% Adjusted-CLT UCL (Chen-1995) | 42.67 |
| | | 95% Modified-t UCL (Johnson-1978) | 40.94 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 1.048 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.752 | Data Not Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.209 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.212 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data follow Appr. Gamma Distribution at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 1.792 | k star (bias corrected MLE) | 1.515 |
| Theta hat (MLE) | 16.27 | Theta star (bias corrected MLE) | 19.24 |
| nu hat (MLE) | 60.92 | nu star (bias corrected) | 51.5 |
| MLE Mean (bias corrected) | 29.15 | MLE Sd (bias corrected) | 23.68 |
| | | Approximate Chi Square Value (0.05) | 36.02 |
| Adjusted Level of Significance | 0.0346 | Adjusted Chi Square Value | 34.67 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50) | 41.67 | 95% Adjusted Gamma UCL (use when n<50) | 43.3 |
| | | | |
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.914 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.892 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.178 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.207 | Data appear Lognormal at 5% Significance Level | |
| **Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | 2.028 | Mean of logged Data | 3.068 |
| Maximum of Logged Data | 4.572 | SD of logged Data | 0.756 |

| | | | |
|---|---|---|---|
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 44.34 | 90% Chebyshev (MVUE) UCL | 44.51 |
| 95% Chebyshev (MVUE) UCL | 51.98 | 97.5% Chebyshev (MVUE) UCL | 62.34 |
| 99% Chebyshev (MVUE) UCL | 82.69 | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| | | | |
| **Nonparametric Distribution Free UCLs** | | | |
| 95% CLT UCL | 39.84 | 95% Jackknife UCL | 40.5 |
| 95% Standard Bootstrap UCL | 39.57 | 95% Bootstrap-t UCL | 46.17 |
| 95% Hall's Bootstrap UCL | 40.14 | 95% Percentile Bootstrap UCL | 39.66 |
| 95% BCA Bootstrap UCL | 42.44 | | |
| 90% Chebyshev(Mean, Sd) UCL | 48.65 | 95% Chebyshev(Mean, Sd) UCL | 57.49 |
| 97.5% Chebyshev(Mean, Sd) UCL | 69.75 | 99% Chebyshev(Mean, Sd) UCL | 93.84 |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% Adjusted Gamma UCL | 43.3 | | |
| | | | |
| When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test | | | |
| When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL | | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| | | | |
| | | | |
| **Lithium** | | | |
| | | | |
| **General Statistics** | | | |
| Total Number of Observations | 17 | Number of Distinct Observations | 9 |
| | | Number of Missing Observations | 0 |
| Minimum | 6 | Mean | 10.94 |
| Maximum | 15 | Median | 11 |
| SD | 2.331 | Std. Error of Mean | 0.565 |
| Coefficient of Variation | 0.213 | Skewness | -0.255 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.978 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.892 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.106 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.207 | Data appear Normal at 5% Significance Level | |
| **Data appear Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 11.93 | 95% Adjusted-CLT UCL (Chen-1995) | 11.83 |
| | | 95% Modified-t UCL (Johnson-1978) | 11.92 |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 650 | **Gamma GOF Test** | | | |
| 651 | A-D Test Statistic | 0.283 | **Anderson-Darling Gamma GOF Test** | |
| 652 | 5% A-D Critical Value | 0.738 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 653 | K-S Test Statistic | 0.127 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 654 | 5% K-S Critical Value | 0.209 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 655 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| 656 | | | | |
| 657 | **Gamma Statistics** | | | |
| 658 | k hat (MLE) | 21.44 | k star (bias corrected MLE) | 17.69 |
| 659 | Theta hat (MLE) | 0.51 | Theta star (bias corrected MLE) | 0.618 |
| 660 | nu hat (MLE) | 728.9 | nu star (bias corrected) | 601.6 |
| 661 | MLE Mean (bias corrected) | 10.94 | MLE Sd (bias corrected) | 2.601 |
| 662 | | | Approximate Chi Square Value (0.05) | 545.7 |
| 663 | Adjusted Level of Significance | 0.0346 | Adjusted Chi Square Value | 540.1 |
| 664 | | | | |
| 665 | **Assuming Gamma Distribution** | | | |
| 666 | 95% Approximate Gamma UCL (use when n>=50)) | 12.06 | 95% Adjusted Gamma UCL (use when n<50) | 12.19 |
| 667 | | | | |
| 668 | **Lognormal GOF Test** | | | |
| 669 | Shapiro Wilk Test Statistic | 0.945 | **Shapiro Wilk Lognormal GOF Test** | |
| 670 | 5% Shapiro Wilk Critical Value | 0.892 | Data appear Lognormal at 5% Significance Level | |
| 671 | Lilliefors Test Statistic | 0.138 | **Lilliefors Lognormal GOF Test** | |
| 672 | 5% Lilliefors Critical Value | 0.207 | Data appear Lognormal at 5% Significance Level | |
| 673 | **Data appear Lognormal at 5% Significance Level** | | | |
| 674 | | | | |
| 675 | **Lognormal Statistics** | | | |
| 676 | Minimum of Logged Data | 1.792 | Mean of logged Data | 2.369 |
| 677 | Maximum of Logged Data | 2.708 | SD of logged Data | 0.23 |
| 678 | | | | |
| 679 | **Assuming Lognormal Distribution** | | | |
| 680 | 95% H-UCL | 12.18 | 90% Chebyshev (MVUE) UCL | 12.8 |
| 681 | 95% Chebyshev (MVUE) UCL | 13.64 | 97.5% Chebyshev (MVUE) UCL | 14.8 |
| 682 | 99% Chebyshev (MVUE) UCL | 17.08 | | |
| 683 | | | | |
| 684 | **Nonparametric Distribution Free UCL Statistics** | | | |
| 685 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| 686 | | | | |
| 687 | **Nonparametric Distribution Free UCLs** | | | |
| 688 | 95% CLT UCL | 11.87 | 95% Jackknife UCL | 11.93 |
| 689 | 95% Standard Bootstrap UCL | 11.84 | 95% Bootstrap-t UCL | 11.88 |
| 690 | 95% Hall's Bootstrap UCL | 11.87 | 95% Percentile Bootstrap UCL | 11.82 |
| 691 | 95% BCA Bootstrap UCL | 11.76 | | |
| 692 | 90% Chebyshev(Mean, Sd) UCL | 12.64 | 95% Chebyshev(Mean, Sd) UCL | 13.41 |
| 693 | 97.5% Chebyshev(Mean, Sd) UCL | 14.47 | 99% Chebyshev(Mean, Sd) UCL | 16.57 |
| 694 | | | | |
| 695 | **Suggested UCL to Use** | | | |
| 696 | 95% Student's-t UCL | 11.93 | | |
| 697 | | | | |
| 698 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 699 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 700 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 701 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 702 | | | | |
| 703 | **Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be** | | | |
| 704 | **reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.** | | | |

**Manganese**

| | | | |
|---|---|---|---|
| **General Statistics** | | | |
| Total Number of Observations | 17 | Number of Distinct Observations | 16 |
| | | Number of Missing Observations | 0 |
| Minimum | 451 | Mean | 1331 |
| Maximum | 2940 | Median | 1160 |
| SD | 597.8 | Std. Error of Mean | 145 |
| Coefficient of Variation | 0.449 | Skewness | 1.058 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.92 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.892 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.142 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.207 | Data appear Normal at 5% Significance Level | |
| **Data appear Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 1584 | 95% Adjusted-CLT UCL (Chen-1995) | 1609 |
| | | 95% Modified-t UCL (Johnson-1978) | 1590 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.259 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.741 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.115 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.21 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 5.467 | k star (bias corrected MLE) | 4.542 |
| Theta hat (MLE) | 243.4 | Theta star (bias corrected MLE) | 293 |
| nu hat (MLE) | 185.9 | nu star (bias corrected) | 154.4 |
| MLE Mean (bias corrected) | 1331 | MLE Sd (bias corrected) | 624.4 |
| | | Approximate Chi Square Value (0.05) | 126.7 |
| Adjusted Level of Significance | 0.0346 | Adjusted Chi Square Value | 124.1 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50)) | 1622 | 95% Adjusted Gamma UCL (use when n<50) | 1656 |
| | | | |
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.973 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.892 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.121 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.207 | Data appear Lognormal at 5% Significance Level | |
| **Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | 6.111 | Mean of logged Data | 7.099 |
| Maximum of Logged Data | 7.986 | SD of logged Data | 0.456 |

**Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% H-UCL | 1686 | 90% Chebyshev (MVUE) UCL | 1790 |
| 95% Chebyshev (MVUE) UCL | 1996 | 97.5% Chebyshev (MVUE) UCL | 2282 |
| 99% Chebyshev (MVUE) UCL | 2844 | | |

**Nonparametric Distribution Free UCL Statistics**

**Data appear to follow a Discernible Distribution at 5% Significance Level**

**Nonparametric Distribution Free UCLs**

| | | | |
|---|---|---|---|
| 95% CLT UCL | 1569 | 95% Jackknife UCL | 1584 |
| 95% Standard Bootstrap UCL | 1560 | 95% Bootstrap-t UCL | 1634 |
| 95% Hall's Bootstrap UCL | 1685 | 95% Percentile Bootstrap UCL | 1565 |
| 95% BCA Bootstrap UCL | 1605 | | |
| 90% Chebyshev(Mean, Sd) UCL | 1766 | 95% Chebyshev(Mean, Sd) UCL | 1963 |
| 97.5% Chebyshev(Mean, Sd) UCL | 2236 | 99% Chebyshev(Mean, Sd) UCL | 2773 |

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% Student's-t UCL | 1584 | | |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Molybdenum**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 17 | Number of Distinct Observations | 2 |
| Number of Detects | 1 | Number of Non-Detects | 16 |
| Number of Distinct Detects | 1 | Number of Distinct Non-Detects | 1 |

**Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!**
**It is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).**

**The data set for variable Molybdenum was not processed!**

**Nickel**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 17 | Number of Distinct Observations | 13 |
| | | Number of Missing Observations | 0 |
| Minimum | 6 | Mean | 24.53 |
| Maximum | 69 | Median | 23 |
| SD | 17.28 | Std. Error of Mean | 4.19 |
| Coefficient of Variation | 0.704 | Skewness | 1.555 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.827 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.892 | Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.221 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.207 | Data Not Normal at 5% Significance Level |

**Data Not Normal at 5% Significance Level**

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 813 | Assuming Normal Distribution | | | |
| 814 | **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 815 | 95% Student's-t UCL | 31.85 | 95% Adjusted-CLT UCL (Chen-1995) | 33.11 |
| 816 | | | 95% Modified-t UCL (Johnson-1978) | 32.11 |
| 817 | | | | |
| 818 | **Gamma GOF Test** | | | |
| 819 | A-D Test Statistic | 0.428 | **Anderson-Darling Gamma GOF Test** | |
| 820 | 5% A-D Critical Value | 0.747 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 821 | K-S Test Statistic | 0.141 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 822 | 5% K-S Critical Value | 0.211 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 823 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| 824 | | | | |
| 825 | **Gamma Statistics** | | | |
| 826 | k hat (MLE) | 2.598 | k star (bias corrected MLE) | 2.179 |
| 827 | Theta hat (MLE) | 9.441 | Theta star (bias corrected MLE) | 11.26 |
| 828 | nu hat (MLE) | 88.34 | nu star (bias corrected) | 74.09 |
| 829 | MLE Mean (bias corrected) | 24.53 | MLE Sd (bias corrected) | 16.62 |
| 830 | | | Approximate Chi Square Value (0.05) | 55.26 |
| 831 | Adjusted Level of Significance | 0.0346 | Adjusted Chi Square Value | 53.56 |
| 832 | | | | |
| 833 | **Assuming Gamma Distribution** | | | |
| 834 | 95% Approximate Gamma UCL (use when n>=50) | 32.88 | 95% Adjusted Gamma UCL (use when n<50) | 33.93 |
| 835 | | | | |
| 836 | **Lognormal GOF Test** | | | |
| 837 | Shapiro Wilk Test Statistic | 0.97 | **Shapiro Wilk Lognormal GOF Test** | |
| 838 | 5% Shapiro Wilk Critical Value | 0.892 | Data appear Lognormal at 5% Significance Level | |
| 839 | Lilliefors Test Statistic | 0.146 | **Lilliefors Lognormal GOF Test** | |
| 840 | 5% Lilliefors Critical Value | 0.207 | Data appear Lognormal at 5% Significance Level | |
| 841 | **Data appear Lognormal at 5% Significance Level** | | | |
| 842 | | | | |
| 843 | **Lognormal Statistics** | | | |
| 844 | Minimum of Logged Data | 1.792 | Mean of logged Data | 2.995 |
| 845 | Maximum of Logged Data | 4.234 | SD of logged Data | 0.655 |
| 846 | | | | |
| 847 | **Assuming Lognormal Distribution** | | | |
| 848 | 95% H-UCL | 35.56 | 90% Chebyshev (MVUE) UCL | 36.68 |
| 849 | 95% Chebyshev (MVUE) UCL | 42.24 | 97.5% Chebyshev (MVUE) UCL | 49.95 |
| 850 | 99% Chebyshev (MVUE) UCL | 65.1 | | |
| 851 | | | | |
| 852 | **Nonparametric Distribution Free UCL Statistics** | | | |
| 853 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| 854 | | | | |
| 855 | **Nonparametric Distribution Free UCLs** | | | |
| 856 | 95% CLT UCL | 31.42 | 95% Jackknife UCL | 31.85 |
| 857 | 95% Standard Bootstrap UCL | 31.2 | 95% Bootstrap-t UCL | 36.84 |
| 858 | 95% Hall's Bootstrap UCL | 44.26 | 95% Percentile Bootstrap UCL | 31.47 |
| 859 | 95% BCA Bootstrap UCL | 32.12 | | |
| 860 | 90% Chebyshev(Mean, Sd) UCL | 37.1 | 95% Chebyshev(Mean, Sd) UCL | 42.8 |
| 861 | 97.5% Chebyshev(Mean, Sd) UCL | 50.7 | 99% Chebyshev(Mean, Sd) UCL | 66.22 |
| 862 | | | | |
| 863 | **Suggested UCL to Use** | | | |
| 864 | 95% Adjusted Gamma UCL | 33.93 | | |
| 865 | | | | |
| 866 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 867 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 868 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 869 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |

Strontium

| | | | |
|---|---|---|---|
| **General Statistics** | | | |
| Total Number of Observations | 17 | Number of Distinct Observations | 14 |
| | | Number of Missing Observations | 0 |
| Minimum | 9 | Mean | 29.18 |
| Maximum | 78 | Median | 21 |
| SD | 19.99 | Std. Error of Mean | 4.849 |
| Coefficient of Variation | 0.685 | Skewness | 1.635 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.752 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.892 | Data Not Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.327 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.207 | Data Not Normal at 5% Significance Level | |
| **Data Not Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 37.64 | 95% Adjusted-CLT UCL (Chen-1995) | 39.21 |
| | | 95% Modified-t UCL (Johnson-1978) | 37.96 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 1.046 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.745 | Data Not Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.252 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.211 | Data Not Gamma Distributed at 5% Significance Level | |
| **Data Not Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 3.063 | k star (bias corrected MLE) | 2.562 |
| Theta hat (MLE) | 9.525 | Theta star (bias corrected MLE) | 11.39 |
| nu hat (MLE) | 104.1 | nu star (bias corrected) | 87.1 |
| MLE Mean (bias corrected) | 29.18 | MLE Sd (bias corrected) | 18.23 |
| | | Approximate Chi Square Value (0.05) | 66.59 |
| Adjusted Level of Significance | 0.0346 | Adjusted Chi Square Value | 64.71 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50)) | 38.17 | 95% Adjusted Gamma UCL (use when n<50) | 39.27 |
| | | | |
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.917 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.892 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.21 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.207 | Data Not Lognormal at 5% Significance Level | |
| **Data appear Approximate Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | 2.197 | Mean of logged Data | 3.201 |
| Maximum of Logged Data | 4.357 | SD of logged Data | 0.575 |
| | | | |
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 39.27 | 90% Chebyshev (MVUE) UCL | 41.17 |
| 95% Chebyshev (MVUE) UCL | 46.83 | 97.5% Chebyshev (MVUE) UCL | 54.69 |
| 99% Chebyshev (MVUE) UCL | 70.13 | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| | | | |
| **Nonparametric Distribution Free UCLs** | | | |
| 95% CLT UCL | 37.15 | 95% Jackknife UCL | 37.64 |
| 95% Standard Bootstrap UCL | 36.92 | 95% Bootstrap-t UCL | 42.34 |
| 95% Hall's Bootstrap UCL | 36.97 | 95% Percentile Bootstrap UCL | 37.88 |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 935 | 95% BCA Bootstrap UCL | 39.71 | | |
| 936 | 90% Chebyshev(Mean, Sd) UCL | 43.72 | 95% Chebyshev(Mean, Sd) UCL | 50.31 |
| 937 | 97.5% Chebyshev(Mean, Sd) UCL | 59.46 | 99% Chebyshev(Mean, Sd) UCL | 77.42 |
| 938 | | | | |
| 939 | **Suggested UCL to Use** | | | |
| 940 | 95% H-UCL | 39.27 | | |
| 941 | | | | |
| 942 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 943 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 944 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 945 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 946 | | | | |
| 947 | **ProUCL computes and outputs H-statistic based UCLs for historical reasons only.** | | | |
| 948 | **H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.** | | | |
| 949 | **It is therefore recommended to avoid the use of H-statistic based 95% UCLs.** | | | |
| 950 | **Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.** | | | |
| 951 | | | | |
| 952 | | | | |
| 953 | Vanadium | | | |
| 954 | | | | |
| 955 | **General Statistics** | | | |
| 956 | Total Number of Observations | 17 | Number of Distinct Observations | 16 |
| 957 | | | Number of Missing Observations | 0 |
| 958 | Minimum | 26 | Mean | 56.65 |
| 959 | Maximum | 100 | Median | 51 |
| 960 | SD | 21.94 | Std. Error of Mean | 5.321 |
| 961 | Coefficient of Variation | 0.387 | Skewness | 0.445 |
| 962 | | | | |
| 963 | **Normal GOF Test** | | | |
| 964 | Shapiro Wilk Test Statistic | 0.952 | **Shapiro Wilk GOF Test** | |
| 965 | 5% Shapiro Wilk Critical Value | 0.892 | Data appear Normal at 5% Significance Level | |
| 966 | Lilliefors Test Statistic | 0.172 | **Lilliefors GOF Test** | |
| 967 | 5% Lilliefors Critical Value | 0.207 | Data appear Normal at 5% Significance Level | |
| 968 | **Data appear Normal at 5% Significance Level** | | | |
| 969 | | | | |
| 970 | **Assuming Normal Distribution** | | | |
| 971 | **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 972 | 95% Student's-t UCL | 65.94 | 95% Adjusted-CLT UCL (Chen-1995) | 66.01 |
| 973 | | | 95% Modified-t UCL (Johnson-1978) | 66.03 |
| 974 | | | | |
| 975 | **Gamma GOF Test** | | | |
| 976 | A-D Test Statistic | 0.232 | **Anderson-Darling Gamma GOF Test** | |
| 977 | 5% A-D Critical Value | 0.74 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 978 | K-S Test Statistic | 0.126 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 979 | 5% K-S Critical Value | 0.209 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 980 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| 981 | | | | |

| Row | A–E | F | G–K | L |
|---|---|---|---|---|
| 982 | Gamma Statistics | | | |
| 983 | k hat (MLE) | 6.928 | k star (bias corrected MLE) | 5.745 |
| 984 | Theta hat (MLE) | 8.177 | Theta star (bias corrected MLE) | 9.861 |
| 985 | nu hat (MLE) | 235.6 | nu star (bias corrected) | 195.3 |
| 986 | MLE Mean (bias corrected) | 56.65 | MLE Sd (bias corrected) | 23.63 |
| 987 | | | Approximate Chi Square Value (0.05) | 164 |
| 988 | Adjusted Level of Significance | 0.0346 | Adjusted Chi Square Value | 161 |
| 989 | | | | |
| 990 | Assuming Gamma Distribution | | | |
| 991 | 95% Approximate Gamma UCL (use when n>=50)) | 67.47 | 95% Adjusted Gamma UCL (use when n<50) | 68.73 |
| 992 | | | | |
| 993 | Lognormal GOF Test | | | |
| 994 | Shapiro Wilk Test Statistic | 0.961 | Shapiro Wilk Lognormal GOF Test | |
| 995 | 5% Shapiro Wilk Critical Value | 0.892 | Data appear Lognormal at 5% Significance Level | |
| 996 | Lilliefors Test Statistic | 0.0998 | Lilliefors Lognormal GOF Test | |
| 997 | 5% Lilliefors Critical Value | 0.207 | Data appear Lognormal at 5% Significance Level | |
| 998 | Data appear Lognormal at 5% Significance Level | | | |
| 999 | | | | |
| 1000 | Lognormal Statistics | | | |
| 1001 | Minimum of Logged Data | 3.258 | Mean of logged Data | 3.963 |
| 1002 | Maximum of Logged Data | 4.605 | SD of logged Data | 0.404 |
| 1003 | | | | |
| 1004 | Assuming Lognormal Distribution | | | |
| 1005 | 95% H-UCL | 69.47 | 90% Chebyshev (MVUE) UCL | 73.85 |
| 1006 | 95% Chebyshev (MVUE) UCL | 81.58 | 97.5% Chebyshev (MVUE) UCL | 92.31 |
| 1007 | 99% Chebyshev (MVUE) UCL | 113.4 | | |
| 1008 | | | | |
| 1009 | Nonparametric Distribution Free UCL Statistics | | | |
| 1010 | Data appear to follow a Discernible Distribution at 5% Significance Level | | | |
| 1011 | | | | |
| 1012 | Nonparametric Distribution Free UCLs | | | |
| 1013 | 95% CLT UCL | 65.4 | 95% Jackknife UCL | 65.94 |
| 1014 | 95% Standard Bootstrap UCL | 65.26 | 95% Bootstrap-t UCL | 66.91 |
| 1015 | 95% Hall's Bootstrap UCL | 65.64 | 95% Percentile Bootstrap UCL | 65.18 |
| 1016 | 95% BCA Bootstrap UCL | 65.53 | | |
| 1017 | 90% Chebyshev(Mean, Sd) UCL | 72.61 | 95% Chebyshev(Mean, Sd) UCL | 79.84 |
| 1018 | 97.5% Chebyshev(Mean, Sd) UCL | 89.88 | 99% Chebyshev(Mean, Sd) UCL | 109.6 |
| 1019 | | | | |
| 1020 | Suggested UCL to Use | | | |
| 1021 | 95% Student's-t UCL | 65.94 | | |
| 1022 | | | | |
| 1023 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 1024 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 1025 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 1026 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 1027 | | | | |
| 1028 | | | | |
| 1029 | Zinc | | | |
| 1030 | | | | |
| 1031 | General Statistics | | | |
| 1032 | Total Number of Observations | 17 | Number of Distinct Observations | 16 |
| 1033 | | | Number of Missing Observations | 0 |
| 1034 | Minimum | 39 | Mean | 123.6 |
| 1035 | Maximum | 329 | Median | 101 |
| 1036 | SD | 76.38 | Std. Error of Mean | 18.53 |
| 1037 | Coefficient of Variation | 0.618 | Skewness | 1.57 |
| 1038 | | | | |

| | | | |
|---|---|---|---|
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.827 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.892 | Data Not Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.219 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.207 | Data Not Normal at 5% Significance Level | |
| **Data Not Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 155.9 | 95% Adjusted-CLT UCL (Chen-1995) | 161.6 |
| | | 95% Modified-t UCL (Johnson-1978) | 157.1 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.575 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.744 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.161 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.21 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 3.509 | k star (bias corrected MLE) | 2.929 |
| Theta hat (MLE) | 35.22 | Theta star (bias corrected MLE) | 42.19 |
| nu hat (MLE) | 119.3 | nu star (bias corrected) | 99.59 |
| MLE Mean (bias corrected) | 123.6 | MLE Sd (bias corrected) | 72.21 |
| | | Approximate Chi Square Value (0.05) | 77.57 |
| Adjusted Level of Significance | 0.0346 | Adjusted Chi Square Value | 75.53 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50) | 158.7 | 95% Adjusted Gamma UCL (use when n<50) | 163 |
| | | | |
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.962 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.892 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.127 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.207 | Data appear Lognormal at 5% Significance Level | |
| **Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | 3.664 | Mean of logged Data | 4.668 |
| Maximum of Logged Data | 5.796 | SD of logged Data | 0.547 |
| | | | |
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 164.3 | 90% Chebyshev (MVUE) UCL | 173 |
| 95% Chebyshev (MVUE) UCL | 195.9 | 97.5% Chebyshev (MVUE) UCL | 227.7 |
| 99% Chebyshev (MVUE) UCL | 290.1 | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| | | | |
| **Nonparametric Distribution Free UCLs** | | | |
| 95% CLT UCL | 154.1 | 95% Jackknife UCL | 155.9 |
| 95% Standard Bootstrap UCL | 153 | 95% Bootstrap-t UCL | 169.7 |
| 95% Hall's Bootstrap UCL | 164.3 | 95% Percentile Bootstrap UCL | 156.4 |
| 95% BCA Bootstrap UCL | 161.2 | | |
| 90% Chebyshev(Mean, Sd) UCL | 179.2 | 95% Chebyshev(Mean, Sd) UCL | 204.3 |
| 97.5% Chebyshev(Mean, Sd) UCL | 239.3 | 99% Chebyshev(Mean, Sd) UCL | 307.9 |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% Adjusted Gamma UCL | 163 | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | UCL Statistics for Data Sets with Non-Detects | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | User Selected Options | | | | | | | | | | | |
| 4 | Date/Time of Computation | | | ProUCL 5.111/15/2018 8:38:55 AM | | | | | | | | |
| 5 | From File | | | WorkSheet.xls | | | | | | | | |
| 6 | Full Precision | | | OFF | | | | | | | | |
| 7 | Confidence Coefficient | | | 95% | | | | | | | | |
| 8 | Number of Bootstrap Operations | | | 2000 | | | | | | | | |
| 9 | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | |
| 11 | Al | | | | | | | | | | | |
| 12 | | | | | | | | | | | | |
| 13 | General Statistics | | | | | | | | | | | |
| 14 | Total Number of Observations | | | | | 15 | Number of Distinct Observations | | | | | 12 |
| 15 | | | | | | | Number of Missing Observations | | | | | 0 |
| 16 | Minimum | | | | | 7190 | Mean | | | | | 10775 |
| 17 | Maximum | | | | | 14300 | Median | | | | | 10900 |
| 18 | SD | | | | | 1828 | Std. Error of Mean | | | | | 472.1 |
| 19 | Coefficient of Variation | | | | | 0.17 | Skewness | | | | | -0.269 |
| 20 | | | | | | | | | | | | |
| 21 | Normal GOF Test | | | | | | | | | | | |
| 22 | Shapiro Wilk Test Statistic | | | | | 0.97 | Shapiro Wilk GOF Test | | | | | |
| 23 | 5% Shapiro Wilk Critical Value | | | | | 0.881 | Data appear Normal at 5% Significance Level | | | | | |
| 24 | Lilliefors Test Statistic | | | | | 0.136 | Lilliefors GOF Test | | | | | |
| 25 | 5% Lilliefors Critical Value | | | | | 0.22 | Data appear Normal at 5% Significance Level | | | | | |
| 26 | Data appear Normal at 5% Significance Level | | | | | | | | | | | |
| 27 | | | | | | | | | | | | |
| 28 | Assuming Normal Distribution | | | | | | | | | | | |
| 29 | 95% Normal UCL | | | | | | 95% UCLs (Adjusted for Skewness) | | | | | |
| 30 | 95% Student's-t UCL | | | | | 11607 | 95% Adjusted-CLT UCL (Chen-1995) | | | | | 11517 |
| 31 | | | | | | | 95% Modified-t UCL (Johnson-1978) | | | | | 11601 |
| 32 | | | | | | | | | | | | |
| 33 | Gamma GOF Test | | | | | | | | | | | |
| 34 | A-D Test Statistic | | | | | 0.365 | Anderson-Darling Gamma GOF Test | | | | | |
| 35 | 5% A-D Critical Value | | | | | 0.735 | Detected data appear Gamma Distributed at 5% Significance Level | | | | | |
| 36 | K-S Test Statistic | | | | | 0.15 | Kolmogorov-Smirnov Gamma GOF Test | | | | | |
| 37 | 5% K-S Critical Value | | | | | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level | | | | | |
| 38 | Detected data appear Gamma Distributed at 5% Significance Level | | | | | | | | | | | |
| 39 | | | | | | | | | | | | |
| 40 | Gamma Statistics | | | | | | | | | | | |
| 41 | k hat (MLE) | | | | | 35.01 | k star (bias corrected MLE) | | | | | 28.05 |
| 42 | Theta hat (MLE) | | | | | 307.8 | Theta star (bias corrected MLE) | | | | | 384.1 |
| 43 | nu hat (MLE) | | | | | 1050 | nu star (bias corrected) | | | | | 841.6 |
| 44 | MLE Mean (bias corrected) | | | | | 10775 | MLE Sd (bias corrected) | | | | | 2034 |
| 45 | | | | | | | Approximate Chi Square Value (0.05) | | | | | 775.3 |
| 46 | Adjusted Level of Significance | | | | | 0.0324 | Adjusted Chi Square Value | | | | | 767.5 |
| 47 | | | | | | | | | | | | |
| 48 | Assuming Gamma Distribution | | | | | | | | | | | |
| 49 | 95% Approximate Gamma UCL (use when n>=50)) | | | | | 11697 | 95% Adjusted Gamma UCL (use when n<50) | | | | | 11817 |
| 50 | | | | | | | | | | | | |

| | | | |
|---|---|---|---|
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.947 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.157 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| **Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | 8.88 | Mean of logged Data | 9.271 |
| Maximum of Logged Data | 9.568 | SD of logged Data | 0.179 |
| | | | |
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 11759 | 90% Chebyshev (MVUE) UCL | 12280 |
| 95% Chebyshev (MVUE) UCL | 12959 | 97.5% Chebyshev (MVUE) UCL | 13901 |
| 99% Chebyshev (MVUE) UCL | 15753 | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| | | | |
| **Nonparametric Distribution Free UCLs** | | | |
| 95% CLT UCL | 11552 | 95% Jackknife UCL | 11607 |
| 95% Standard Bootstrap UCL | 11540 | 95% Bootstrap-t UCL | 11554 |
| 95% Hall's Bootstrap UCL | 11533 | 95% Percentile Bootstrap UCL | 11497 |
| 95% BCA Bootstrap UCL | 11480 | | |
| 90% Chebyshev(Mean, Sd) UCL | 12192 | 95% Chebyshev(Mean, Sd) UCL | 12833 |
| 97.5% Chebyshev(Mean, Sd) UCL | 13724 | 99% Chebyshev(Mean, Sd) UCL | 15473 |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% Student's-t UCL | 11607 | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| | | | |
| **Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be** | | | |
| **reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.** | | | |
| | | | |
| Sb | | | |
| | | | |
| **General Statistics** | | | |
| Total Number of Observations | 15 | Number of Distinct Observations | 4 |
| Number of Detects | 8 | Number of Non-Detects | 7 |
| Number of Distinct Detects | 4 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | 1 | Minimum Non-Detect | 1 |
| Maximum Detect | 28 | Maximum Non-Detect | 1 |
| Variance Detects | 86.86 | Percent Non-Detects | 46.67% |
| Mean Detects | 5 | SD Detects | 9.32 |
| Median Detects | 2 | CV Detects | 1.864 |
| Skewness Detects | 2.797 | Kurtosis Detects | 7.865 |
| Mean of Logged Detects | 0.814 | SD of Logged Detects | 1.099 |
| | | | |
| **Normal GOF Test on Detects Only** | | | |
| Shapiro Wilk Test Statistic | 0.484 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.818 | Detected Data Not Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.46 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.283 | Detected Data Not Normal at 5% Significance Level | |
| **Detected Data Not Normal at 5% Significance Level** | | | |
| | | | |
| **Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs** | | | |
| KM Mean | 3.133 | KM Standard Error of Mean | 1.842 |
| KM SD | 6.672 | 95% KM (BCA) UCL | N/A |
| 95% KM (t) UCL | 6.377 | 95% KM (Percentile Bootstrap) UCL | N/A |
| 95% KM (z) UCL | 6.163 | 95% KM Bootstrap t UCL | N/A |
| 90% KM Chebyshev UCL | 8.658 | 95% KM Chebyshev UCL | 11.16 |
| 97.5% KM Chebyshev UCL | 14.63 | 99% KM Chebyshev UCL | 21.46 |

| | A B C D E | F | G H I J K | L |
|---|---|---|---|---|
| 117 | | | | |
| 118 | **Gamma GOF Tests on Detected Observations Only** | | | |
| 119 | A-D Test Statistic | 1.445 | **Anderson-Darling GOF Test** | |
| 120 | 5% A-D Critical Value | 0.745 | Detected Data Not Gamma Distributed at 5% Significance Level | |
| 121 | K-S Test Statistic | 0.378 | **Kolmogorov-Smirnov GOF** | |
| 122 | 5% K-S Critical Value | 0.304 | Detected Data Not Gamma Distributed at 5% Significance Level | |
| 123 | **Detected Data Not Gamma Distributed at 5% Significance Level** | | | |
| 124 | | | | |
| 125 | **Gamma Statistics on Detected Data Only** | | | |
| 126 | k hat (MLE) | 0.752 | k star (bias corrected MLE) | 0.553 |
| 127 | Theta hat (MLE) | 6.648 | Theta star (bias corrected MLE) | 9.035 |
| 128 | nu hat (MLE) | 12.03 | nu star (bias corrected) | 8.854 |
| 129 | Mean (detects) | 5 | | |
| 130 | | | | |
| 131 | **Gamma ROS Statistics using Imputed Non-Detects** | | | |
| 132 | GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| 133 | GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| 134 | For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| 135 | This is especially true when the sample size is small. | | | |
| 136 | For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| 137 | Minimum | 0.01 | Mean | 2.671 |
| 138 | Maximum | 28 | Median | 1 |
| 139 | SD | 7.076 | CV | 2.649 |
| 140 | k hat (MLE) | 0.261 | k star (bias corrected MLE) | 0.254 |
| 141 | Theta hat (MLE) | 10.22 | Theta star (bias corrected MLE) | 10.53 |
| 142 | nu hat (MLE) | 7.842 | nu star (bias corrected) | 7.607 |
| 143 | Adjusted Level of Significance (β) | 0.0324 | | |
| 144 | Approximate Chi Square Value (7.61, α) | 2.51 | Adjusted Chi Square Value (7.61, β) | 2.164 |
| 145 | 95% Gamma Approximate UCL (use when n>=50) | 8.097 | 95% Gamma Adjusted UCL (use when n<50) | 9.391 |
| 146 | | | | |
| 147 | **Estimates of Gamma Parameters using KM Estimates** | | | |
| 148 | Mean (KM) | 3.133 | SD (KM) | 6.672 |
| 149 | Variance (KM) | 44.52 | SE of Mean (KM) | 1.842 |
| 150 | k hat (KM) | 0.221 | k star (KM) | 0.221 |
| 151 | nu hat (KM) | 6.616 | nu star (KM) | 6.626 |
| 152 | theta hat (KM) | 14.21 | theta star (KM) | 14.19 |
| 153 | 80% gamma percentile (KM) | 4.332 | 90% gamma percentile (KM) | 9.465 |
| 154 | 95% gamma percentile (KM) | 15.72 | 99% gamma percentile (KM) | 32.67 |
| 155 | | | | |
| 156 | **Gamma Kaplan-Meier (KM) Statistics** | | | |
| 157 | Approximate Chi Square Value (6.63, α) | 1.968 | Adjusted Chi Square Value (6.63, β) | 1.672 |
| 158 | 95% Gamma Approximate KM-UCL (use when n>=50) | 10.55 | 95% Gamma Adjusted KM-UCL (use when n<50) | 12.42 |
| 159 | | | | |
| 160 | **Lognormal GOF Test on Detected Observations Only** | | | |
| 161 | Shapiro Wilk Test Statistic | 0.73 | **Shapiro Wilk GOF Test** | |
| 162 | 5% Shapiro Wilk Critical Value | 0.818 | Detected Data Not Lognormal at 5% Significance Level | |
| 163 | Lilliefors Test Statistic | 0.294 | **Lilliefors GOF Test** | |
| 164 | 5% Lilliefors Critical Value | 0.283 | Detected Data Not Lognormal at 5% Significance Level | |
| 165 | **Detected Data Not Lognormal at 5% Significance Level** | | | |
| 166 | | | | |
| 167 | **Lognormal ROS Statistics Using Imputed Non-Detects** | | | |
| 168 | Mean in Original Scale | 2.746 | Mean in Log Scale | -0.534 |
| 169 | SD in Original Scale | 7.047 | SD in Log Scale | 1.784 |
| 170 | 95% t UCL (assumes normality of ROS data) | 5.95 | 95% Percentile Bootstrap UCL | 6.16 |
| 171 | 95% BCA Bootstrap UCL | 8.197 | 95% Bootstrap t UCL | 21.6 |
| 172 | 95% H-UCL (Log ROS) | 20.79 | | |
| 173 | | | | |
| 174 | **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | |
| 175 | KM Mean (logged) | 0.434 | KM Geo Mean | 1.543 |
| 176 | KM SD (logged) | 0.853 | 95% Critical H Value (KM-Log) | 2.52 |
| 177 | KM Standard Error of Mean (logged) | 0.236 | 95% H-UCL (KM -Log) | 3.947 |
| 178 | KM SD (logged) | 0.853 | 95% Critical H Value (KM-Log) | 2.52 |
| 179 | KM Standard Error of Mean (logged) | 0.236 | | |
| 180 | | | | |
| 181 | **DL/2 Statistics** | | | |
| 182 | **DL/2 Normal** | | **DL/2 Log-Transformed** | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 183 | Mean in Original Scale | | | | | 2.9 | Mean in Log Scale | | | | | 0.111 |
| 184 | SD in Original Scale | | | | | 6.988 | SD in Log Scale | | | | | 1.1 |
| 185 | 95% t UCL (Assumes normality) | | | | | 6.078 | 95% H-Stat UCL | | | | | 4.803 |
| 186 | **DL/2 is not a recommended method, provided for comparisons and historical reasons** | | | | | | | | | | | |
| 187 | | | | | | | | | | | | |
| 188 | **Nonparametric Distribution Free UCL Statistics** | | | | | | | | | | | |
| 189 | **Data do not follow a Discernible Distribution at 5% Significance Level** | | | | | | | | | | | |
| 190 | | | | | | | | | | | | |
| 191 | **Suggested UCL to Use** | | | | | | | | | | | |
| 192 | 95% KM (Chebyshev) UCL | | | | | 11.16 | | | | | | |
| 193 | | | | | | | | | | | | |
| 194 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | | | | | | | | | |
| 195 | Recommendations are based upon data size, data distribution, and skewness. | | | | | | | | | | | |
| 196 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | | | | | | | | | |
| 197 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | | | | | | | | | |
| 198 | | | | | | | | | | | | |
| 199 | | | | | | | | | | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 200 | As | | | |
| 201 | | | | |
| 202 | **General Statistics** | | | |
| 203 | Total Number of Observations | 15 | Number of Distinct Observations | 12 |
| 204 | | | Number of Missing Observations | 0 |
| 205 | Minimum | 17 | Mean | 31.13 |
| 206 | Maximum | 78 | Median | 24 |
| 207 | SD | 17.76 | Std. Error of Mean | 4.586 |
| 208 | Coefficient of Variation | 0.57 | Skewness | 1.943 |
| 209 | | | | |
| 210 | **Normal GOF Test** | | | |
| 211 | Shapiro Wilk Test Statistic | 0.726 | **Shapiro Wilk GOF Test** | |
| 212 | 5% Shapiro Wilk Critical Value | 0.881 | Data Not Normal at 5% Significance Level | |
| 213 | Lilliefors Test Statistic | 0.237 | **Lilliefors GOF Test** | |
| 214 | 5% Lilliefors Critical Value | 0.22 | Data Not Normal at 5% Significance Level | |
| 215 | **Data Not Normal at 5% Significance Level** | | | |
| 216 | | | | |
| 217 | **Assuming Normal Distribution** | | | |
| 218 | **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 219 | 95% Student's-t UCL | 39.21 | 95% Adjusted-CLT UCL (Chen-1995) | 41.13 |
| 220 | | | 95% Modified-t UCL (Johnson-1978) | 39.59 |
| 221 | | | | |
| 222 | **Gamma GOF Test** | | | |
| 223 | A-D Test Statistic | 1.125 | **Anderson-Darling Gamma GOF Test** | |
| 224 | 5% A-D Critical Value | 0.739 | Data Not Gamma Distributed at 5% Significance Level | |
| 225 | K-S Test Statistic | 0.219 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 226 | 5% K-S Critical Value | 0.222 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 227 | **Detected data follow Appr. Gamma Distribution at 5% Significance Level** | | | |
| 228 | | | | |
| 229 | **Gamma Statistics** | | | |
| 230 | k hat (MLE) | 4.708 | k star (bias corrected MLE) | 3.811 |
| 231 | Theta hat (MLE) | 6.612 | Theta star (bias corrected MLE) | 8.169 |
| 232 | nu hat (MLE) | 141.2 | nu star (bias corrected) | 114.3 |
| 233 | MLE Mean (bias corrected) | 31.13 | MLE Sd (bias corrected) | 15.95 |
| 234 | | | Approximate Chi Square Value (0.05) | 90.65 |
| 235 | Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 88.05 |
| 236 | | | | |
| 237 | **Assuming Gamma Distribution** | | | |
| 238 | 95% Approximate Gamma UCL (use when n>=50) | 39.27 | 95% Adjusted Gamma UCL (use when n<50) | 40.43 |
| 239 | | | | |
| 240 | **Lognormal GOF Test** | | | |
| 241 | Shapiro Wilk Test Statistic | 0.857 | **Shapiro Wilk Lognormal GOF Test** | |
| 242 | 5% Shapiro Wilk Critical Value | 0.881 | Data Not Lognormal at 5% Significance Level | |
| 243 | Lilliefors Test Statistic | 0.196 | **Lilliefors Lognormal GOF Test** | |
| 244 | 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| 245 | **Data appear Approximate Lognormal at 5% Significance Level** | | | |
| 246 | | | | |
| 247 | **Lognormal Statistics** | | | |
| 248 | Minimum of Logged Data | 2.833 | Mean of logged Data | 3.328 |
| 249 | Maximum of Logged Data | 4.357 | SD of logged Data | 0.449 |
| 250 | | | | |

| | | | |
|---|---|---|---|
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 39.3 | 90% Chebyshev (MVUE) UCL | 41.55 |
| 95% Chebyshev (MVUE) UCL | 46.5 | 97.5% Chebyshev (MVUE) UCL | 53.37 |
| 99% Chebyshev (MVUE) UCL | 66.86 | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| | | | |
| **Nonparametric Distribution Free UCLs** | | | |
| 95% CLT UCL | 38.68 | 95% Jackknife UCL | 39.21 |
| 95% Standard Bootstrap UCL | 38.5 | 95% Bootstrap-t UCL | 50.75 |
| 95% Hall's Bootstrap UCL | 74.95 | 95% Percentile Bootstrap UCL | 38.47 |
| 95% BCA Bootstrap UCL | 41.4 | | |
| 90% Chebyshev(Mean, Sd) UCL | 44.89 | 95% Chebyshev(Mean, Sd) UCL | 51.12 |
| 97.5% Chebyshev(Mean, Sd) UCL | 59.77 | 99% Chebyshev(Mean, Sd) UCL | 76.76 |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% Adjusted Gamma UCL | 40.43 | | |
| | | | |
| When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test | | | |
| When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL | | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| | | | |
| | | | |
| Ba | | | |
| | | | |
| **General Statistics** | | | |
| Total Number of Observations | 15 | Number of Distinct Observations | 15 |
| | | Number of Missing Observations | 0 |
| Minimum | 48 | Mean | 124.5 |
| Maximum | 250 | Median | 120 |
| SD | 55.47 | Std. Error of Mean | 14.32 |
| Coefficient of Variation | 0.445 | Skewness | 0.882 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.943 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.13 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |
| **Data appear Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 149.8 | 95% Adjusted-CLT UCL (Chen-1995) | 151.6 |
| | | 95% Modified-t UCL (Johnson-1978) | 150.3 |
| | | | |

| | A B C D E | F | G H I J K | L |
|---|---|---|---|---|
| 301 | Gamma GOF Test | | | |
| 302 | A-D Test Statistic | 0.127 | Anderson-Darling Gamma GOF Test | |
| 303 | 5% A-D Critical Value | 0.738 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 304 | K-S Test Statistic | 0.0823 | Kolmogorov-Smirnov Gamma GOF Test | |
| 305 | 5% K-S Critical Value | 0.222 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 306 | Detected data appear Gamma Distributed at 5% Significance Level | | | |
| 307 | | | | |
| 308 | Gamma Statistics | | | |
| 309 | k hat (MLE) | 5.575 | k star (bias corrected MLE) | 4.505 |
| 310 | Theta hat (MLE) | 22.34 | Theta star (bias corrected MLE) | 27.65 |
| 311 | nu hat (MLE) | 167.3 | nu star (bias corrected) | 135.1 |
| 312 | MLE Mean (bias corrected) | 124.5 | MLE Sd (bias corrected) | 58.68 |
| 313 | | | Approximate Chi Square Value (0.05) | 109.3 |
| 314 | Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 106.4 |
| 315 | | | | |
| 316 | Assuming Gamma Distribution | | | |
| 317 | 95% Approximate Gamma UCL (use when n>=50)) | 154 | 95% Adjusted Gamma UCL (use when n<50) | 158.1 |
| 318 | | | | |
| 319 | Lognormal GOF Test | | | |
| 320 | Shapiro Wilk Test Statistic | 0.987 | Shapiro Wilk Lognormal GOF Test | |
| 321 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| 322 | Lilliefors Test Statistic | 0.0821 | Lilliefors Lognormal GOF Test | |
| 323 | 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| 324 | Data appear Lognormal at 5% Significance Level | | | |
| 325 | | | | |
| 326 | Lognormal Statistics | | | |
| 327 | Minimum of Logged Data | 3.871 | Mean of logged Data | 4.732 |
| 328 | Maximum of Logged Data | 5.521 | SD of logged Data | 0.451 |
| 329 | | | | |
| 330 | Assuming Lognormal Distribution | | | |
| 331 | 95% H-UCL | 160.4 | 90% Chebyshev (MVUE) UCL | 169.5 |
| 332 | 95% Chebyshev (MVUE) UCL | 189.8 | 97.5% Chebyshev (MVUE) UCL | 217.9 |
| 333 | 99% Chebyshev (MVUE) UCL | 273.1 | | |
| 334 | | | | |
| 335 | Nonparametric Distribution Free UCL Statistics | | | |
| 336 | Data appear to follow a Discernible Distribution at 5% Significance Level | | | |
| 337 | | | | |
| 338 | Nonparametric Distribution Free UCLs | | | |
| 339 | 95% CLT UCL | 148.1 | 95% Jackknife UCL | 149.8 |
| 340 | 95% Standard Bootstrap UCL | 148 | 95% Bootstrap-t UCL | 156.1 |
| 341 | 95% Hall's Bootstrap UCL | 162.1 | 95% Percentile Bootstrap UCL | 147.1 |
| 342 | 95% BCA Bootstrap UCL | 149.8 | | |
| 343 | 90% Chebyshev(Mean, Sd) UCL | 167.5 | 95% Chebyshev(Mean, Sd) UCL | 187 |
| 344 | 97.5% Chebyshev(Mean, Sd) UCL | 214 | 99% Chebyshev(Mean, Sd) UCL | 267 |
| 345 | | | | |
| 346 | Suggested UCL to Use | | | |
| 347 | 95% Student's-t UCL | 149.8 | | |
| 348 | | | | |
| 349 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 350 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 351 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 352 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 353 | | | | |
| 354 | Be | | | |
| 355 | | | | |
| 356 | General Statistics | | | |
| 357 | Total Number of Observations | 15 | Number of Distinct Observations | 1 |
| 358 | Number of Detects | 0 | Number of Non-Detects | 15 |
| 359 | Number of Distinct Detects | 0 | Number of Distinct Non-Detects | 1 |
| 360 | | | | |
| 361 | Warning: All observations are Non-Detects (NDs), therefore all statistics and estimates should also be NDs! | | | |
| 362 | Specifically, sample mean, UCLs, UPLs, and other statistics are also NDs lying below the largest detection limit! | | | |
| 363 | The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV). | | | |
| 364 | | | | |
| 365 | The data set for variable Be was not processed! | | | |
| 366 | | | | |

B

| | | | |
|---|---|---|---|
| **General Statistics** | | | |
| Total Number of Observations | 15 | Number of Distinct Observations | 14 |
| | | Number of Missing Observations | 0 |
| Minimum | 26 | Mean | 60.67 |
| Maximum | 152 | Median | 50 |
| SD | 35.21 | Std. Error of Mean | 9.091 |
| Coefficient of Variation | 0.58 | Skewness | 1.487 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.835 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data Not Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.253 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data Not Normal at 5% Significance Level | |
| **Data Not Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 76.68 | 95% Adjusted-CLT UCL (Chen-1995) | 79.35 |
| | | 95% Modified-t UCL (Johnson-1978) | 77.26 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.544 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.74 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.204 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.223 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 3.968 | k star (bias corrected MLE) | 3.219 |
| Theta hat (MLE) | 15.29 | Theta star (bias corrected MLE) | 18.85 |
| nu hat (MLE) | 119 | nu star (bias corrected) | 96.57 |
| MLE Mean (bias corrected) | 60.67 | MLE Sd (bias corrected) | 33.81 |
| | | Approximate Chi Square Value (0.05) | 74.91 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 72.56 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50) | 78.22 | 95% Adjusted Gamma UCL (use when n<50) | 80.75 |
| | | | |
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.946 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.17 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| **Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | 3.258 | Mean of logged Data | 3.974 |
| Maximum of Logged Data | 5.024 | SD of logged Data | 0.511 |
| | | | |
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 80.58 | 90% Chebyshev (MVUE) UCL | 84.59 |
| 95% Chebyshev (MVUE) UCL | 95.7 | 97.5% Chebyshev (MVUE) UCL | 111.1 |
| 99% Chebyshev (MVUE) UCL | 141.4 | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| | | | |
| **Nonparametric Distribution Free UCLs** | | | |
| 95% CLT UCL | 75.62 | 95% Jackknife UCL | 76.68 |
| 95% Standard Bootstrap UCL | 75.66 | 95% Bootstrap-t UCL | 84.18 |
| 95% Hall's Bootstrap UCL | 81.8 | 95% Percentile Bootstrap UCL | 76.53 |
| 95% BCA Bootstrap UCL | 79.47 | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 433 | | | | | 90% Chebyshev(Mean, Sd) UCL | 87.94 | | | | | 95% Chebyshev(Mean, Sd) UCL | 100.3 |
| 434 | | | | | 97.5% Chebyshev(Mean, Sd) UCL | 117.4 | | | | | 99% Chebyshev(Mean, Sd) UCL | 151.1 |
| 435 | | | | | | | | | | | | |
| 436 | | | | | | Suggested UCL to Use | | | | | | |
| 437 | | | | | 95% Adjusted Gamma UCL | 80.75 | | | | | | |
| 438 | | | | | | | | | | | | |
| 439 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | | | | | | | | | |
| 440 | Recommendations are based upon data size, data distribution, and skewness. | | | | | | | | | | | |
| 441 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | | | | | | | | | |
| 442 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | | | | | | | | | |
| 443 | | | | | | | | | | | | |
| 444 | Cd | | | | | | | | | | | |
| 445 | | | | | | | | | | | | |
| 446 | | | | | | General Statistics | | | | | | |
| 447 | | | | | Total Number of Observations | 15 | | | | | Number of Distinct Observations | 5 |
| 448 | | | | | Number of Detects | 12 | | | | | Number of Non-Detects | 3 |
| 449 | | | | | Number of Distinct Detects | 5 | | | | | Number of Distinct Non-Detects | 1 |
| 450 | | | | | Minimum Detect | 0.3 | | | | | Minimum Non-Detect | 0.3 |
| 451 | | | | | Maximum Detect | 1 | | | | | Maximum Non-Detect | 0.3 |
| 452 | | | | | Variance Detects | 0.039 | | | | | Percent Non-Detects | 20% |
| 453 | | | | | Mean Detects | 0.458 | | | | | SD Detects | 0.198 |
| 454 | | | | | Median Detects | 0.4 | | | | | CV Detects | 0.431 |
| 455 | | | | | Skewness Detects | 2.06 | | | | | Kurtosis Detects | 5.185 |
| 456 | | | | | Mean of Logged Detects | -0.846 | | | | | SD of Logged Detects | 0.36 |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 457 | | | | |
| 458 | **Normal GOF Test on Detects Only** | | | |
| 459 | Shapiro Wilk Test Statistic | 0.759 | **Shapiro Wilk GOF Test** | |
| 460 | 5% Shapiro Wilk Critical Value | 0.859 | Detected Data Not Normal at 5% Significance Level | |
| 461 | Lilliefors Test Statistic | 0.25 | **Lilliefors GOF Test** | |
| 462 | 5% Lilliefors Critical Value | 0.243 | Detected Data Not Normal at 5% Significance Level | |
| 463 | **Detected Data Not Normal at 5% Significance Level** | | | |
| 464 | | | | |
| 465 | **Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs** | | | |
| 466 | KM Mean | 0.427 | KM Standard Error of Mean | 0.0487 |
| 467 | KM SD | 0.181 | 95% KM (BCA) UCL | 0.507 |
| 468 | 95% KM (t) UCL | 0.512 | 95% KM (Percentile Bootstrap) UCL | 0.507 |
| 469 | 95% KM (z) UCL | 0.507 | 95% KM Bootstrap t UCL | 0.578 |
| 470 | 90% KM Chebyshev UCL | 0.573 | 95% KM Chebyshev UCL | 0.639 |
| 471 | 97.5% KM Chebyshev UCL | 0.731 | 99% KM Chebyshev UCL | 0.911 |
| 472 | | | | |
| 473 | **Gamma GOF Tests on Detected Observations Only** | | | |
| 474 | A-D Test Statistic | 0.698 | **Anderson-Darling GOF Test** | |
| 475 | 5% A-D Critical Value | 0.731 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 476 | K-S Test Statistic | 0.191 | **Kolmogorov-Smirnov GOF** | |
| 477 | 5% K-S Critical Value | 0.246 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 478 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| 479 | | | | |
| 480 | **Gamma Statistics on Detected Data Only** | | | |
| 481 | k hat (MLE) | 7.728 | k star (bias corrected MLE) | 5.851 |
| 482 | Theta hat (MLE) | 0.0593 | Theta star (bias corrected MLE) | 0.0783 |
| 483 | nu hat (MLE) | 185.5 | nu star (bias corrected) | 140.4 |
| 484 | Mean (detects) | 0.458 | | |
| 485 | | | | |
| 486 | **Gamma ROS Statistics using Imputed Non-Detects** | | | |
| 487 | GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| 488 | GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| 489 | For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| 490 | This is especially true when the sample size is small. | | | |
| 491 | For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| 492 | Minimum | 0.0412 | Mean | 0.386 |
| 493 | Maximum | 1 | Median | 0.4 |
| 494 | SD | 0.232 | CV | 0.6 |
| 495 | k hat (MLE) | 2.433 | k star (bias corrected MLE) | 1.991 |
| 496 | Theta hat (MLE) | 0.159 | Theta star (bias corrected MLE) | 0.194 |
| 497 | nu hat (MLE) | 72.98 | nu star (bias corrected) | 59.72 |
| 498 | Adjusted Level of Significance (β) | 0.0324 | | |
| 499 | Approximate Chi Square Value (59.72, α) | 42.95 | Adjusted Chi Square Value (59.72, β) | 41.2 |
| 500 | 95% Gamma Approximate UCL (use when n>=50) | 0.536 | 95% Gamma Adjusted UCL (use when n<50) | 0.559 |
| 501 | | | | |
| 502 | **Estimates of Gamma Parameters using KM Estimates** | | | |
| 503 | Mean (KM) | 0.427 | SD (KM) | 0.181 |
| 504 | Variance (KM) | 0.0326 | SE of Mean (KM) | 0.0487 |
| 505 | k hat (KM) | 5.58 | k star (KM) | 4.509 |
| 506 | nu hat (KM) | 167.4 | nu star (KM) | 135.3 |
| 507 | theta hat (KM) | 0.0765 | theta star (KM) | 0.0946 |
| 508 | 80% gamma percentile (KM) | 0.58 | 90% gamma percentile (KM) | 0.696 |
| 509 | 95% gamma percentile (KM) | 0.802 | 99% gamma percentile (KM) | 1.026 |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 510 | | | | | | | | | | | | |
| 511 | **Gamma Kaplan-Meier (KM) Statistics** | | | | | | | | | | | |
| 512 | Approximate Chi Square Value (135.26, α) | | | | | 109.4 | Adjusted Chi Square Value (135.26, β) | | | | | 106.5 |
| 513 | 95% Gamma Approximate KM-UCL (use when n>=50) | | | | | 0.528 | 95% Gamma Adjusted KM-UCL (use when n<50) | | | | | 0.542 |
| 514 | | | | | | | | | | | | |
| 515 | **Lognormal GOF Test on Detected Observations Only** | | | | | | | | | | | |
| 516 | Shapiro Wilk Test Statistic | | | | | 0.866 | **Shapiro Wilk GOF Test** | | | | | |
| 517 | 5% Shapiro Wilk Critical Value | | | | | 0.859 | Detected Data appear Lognormal at 5% Significance Level | | | | | |
| 518 | Lilliefors Test Statistic | | | | | 0.173 | **Lilliefors GOF Test** | | | | | |
| 519 | 5% Lilliefors Critical Value | | | | | 0.243 | Detected Data appear Lognormal at 5% Significance Level | | | | | |
| 520 | **Detected Data appear Lognormal at 5% Significance Level** | | | | | | | | | | | |
| 521 | | | | | | | | | | | | |
| 522 | **Lognormal ROS Statistics Using Imputed Non-Detects** | | | | | | | | | | | |
| 523 | Mean in Original Scale | | | | | 0.404 | Mean in Log Scale | | | | | -1.014 |
| 524 | SD in Original Scale | | | | | 0.208 | SD in Log Scale | | | | | 0.475 |
| 525 | 95% t UCL (assumes normality of ROS data) | | | | | 0.499 | 95% Percentile Bootstrap UCL | | | | | 0.494 |
| 526 | 95% BCA Bootstrap UCL | | | | | 0.52 | 95% Bootstrap t UCL | | | | | 0.536 |
| 527 | 95% H-UCL (Log ROS) | | | | | 0.526 | | | | | | |
| 528 | | | | | | | | | | | | |
| 529 | **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | | | | | | | | | |
| 530 | KM Mean (logged) | | | | | -0.918 | KM Geo Mean | | | | | 0.399 |
| 531 | KM SD (logged) | | | | | 0.34 | 95% Critical H Value (KM-Log) | | | | | 1.915 |
| 532 | KM Standard Error of Mean (logged) | | | | | 0.0917 | 95% H-UCL (KM -Log) | | | | | 0.504 |
| 533 | KM SD (logged) | | | | | 0.34 | 95% Critical H Value (KM-Log) | | | | | 1.915 |
| 534 | KM Standard Error of Mean (logged) | | | | | 0.0917 | | | | | | |
| 535 | | | | | | | | | | | | |
| 536 | **DL/2 Statistics** | | | | | | | | | | | |
| 537 | **DL/2 Normal** | | | | | | **DL/2 Log-Transformed** | | | | | |
| 538 | Mean in Original Scale | | | | | 0.397 | Mean in Log Scale | | | | | -1.056 |
| 539 | SD in Original Scale | | | | | 0.217 | SD in Log Scale | | | | | 0.54 |
| 540 | 95% t UCL (Assumes normality) | | | | | 0.495 | 95% H-Stat UCL | | | | | 0.545 |
| 541 | **DL/2 is not a recommended method, provided for comparisons and historical reasons** | | | | | | | | | | | |
| 542 | | | | | | | | | | | | |
| 543 | **Nonparametric Distribution Free UCL Statistics** | | | | | | | | | | | |
| 544 | **Detected Data appear Gamma Distributed at 5% Significance Level** | | | | | | | | | | | |
| 545 | | | | | | | | | | | | |
| 546 | **Suggested UCL to Use** | | | | | | | | | | | |
| 547 | 95% KM Adjusted Gamma UCL | | | | | 0.542 | 95% GROS Adjusted Gamma UCL | | | | | 0.559 |
| 548 | | | | | | | | | | | | |
| 549 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | | | | | | | | | |
| 550 | Recommendations are based upon data size, data distribution, and skewness. | | | | | | | | | | | |
| 551 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | | | | | | | | | |
| 552 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | | | | | | | | | |
| 553 | | | | | | | | | | | | |

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|---|---|---|---|
| **General Statistics** | | | |
| Total Number of Observations | 15 | Number of Distinct Observations | 13 |
| | | Number of Missing Observations | 0 |
| Minimum | 11 | Mean | 34.4 |
| Maximum | 98 | Median | 31 |
| SD | 22.64 | Std. Error of Mean | 5.846 |
| Coefficient of Variation | 0.658 | Skewness | 1.933 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.78 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data Not Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.286 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data Not Normal at 5% Significance Level | |
| **Data Not Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 44.7 | 95% Adjusted-CLT UCL (Chen-1995) | 47.13 |
| | | 95% Modified-t UCL (Johnson-1978) | 45.18 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.612 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.744 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.206 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.223 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 3.216 | k star (bias corrected MLE) | 2.617 |
| Theta hat (MLE) | 10.7 | Theta star (bias corrected MLE) | 13.14 |
| nu hat (MLE) | 96.47 | nu star (bias corrected) | 78.51 |
| MLE Mean (bias corrected) | 34.4 | MLE Sd (bias corrected) | 21.26 |
| | | Approximate Chi Square Value (0.05) | 59.1 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 57.03 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50) | 45.7 | 95% Adjusted Gamma UCL (use when n<50) | 47.36 |
| | | | |
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.938 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.176 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| **Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | 2.398 | Mean of logged Data | 3.375 |
| Maximum of Logged Data | 4.585 | SD of logged Data | 0.58 |

**Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% H-UCL | 48.31 | 90% Chebyshev (MVUE) UCL | 50.08 |
| 95% Chebyshev (MVUE) UCL | 57.3 | 97.5% Chebyshev (MVUE) UCL | 67.33 |
| 99% Chebyshev (MVUE) UCL | 87.02 | | |

**Nonparametric Distribution Free UCL Statistics**

**Data appear to follow a Discernible Distribution at 5% Significance Level**

**Nonparametric Distribution Free UCLs**

| | | | |
|---|---|---|---|
| 95% CLT UCL | 44.02 | 95% Jackknife UCL | 44.7 |
| 95% Standard Bootstrap UCL | 43.68 | 95% Bootstrap-t UCL | 55.06 |
| 95% Hall's Bootstrap UCL | 105.1 | 95% Percentile Bootstrap UCL | 44.27 |
| 95% BCA Bootstrap UCL | 46.4 | | |
| 90% Chebyshev(Mean, Sd) UCL | 51.94 | 95% Chebyshev(Mean, Sd) UCL | 59.88 |
| 97.5% Chebyshev(Mean, Sd) UCL | 70.91 | 99% Chebyshev(Mean, Sd) UCL | 92.57 |

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% Adjusted Gamma UCL | 47.36 | | |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Co

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 10 |
| | | Number of Missing Observations | 0 |
| Minimum | 8 | Mean | 13.53 |
| Maximum | 22 | Median | 13 |
| SD | 3.739 | Std. Error of Mean | 0.965 |
| Coefficient of Variation | 0.276 | Skewness | 0.859 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.922 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.223 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.22 | Data Not Normal at 5% Significance Level |

**Data appear Approximate Normal at 5% Significance Level**

**Assuming Normal Distribution**

| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
|---|---|---|---|
| 95% Student's-t UCL | 15.23 | 95% Adjusted-CLT UCL (Chen-1995) | 15.35 |
| | | 95% Modified-t UCL (Johnson-1978) | 15.27 |

**Gamma GOF Test**

| | | |
|---|---|---|
| A-D Test Statistic | 0.436 | **Anderson-Darling Gamma GOF Test** |
| 5% A-D Critical Value | 0.736 | Detected data appear Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.193 | **Kolmogorov-Smirnov Gamma GOF Test** |
| 5% K-S Critical Value | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level |

**Detected data appear Gamma Distributed at 5% Significance Level**

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 14.85 | k star (bias corrected MLE) | 11.93 |
| Theta hat (MLE) | 0.911 | Theta star (bias corrected MLE) | 1.135 |
| nu hat (MLE) | 445.6 | nu star (bias corrected) | 357.8 |
| MLE Mean (bias corrected) | 13.53 | MLE Sd (bias corrected) | 3.919 |
| | | Approximate Chi Square Value (0.05) | 315 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 310 |

**Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Approximate Gamma UCL (use when n>=50)) | 15.37 | 95% Adjusted Gamma UCL (use when n<50) | 15.62 |

**Lognormal GOF Test**

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 672 | | | | | Shapiro Wilk Test Statistic | 0.959 | **Shapiro Wilk Lognormal GOF Test** | | | | | |
| 673 | | | | | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | | | | | |
| 674 | | | | | Lilliefors Test Statistic | 0.176 | **Lilliefors Lognormal GOF Test** | | | | | |
| 675 | | | | | 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | | | | | |
| 676 | **Data appear Lognormal at 5% Significance Level** | | | | | | | | | | | |
| 677 | | | | | | | | | | | | |
| 678 | **Lognormal Statistics** | | | | | | | | | | | |
| 679 | | | | | Minimum of Logged Data | 2.079 | | | | | Mean of logged Data | 2.571 |
| 680 | | | | | Maximum of Logged Data | 3.091 | | | | | SD of logged Data | 0.269 |
| 681 | | | | | | | | | | | | |
| 682 | **Assuming Lognormal Distribution** | | | | | | | | | | | |
| 683 | | | | | 95% H-UCL | 15.5 | | | | | 90% Chebyshev (MVUE) UCL | 16.37 |
| 684 | | | | | 95% Chebyshev (MVUE) UCL | 17.66 | | | | | 97.5% Chebyshev (MVUE) UCL | 19.44 |
| 685 | | | | | 99% Chebyshev (MVUE) UCL | 22.95 | | | | | | |
| 686 | | | | | | | | | | | | |
| 687 | **Nonparametric Distribution Free UCL Statistics** | | | | | | | | | | | |
| 688 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | | | | | | | | | |
| 689 | | | | | | | | | | | | |
| 690 | **Nonparametric Distribution Free UCLs** | | | | | | | | | | | |
| 691 | | | | | 95% CLT UCL | 15.12 | | | | | 95% Jackknife UCL | 15.23 |
| 692 | | | | | 95% Standard Bootstrap UCL | 15.06 | | | | | 95% Bootstrap-t UCL | 15.61 |
| 693 | | | | | 95% Hall's Bootstrap UCL | 15.69 | | | | | 95% Percentile Bootstrap UCL | 15 |
| 694 | | | | | 95% BCA Bootstrap UCL | 15.2 | | | | | | |
| 695 | | | | | 90% Chebyshev(Mean, Sd) UCL | 16.43 | | | | | 95% Chebyshev(Mean, Sd) UCL | 17.74 |
| 696 | | | | | 97.5% Chebyshev(Mean, Sd) UCL | 19.56 | | | | | 99% Chebyshev(Mean, Sd) UCL | 23.14 |
| 697 | | | | | | | | | | | | |
| 698 | **Suggested UCL to Use** | | | | | | | | | | | |
| 699 | | | | | 95% Student's-t UCL | 15.23 | | | | | | |
| 700 | | | | | | | | | | | | |
| 701 | When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test | | | | | | | | | | | |
| 702 | When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL | | | | | | | | | | | |
| 703 | | | | | | | | | | | | |
| 704 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | | | | | | | | | |
| 705 | Recommendations are based upon data size, data distribution, and skewness. | | | | | | | | | | | |
| 706 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | | | | | | | | | |
| 707 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | | | | | | | | | |
| 708 | | | | | | | | | | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 709 | | | | |
| 710 | Cu | | | |
| 711 | | | | |
| 712 | | **General Statistics** | | |
| 713 | Total Number of Observations | 15 | Number of Distinct Observations | 14 |
| 714 | | | Number of Missing Observations | 0 |
| 715 | Minimum | 63 | Mean | 145.3 |
| 716 | Maximum | 260 | Median | 147 |
| 717 | SD | 50.21 | Std. Error of Mean | 12.96 |
| 718 | Coefficient of Variation | 0.345 | Skewness | 0.443 |
| 719 | | | | |
| 720 | | **Normal GOF Test** | | |
| 721 | Shapiro Wilk Test Statistic | 0.952 | **Shapiro Wilk GOF Test** | |
| 722 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| 723 | Lilliefors Test Statistic | 0.171 | **Lilliefors GOF Test** | |
| 724 | 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |
| 725 | | **Data appear Normal at 5% Significance Level** | | |
| 726 | | | | |
| 727 | | **Assuming Normal Distribution** | | |
| 728 | **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 729 | 95% Student's-t UCL | 168.2 | 95% Adjusted-CLT UCL (Chen-1995) | 168.2 |
| 730 | | | 95% Modified-t UCL (Johnson-1978) | 168.4 |
| 731 | | | | |
| 732 | | **Gamma GOF Test** | | |
| 733 | A-D Test Statistic | 0.412 | **Anderson-Darling Gamma GOF Test** | |
| 734 | 5% A-D Critical Value | 0.738 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 735 | K-S Test Statistic | 0.202 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 736 | 5% K-S Critical Value | 0.222 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 737 | | **Detected data appear Gamma Distributed at 5% Significance Level** | | |
| 738 | | | | |
| 739 | | **Gamma Statistics** | | |
| 740 | k hat (MLE) | 8.461 | k star (bias corrected MLE) | 6.814 |
| 741 | Theta hat (MLE) | 17.18 | Theta star (bias corrected MLE) | 21.33 |
| 742 | nu hat (MLE) | 253.8 | nu star (bias corrected) | 204.4 |
| 743 | MLE Mean (bias corrected) | 145.3 | MLE Sd (bias corrected) | 55.68 |
| 744 | | | Approximate Chi Square Value (0.05) | 172.3 |
| 745 | Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 168.7 |
| 746 | | | | |
| 747 | | **Assuming Gamma Distribution** | | |
| 748 | 95% Approximate Gamma UCL (use when n>=50)) | 172.4 | 95% Adjusted Gamma UCL (use when n<50) | 176.1 |
| 749 | | | | |
| 750 | | **Lognormal GOF Test** | | |
| 751 | Shapiro Wilk Test Statistic | 0.944 | **Shapiro Wilk Lognormal GOF Test** | |
| 752 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| 753 | Lilliefors Test Statistic | 0.221 | **Lilliefors Lognormal GOF Test** | |
| 754 | 5% Lilliefors Critical Value | 0.22 | Data Not Lognormal at 5% Significance Level | |
| 755 | | **Data appear Approximate Lognormal at 5% Significance Level** | | |
| 756 | | | | |
| 757 | | **Lognormal Statistics** | | |
| 758 | Minimum of Logged Data | 4.143 | Mean of logged Data | 4.919 |
| 759 | Maximum of Logged Data | 5.561 | SD of logged Data | 0.371 |
| 760 | | | | |

| | | | |
|---|---|---|---|
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 177.7 | 90% Chebyshev (MVUE) UCL | 188.6 |
| 95% Chebyshev (MVUE) UCL | 207.9 | 97.5% Chebyshev (MVUE) UCL | 234.7 |
| 99% Chebyshev (MVUE) UCL | 287.4 | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| | | | |
| **Nonparametric Distribution Free UCLs** | | | |
| 95% CLT UCL | 166.7 | 95% Jackknife UCL | 168.2 |
| 95% Standard Bootstrap UCL | 166.4 | 95% Bootstrap-t UCL | 170.1 |
| 95% Hall's Bootstrap UCL | 171.7 | 95% Percentile Bootstrap UCL | 166.8 |
| 95% BCA Bootstrap UCL | 166.9 | | |
| 90% Chebyshev(Mean, Sd) UCL | 184.2 | 95% Chebyshev(Mean, Sd) UCL | 201.8 |
| 97.5% Chebyshev(Mean, Sd) UCL | 226.3 | 99% Chebyshev(Mean, Sd) UCL | 274.3 |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% Student's-t UCL | 168.2 | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| | | | |
| | | | |
| **Fe** | | | |
| | | | |
| **General Statistics** | | | |
| Total Number of Observations | 15 | Number of Distinct Observations | 15 |
| | | Number of Missing Observations | 0 |
| Minimum | 19400 | Mean | 33507 |
| Maximum | 50000 | Median | 31300 |
| SD | 9302 | Std. Error of Mean | 2402 |
| Coefficient of Variation | 0.278 | Skewness | 0.381 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.961 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.127 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |
| **Data appear Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 37737 | 95% Adjusted-CLT UCL (Chen-1995) | 37710 |
| | | 95% Modified-t UCL (Johnson-1978) | 37777 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.169 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.736 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.108 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 13.9 | k star (bias corrected MLE) | 11.16 |
| Theta hat (MLE) | 2411 | Theta star (bias corrected MLE) | 3002 |
| nu hat (MLE) | 416.9 | nu star (bias corrected) | 334.9 |
| MLE Mean (bias corrected) | 33507 | MLE Sd (bias corrected) | 10029 |
| | | Approximate Chi Square Value (0.05) | 293.5 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 288.7 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50)) | 38233 | 95% Adjusted Gamma UCL (use when n<50) | 38865 |
| | | | |
| **Lognormal GOF Test** | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 827 | Shapiro Wilk Test Statistic | 0.976 | **Shapiro Wilk Lognormal GOF Test** | |
| 828 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| 829 | Lilliefors Test Statistic | 0.0902 | **Lilliefors Lognormal GOF Test** | |
| 830 | 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| 831 | **Data appear Lognormal at 5% Significance Level** | | | |
| 832 | | | | |
| 833 | **Lognormal Statistics** | | | |
| 834 | Minimum of Logged Data | 9.873 | Mean of logged Data | 10.38 |
| 835 | Maximum of Logged Data | 10.82 | SD of logged Data | 0.281 |
| 836 | | | | |
| 837 | **Assuming Lognormal Distribution** | | | |
| 838 | 95% H-UCL | 38673 | 90% Chebyshev (MVUE) UCL | 40893 |
| 839 | 95% Chebyshev (MVUE) UCL | 44233 | 97.5% Chebyshev (MVUE) UCL | 48868 |
| 840 | 99% Chebyshev (MVUE) UCL | 57973 | | |
| 841 | | | | |
| 842 | **Nonparametric Distribution Free UCL Statistics** | | | |
| 843 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| 844 | | | | |
| 845 | **Nonparametric Distribution Free UCLs** | | | |
| 846 | 95% CLT UCL | 37457 | 95% Jackknife UCL | 37737 |
| 847 | 95% Standard Bootstrap UCL | 37270 | 95% Bootstrap-t UCL | 38040 |
| 848 | 95% Hall's Bootstrap UCL | 37931 | 95% Percentile Bootstrap UCL | 37327 |
| 849 | 95% BCA Bootstrap UCL | 37333 | | |
| 850 | 90% Chebyshev(Mean, Sd) UCL | 40712 | 95% Chebyshev(Mean, Sd) UCL | 43976 |
| 851 | 97.5% Chebyshev(Mean, Sd) UCL | 48506 | 99% Chebyshev(Mean, Sd) UCL | 57405 |
| 852 | | | | |
| 853 | **Suggested UCL to Use** | | | |
| 854 | 95% Student's-t UCL | 37737 | | |
| 855 | | | | |
| 856 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 857 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 858 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 859 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 860 | | | | |
| 861 | | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 862 | Pb | | | |
| 863 | | | | |
| 864 | **General Statistics** | | | |
| 865 | Total Number of Observations | 15 | Number of Distinct Observations | 13 |
| 866 | | | Number of Missing Observations | 0 |
| 867 | Minimum | 54.4 | Mean | 286.9 |
| 868 | Maximum | 728 | Median | 252 |
| 869 | SD | 165.1 | Std. Error of Mean | 42.62 |
| 870 | Coefficient of Variation | 0.575 | Skewness | 1.26 |
| 871 | | | | |
| 872 | **Normal GOF Test** | | | |
| 873 | Shapiro Wilk Test Statistic | 0.91 | **Shapiro Wilk GOF Test** | |
| 874 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| 875 | Lilliefors Test Statistic | 0.151 | **Lilliefors GOF Test** | |
| 876 | 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |
| 877 | **Data appear Normal at 5% Significance Level** | | | |
| 878 | | | | |
| 879 | **Assuming Normal Distribution** | | | |
| 880 | **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 881 | 95% Student's-t UCL | 362 | 95% Adjusted-CLT UCL (Chen-1995) | 371.8 |
| 882 | | | 95% Modified-t UCL (Johnson-1978) | 364.3 |
| 883 | | | | |
| 884 | **Gamma GOF Test** | | | |
| 885 | A-D Test Statistic | 0.267 | **Anderson-Darling Gamma GOF Test** | |
| 886 | 5% A-D Critical Value | 0.744 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 887 | K-S Test Statistic | 0.136 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 888 | 5% K-S Critical Value | 0.223 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 889 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| 890 | | | | |
| 891 | **Gamma Statistics** | | | |
| 892 | k hat (MLE) | 3.186 | k star (bias corrected MLE) | 2.593 |
| 893 | Theta hat (MLE) | 90.06 | Theta star (bias corrected MLE) | 110.6 |
| 894 | nu hat (MLE) | 95.57 | nu star (bias corrected) | 77.79 |
| 895 | MLE Mean (bias corrected) | 286.9 | MLE Sd (bias corrected) | 178.2 |
| 896 | | | Approximate Chi Square Value (0.05) | 58.47 |
| 897 | Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 56.41 |
| 898 | | | | |
| 899 | **Assuming Gamma Distribution** | | | |
| 900 | 95% Approximate Gamma UCL (use when n>=50)) | 381.7 | 95% Adjusted Gamma UCL (use when n<50) | 395.6 |
| 901 | | | | |
| 902 | **Lognormal GOF Test** | | | |
| 903 | Shapiro Wilk Test Statistic | 0.949 | **Shapiro Wilk Lognormal GOF Test** | |
| 904 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| 905 | Lilliefors Test Statistic | 0.176 | **Lilliefors Lognormal GOF Test** | |
| 906 | 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| 907 | **Data appear Lognormal at 5% Significance Level** | | | |
| 908 | | | | |
| 909 | **Lognormal Statistics** | | | |
| 910 | Minimum of Logged Data | 3.996 | Mean of logged Data | 5.494 |
| 911 | Maximum of Logged Data | 6.59 | SD of logged Data | 0.633 |
| 912 | | | | |

| | | | |
|---|---|---|---|
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 432.6 | 90% Chebyshev (MVUE) UCL | 442.5 |
| 95% Chebyshev (MVUE) UCL | 510.4 | 97.5% Chebyshev (MVUE) UCL | 604.7 |
| 99% Chebyshev (MVUE) UCL | 789.8 | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| | | | |
| **Nonparametric Distribution Free UCLs** | | | |
| 95% CLT UCL | 357 | 95% Jackknife UCL | 362 |
| 95% Standard Bootstrap UCL | 355 | 95% Bootstrap-t UCL | 382.2 |
| 95% Hall's Bootstrap UCL | 446.1 | 95% Percentile Bootstrap UCL | 360.1 |
| 95% BCA Bootstrap UCL | 363.3 | | |
| 90% Chebyshev(Mean, Sd) UCL | 414.7 | 95% Chebyshev(Mean, Sd) UCL | 472.7 |
| 97.5% Chebyshev(Mean, Sd) UCL | 553 | 99% Chebyshev(Mean, Sd) UCL | 710.9 |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% Student's-t UCL | 362 | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| | | | |
| | | | |
| Li | | | |
| | | | |
| **General Statistics** | | | |
| Total Number of Observations | 15 | Number of Distinct Observations | 8 |
| | | Number of Missing Observations | 0 |
| Minimum | 13 | Mean | 17.53 |
| Maximum | 22 | Median | 17 |
| SD | 2.774 | Std. Error of Mean | 0.716 |
| Coefficient of Variation | 0.158 | Skewness | 0.00522 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.956 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.11 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |
| **Data appear Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 18.79 | 95% Adjusted-CLT UCL (Chen-1995) | 18.71 |
| | | 95% Modified-t UCL (Johnson-1978) | 18.8 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.265 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.735 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.108 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.221 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 41.82 | k star (bias corrected MLE) | 33.5 |
| Theta hat (MLE) | 0.419 | Theta star (bias corrected MLE) | 0.523 |
| nu hat (MLE) | 1255 | nu star (bias corrected) | 1005 |
| MLE Mean (bias corrected) | 17.53 | MLE Sd (bias corrected) | 3.029 |
| | | Approximate Chi Square Value (0.05) | 932.4 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 923.8 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50)) | 18.9 | 95% Adjusted Gamma UCL (use when n<50) | 19.07 |
| | | | |
| **Lognormal GOF Test** | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 979 | | | | | Shapiro Wilk Test Statistic | 0.948 | **Shapiro Wilk Lognormal GOF Test** | | | | | |
| 980 | | | | | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | | | | | |
| 981 | | | | | Lilliefors Test Statistic | 0.12 | **Lilliefors Lognormal GOF Test** | | | | | |
| 982 | | | | | 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | | | | | |
| 983 | **Data appear Lognormal at 5% Significance Level** | | | | | | | | | | | |
| 984 | | | | | | | | | | | | |
| 985 | **Lognormal Statistics** | | | | | | | | | | | |
| 986 | | | | | Minimum of Logged Data | 2.565 | | | | | Mean of logged Data | 2.852 |
| 987 | | | | | Maximum of Logged Data | 3.091 | | | | | SD of logged Data | 0.162 |
| 988 | | | | | | | | | | | | |
| 989 | **Assuming Lognormal Distribution** | | | | | | | | | | | |
| 990 | | | | | 95% H-UCL | 18.96 | | | | | 90% Chebyshev (MVUE) UCL | 19.74 |
| 991 | | | | | 95% Chebyshev (MVUE) UCL | 20.74 | | | | | 97.5% Chebyshev (MVUE) UCL | 22.13 |
| 992 | | | | | 99% Chebyshev (MVUE) UCL | 24.85 | | | | | | |
| 993 | | | | | | | | | | | | |
| 994 | **Nonparametric Distribution Free UCL Statistics** | | | | | | | | | | | |
| 995 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | | | | | | | | | |
| 996 | | | | | | | | | | | | |
| 997 | **Nonparametric Distribution Free UCLs** | | | | | | | | | | | |
| 998 | | | | | 95% CLT UCL | 18.71 | | | | | 95% Jackknife UCL | 18.79 |
| 999 | | | | | 95% Standard Bootstrap UCL | 18.67 | | | | | 95% Bootstrap-t UCL | 18.9 |
| 1000 | | | | | 95% Hall's Bootstrap UCL | 18.75 | | | | | 95% Percentile Bootstrap UCL | 18.73 |
| 1001 | | | | | 95% BCA Bootstrap UCL | 18.53 | | | | | | |
| 1002 | | | | | 90% Chebyshev(Mean, Sd) UCL | 19.68 | | | | | 95% Chebyshev(Mean, Sd) UCL | 20.66 |
| 1003 | | | | | 97.5% Chebyshev(Mean, Sd) UCL | 22.01 | | | | | 99% Chebyshev(Mean, Sd) UCL | 24.66 |
| 1004 | | | | | | | | | | | | |
| 1005 | **Suggested UCL to Use** | | | | | | | | | | | |
| 1006 | | | | | 95% Student's-t UCL | 18.79 | | | | | | |
| 1007 | | | | | | | | | | | | |
| 1008 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | | | | | | | | | |
| 1009 | Recommendations are based upon data size, data distribution, and skewness. | | | | | | | | | | | |
| 1010 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | | | | | | | | | |
| 1011 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | | | | | | | | | |
| 1012 | | | | | | | | | | | | |
| 1013 | | | | | | | | | | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 1014 | **Mn** | | | |
| 1015 | | | | |
| 1016 | **General Statistics** | | | |
| 1017 | Total Number of Observations | 15 | Number of Distinct Observations | 15 |
| 1018 | | | Number of Missing Observations | 0 |
| 1019 | Minimum | 115 | Mean | 319.6 |
| 1020 | Maximum | 559 | Median | 326 |
| 1021 | SD | 107.8 | Std. Error of Mean | 27.82 |
| 1022 | Coefficient of Variation | 0.337 | Skewness | -0.152 |
| 1023 | | | | |
| 1024 | **Normal GOF Test** | | | |
| 1025 | Shapiro Wilk Test Statistic | 0.898 | **Shapiro Wilk GOF Test** | |
| 1026 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| 1027 | Lilliefors Test Statistic | 0.203 | **Lilliefors GOF Test** | |
| 1028 | 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |
| 1029 | **Data appear Normal at 5% Significance Level** | | | |
| 1030 | | | | |
| 1031 | **Assuming Normal Distribution** | | | |
| 1032 | **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 1033 | 95% Student's-t UCL | 368.6 | 95% Adjusted-CLT UCL (Chen-1995) | 364.2 |
| 1034 | | | 95% Modified-t UCL (Johnson-1978) | 368.4 |
| 1035 | | | | |
| 1036 | **Gamma GOF Test** | | | |
| 1037 | A-D Test Statistic | 1.139 | **Anderson-Darling Gamma GOF Test** | |
| 1038 | 5% A-D Critical Value | 0.738 | Data Not Gamma Distributed at 5% Significance Level | |
| 1039 | K-S Test Statistic | 0.256 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 1040 | 5% K-S Critical Value | 0.222 | Data Not Gamma Distributed at 5% Significance Level | |
| 1041 | **Data Not Gamma Distributed at 5% Significance Level** | | | |
| 1042 | | | | |
| 1043 | **Gamma Statistics** | | | |
| 1044 | k hat (MLE) | 7.32 | k star (bias corrected MLE) | 5.901 |
| 1045 | Theta hat (MLE) | 43.66 | Theta star (bias corrected MLE) | 54.16 |
| 1046 | nu hat (MLE) | 219.6 | nu star (bias corrected) | 177 |
| 1047 | MLE Mean (bias corrected) | 319.6 | MLE Sd (bias corrected) | 131.6 |
| 1048 | | | Approximate Chi Square Value (0.05) | 147.2 |
| 1049 | Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 143.9 |
| 1050 | | | | |
| 1051 | **Assuming Gamma Distribution** | | | |
| 1052 | 95% Approximate Gamma UCL (use when n>=50)) | 384.2 | 95% Adjusted Gamma UCL (use when n<50) | 393.1 |
| 1053 | | | | |
| 1054 | **Lognormal GOF Test** | | | |
| 1055 | Shapiro Wilk Test Statistic | 0.79 | **Shapiro Wilk Lognormal GOF Test** | |
| 1056 | 5% Shapiro Wilk Critical Value | 0.881 | Data Not Lognormal at 5% Significance Level | |
| 1057 | Lilliefors Test Statistic | 0.288 | **Lilliefors Lognormal GOF Test** | |
| 1058 | 5% Lilliefors Critical Value | 0.22 | Data Not Lognormal at 5% Significance Level | |
| 1059 | **Data Not Lognormal at 5% Significance Level** | | | |
| 1060 | | | | |
| 1061 | **Lognormal Statistics** | | | |
| 1062 | Minimum of Logged Data | 4.745 | Mean of logged Data | 5.697 |
| 1063 | Maximum of Logged Data | 6.326 | SD of logged Data | 0.423 |
| 1064 | | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1065 | **Assuming Lognormal Distribution** | | | | | | | | | | | |
| 1066 | | | | | 95% H-UCL | 408.1 | | | | | 90% Chebyshev (MVUE) UCL | 432.2 |
| 1067 | | | | | 95% Chebyshev (MVUE) UCL | 481.3 | | | | | 97.5% Chebyshev (MVUE) UCL | 549.5 |
| 1068 | | | | | 99% Chebyshev (MVUE) UCL | 683.4 | | | | | | |
| 1069 | | | | | | | | | | | | |
| 1070 | **Nonparametric Distribution Free UCL Statistics** | | | | | | | | | | | |
| 1071 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | | | | | | | | | |
| 1072 | | | | | | | | | | | | |
| 1073 | **Nonparametric Distribution Free UCLs** | | | | | | | | | | | |
| 1074 | | | | | 95% CLT UCL | 365.4 | | | | | 95% Jackknife UCL | 368.6 |
| 1075 | | | | | 95% Standard Bootstrap UCL | 363 | | | | | 95% Bootstrap-t UCL | 365.5 |
| 1076 | | | | | 95% Hall's Bootstrap UCL | 372 | | | | | 95% Percentile Bootstrap UCL | 362.8 |
| 1077 | | | | | 95% BCA Bootstrap UCL | 363.3 | | | | | | |
| 1078 | | | | | 90% Chebyshev(Mean, Sd) UCL | 403.1 | | | | | 95% Chebyshev(Mean, Sd) UCL | 440.9 |
| 1079 | | | | | 97.5% Chebyshev(Mean, Sd) UCL | 493.4 | | | | | 99% Chebyshev(Mean, Sd) UCL | 596.5 |
| 1080 | | | | | | | | | | | | |
| 1081 | **Suggested UCL to Use** | | | | | | | | | | | |
| 1082 | | | | | 95% Student's-t UCL | 368.6 | | | | | | |
| 1083 | | | | | | | | | | | | |
| 1084 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | | | | | | | | | |
| 1085 | Recommendations are based upon data size, data distribution, and skewness. | | | | | | | | | | | |
| 1086 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | | | | | | | | | |
| 1087 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | | | | | | | | | |
| 1088 | | | | | | | | | | | | |
| 1089 | **Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be** | | | | | | | | | | | |
| 1090 | **reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.** | | | | | | | | | | | |
| 1091 | | | | | | | | | | | | |
| 1092 | | | | | | | | | | | | |
| 1093 | Hg | | | | | | | | | | | |
| 1094 | | | | | | | | | | | | |
| 1095 | **General Statistics** | | | | | | | | | | | |
| 1096 | | | | | Total Number of Observations | 15 | | | | | Number of Distinct Observations | 9 |
| 1097 | | | | | | | | | | | Number of Missing Observations | 0 |
| 1098 | | | | | Minimum | 0.05 | | | | | Mean | 0.118 |
| 1099 | | | | | Maximum | 0.64 | | | | | Median | 0.07 |
| 1100 | | | | | SD | 0.148 | | | | | Std. Error of Mean | 0.0381 |
| 1101 | | | | | Coefficient of Variation | 1.251 | | | | | Skewness | 3.601 |
| 1102 | | | | | | | | | | | | |
| 1103 | **Normal GOF Test** | | | | | | | | | | | |
| 1104 | | | | | Shapiro Wilk Test Statistic | 0.461 | **Shapiro Wilk GOF Test** | | | | | |
| 1105 | | | | | 5% Shapiro Wilk Critical Value | 0.881 | Data Not Normal at 5% Significance Level | | | | | |
| 1106 | | | | | Lilliefors Test Statistic | 0.374 | **Lilliefors GOF Test** | | | | | |
| 1107 | | | | | 5% Lilliefors Critical Value | 0.22 | Data Not Normal at 5% Significance Level | | | | | |
| 1108 | **Data Not Normal at 5% Significance Level** | | | | | | | | | | | |
| 1109 | | | | | | | | | | | | |
| 1110 | **Assuming Normal Distribution** | | | | | | | | | | | |
| 1111 | **95% Normal UCL** | | | | | | **95% UCLs (Adjusted for Skewness)** | | | | | |
| 1112 | | | | | 95% Student's-t UCL | 0.185 | | | | | 95% Adjusted-CLT UCL (Chen-1995) | 0.219 |
| 1113 | | | | | | | | | | | 95% Modified-t UCL (Johnson-1978) | 0.191 |
| 1114 | | | | | | | | | | | | |

**Gamma GOF Test**

| | | | |
|---|---|---|---|
| A-D Test Statistic | 1.766 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.75 | Data Not Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.248 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.225 | Data Not Gamma Distributed at 5% Significance Level | |

**Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 1.801 | k star (bias corrected MLE) | 1.485 |
| Theta hat (MLE) | 0.0655 | Theta star (bias corrected MLE) | 0.0795 |
| nu hat (MLE) | 54.02 | nu star (bias corrected) | 44.55 |
| MLE Mean (bias corrected) | 0.118 | MLE Sd (bias corrected) | 0.0968 |
| | | Approximate Chi Square Value (0.05) | 30.24 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 28.79 |

**Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Approximate Gamma UCL (use when n>=50)) | 0.174 | 95% Adjusted Gamma UCL (use when n<50) | 0.183 |

**Lognormal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.771 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data Not Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.198 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |

**Data appear Approximate Lognormal at 5% Significance Level**

**Lognormal Statistics**

| | | | |
|---|---|---|---|
| Minimum of Logged Data | -2.996 | Mean of logged Data | -2.44 |
| Maximum of Logged Data | -0.446 | SD of logged Data | 0.656 |

**Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% H-UCL | 0.16 | 90% Chebyshev (MVUE) UCL | 0.163 |
| 95% Chebyshev (MVUE) UCL | 0.189 | 97.5% Chebyshev (MVUE) UCL | 0.224 |
| 99% Chebyshev (MVUE) UCL | 0.294 | | |

**Nonparametric Distribution Free UCL Statistics**

**Data appear to follow a Discernible Distribution at 5% Significance Level**

**Nonparametric Distribution Free UCLs**

| | | | |
|---|---|---|---|
| 95% CLT UCL | 0.181 | 95% Jackknife UCL | 0.185 |
| 95% Standard Bootstrap UCL | 0.181 | 95% Bootstrap-t UCL | 0.386 |
| 95% Hall's Bootstrap UCL | 0.408 | 95% Percentile Bootstrap UCL | 0.191 |
| 95% BCA Bootstrap UCL | 0.233 | | |
| 90% Chebyshev(Mean, Sd) UCL | 0.232 | 95% Chebyshev(Mean, Sd) UCL | 0.284 |
| 97.5% Chebyshev(Mean, Sd) UCL | 0.356 | 99% Chebyshev(Mean, Sd) UCL | 0.497 |

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% H-UCL | 0.16 | | |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**ProUCL computes and outputs H-statistic based UCLs for historical reasons only.**
**H-statistic often results in unstable (both high and low) values of UCL95 as shown in examples in the Technical Guide.**
**It is therefore recommended to avoid the use of H-statistic based 95% UCLs.**
**Use of nonparametric methods are preferred to compute UCL95 for skewed data sets which do not follow a gamma distribution.**

**Mo**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 6 |
| Number of Detects | 14 | Number of Non-Detects | 1 |
| Number of Distinct Detects | 6 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | 2 | Minimum Non-Detect | 2 |
| Maximum Detect | 9 | Maximum Non-Detect | 2 |

| | | | | |
|---|---|---|---|---|
| 1181 | Variance Detects | 5.824 | Percent Non-Detects | 6.667% |
| 1182 | Mean Detects | 5.143 | SD Detects | 2.413 |
| 1183 | Median Detects | 4.5 | CV Detects | 0.469 |
| 1184 | Skewness Detects | 0.61 | Kurtosis Detects | -0.637 |
| 1185 | Mean of Logged Detects | 1.53 | SD of Logged Detects | 0.493 |
| 1186 | | | | |
| 1187 | **Normal GOF Test on Detects Only** | | | |
| 1188 | Shapiro Wilk Test Statistic | 0.884 | **Shapiro Wilk GOF Test** | |
| 1189 | 5% Shapiro Wilk Critical Value | 0.874 | Detected Data appear Normal at 5% Significance Level | |
| 1190 | Lilliefors Test Statistic | 0.182 | **Lilliefors GOF Test** | |
| 1191 | 5% Lilliefors Critical Value | 0.226 | Detected Data appear Normal at 5% Significance Level | |
| 1192 | **Detected Data appear Normal at 5% Significance Level** | | | |
| 1193 | | | | |
| 1194 | **Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs** | | | |
| 1195 | KM Mean | 4.933 | KM Standard Error of Mean | 0.638 |
| 1196 | KM SD | 2.38 | 95% KM (BCA) UCL | 5.933 |
| 1197 | 95% KM (t) UCL | 6.056 | 95% KM (Percentile Bootstrap) UCL | 5.933 |
| 1198 | 95% KM (z) UCL | 5.982 | 95% KM Bootstrap t UCL | 6.324 |
| 1199 | 90% KM Chebyshev UCL | 6.846 | 95% KM Chebyshev UCL | 7.713 |
| 1200 | 97.5% KM Chebyshev UCL | 8.915 | 99% KM Chebyshev UCL | 11.28 |
| 1201 | | | | |
| 1202 | **Gamma GOF Tests on Detected Observations Only** | | | |
| 1203 | A-D Test Statistic | 0.446 | **Anderson-Darling GOF Test** | |
| 1204 | 5% A-D Critical Value | 0.738 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 1205 | K-S Test Statistic | 0.147 | **Kolmogorov-Smirnov GOF** | |
| 1206 | 5% K-S Critical Value | 0.229 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 1207 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| 1208 | | | | |
| 1209 | **Gamma Statistics on Detected Data Only** | | | |
| 1210 | k hat (MLE) | 4.82 | k star (bias corrected MLE) | 3.835 |
| 1211 | Theta hat (MLE) | 1.067 | Theta star (bias corrected MLE) | 1.341 |
| 1212 | nu hat (MLE) | 135 | nu star (bias corrected) | 107.4 |
| 1213 | Mean (detects) | 5.143 | | |
| 1214 | | | | |
| 1215 | **Gamma ROS Statistics using Imputed Non-Detects** | | | |
| 1216 | GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| 1217 | GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| 1218 | For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| 1219 | This is especially true when the sample size is small. | | | |
| 1220 | For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| 1221 | Minimum | 0.828 | Mean | 4.855 |
| 1222 | Maximum | 9 | Median | 4 |
| 1223 | SD | 2.579 | CV | 0.531 |
| 1224 | k hat (MLE) | 3.199 | k star (bias corrected MLE) | 2.604 |
| 1225 | Theta hat (MLE) | 1.518 | Theta star (bias corrected MLE) | 1.865 |
| 1226 | nu hat (MLE) | 95.98 | nu star (bias corrected) | 78.12 |
| 1227 | Adjusted Level of Significance (β) | 0.0324 | | |
| 1228 | Approximate Chi Square Value (78.12, α) | 58.76 | Adjusted Chi Square Value (78.12, β) | 56.69 |
| 1229 | 95% Gamma Approximate UCL (use when n>=50) | 6.455 | 95% Gamma Adjusted UCL (use when n<50) | 6.69 |
| 1230 | | | | |
| 1231 | **Estimates of Gamma Parameters using KM Estimates** | | | |
| 1232 | Mean (KM) | 4.933 | SD (KM) | 2.38 |
| 1233 | Variance (KM) | 5.662 | SE of Mean (KM) | 0.638 |
| 1234 | k hat (KM) | 4.298 | k star (KM) | 3.483 |
| 1235 | nu hat (KM) | 128.9 | nu star (KM) | 104.5 |
| 1236 | theta hat (KM) | 1.148 | theta star (KM) | 1.416 |
| 1237 | 80% gamma percentile (KM) | 6.913 | 90% gamma percentile (KM) | 8.478 |
| 1238 | 95% gamma percentile (KM) | 9.927 | 99% gamma percentile (KM) | 13.04 |
| 1239 | | | | |
| 1240 | **Gamma Kaplan-Meier (KM) Statistics** | | | |
| 1241 | Approximate Chi Square Value (104.49, α) | 81.9 | Adjusted Chi Square Value (104.49, β) | 79.44 |
| 1242 | 95% Gamma Approximate KM-UCL (use when n>=50) | 6.294 | 95% Gamma Adjusted KM-UCL (use when n<50) | 6.489 |
| 1243 | | | | |
| 1244 | **Lognormal GOF Test on Detected Observations Only** | | | |
| 1245 | Shapiro Wilk Test Statistic | 0.92 | **Shapiro Wilk GOF Test** | |
| 1246 | 5% Shapiro Wilk Critical Value | 0.874 | Detected Data appear Lognormal at 5% Significance Level | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1247 | | | | | Lilliefors Test Statistic | 0.171 | | | Lilliefors GOF Test | | | |
| 1248 | | | | | 5% Lilliefors Critical Value | 0.226 | | Detected Data appear Lognormal at 5% Significance Level | | | | |
| 1249 | | | | Detected Data appear Lognormal at 5% Significance Level | | | | | | | | |
| 1250 | | | | | | | | | | | | |
| 1251 | | | | | Lognormal ROS Statistics Using Imputed Non-Detects | | | | | | | |
| 1252 | | | | | Mean in Original Scale | 4.894 | | | | | Mean in Log Scale | 1.451 |
| 1253 | | | | | SD in Original Scale | 2.517 | | | | | SD in Log Scale | 0.565 |
| 1254 | | | | | 95% t UCL (assumes normality of ROS data) | 6.039 | | | | | 95% Percentile Bootstrap UCL | 6 |
| 1255 | | | | | 95% BCA Bootstrap UCL | 6.067 | | | | | 95% Bootstrap t UCL | 6.206 |
| 1256 | | | | | 95% H-UCL (Log ROS) | 6.914 | | | | | | |
| 1257 | | | | | | | | | | | | |
| 1258 | | | | Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution | | | | | | | | |
| 1259 | | | | | KM Mean (logged) | 1.474 | | | | | KM Geo Mean | 4.369 |
| 1260 | | | | | KM SD (logged) | 0.504 | | | | | 95% Critical H Value (KM-Log) | 2.072 |
| 1261 | | | | | KM Standard Error of Mean (logged) | 0.135 | | | | | 95% H-UCL (KM -Log) | 6.557 |
| 1262 | | | | | KM SD (logged) | 0.504 | | | | | 95% Critical H Value (KM-Log) | 2.072 |
| 1263 | | | | | KM Standard Error of Mean (logged) | 0.135 | | | | | | |
| 1264 | | | | | | | | | | | | |
| 1265 | | | | | | DL/2 Statistics | | | | | | |
| 1266 | | | | DL/2 Normal | | | | | DL/2 Log-Transformed | | | |
| 1267 | | | | | Mean in Original Scale | 4.867 | | | | | Mean in Log Scale | 1.428 |
| 1268 | | | | | SD in Original Scale | 2.56 | | | | | SD in Log Scale | 0.618 |
| 1269 | | | | | 95% t UCL (Assumes normality) | 6.031 | | | | | 95% H-Stat UCL | 7.261 |
| 1270 | | | | DL/2 is not a recommended method, provided for comparisons and historical reasons | | | | | | | | |
| 1271 | | | | | | | | | | | | |

| | | | |
|---|---|---|---|
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Detected Data appear Normal Distributed at 5% Significance Level** | | | |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% KM (t) UCL | 6.056 | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| | | | |
| | | | |
| **Ni** | | | |
| | | | |
| **General Statistics** | | | |
| Total Number of Observations | 15 | Number of Distinct Observations | 10 |
| | | Number of Missing Observations | 0 |
| Minimum | 9 | Mean | 21.73 |
| Maximum | 45 | Median | 22 |
| SD | 8.102 | Std. Error of Mean | 2.092 |
| Coefficient of Variation | 0.373 | Skewness | 1.516 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.853 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data Not Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.21 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |
| **Data appear Approximate Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 25.42 | 95% Adjusted-CLT UCL (Chen-1995) | 26.05 |
| | | 95% Modified-t UCL (Johnson-1978) | 25.55 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.563 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.738 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.164 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.222 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 8.487 | k star (bias corrected MLE) | 6.834 |
| Theta hat (MLE) | 2.561 | Theta star (bias corrected MLE) | 3.18 |
| nu hat (MLE) | 254.6 | nu star (bias corrected) | 205 |
| MLE Mean (bias corrected) | 21.73 | MLE Sd (bias corrected) | 8.314 |
| | | Approximate Chi Square Value (0.05) | 172.9 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 169.2 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50)) | 25.77 | 95% Adjusted Gamma UCL (use when n<50) | 26.33 |
| | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1324 | **Lognormal GOF Test** | | | | | | | | | | | |
| 1325 | Shapiro Wilk Test Statistic | | | | | 0.93 | **Shapiro Wilk Lognormal GOF Test** | | | | | |
| 1326 | 5% Shapiro Wilk Critical Value | | | | | 0.881 | Data appear Lognormal at 5% Significance Level | | | | | |
| 1327 | Lilliefors Test Statistic | | | | | 0.179 | **Lilliefors Lognormal GOF Test** | | | | | |
| 1328 | 5% Lilliefors Critical Value | | | | | 0.22 | Data appear Lognormal at 5% Significance Level | | | | | |
| 1329 | **Data appear Lognormal at 5% Significance Level** | | | | | | | | | | | |
| 1330 | | | | | | | | | | | | |
| 1331 | **Lognormal Statistics** | | | | | | | | | | | |
| 1332 | Minimum of Logged Data | | | | | 2.197 | Mean of logged Data | | | | | 3.019 |
| 1333 | Maximum of Logged Data | | | | | 3.807 | SD of logged Data | | | | | 0.361 |
| 1334 | | | | | | | | | | | | |
| 1335 | **Assuming Lognormal Distribution** | | | | | | | | | | | |
| 1336 | 95% H-UCL | | | | | 26.31 | 90% Chebyshev (MVUE) UCL | | | | | 27.91 |
| 1337 | 95% Chebyshev (MVUE) UCL | | | | | 30.71 | 97.5% Chebyshev (MVUE) UCL | | | | | 34.59 |
| 1338 | 99% Chebyshev (MVUE) UCL | | | | | 42.21 | | | | | | |
| 1339 | | | | | | | | | | | | |
| 1340 | **Nonparametric Distribution Free UCL Statistics** | | | | | | | | | | | |
| 1341 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | | | | | | | | | |
| 1342 | | | | | | | | | | | | |
| 1343 | **Nonparametric Distribution Free UCLs** | | | | | | | | | | | |
| 1344 | 95% CLT UCL | | | | | 25.17 | 95% Jackknife UCL | | | | | 25.42 |
| 1345 | 95% Standard Bootstrap UCL | | | | | 25 | 95% Bootstrap-t UCL | | | | | 26.67 |
| 1346 | 95% Hall's Bootstrap UCL | | | | | 32.44 | 95% Percentile Bootstrap UCL | | | | | 25.2 |
| 1347 | 95% BCA Bootstrap UCL | | | | | 26.13 | | | | | | |
| 1348 | 90% Chebyshev(Mean, Sd) UCL | | | | | 28.01 | 95% Chebyshev(Mean, Sd) UCL | | | | | 30.85 |
| 1349 | 97.5% Chebyshev(Mean, Sd) UCL | | | | | 34.8 | 99% Chebyshev(Mean, Sd) UCL | | | | | 42.55 |
| 1350 | | | | | | | | | | | | |
| 1351 | **Suggested UCL to Use** | | | | | | | | | | | |
| 1352 | 95% Student's-t UCL | | | | | 25.42 | | | | | | |
| 1353 | | | | | | | | | | | | |
| 1354 | When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test | | | | | | | | | | | |
| 1355 | When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL | | | | | | | | | | | |
| 1356 | | | | | | | | | | | | |
| 1357 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | | | | | | | | | |
| 1358 | Recommendations are based upon data size, data distribution, and skewness. | | | | | | | | | | | |
| 1359 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | | | | | | | | | |
| 1360 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | | | | | | | | | |
| 1361 | | | | | | | | | | | | |
| 1362 | Se | | | | | | | | | | | |
| 1363 | | | | | | | | | | | | |
| 1364 | **General Statistics** | | | | | | | | | | | |
| 1365 | Total Number of Observations | | | | | 15 | Number of Distinct Observations | | | | | 3 |
| 1366 | Number of Detects | | | | | 12 | Number of Non-Detects | | | | | 3 |
| 1367 | Number of Distinct Detects | | | | | 3 | Number of Distinct Non-Detects | | | | | 1 |
| 1368 | Minimum Detect | | | | | 1 | Minimum Non-Detect | | | | | 1 |
| 1369 | Maximum Detect | | | | | 3 | Maximum Non-Detect | | | | | 1 |
| 1370 | Variance Detects | | | | | 0.447 | Percent Non-Detects | | | | | 20% |
| 1371 | Mean Detects | | | | | 1.417 | SD Detects | | | | | 0.669 |
| 1372 | Median Detects | | | | | 1 | CV Detects | | | | | 0.472 |
| 1373 | Skewness Detects | | | | | 1.455 | Kurtosis Detects | | | | | 1.388 |
| 1374 | Mean of Logged Detects | | | | | 0.265 | SD of Logged Detects | | | | | 0.405 |
| 1375 | | | | | | | | | | | | |

| | | | | |
|---|---|---|---|---|
| 1376 | Normal GOF Test on Detects Only | | | |
| 1377 | Shapiro Wilk Test Statistic | 0.674 | Shapiro Wilk GOF Test | |
| 1378 | 5% Shapiro Wilk Critical Value | 0.859 | Detected Data Not Normal at 5% Significance Level | |
| 1379 | Lilliefors Test Statistic | 0.4 | Lilliefors GOF Test | |
| 1380 | 5% Lilliefors Critical Value | 0.243 | Detected Data Not Normal at 5% Significance Level | |
| 1381 | Detected Data Not Normal at 5% Significance Level | | | |
| 1382 | | | | |
| 1383 | Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs | | | |
| 1384 | KM Mean | 1.333 | KM Standard Error of Mean | 0.161 |
| 1385 | KM SD | 0.596 | 95% KM (BCA) UCL | N/A |
| 1386 | 95% KM (t) UCL | 1.617 | 95% KM (Percentile Bootstrap) UCL | N/A |
| 1387 | 95% KM (z) UCL | 1.598 | 95% KM Bootstrap t UCL | N/A |
| 1388 | 90% KM Chebyshev UCL | 1.816 | 95% KM Chebyshev UCL | 2.034 |
| 1389 | 97.5% KM Chebyshev UCL | 2.338 | 99% KM Chebyshev UCL | 2.933 |
| 1390 | | | | |
| 1391 | Gamma GOF Tests on Detected Observations Only | | | |
| 1392 | A-D Test Statistic | 2.006 | Anderson-Darling GOF Test | |
| 1393 | 5% A-D Critical Value | 0.732 | Detected Data Not Gamma Distributed at 5% Significance Level | |
| 1394 | K-S Test Statistic | 0.418 | Kolmogorov-Smirnov GOF | |
| 1395 | 5% K-S Critical Value | 0.246 | Detected Data Not Gamma Distributed at 5% Significance Level | |
| 1396 | Detected Data Not Gamma Distributed at 5% Significance Level | | | |
| 1397 | | | | |
| 1398 | Gamma Statistics on Detected Data Only | | | |
| 1399 | k hat (MLE) | 6.152 | k star (bias corrected MLE) | 4.67 |
| 1400 | Theta hat (MLE) | 0.23 | Theta star (bias corrected MLE) | 0.303 |
| 1401 | nu hat (MLE) | 147.7 | nu star (bias corrected) | 112.1 |
| 1402 | Mean (detects) | 1.417 | | |
| 1403 | | | | |
| 1404 | Gamma ROS Statistics using Imputed Non-Detects | | | |
| 1405 | GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| 1406 | GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| 1407 | For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| 1408 | This is especially true when the sample size is small. | | | |
| 1409 | For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| 1410 | Minimum | 0.0812 | Mean | 1.183 |
| 1411 | Maximum | 3 | Median | 1 |
| 1412 | SD | 0.767 | CV | 0.649 |
| 1413 | k hat (MLE) | 1.977 | k star (bias corrected MLE) | 1.626 |
| 1414 | Theta hat (MLE) | 0.598 | Theta star (bias corrected MLE) | 0.728 |
| 1415 | nu hat (MLE) | 59.3 | nu star (bias corrected) | 48.77 |
| 1416 | Adjusted Level of Significance (β) | 0.0324 | | |
| 1417 | Approximate Chi Square Value (48.77, α) | 33.74 | Adjusted Chi Square Value (48.77, β) | 32.21 |
| 1418 | 95% Gamma Approximate UCL (use when n>=50) | 1.71 | 95% Gamma Adjusted UCL (use when n<50) | 1.791 |
| 1419 | | | | |
| 1420 | Estimates of Gamma Parameters using KM Estimates | | | |
| 1421 | Mean (KM) | 1.333 | SD (KM) | 0.596 |
| 1422 | Variance (KM) | 0.356 | SE of Mean (KM) | 0.161 |
| 1423 | k hat (KM) | 5 | k star (KM) | 4.044 |
| 1424 | nu hat (KM) | 150 | nu star (KM) | 121.3 |
| 1425 | theta hat (KM) | 0.267 | theta star (KM) | 0.33 |
| 1426 | 80% gamma percentile (KM) | 1.836 | 90% gamma percentile (KM) | 2.222 |
| 1427 | 95% gamma percentile (KM) | 2.577 | 99% gamma percentile (KM) | 3.335 |
| 1428 | | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 1429 | Gamma Kaplan-Meier (KM) Statistics | | | |
| 1430 | Approximate Chi Square Value (121.33, α) | 96.9 | Adjusted Chi Square Value (121.33, β) | 94.21 |
| 1431 | 95% Gamma Approximate KM-UCL (use when n>=50) | 1.67 | 95% Gamma Adjusted KM-UCL (use when n<50) | 1.717 |
| 1432 | | | | |
| 1433 | **Lognormal GOF Test on Detected Observations Only** | | | |
| 1434 | Shapiro Wilk Test Statistic | 0.675 | **Shapiro Wilk GOF Test** | |
| 1435 | 5% Shapiro Wilk Critical Value | 0.859 | Detected Data Not Lognormal at 5% Significance Level | |
| 1436 | Lilliefors Test Statistic | 0.41 | **Lilliefors GOF Test** | |
| 1437 | 5% Lilliefors Critical Value | 0.243 | Detected Data Not Lognormal at 5% Significance Level | |
| 1438 | **Detected Data Not Lognormal at 5% Significance Level** | | | |
| 1439 | | | | |
| 1440 | **Lognormal ROS Statistics Using Imputed Non-Detects** | | | |
| 1441 | Mean in Original Scale | 1.244 | Mean in Log Scale | 0.0924 |
| 1442 | SD in Original Scale | 0.693 | SD in Log Scale | 0.51 |
| 1443 | 95% t UCL (assumes normality of ROS data) | 1.559 | 95% Percentile Bootstrap UCL | 1.542 |
| 1444 | 95% BCA Bootstrap UCL | 1.619 | 95% Bootstrap t UCL | 1.66 |
| 1445 | 95% H-UCL (Log ROS) | 1.658 | | |
| 1446 | | | | |
| 1447 | **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | |
| 1448 | KM Mean (logged) | 0.212 | KM Geo Mean | 1.236 |
| 1449 | KM SD (logged) | 0.363 | 95% Critical H Value (KM-Log) | 1.935 |
| 1450 | KM Standard Error of Mean (logged) | 0.0979 | 95% H-UCL (KM -Log) | 1.593 |
| 1451 | KM SD (logged) | 0.363 | 95% Critical H Value (KM-Log) | 1.935 |
| 1452 | KM Standard Error of Mean (logged) | 0.0979 | | |
| 1453 | | | | |
| 1454 | **DL/2 Statistics** | | | |
| 1455 | **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| 1456 | Mean in Original Scale | 1.233 | Mean in Log Scale | 0.0732 |
| 1457 | SD in Original Scale | 0.704 | SD in Log Scale | 0.535 |
| 1458 | 95% t UCL (Assumes normality) | 1.553 | 95% H-Stat UCL | 1.678 |
| 1459 | **DL/2 is not a recommended method, provided for comparisons and historical reasons** | | | |
| 1460 | | | | |
| 1461 | **Nonparametric Distribution Free UCL Statistics** | | | |
| 1462 | **Data do not follow a Discernible Distribution at 5% Significance Level** | | | |
| 1463 | | | | |
| 1464 | **Suggested UCL to Use** | | | |
| 1465 | 95% KM (t) UCL | 1.617 | KM H-UCL | 1.593 |
| 1466 | 95% KM (BCA) UCL | N/A | | |
| 1467 | **Warning: One or more Recommended UCL(s) not available!** | | | |
| 1468 | | | | |
| 1469 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 1470 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 1471 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 1472 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 1473 | | | | |
| 1474 | Ag | | | |
| 1475 | | | | |
| 1476 | **General Statistics** | | | |
| 1477 | Total Number of Observations | 15 | Number of Distinct Observations | 1 |
| 1478 | Number of Detects | 0 | Number of Non-Detects | 15 |
| 1479 | Number of Distinct Detects | 0 | Number of Distinct Non-Detects | 1 |
| 1480 | | | | |
| 1481 | **Warning: All observations are Non-Detects (NDs), therefore all statistics and estimates should also be NDs!** | | | |
| 1482 | **Specifically, sample mean, UCLs, UPLs, and other statistics are also NDs lying below the largest detection limit!** | | | |
| 1483 | **The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).** | | | |
| 1484 | | | | |
| 1485 | **The data set for variable Ag was not processed!** | | | |

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| | | | |
|---|---|---|---|
| **General Statistics** | | | |
| Total Number of Observations | 15 | Number of Distinct Observations | 15 |
| | | Number of Missing Observations | 0 |
| Minimum | 15 | Mean | 84.67 |
| Maximum | 345 | Median | 50 |
| SD | 85.5 | Std. Error of Mean | 22.08 |
| Coefficient of Variation | 1.01 | Skewness | 2.396 |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.706 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data Not Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.269 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data Not Normal at 5% Significance Level | |
| **Data Not Normal at 5% Significance Level** | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 123.5 | 95% Adjusted-CLT UCL (Chen-1995) | 135.6 |
| | | 95% Modified-t UCL (Johnson-1978) | 125.8 |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.561 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.752 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.176 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.225 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 1.657 | k star (bias corrected MLE) | 1.37 |
| Theta hat (MLE) | 51.1 | Theta star (bias corrected MLE) | 61.8 |
| nu hat (MLE) | 49.71 | nu star (bias corrected) | 41.1 |
| MLE Mean (bias corrected) | 84.67 | MLE Sd (bias corrected) | 72.33 |
| | | Approximate Chi Square Value (0.05) | 27.41 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 26.04 |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50) | 127 | 95% Adjusted Gamma UCL (use when n<50) | 133.7 |
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.975 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.13 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| **Data appear Lognormal at 5% Significance Level** | | | |
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | 2.708 | Mean of logged Data | 4.108 |
| Maximum of Logged Data | 5.844 | SD of logged Data | 0.802 |
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 141.7 | 90% Chebyshev (MVUE) UCL | 135.8 |
| 95% Chebyshev (MVUE) UCL | 160.3 | 97.5% Chebyshev (MVUE) UCL | 194.3 |
| 99% Chebyshev (MVUE) UCL | 261.2 | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |

**Nonparametric Distribution Free UCLs**

| | | | |
|---|---|---|---|
| 95% CLT UCL | 121 | 95% Jackknife UCL | 123.5 |
| 95% Standard Bootstrap UCL | 119.4 | 95% Bootstrap-t UCL | 177.1 |
| 95% Hall's Bootstrap UCL | 294.5 | 95% Percentile Bootstrap UCL | 124.1 |
| 95% BCA Bootstrap UCL | 134.2 | | |
| 90% Chebyshev(Mean, Sd) UCL | 150.9 | 95% Chebyshev(Mean, Sd) UCL | 180.9 |
| 97.5% Chebyshev(Mean, Sd) UCL | 222.5 | 99% Chebyshev(Mean, Sd) UCL | 304.3 |

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% Adjusted Gamma UCL | 133.7 | | |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Tl

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 1 |
| Number of Detects | 0 | Number of Non-Detects | 15 |
| Number of Distinct Detects | 0 | Number of Distinct Non-Detects | 1 |

**Warning: All observations are Non-Detects (NDs), therefore all statistics and estimates should also be NDs!**
**Specifically, sample mean, UCLs, UPLs, and other statistics are also NDs lying below the largest detection limit!**
**The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).**

**The data set for variable Tl was not processed!**

Sn

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 11 |
| | | Number of Missing Observations | 0 |
| Minimum | 7 | Mean | 14.73 |
| Maximum | 28 | Median | 13 |
| SD | 6.617 | Std. Error of Mean | 1.708 |
| Coefficient of Variation | 0.449 | Skewness | 0.826 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.906 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.163 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level |

**Data appear Normal at 5% Significance Level**

**Assuming Normal Distribution**

| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
|---|---|---|---|
| 95% Student's-t UCL | 17.74 | 95% Adjusted-CLT UCL (Chen-1995) | 17.93 |
| | | 95% Modified-t UCL (Johnson-1978) | 17.8 |

**Gamma GOF Test**

| | | |
|---|---|---|
| A-D Test Statistic | 0.338 | **Anderson-Darling Gamma GOF Test** |
| 5% A-D Critical Value | 0.738 | Detected data appear Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.166 | **Kolmogorov-Smirnov Gamma GOF Test** |
| 5% K-S Critical Value | 0.222 | Detected data appear Gamma Distributed at 5% Significance Level |

**Detected data appear Gamma Distributed at 5% Significance Level**

| | | | | |
|---|---|---|---|---|
| 1608 | Gamma Statistics | | | |
| 1609 | k hat (MLE) | 5.709 | k star (bias corrected MLE) | 4.612 |
| 1610 | Theta hat (MLE) | 2.581 | Theta star (bias corrected MLE) | 3.195 |
| 1611 | nu hat (MLE) | 171.3 | nu star (bias corrected) | 138.4 |
| 1612 | MLE Mean (bias corrected) | 14.73 | MLE Sd (bias corrected) | 6.861 |
| 1613 | | | Approximate Chi Square Value (0.05) | 112.2 |
| 1614 | Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 109.3 |
| 1615 | | | | |
| 1616 | Assuming Gamma Distribution | | | |
| 1617 | 95% Approximate Gamma UCL (use when n>=50)) | 18.17 | 95% Adjusted Gamma UCL (use when n<50) | 18.65 |
| 1618 | | | | |
| 1619 | Lognormal GOF Test | | | |
| 1620 | Shapiro Wilk Test Statistic | 0.954 | Shapiro Wilk Lognormal GOF Test | |
| 1621 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| 1622 | Lilliefors Test Statistic | 0.152 | Lilliefors Lognormal GOF Test | |
| 1623 | 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| 1624 | Data appear Lognormal at 5% Significance Level | | | |
| 1625 | | | | |
| 1626 | Lognormal Statistics | | | |
| 1627 | Minimum of Logged Data | 1.946 | Mean of logged Data | 2.6 |
| 1628 | Maximum of Logged Data | 3.332 | SD of logged Data | 0.437 |
| 1629 | | | | |
| 1630 | Assuming Lognormal Distribution | | | |
| 1631 | 95% H-UCL | 18.72 | 90% Chebyshev (MVUE) UCL | 19.81 |
| 1632 | 95% Chebyshev (MVUE) UCL | 22.11 | 97.5% Chebyshev (MVUE) UCL | 25.32 |
| 1633 | 99% Chebyshev (MVUE) UCL | 31.61 | | |
| 1634 | | | | |
| 1635 | Nonparametric Distribution Free UCL Statistics | | | |
| 1636 | Data appear to follow a Discernible Distribution at 5% Significance Level | | | |
| 1637 | | | | |
| 1638 | Nonparametric Distribution Free UCLs | | | |
| 1639 | 95% CLT UCL | 17.54 | 95% Jackknife UCL | 17.74 |
| 1640 | 95% Standard Bootstrap UCL | 17.41 | 95% Bootstrap-t UCL | 18.33 |
| 1641 | 95% Hall's Bootstrap UCL | 17.81 | 95% Percentile Bootstrap UCL | 17.47 |
| 1642 | 95% BCA Bootstrap UCL | 17.67 | | |
| 1643 | 90% Chebyshev(Mean, Sd) UCL | 19.86 | 95% Chebyshev(Mean, Sd) UCL | 22.18 |
| 1644 | 97.5% Chebyshev(Mean, Sd) UCL | 25.4 | 99% Chebyshev(Mean, Sd) UCL | 31.73 |
| 1645 | | | | |
| 1646 | Suggested UCL to Use | | | |
| 1647 | 95% Student's-t UCL | 17.74 | | |
| 1648 | | | | |
| 1649 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 1650 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 1651 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 1652 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 1653 | | | | |
| 1654 | | | | |
| 1655 | U | | | |
| 1656 | | | | |
| 1657 | General Statistics | | | |
| 1658 | Total Number of Observations | 15 | Number of Distinct Observations | 11 |
| 1659 | | | Number of Missing Observations | 0 |
| 1660 | Minimum | 0.7 | Mean | 1.373 |
| 1661 | Maximum | 2.5 | Median | 1.2 |
| 1662 | SD | 0.554 | Std. Error of Mean | 0.143 |
| 1663 | Coefficient of Variation | 0.403 | Skewness | 1.063 |
| 1664 | | | | |
| 1665 | Normal GOF Test | | | |
| 1666 | Shapiro Wilk Test Statistic | 0.86 | Shapiro Wilk GOF Test | |
| 1667 | 5% Shapiro Wilk Critical Value | 0.881 | Data Not Normal at 5% Significance Level | |
| 1668 | Lilliefors Test Statistic | 0.223 | Lilliefors GOF Test | |
| 1669 | 5% Lilliefors Critical Value | 0.22 | Data Not Normal at 5% Significance Level | |
| 1670 | Data Not Normal at 5% Significance Level | | | |

| | | | |
|---|---|---|---|
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 1.625 | 95% Adjusted-CLT UCL (Chen-1995) | 1.65 |
| | | 95% Modified-t UCL (Johnson-1978) | 1.632 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.659 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.738 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.194 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.222 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 7.514 | k star (bias corrected MLE) | 6.056 |
| Theta hat (MLE) | 0.183 | Theta star (bias corrected MLE) | 0.227 |
| nu hat (MLE) | 225.4 | nu star (bias corrected) | 181.7 |
| MLE Mean (bias corrected) | 1.373 | MLE Sd (bias corrected) | 0.558 |
| | | Approximate Chi Square Value (0.05) | 151.5 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 148.1 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50) | 1.647 | 95% Adjusted Gamma UCL (use when n<50) | 1.685 |
| | | | |
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.929 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.171 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| **Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | -0.357 | Mean of logged Data | 0.249 |
| Maximum of Logged Data | 0.916 | SD of logged Data | 0.373 |
| | | | |
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 1.669 | 90% Chebyshev (MVUE) UCL | 1.771 |
| 95% Chebyshev (MVUE) UCL | 1.953 | 97.5% Chebyshev (MVUE) UCL | 2.206 |
| 99% Chebyshev (MVUE) UCL | 2.703 | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| | | | |
| **Nonparametric Distribution Free UCLs** | | | |
| 95% CLT UCL | 1.608 | 95% Jackknife UCL | 1.625 |
| 95% Standard Bootstrap UCL | 1.6 | 95% Bootstrap-t UCL | 1.715 |
| 95% Hall's Bootstrap UCL | 1.659 | 95% Percentile Bootstrap UCL | 1.607 |
| 95% BCA Bootstrap UCL | 1.653 | | |
| 90% Chebyshev(Mean, Sd) UCL | 1.802 | 95% Chebyshev(Mean, Sd) UCL | 1.996 |
| 97.5% Chebyshev(Mean, Sd) UCL | 2.266 | 99% Chebyshev(Mean, Sd) UCL | 2.795 |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% Adjusted Gamma UCL | 1.685 | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |

V

| | | | |
|---|---|---|---|
| **General Statistics** | | | |
| Total Number of Observations | 15 | Number of Distinct Observations | 13 |
| | | Number of Missing Observations | 0 |
| Minimum | 14 | Mean | 40.93 |
| Maximum | 63 | Median | 45 |
| SD | 13.61 | Std. Error of Mean | 3.514 |
| Coefficient of Variation | 0.332 | Skewness | -0.902 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.878 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data Not Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.244 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data Not Normal at 5% Significance Level | |
| **Data Not Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 47.12 | 95% Adjusted-CLT UCL (Chen-1995) | 45.84 |
| | | 95% Modified-t UCL (Johnson-1978) | 46.99 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 1.399 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.738 | Data Not Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.301 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.222 | Data Not Gamma Distributed at 5% Significance Level | |
| **Data Not Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 6.88 | k star (bias corrected MLE) | 5.549 |
| Theta hat (MLE) | 5.95 | Theta star (bias corrected MLE) | 7.377 |
| nu hat (MLE) | 206.4 | nu star (bias corrected) | 166.5 |
| MLE Mean (bias corrected) | 40.93 | MLE Sd (bias corrected) | 17.38 |
| | | Approximate Chi Square Value (0.05) | 137.6 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 134.4 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50)) | 49.51 | 95% Adjusted Gamma UCL (use when n<50) | 50.7 |
| | | | |
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.773 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data Not Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.324 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data Not Lognormal at 5% Significance Level | |
| **Data Not Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | 2.639 | Mean of logged Data | 3.638 |
| Maximum of Logged Data | 4.143 | SD of logged Data | 0.441 |
| | | | |
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 53.04 | 90% Chebyshev (MVUE) UCL | 56.11 |
| 95% Chebyshev (MVUE) UCL | 62.69 | 97.5% Chebyshev (MVUE) UCL | 71.83 |
| 99% Chebyshev (MVUE) UCL | 89.77 | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data do not follow a Discernible Distribution (0.05)** | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 1790 | **Nonparametric Distribution Free UCLs** | | | |
| 1791 | 95% CLT UCL | 46.71 | 95% Jackknife UCL | 47.12 |
| 1792 | 95% Standard Bootstrap UCL | 46.58 | 95% Bootstrap-t UCL | 46 |
| 1793 | 95% Hall's Bootstrap UCL | 45.89 | 95% Percentile Bootstrap UCL | 46.2 |
| 1794 | 95% BCA Bootstrap UCL | 45.8 | | |
| 1795 | 90% Chebyshev(Mean, Sd) UCL | 51.47 | 95% Chebyshev(Mean, Sd) UCL | 56.25 |
| 1796 | 97.5% Chebyshev(Mean, Sd) UCL | 62.88 | 99% Chebyshev(Mean, Sd) UCL | 75.9 |
| 1797 | | | | |
| 1798 | **Suggested UCL to Use** | | | |
| 1799 | 95% Student's-t UCL | 47.12 | or 95% Modified-t UCL | 46.99 |
| 1800 | | | | |
| 1801 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 1802 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 1803 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 1804 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 1805 | | | | |
| 1806 | **Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be** | | | |
| 1807 | **reliable. Chen's and Johnson's methods provide adjustments for positvely skewed data sets.** | | | |
| 1808 | | | | |
| 1809 | | | | |
| 1810 | **Zn** | | | |
| 1811 | | | | |
| 1812 | **General Statistics** | | | |
| 1813 | Total Number of Observations | 15 | Number of Distinct Observations | 15 |
| 1814 | | | Number of Missing Observations | 0 |
| 1815 | Minimum | 267 | Mean | 1026 |
| 1816 | Maximum | 5020 | Median | 629 |
| 1817 | SD | 1210 | Std. Error of Mean | 312.5 |
| 1818 | Coefficient of Variation | 1.18 | Skewness | 2.89 |
| 1819 | | | | |
| 1820 | **Normal GOF Test** | | | |
| 1821 | Shapiro Wilk Test Statistic | 0.623 | **Shapiro Wilk GOF Test** | |
| 1822 | 5% Shapiro Wilk Critical Value | 0.881 | Data Not Normal at 5% Significance Level | |
| 1823 | Lilliefors Test Statistic | 0.285 | **Lilliefors GOF Test** | |
| 1824 | 5% Lilliefors Critical Value | 0.22 | Data Not Normal at 5% Significance Level | |
| 1825 | **Data Not Normal at 5% Significance Level** | | | |
| 1826 | | | | |
| 1827 | **Assuming Normal Distribution** | | | |
| 1828 | **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 1829 | 95% Student's-t UCL | 1576 | 95% Adjusted-CLT UCL (Chen-1995) | 1789 |
| 1830 | | | 95% Modified-t UCL (Johnson-1978) | 1615 |
| 1831 | | | | |
| 1832 | **Gamma GOF Test** | | | |
| 1833 | A-D Test Statistic | 0.834 | **Anderson-Darling Gamma GOF Test** | |
| 1834 | 5% A-D Critical Value | 0.755 | Data Not Gamma Distributed at 5% Significance Level | |
| 1835 | K-S Test Statistic | 0.197 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 1836 | 5% K-S Critical Value | 0.226 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 1837 | **Detected data follow Appr. Gamma Distribution at 5% Significance Level** | | | |
| 1838 | | | | |
| 1839 | **Gamma Statistics** | | | |
| 1840 | k hat (MLE) | 1.433 | k star (bias corrected MLE) | 1.19 |
| 1841 | Theta hat (MLE) | 716.1 | Theta star (bias corrected MLE) | 861.7 |
| 1842 | nu hat (MLE) | 42.98 | nu star (bias corrected) | 35.71 |
| 1843 | MLE Mean (bias corrected) | 1026 | MLE Sd (bias corrected) | 940.2 |
| 1844 | | | Approximate Chi Square Value (0.05) | 23.04 |
| 1845 | Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 21.79 |
| 1846 | | | | |
| 1847 | **Assuming Gamma Distribution** | | | |
| 1848 | 95% Approximate Gamma UCL (use when n>=50) | 1590 | 95% Adjusted Gamma UCL (use when n<50) | 1681 |
| 1849 | | | | |
| 1850 | **Lognormal GOF Test** | | | |
| 1851 | Shapiro Wilk Test Statistic | 0.913 | **Shapiro Wilk Lognormal GOF Test** | |
| 1852 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| 1853 | Lilliefors Test Statistic | 0.15 | **Lilliefors Lognormal GOF Test** | |
| 1854 | 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| 1855 | **Data appear Lognormal at 5% Significance Level** | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1856 | | | | | | | | | | | | |
| 1857 | Lognormal Statistics | | | | | | | | | | | |
| 1858 | | | | | Minimum of Logged Data | 5.587 | | | | | Mean of logged Data | 6.545 |
| 1859 | | | | | Maximum of Logged Data | 8.521 | | | | | SD of logged Data | 0.831 |
| 1860 | | | | | | | | | | | | |
| 1861 | Assuming Lognormal Distribution | | | | | | | | | | | |
| 1862 | | | | | 95% H-UCL | 1708 | | | | | 90% Chebyshev (MVUE) UCL | 1613 |
| 1863 | | | | | 95% Chebyshev (MVUE) UCL | 1911 | | | | | 97.5% Chebyshev (MVUE) UCL | 2325 |
| 1864 | | | | | 99% Chebyshev (MVUE) UCL | 3138 | | | | | | |
| 1865 | | | | | | | | | | | | |
| 1866 | Nonparametric Distribution Free UCL Statistics | | | | | | | | | | | |
| 1867 | Data appear to follow a Discernible Distribution at 5% Significance Level | | | | | | | | | | | |
| 1868 | | | | | | | | | | | | |
| 1869 | Nonparametric Distribution Free UCLs | | | | | | | | | | | |
| 1870 | | | | | 95% CLT UCL | 1540 | | | | | 95% Jackknife UCL | 1576 |
| 1871 | | | | | 95% Standard Bootstrap UCL | 1532 | | | | | 95% Bootstrap-t UCL | 2277 |
| 1872 | | | | | 95% Hall's Bootstrap UCL | 3352 | | | | | 95% Percentile Bootstrap UCL | 1537 |
| 1873 | | | | | 95% BCA Bootstrap UCL | 1852 | | | | | | |
| 1874 | | | | | 90% Chebyshev(Mean, Sd) UCL | 1963 | | | | | 95% Chebyshev(Mean, Sd) UCL | 2388 |
| 1875 | | | | | 97.5% Chebyshev(Mean, Sd) UCL | 2977 | | | | | 99% Chebyshev(Mean, Sd) UCL | 4135 |
| 1876 | | | | | | | | | | | | |
| 1877 | Suggested UCL to Use | | | | | | | | | | | |
| 1878 | | | | | 95% Adjusted Gamma UCL | 1681 | | | | | | |
| 1879 | | | | | | | | | | | | |
| 1880 | When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test | | | | | | | | | | | |
| 1881 | When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL | | | | | | | | | | | |
| 1882 | | | | | | | | | | | | |
| 1883 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | | | | | | | | | |
| 1884 | Recommendations are based upon data size, data distribution, and skewness. | | | | | | | | | | | |
| 1885 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | | | | | | | | | |
| 1886 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | | | | | | | | | |
| 1887 | | | | | | | | | | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | UCL Statistics for Data Sets with Non-Detects | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | User Selected Options | | | | | | | | | | | |
| 4 | Date/Time of Computation | | | ProUCL 5.111/16/2018 12:40:30 PM | | | | | | | | |
| 5 | From File | | | WorkSheet.xls | | | | | | | | |
| 6 | Full Precision | | | OFF | | | | | | | | |
| 7 | Confidence Coefficient | | | 95% | | | | | | | | |
| 8 | Number of Bootstrap Operations | | | 2000 | | | | | | | | |
| 9 | | | | | | | | | | | | |
| 10 | | | | | | | | | | | | |
| 11 | B(a)P TPE | | | | | | | | | | | |
| 12 | | | | | | | | | | | | |
| 13 | General Statistics | | | | | | | | | | | |
| 14 | Total Number of Observations | | | | | 15 | Number of Distinct Observations | | | | | 15 |
| 15 | | | | | | | Number of Missing Observations | | | | | 0 |
| 16 | Minimum | | | | | 0.138 | Mean | | | | | 0.866 |
| 17 | Maximum | | | | | 1.941 | Median | | | | | 0.74 |
| 18 | SD | | | | | 0.565 | Std. Error of Mean | | | | | 0.146 |
| 19 | Coefficient of Variation | | | | | 0.653 | Skewness | | | | | 0.875 |
| 20 | | | | | | | | | | | | |
| 21 | Normal GOF Test | | | | | | | | | | | |
| 22 | Shapiro Wilk Test Statistic | | | | | 0.892 | Shapiro Wilk GOF Test | | | | | |
| 23 | 5% Shapiro Wilk Critical Value | | | | | 0.881 | Data appear Normal at 5% Significance Level | | | | | |
| 24 | Lilliefors Test Statistic | | | | | 0.189 | Lilliefors GOF Test | | | | | |
| 25 | 5% Lilliefors Critical Value | | | | | 0.22 | Data appear Normal at 5% Significance Level | | | | | |
| 26 | Data appear Normal at 5% Significance Level | | | | | | | | | | | |
| 27 | | | | | | | | | | | | |
| 28 | Assuming Normal Distribution | | | | | | | | | | | |
| 29 | 95% Normal UCL | | | | | | 95% UCLs (Adjusted for Skewness) | | | | | |
| 30 | 95% Student's-t UCL | | | | | 1.123 | 95% Adjusted-CLT UCL (Chen-1995) | | | | | 1.141 |
| 31 | | | | | | | 95% Modified-t UCL (Johnson-1978) | | | | | 1.129 |
| 32 | | | | | | | | | | | | |
| 33 | Gamma GOF Test | | | | | | | | | | | |
| 34 | A-D Test Statistic | | | | | 0.253 | Anderson-Darling Gamma GOF Test | | | | | |
| 35 | 5% A-D Critical Value | | | | | 0.746 | Detected data appear Gamma Distributed at 5% Significance Level | | | | | |
| 36 | K-S Test Statistic | | | | | 0.124 | Kolmogorov-Smirnov Gamma GOF Test | | | | | |
| 37 | 5% K-S Critical Value | | | | | 0.224 | Detected data appear Gamma Distributed at 5% Significance Level | | | | | |
| 38 | Detected data appear Gamma Distributed at 5% Significance Level | | | | | | | | | | | |
| 39 | | | | | | | | | | | | |
| 40 | Gamma Statistics | | | | | | | | | | | |
| 41 | k hat (MLE) | | | | | 2.459 | k star (bias corrected MLE) | | | | | 2.012 |
| 42 | Theta hat (MLE) | | | | | 0.352 | Theta star (bias corrected MLE) | | | | | 0.431 |
| 43 | nu hat (MLE) | | | | | 73.77 | nu star (bias corrected) | | | | | 60.35 |
| 44 | MLE Mean (bias corrected) | | | | | 0.866 | MLE Sd (bias corrected) | | | | | 0.611 |
| 45 | | | | | | | Approximate Chi Square Value (0.05) | | | | | 43.48 |
| 46 | Adjusted Level of Significance | | | | | 0.0324 | Adjusted Chi Square Value | | | | | 41.72 |
| 47 | | | | | | | | | | | | |
| 48 | Assuming Gamma Distribution | | | | | | | | | | | |
| 49 | 95% Approximate Gamma UCL (use when n>=50)) | | | | | 1.202 | 95% Adjusted Gamma UCL (use when n<50) | | | | | 1.253 |
| 50 | | | | | | | | | | | | |

| | | | |
|---|---|---|---|
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.959 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.108 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| **Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | -1.981 | Mean of logged Data | -0.361 |
| Maximum of Logged Data | 0.663 | SD of logged Data | 0.72 |
| | | | |
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 1.416 | 90% Chebyshev (MVUE) UCL | 1.407 |
| 95% Chebyshev (MVUE) UCL | 1.643 | 97.5% Chebyshev (MVUE) UCL | 1.971 |
| 99% Chebyshev (MVUE) UCL | 2.615 | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| | | | |
| **Nonparametric Distribution Free UCLs** | | | |
| 95% CLT UCL | 1.106 | 95% Jackknife UCL | 1.123 |
| 95% Standard Bootstrap UCL | 1.104 | 95% Bootstrap-t UCL | 1.198 |
| 95% Hall's Bootstrap UCL | 1.162 | 95% Percentile Bootstrap UCL | 1.104 |
| 95% BCA Bootstrap UCL | 1.14 | | |
| 90% Chebyshev(Mean, Sd) UCL | 1.304 | 95% Chebyshev(Mean, Sd) UCL | 1.502 |
| 97.5% Chebyshev(Mean, Sd) UCL | 1.778 | 99% Chebyshev(Mean, Sd) UCL | 2.318 |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% Student's-t UCL | 1.123 | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| | | | |
| | | | |
| F3 | | | |
| | | | |
| **General Statistics** | | | |
| Total Number of Observations | 15 | Number of Distinct Observations | 15 |
| | | Number of Missing Observations | 0 |
| Minimum | 38 | Mean | 187.9 |
| Maximum | 419 | Median | 200 |
| SD | 112.2 | Std. Error of Mean | 28.96 |
| Coefficient of Variation | 0.597 | Skewness | 0.279 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.926 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.167 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |
| **Data appear Normal at 5% Significance Level** | | | |

### Assuming Normal Distribution

| 95% Normal UCL | | 95% UCLs (Adjusted for Skewness) | |
|---|---|---|---|
| 95% Student's-t UCL | 238.9 | 95% Adjusted-CLT UCL (Chen-1995) | 237.8 |
| | | 95% Modified-t UCL (Johnson-1978) | 239.3 |

### Gamma GOF Test

| | | | |
|---|---|---|---|
| A-D Test Statistic | 0.647 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.746 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.201 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.224 | Detected data appear Gamma Distributed at 5% Significance Level | |

**Detected data appear Gamma Distributed at 5% Significance Level**

### Gamma Statistics

| | | | |
|---|---|---|---|
| k hat (MLE) | 2.423 | k star (bias corrected MLE) | 1.983 |
| Theta hat (MLE) | 77.56 | Theta star (bias corrected MLE) | 94.78 |
| nu hat (MLE) | 72.69 | nu star (bias corrected) | 59.49 |
| MLE Mean (bias corrected) | 187.9 | MLE Sd (bias corrected) | 133.5 |
| | | Approximate Chi Square Value (0.05) | 42.75 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 41.01 |

### Assuming Gamma Distribution

| | | | |
|---|---|---|---|
| 95% Approximate Gamma UCL (use when n>=50)) | 261.5 | 95% Adjusted Gamma UCL (use when n<50) | 272.6 |

### Lognormal GOF Test

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.899 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.23 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data Not Lognormal at 5% Significance Level | |

**Data appear Approximate Lognormal at 5% Significance Level**

### Lognormal Statistics

| | | | |
|---|---|---|---|
| Minimum of Logged Data | 3.638 | Mean of logged Data | 5.016 |
| Maximum of Logged Data | 6.038 | SD of logged Data | 0.746 |

### Assuming Lognormal Distribution

| | | | |
|---|---|---|---|
| 95% H-UCL | 319.2 | 90% Chebyshev (MVUE) UCL | 313.9 |
| 95% Chebyshev (MVUE) UCL | 367.9 | 97.5% Chebyshev (MVUE) UCL | 442.8 |
| 99% Chebyshev (MVUE) UCL | 590 | | |

### Nonparametric Distribution Free UCL Statistics

**Data appear to follow a Discernible Distribution at 5% Significance Level**

### Nonparametric Distribution Free UCLs

| | | | |
|---|---|---|---|
| 95% CLT UCL | 235.6 | 95% Jackknife UCL | 238.9 |
| 95% Standard Bootstrap UCL | 234.9 | 95% Bootstrap-t UCL | 240 |
| 95% Hall's Bootstrap UCL | 238.1 | 95% Percentile Bootstrap UCL | 232.8 |
| 95% BCA Bootstrap UCL | 236.1 | | |
| 90% Chebyshev(Mean, Sd) UCL | 274.8 | 95% Chebyshev(Mean, Sd) UCL | 314.2 |
| 97.5% Chebyshev(Mean, Sd) UCL | 368.8 | 99% Chebyshev(Mean, Sd) UCL | 476.1 |

### Suggested UCL to Use

| | | | |
|---|---|---|---|
| 95% Student's-t UCL | 238.9 | | |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 1 | UCL Statistics for Data Sets with Non-Detects | | | |
| 2 | | | | |
| 3 | User Selected Options | | | |
| 4 | Date/Time of Computation | ProUCL 5.111/17/2018 3:36:40 PM | | |
| 5 | From File | WorkSheet.xls | | |
| 6 | Full Precision | OFF | | |
| 7 | Confidence Coefficient | 95% | | |
| 8 | mber of Bootstrap Operations | 2000 | | |
| 9 | | | | |
| 10 | | | | |
| 11 | HMW PAHs | | | |
| 12 | | | | |
| 13 | General Statistics | | | |
| 14 | Total Number of Observations | 15 | Number of Distinct Observations | 15 |
| 15 | | | Number of Missing Observations | 0 |
| 16 | Minimum | 0.847 | Mean | 4.53 |
| 17 | Maximum | 12.18 | Median | 3.732 |
| 18 | SD | 3.08 | Std. Error of Mean | 0.795 |
| 19 | Coefficient of Variation | 0.68 | Skewness | 1.154 |
| 20 | | | | |
| 21 | Normal GOF Test | | | |
| 22 | Shapiro Wilk Test Statistic | 0.912 | Shapiro Wilk GOF Test | |
| 23 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| 24 | Lilliefors Test Statistic | 0.144 | Lilliefors GOF Test | |
| 25 | 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |
| 26 | Data appear Normal at 5% Significance Level | | | |
| 27 | | | | |
| 28 | Assuming Normal Distribution | | | |
| 29 | 95% Normal UCL | | 95% UCLs (Adjusted for Skewness) | |
| 30 | 95% Student's-t UCL | 5.931 | 95% Adjusted-CLT UCL (Chen-1995) | 6.091 |
| 31 | | | 95% Modified-t UCL (Johnson-1978) | 5.97 |
| 32 | | | | |
| 33 | Gamma GOF Test | | | |
| 34 | A-D Test Statistic | 0.127 | Anderson-Darling Gamma GOF Test | |
| 35 | 5% A-D Critical Value | 0.746 | etected data appear Gamma Distributed at 5% Significance Leve | |
| 36 | K-S Test Statistic | 0.0838 | Kolmogorov-Smirnov Gamma GOF Test | |
| 37 | 5% K-S Critical Value | 0.224 | etected data appear Gamma Distributed at 5% Significance Leve | |
| 38 | Detected data appear Gamma Distributed at 5% Significance Level | | | |
| 39 | | | | |
| 40 | Gamma Statistics | | | |
| 41 | k hat (MLE) | 2.358 | k star (bias corrected MLE) | 1.931 |
| 42 | Theta hat (MLE) | 1.921 | Theta star (bias corrected MLE) | 2.346 |
| 43 | nu hat (MLE) | 70.75 | nu star (bias corrected) | 57.93 |
| 44 | MLE Mean (bias corrected) | 4.53 | MLE Sd (bias corrected) | 3.26 |
| 45 | | | Approximate Chi Square Value (0.05) | 41.44 |
| 46 | Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 39.72 |
| 47 | | | | |
| 48 | Assuming Gamma Distribution | | | |
| 49 | 95% Approximate Gamma UCL (use when n>=50)) | 6.334 | 95% Adjusted Gamma UCL (use when n<50) | 6.607 |
| 50 | | | | |
| 51 | Lognormal GOF Test | | | |
| 52 | Shapiro Wilk Test Statistic | 0.983 | Shapiro Wilk Lognormal GOF Test | |
| 53 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| 54 | Lilliefors Test Statistic | 0.106 | Lilliefors Lognormal GOF Test | |
| 55 | 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| 56 | Data appear Lognormal at 5% Significance Level | | | |
| 57 | | | | |
| 58 | Lognormal Statistics | | | |
| 59 | Minimum of Logged Data | -0.166 | Mean of logged Data | 1.284 |
| 60 | Maximum of Logged Data | 2.5 | SD of logged Data | 0.729 |
| 61 | | | | |
| 62 | Assuming Lognormal Distribution | | | |
| 63 | 95% H-UCL | 7.434 | 90% Chebyshev (MVUE) UCL | 7.361 |
| 64 | 95% Chebyshev (MVUE) UCL | 8.607 | 97.5% Chebyshev (MVUE) UCL | 10.34 |
| 65 | 99% Chebyshev (MVUE) UCL | 13.74 | | |
| 66 | | | | |

| | | | |
|---|---|---|---|
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| | | | |
| **Nonparametric Distribution Free UCLs** | | | |
| 95% CLT UCL | 5.838 | 95% Jackknife UCL | 5.931 |
| 95% Standard Bootstrap UCL | 5.759 | 95% Bootstrap-t UCL | 6.292 |
| 95% Hall's Bootstrap UCL | 6.433 | 95% Percentile Bootstrap UCL | 5.861 |
| 95% BCA Bootstrap UCL | 6.051 | | |
| 90% Chebyshev(Mean, Sd) UCL | 6.916 | 95% Chebyshev(Mean, Sd) UCL | 7.996 |
| 97.5% Chebyshev(Mean, Sd) UCL | 9.496 | 99% Chebyshev(Mean, Sd) UCL | 12.44 |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% Student's-t UCL | 5.931 | | |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
lowever, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statisticiar

**LMW PAHs**

| | | | |
|---|---|---|---|
| **General Statistics** | | | |
| Total Number of Observations | 15 | Number of Distinct Observations | 15 |
| | | Number of Missing Observations | 0 |
| Minimum | 0.916 | Mean | 5.765 |
| Maximum | 12.77 | Median | 4.906 |
| SD | 3.764 | Std. Error of Mean | 0.972 |
| Coefficient of Variation | 0.653 | Skewness | 0.792 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.901 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.185 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |
| **Data appear Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 7.476 | 95% Adjusted-CLT UCL (Chen-1995) | 7.576 |
| | | 95% Modified-t UCL (Johnson-1978) | 7.51 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.227 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.746 | etected data appear Gamma Distributed at 5% Significance Leve | |
| K-S Test Statistic | 0.126 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.224 | etected data appear Gamma Distributed at 5% Significance Leve | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 2.398 | k star (bias corrected MLE) | 1.963 |
| Theta hat (MLE) | 2.404 | Theta star (bias corrected MLE) | 2.936 |
| nu hat (MLE) | 71.95 | nu star (bias corrected) | 58.9 |
| MLE Mean (bias corrected) | 5.765 | MLE Sd (bias corrected) | 4.114 |
| | | Approximate Chi Square Value (0.05) | 42.25 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 40.52 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50)) | 8.036 | 95% Adjusted Gamma UCL (use when n<50) | 8.379 |
| | | | |
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.96 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.11 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| **Data appear Lognormal at 5% Significance Level** | | | |

| | | | | |
|---|---|---|---|---|
| 133 | | | | |
| 134 | **Lognormal Statistics** | | | |
| 135 | Minimum of Logged Data | -0.0877 | Mean of logged Data | 1.529 |
| 136 | Maximum of Logged Data | 2.547 | SD of logged Data | 0.732 |
| 137 | | | | |
| 138 | **Assuming Lognormal Distribution** | | | |
| 139 | 95% H-UCL | 9.556 | 90% Chebyshev (MVUE) UCL | 9.448 |
| 140 | 95% Chebyshev (MVUE) UCL | 11.05 | 97.5% Chebyshev (MVUE) UCL | 13.28 |
| 141 | 99% Chebyshev (MVUE) UCL | 17.66 | | |
| 142 | | | | |
| 143 | **Nonparametric Distribution Free UCL Statistics** | | | |
| 144 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| 145 | | | | |
| 146 | **Nonparametric Distribution Free UCLs** | | | |
| 147 | 95% CLT UCL | 7.363 | 95% Jackknife UCL | 7.476 |
| 148 | 95% Standard Bootstrap UCL | 7.281 | 95% Bootstrap-t UCL | 7.903 |
| 149 | 95% Hall's Bootstrap UCL | 7.581 | 95% Percentile Bootstrap UCL | 7.279 |
| 150 | 95% BCA Bootstrap UCL | 7.586 | | |
| 151 | 90% Chebyshev(Mean, Sd) UCL | 8.68 | 95% Chebyshev(Mean, Sd) UCL | 10 |
| 152 | 97.5% Chebyshev(Mean, Sd) UCL | 11.83 | 99% Chebyshev(Mean, Sd) UCL | 15.43 |
| 153 | | | | |
| 154 | **Suggested UCL to Use** | | | |
| 155 | 95% Student's-t UCL | 7.476 | | |
| 156 | | | | |
| 157 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 158 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 159 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 160 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician | | | |
| 161 | | | | |

## UCL Statistics for Data Sets with Non-Detects

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | ProUCL 5.111/15/2018 8:48:09 AM |
| From File | WorkSheet_a.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

PCBs

### General Statistics

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 11 |
| Number of Detects | 12 | Number of Non-Detects | 3 |
| Number of Distinct Detects | 10 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | 0.03 | Minimum Non-Detect | 0.02 |
| Maximum Detect | 0.65 | Maximum Non-Detect | 0.02 |
| Variance Detects | 0.0404 | Percent Non-Detects | 20% |
| Mean Detects | 0.186 | SD Detects | 0.201 |
| Median Detects | 0.1 | CV Detects | 1.082 |
| Skewness Detects | 1.722 | Kurtosis Detects | 1.958 |
| Mean of Logged Detects | -2.123 | SD of Logged Detects | 0.945 |

### Normal GOF Test on Detects Only

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.733 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.859 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.281 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.243 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

### Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

| | | | |
|---|---|---|---|
| KM Mean | 0.153 | KM Standard Error of Mean | 0.0498 |
| KM SD | 0.185 | 95% KM (BCA) UCL | 0.243 |
| 95% KM (t) UCL | 0.24 | 95% KM (Percentile Bootstrap) UCL | 0.235 |
| 95% KM (z) UCL | 0.235 | 95% KM Bootstrap t UCL | 0.364 |
| 90% KM Chebyshev UCL | 0.302 | 95% KM Chebyshev UCL | 0.37 |
| 97.5% KM Chebyshev UCL | 0.463 | 99% KM Chebyshev UCL | 0.648 |

### Gamma GOF Tests on Detected Observations Only

| | | |
|---|---|---|
| A-D Test Statistic | 0.618 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.751 | Detected data appear Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.211 | **Kolmogorov-Smirnov GOF** |
| 5% K-S Critical Value | 0.251 | Detected data appear Gamma Distributed at 5% Significance Level |

**Detected data appear Gamma Distributed at 5% Significance Level**

### Gamma Statistics on Detected Data Only

| | | | |
|---|---|---|---|
| k hat (MLE) | 1.277 | k star (bias corrected MLE) | 1.013 |
| Theta hat (MLE) | 0.146 | Theta star (bias corrected MLE) | 0.183 |
| nu hat (MLE) | 30.65 | nu star (bias corrected) | 24.32 |
| Mean (detects) | 0.186 | | |

## UCL Statistics for Data Sets with Non-Detects

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | ProUCL 5.111/14/2018 4:02:11 PM |
| From File | WorkSheet_b.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

**F2**

### General Statistics

| | | | |
|---|---|---|---|
| Total Number of Observations | 14 | Number of Distinct Observations | 11 |
| Number of Detects | 10 | Number of Non-Detects | 4 |
| Number of Distinct Detects | 10 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | 0.06 | Minimum Non-Detect | 0.05 |
| Maximum Detect | 230 | Maximum Non-Detect | 0.05 |
| Variance Detects | 5228 | Percent Non-Detects | 28.57% |
| Mean Detects | 24.28 | SD Detects | 72.31 |
| Median Detects | 0.86 | CV Detects | 2.978 |
| Skewness Detects | 3.158 | Kurtosis Detects | 9.98 |
| Mean of Logged Detects | 0.0369 | SD of Logged Detects | 2.387 |

### Normal GOF Test on Detects Only

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.385 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.842 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.497 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.262 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

### Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs

| | | | |
|---|---|---|---|
| KM Mean | 17.36 | KM Standard Error of Mean | 16.62 |
| KM SD | 59 | 95% KM (BCA) UCL | 50.02 |
| 95% KM (t) UCL | 46.79 | 95% KM (Percentile Bootstrap) UCL | 49.73 |
| 95% KM (z) UCL | 44.7 | 95% KM Bootstrap t UCL | 1482 |
| 90% KM Chebyshev UCL | 67.22 | 95% KM Chebyshev UCL | 89.81 |
| 97.5% KM Chebyshev UCL | 121.2 | 99% KM Chebyshev UCL | 182.7 |

### Gamma GOF Tests on Detected Observations Only

| | | |
|---|---|---|
| A-D Test Statistic | 1.492 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.843 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.359 | **Kolmogorov-Smirnov GOF** |
| 5% K-S Critical Value | 0.293 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

### Gamma Statistics on Detected Data Only

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.229 | k star (bias corrected MLE) | 0.227 |
| Theta hat (MLE) | 106.2 | Theta star (bias corrected MLE) | 107.1 |
| nu hat (MLE) | 4.571 | nu star (bias corrected) | 4.533 |
| Mean (detects) | 24.28 | | |

| | | | | |
|---|---|---|---|---|
| 52 | **Gamma ROS Statistics using Imputed Non-Detects** | | | |
| 53 | GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| 54 | GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| 55 | For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| 56 | This is especially true when the sample size is small. | | | |
| 57 | For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| 58 | Minimum | 0.01 | Mean | 17.35 |
| 59 | Maximum | 230 | Median | 0.28 |
| 60 | SD | 61.23 | CV | 3.53 |
| 61 | k hat (MLE) | 0.18 | k star (bias corrected MLE) | 0.189 |
| 62 | Theta hat (MLE) | 96.12 | Theta star (bias corrected MLE) | 91.58 |
| 63 | nu hat (MLE) | 5.053 | nu star (bias corrected) | 5.304 |
| 64 | Adjusted Level of Significance (β) | 0.0312 | | |
| 65 | Approximate Chi Square Value (5.30, α) | 1.295 | Adjusted Chi Square Value (5.30, β) | 1.054 |
| 66 | 95% Gamma Approximate UCL (use when n>=50) | 71.05 | 95% Gamma Adjusted UCL (use when n<50) | 87.33 |
| 67 | | | | |
| 68 | **Estimates of Gamma Parameters using KM Estimates** | | | |
| 69 | Mean (KM) | 17.36 | SD (KM) | 59 |
| 70 | Variance (KM) | 3481 | SE of Mean (KM) | 16.62 |
| 71 | k hat (KM) | 0.0866 | k star (KM) | 0.116 |
| 72 | nu hat (KM) | 2.424 | nu star (KM) | 3.238 |
| 73 | theta hat (KM) | 200.5 | theta star (KM) | 150.1 |
| 74 | 80% gamma percentile (KM) | 14.58 | 90% gamma percentile (KM) | 48.66 |
| 75 | 95% gamma percentile (KM) | 99.5 | 99% gamma percentile (KM) | 256.1 |
| 76 | | | | |
| 77 | **Gamma Kaplan-Meier (KM) Statistics** | | | |
| 78 | Approximate Chi Square Value (3.24, α) | 0.446 | Adjusted Chi Square Value (3.24, β) | 0.337 |
| 79 | 95% Gamma Approximate KM-UCL (use when n>=50) | 126 | 95% Gamma Adjusted KM-UCL (use when n<50) | 166.7 |
| 80 | | | | |
| 81 | **Lognormal GOF Test on Detected Observations Only** | | | |
| 82 | Shapiro Wilk Test Statistic | 0.907 | **Shapiro Wilk GOF Test** | |
| 83 | 5% Shapiro Wilk Critical Value | 0.842 | Detected Data appear Lognormal at 5% Significance Level | |
| 84 | Lilliefors Test Statistic | 0.192 | **Lilliefors GOF Test** | |
| 85 | 5% Lilliefors Critical Value | 0.262 | Detected Data appear Lognormal at 5% Significance Level | |
| 86 | **Detected Data appear Lognormal at 5% Significance Level** | | | |
| 87 | | | | |
| 88 | **Lognormal ROS Statistics Using Imputed Non-Detects** | | | |
| 89 | Mean in Original Scale | 17.35 | Mean in Log Scale | -1.645 |
| 90 | SD in Original Scale | 61.23 | SD in Log Scale | 3.463 |
| 91 | 95% t UCL (assumes normality of ROS data) | 46.33 | 95% Percentile Bootstrap UCL | 50.06 |
| 92 | 95% BCA Bootstrap UCL | 66.55 | 95% Bootstrap t UCL | 1488 |
| 93 | 95% H-UCL (Log ROS) | 128575 | | |
| 94 | | | | |
| 95 | **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | |
| 96 | KM Mean (logged) | -0.83 | KM Geo Mean | 0.436 |
| 97 | KM SD (logged) | 2.354 | 95% Critical H Value (KM-Log) | 5.395 |
| 98 | KM Standard Error of Mean (logged) | 0.663 | 95% H-UCL (KM -Log) | 235.6 |
| 99 | KM SD (logged) | 2.354 | 95% Critical H Value (KM-Log) | 5.395 |
| 100 | KM Standard Error of Mean (logged) | 0.663 | | |
| 101 | | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 102 | DL/2 Statistics | | | |
| 103 | DL/2 Normal | | DL/2 Log-Transformed | |
| 104 | Mean in Original Scale | 17.35 | Mean in Log Scale | -1.028 |
| 105 | SD in Original Scale | 61.23 | SD in Log Scale | 2.645 |
| 106 | 95% t UCL (Assumes normality) | 46.33 | 95% H-Stat UCL | 963.1 |
| 107 | DL/2 is not a recommended method, provided for comparisons and historical reasons | | | |
| 108 | | | | |
| 109 | Nonparametric Distribution Free UCL Statistics | | | |
| 110 | Detected Data appear Lognormal Distributed at 5% Significance Level | | | |
| 111 | | | | |
| 112 | Suggested UCL to Use | | | |
| 113 | 99% KM (Chebyshev) UCL | 182.7 | | |
| 114 | | | | |
| 115 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 116 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 117 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 118 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 119 | | | | |
| 120 | F3 | | | |
| 121 | | | | |
| 122 | General Statistics | | | |
| 123 | Total Number of Observations | 14 | Number of Distinct Observations | 11 |
| 124 | Number of Detects | 10 | Number of Non-Detects | 4 |
| 125 | Number of Distinct Detects | 10 | Number of Distinct Non-Detects | 1 |
| 126 | Minimum Detect | 0.02 | Minimum Non-Detect | 0.1 |
| 127 | Maximum Detect | 216 | Maximum Non-Detect | 0.1 |
| 128 | Variance Detects | 4588 | Percent Non-Detects | 28.57% |
| 129 | Mean Detects | 23.31 | SD Detects | 67.73 |
| 130 | Median Detects | 1.355 | CV Detects | 2.906 |
| 131 | Skewness Detects | 3.158 | Kurtosis Detects | 9.978 |
| 132 | Mean of Logged Detects | 0.294 | SD of Logged Detects | 2.473 |
| 133 | | | | |
| 134 | Normal GOF Test on Detects Only | | | |
| 135 | Shapiro Wilk Test Statistic | 0.39 | Shapiro Wilk GOF Test | |
| 136 | 5% Shapiro Wilk Critical Value | 0.842 | Detected Data Not Normal at 5% Significance Level | |
| 137 | Lilliefors Test Statistic | 0.503 | Lilliefors GOF Test | |
| 138 | 5% Lilliefors Critical Value | 0.262 | Detected Data Not Normal at 5% Significance Level | |
| 139 | Detected Data Not Normal at 5% Significance Level | | | |
| 140 | | | | |
| 141 | Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs | | | |
| 142 | KM Mean | 16.66 | KM Standard Error of Mean | 15.58 |
| 143 | KM SD | 55.32 | 95% KM (BCA) UCL | 47.61 |
| 144 | 95% KM (t) UCL | 44.25 | 95% KM (Percentile Bootstrap) UCL | 47.13 |
| 145 | 95% KM (z) UCL | 42.29 | 95% KM Bootstrap t UCL | 669 |
| 146 | 90% KM Chebyshev UCL | 63.41 | 95% KM Chebyshev UCL | 84.58 |
| 147 | 97.5% KM Chebyshev UCL | 114 | 99% KM Chebyshev UCL | 171.7 |
| 148 | | | | |
| 149 | Gamma GOF Tests on Detected Observations Only | | | |
| 150 | A-D Test Statistic | 1.2 | Anderson-Darling GOF Test | |
| 151 | 5% A-D Critical Value | 0.835 | Detected Data Not Gamma Distributed at 5% Significance Level | |
| 152 | K-S Test Statistic | 0.36 | Kolmogorov-Smirnov GOF | |
| 153 | 5% K-S Critical Value | 0.291 | Detected Data Not Gamma Distributed at 5% Significance Level | |
| 154 | Detected Data Not Gamma Distributed at 5% Significance Level | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 155 | | | | |
| 156 | **Gamma Statistics on Detected Data Only** | | | |
| 157 | k hat (MLE) | 0.249 | k star (bias corrected MLE) | 0.241 |
| 158 | Theta hat (MLE) | 93.63 | Theta star (bias corrected MLE) | 96.75 |
| 159 | nu hat (MLE) | 4.979 | nu star (bias corrected) | 4.819 |
| 160 | Mean (detects) | 23.31 | | |
| 161 | | | | |
| 162 | **Gamma ROS Statistics using Imputed Non-Detects** | | | |
| 163 | GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| 164 | GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| 165 | For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| 166 | This is especially true when the sample size is small. | | | |
| 167 | For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| 168 | Minimum | 0.01 | Mean | 16.65 |
| 169 | Maximum | 216 | Median | 0.505 |
| 170 | SD | 57.4 | CV | 3.447 |
| 171 | k hat (MLE) | 0.189 | k star (bias corrected MLE) | 0.196 |
| 172 | Theta hat (MLE) | 87.92 | Theta star (bias corrected MLE) | 84.77 |
| 173 | nu hat (MLE) | 5.303 | nu star (bias corrected) | 5.5 |
| 174 | Adjusted Level of Significance (β) | 0.0312 | | |
| 175 | Approximate Chi Square Value (5.50, α) | 1.39 | Adjusted Chi Square Value (5.50, β) | 1.137 |
| 176 | 95% Gamma Approximate UCL (use when n>=50) | 65.89 | 95% Gamma Adjusted UCL (use when n<50) | 80.57 |
| 177 | | | | |
| 178 | **Estimates of Gamma Parameters using KM Estimates** | | | |
| 179 | Mean (KM) | 16.66 | SD (KM) | 55.32 |
| 180 | Variance (KM) | 3060 | SE of Mean (KM) | 15.58 |
| 181 | k hat (KM) | 0.0907 | k star (KM) | 0.119 |
| 182 | nu hat (KM) | 2.539 | nu star (KM) | 3.328 |
| 183 | theta hat (KM) | 183.7 | theta star (KM) | 140.1 |
| 184 | 80% gamma percentile (KM) | 14.45 | 90% gamma percentile (KM) | 47.06 |
| 185 | 95% gamma percentile (KM) | 95.16 | 99% gamma percentile (KM) | 242.3 |
| 186 | | | | |
| 187 | **Gamma Kaplan-Meier (KM) Statistics** | | | |
| 188 | Approximate Chi Square Value (3.33, α) | 0.476 | Adjusted Chi Square Value (3.33, β) | 0.361 |
| 189 | 95% Gamma Approximate KM-UCL (use when n>=50) | 116.5 | 95% Gamma Adjusted KM-UCL (use when n<50) | 153.7 |
| 190 | | | | |
| 191 | **Lognormal GOF Test on Detected Observations Only** | | | |
| 192 | Shapiro Wilk Test Statistic | 0.96 | **Shapiro Wilk GOF Test** | |
| 193 | 5% Shapiro Wilk Critical Value | 0.842 | Detected Data appear Lognormal at 5% Significance Level | |
| 194 | Lilliefors Test Statistic | 0.183 | **Lilliefors GOF Test** | |
| 195 | 5% Lilliefors Critical Value | 0.262 | Detected Data appear Lognormal at 5% Significance Level | |
| 196 | **Detected Data appear Lognormal at 5% Significance Level** | | | |
| 197 | | | | |
| 198 | **Lognormal ROS Statistics Using Imputed Non-Detects** | | | |
| 199 | Mean in Original Scale | 16.66 | Mean in Log Scale | -1.034 |
| 200 | SD in Original Scale | 57.4 | SD in Log Scale | 3.063 |
| 201 | 95% t UCL (assumes normality of ROS data) | 43.83 | 95% Percentile Bootstrap UCL | 47.11 |
| 202 | 95% BCA Bootstrap UCL | 63.27 | 95% Bootstrap t UCL | 684.2 |
| 203 | 95% H-UCL (Log ROS) | 13376 | | |
| 204 | | | | |
| 205 | **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | |
| 206 | KM Mean (logged) | -0.908 | KM Geo Mean | 0.403 |
| 207 | KM SD (logged) | 2.746 | 95% Critical H Value (KM-Log) | 6.21 |
| 208 | KM Standard Error of Mean (logged) | 0.774 | 95% H-UCL (KM -Log) | 1987 |
| 209 | KM SD (logged) | 2.746 | 95% Critical H Value (KM-Log) | 6.21 |
| 210 | KM Standard Error of Mean (logged) | 0.774 | | |

**DL/2 Statistics**

| DL/2 Normal | | DL/2 Log-Transformed | |
|---|---|---|---|
| Mean in Original Scale | 16.66 | Mean in Log Scale | -0.646 |
| SD in Original Scale | 57.4 | SD in Log Scale | 2.572 |
| 95% t UCL (Assumes normality) | 43.83 | 95% H-Stat UCL | 926.1 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Detected Data appear Lognormal Distributed at 5% Significance Level**

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 99% KM (Chebyshev) UCL | 171.7 | | |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

mTPH

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 14 | Number of Distinct Observations | 10 |
| Number of Detects | 9 | Number of Non-Detects | 5 |
| Number of Distinct Detects | 9 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | 0.3 | Minimum Non-Detect | 0.1 |
| Maximum Detect | 447 | Maximum Non-Detect | 0.1 |
| Variance Detects | 21838 | Percent Non-Detects | 35.71% |
| Mean Detects | 53.06 | SD Detects | 147.8 |
| Median Detects | 3.3 | CV Detects | 2.785 |
| Skewness Detects | 2.996 | Kurtosis Detects | 8.983 |
| Mean of Logged Detects | 1.325 | SD of Logged Detects | 2.161 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.412 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.829 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.498 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.274 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| KM Mean | 34.14 | KM Standard Error of Mean | 32.47 |
| KM SD | 114.6 | 95% KM (BCA) UCL | 97.91 |
| 95% KM (t) UCL | 91.65 | 95% KM (Percentile Bootstrap) UCL | 97.51 |
| 95% KM (z) UCL | 87.56 | 95% KM Bootstrap t UCL | 1964 |
| 90% KM Chebyshev UCL | 131.6 | 95% KM Chebyshev UCL | 175.7 |
| 97.5% KM Chebyshev UCL | 236.9 | 99% KM Chebyshev UCL | 357.2 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 1.365 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.821 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.368 | **Kolmogorov-Smirnov GOF** |
| 5% K-S Critical Value | 0.304 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 266 | **Gamma Statistics on Detected Data Only** | | | |
| 267 | k hat (MLE) | 0.266 | k star (bias corrected MLE) | 0.251 |
| 268 | Theta hat (MLE) | 199.6 | Theta star (bias corrected MLE) | 211.2 |
| 269 | nu hat (MLE) | 4.784 | nu star (bias corrected) | 4.522 |
| 270 | Mean (detects) | 53.06 | | |
| 271 | | | | |
| 272 | **Gamma ROS Statistics using Imputed Non-Detects** | | | |
| 273 | GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| 274 | GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| 275 | For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| 276 | This is especially true when the sample size is small. | | | |
| 277 | For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| 278 | Minimum | 0.01 | Mean | 34.11 |
| 279 | Maximum | 447 | Median | 0.85 |
| 280 | SD | 118.9 | CV | 3.485 |
| 281 | k hat (MLE) | 0.174 | k star (bias corrected MLE) | 0.184 |
| 282 | Theta hat (MLE) | 196.1 | Theta star (bias corrected MLE) | 185.1 |
| 283 | nu hat (MLE) | 4.87 | nu star (bias corrected) | 5.16 |
| 284 | Adjusted Level of Significance (β) | 0.0312 | | |
| 285 | Approximate Chi Square Value (5.16, α) | 1.227 | Adjusted Chi Square Value (5.16, β) | 0.994 |
| 286 | 95% Gamma Approximate UCL (use when n>=50) | 143.5 | 95% Gamma Adjusted UCL (use when n<50) | 177.1 |
| 287 | | | | |
| 288 | **Estimates of Gamma Parameters using KM Estimates** | | | |
| 289 | Mean (KM) | 34.14 | SD (KM) | 114.6 |
| 290 | Variance (KM) | 13123 | SE of Mean (KM) | 32.47 |
| 291 | k hat (KM) | 0.0888 | k star (KM) | 0.117 |
| 292 | nu hat (KM) | 2.487 | nu star (KM) | 3.288 |
| 293 | theta hat (KM) | 384.4 | theta star (KM) | 290.8 |
| 294 | 80% gamma percentile (KM) | 29.21 | 90% gamma percentile (KM) | 96.14 |
| 295 | 95% gamma percentile (KM) | 195.4 | 99% gamma percentile (KM) | 499.8 |
| 296 | | | | |
| 297 | **Gamma Kaplan-Meier (KM) Statistics** | | | |
| 298 | Approximate Chi Square Value (3.29, α) | 0.462 | Adjusted Chi Square Value (3.29, β) | 0.35 |
| 299 | 95% Gamma Approximate KM-UCL (use when n>=50) | 242.7 | 95% Gamma Adjusted KM-UCL (use when n<50) | 320.6 |
| 300 | | | | |
| 301 | **Lognormal GOF Test on Detected Observations Only** | | | |
| 302 | Shapiro Wilk Test Statistic | 0.897 | **Shapiro Wilk GOF Test** | |
| 303 | 5% Shapiro Wilk Critical Value | 0.829 | Detected Data appear Lognormal at 5% Significance Level | |
| 304 | Lilliefors Test Statistic | 0.192 | **Lilliefors GOF Test** | |
| 305 | 5% Lilliefors Critical Value | 0.274 | Detected Data appear Lognormal at 5% Significance Level | |
| 306 | **Detected Data appear Lognormal at 5% Significance Level** | | | |
| 307 | | | | |
| 308 | **Lognormal ROS Statistics Using Imputed Non-Detects** | | | |
| 309 | Mean in Original Scale | 34.12 | Mean in Log Scale | -0.66 |
| 310 | SD in Original Scale | 118.9 | SD in Log Scale | 3.344 |
| 311 | 95% t UCL (assumes normality of ROS data) | 90.39 | 95% Percentile Bootstrap UCL | 97.32 |
| 312 | 95% BCA Bootstrap UCL | 130.2 | 95% Bootstrap t UCL | 1979 |
| 313 | 95% H-UCL (Log ROS) | 141032 | | |
| 314 | | | | |
| 315 | **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | |
| 316 | KM Mean (logged) | 0.0294 | KM Geo Mean | 1.03 |
| 317 | KM SD (logged) | 2.385 | 95% Critical H Value (KM-Log) | 5.46 |
| 318 | KM Standard Error of Mean (logged) | 0.676 | 95% H-UCL (KM -Log) | 656.3 |
| 319 | KM SD (logged) | 2.385 | 95% Critical H Value (KM-Log) | 5.46 |
| 320 | KM Standard Error of Mean (logged) | 0.676 | | |
| 321 | | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 322 | **DL/2 Statistics** | | | | | | | | | | | |
| 323 | **DL/2 Normal** | | | | | | **DL/2 Log-Transformed** | | | | | |
| 324 | Mean in Original Scale | | | | | 34.13 | Mean in Log Scale | | | | | -0.218 |
| 325 | SD in Original Scale | | | | | 118.9 | SD in Log Scale | | | | | 2.737 |
| 326 | 95% t UCL (Assumes normality) | | | | | 90.39 | 95% H-Stat UCL | | | | | 3733 |
| 327 | **DL/2 is not a recommended method, provided for comparisons and historical reasons** | | | | | | | | | | | |
| 328 | | | | | | | | | | | | |
| 329 | **Nonparametric Distribution Free UCL Statistics** | | | | | | | | | | | |
| 330 | **Detected Data appear Lognormal Distributed at 5% Significance Level** | | | | | | | | | | | |
| 331 | | | | | | | | | | | | |
| 332 | **Suggested UCL to Use** | | | | | | | | | | | |
| 333 | 99% KM (Chebyshev) UCL | | | | | 357.2 | | | | | | |
| 334 | | | | | | | | | | | | |
| 335 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | | | | | | | | | |
| 336 | Recommendations are based upon data size, data distribution, and skewness. | | | | | | | | | | | |
| 337 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | | | | | | | | | |
| 338 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | | | | | | | | | |
| 339 | | | | | | | | | | | | |

| | | | | |
|---|---|---|---|---|
| 52 | **Gamma ROS Statistics using Imputed Non-Detects** | | | |
| 53 | GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| 54 | GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| 55 | For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| 56 | This is especially true when the sample size is small. | | | |
| 57 | For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| 58 | Minimum | 0.01 | Mean | 0.151 |
| 59 | Maximum | 0.65 | Median | 0.08 |
| 60 | SD | 0.193 | CV | 1.278 |
| 61 | k hat (MLE) | 0.815 | k star (bias corrected MLE) | 0.696 |
| 62 | Theta hat (MLE) | 0.185 | Theta star (bias corrected MLE) | 0.216 |
| 63 | nu hat (MLE) | 24.44 | nu star (bias corrected) | 20.89 |
| 64 | Adjusted Level of Significance (β) | 0.0324 | | |
| 65 | Approximate Chi Square Value (20.89, α) | 11.51 | Adjusted Chi Square Value (20.89, β) | 10.66 |
| 66 | 95% Gamma Approximate UCL (use when n>=50) | 0.273 | 95% Gamma Adjusted UCL (use when n<50) | 0.295 |
| 67 | | | | |
| 68 | **Estimates of Gamma Parameters using KM Estimates** | | | |
| 69 | Mean (KM) | 0.153 | SD (KM) | 0.185 |
| 70 | Variance (KM) | 0.0341 | SE of Mean (KM) | 0.0498 |
| 71 | k hat (KM) | 0.684 | k star (KM) | 0.592 |
| 72 | nu hat (KM) | 20.53 | nu star (KM) | 17.76 |
| 73 | theta hat (KM) | 0.223 | theta star (KM) | 0.258 |
| 74 | 80% gamma percentile (KM) | 0.252 | 90% gamma percentile (KM) | 0.398 |
| 75 | 95% gamma percentile (KM) | 0.552 | 99% gamma percentile (KM) | 0.924 |
| 76 | | | | |
| 77 | **Gamma Kaplan-Meier (KM) Statistics** | | | |
| 78 | Approximate Chi Square Value (17.76, α) | 9.215 | Adjusted Chi Square Value (17.76, β) | 8.466 |
| 79 | 95% Gamma Approximate KM-UCL (use when n>=50) | 0.294 | 95% Gamma Adjusted KM-UCL (use when n<50) | 0.32 |
| 80 | | | | |
| 81 | **Lognormal GOF Test on Detected Observations Only** | | | |
| 82 | Shapiro Wilk Test Statistic | 0.947 | **Shapiro Wilk GOF Test** | |
| 83 | 5% Shapiro Wilk Critical Value | 0.859 | Detected Data appear Lognormal at 5% Significance Level | |
| 84 | Lilliefors Test Statistic | 0.159 | **Lilliefors GOF Test** | |
| 85 | 5% Lilliefors Critical Value | 0.243 | Detected Data appear Lognormal at 5% Significance Level | |
| 86 | **Detected Data appear Lognormal at 5% Significance Level** | | | |
| 87 | | | | |
| 88 | **Lognormal ROS Statistics Using Imputed Non-Detects** | | | |
| 89 | Mean in Original Scale | 0.151 | Mean in Log Scale | -2.579 |
| 90 | SD in Original Scale | 0.192 | SD in Log Scale | 1.273 |
| 91 | 95% t UCL (assumes normality of ROS data) | 0.239 | 95% Percentile Bootstrap UCL | 0.228 |
| 92 | 95% BCA Bootstrap UCL | 0.261 | 95% Bootstrap t UCL | 0.362 |
| 93 | 95% H-UCL (Log ROS) | 0.507 | | |
| 94 | | | | |
| 95 | **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | |
| 96 | KM Mean (logged) | -2.481 | KM Geo Mean | 0.0837 |
| 97 | KM SD (logged) | 1.08 | 95% Critical H Value (KM-Log) | 2.874 |
| 98 | KM Standard Error of Mean (logged) | 0.291 | 95% H-UCL (KM -Log) | 0.344 |
| 99 | KM SD (logged) | 1.08 | 95% Critical H Value (KM-Log) | 2.874 |
| 100 | KM Standard Error of Mean (logged) | 0.291 | | |
| 101 | | | | |

| | | | | |
|---|---|---|---|---|
| 102 | **DL/2 Statistics** | | | |
| 103 | **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| 104 | Mean in Original Scale | 0.151 | Mean in Log Scale | -2.619 |
| 105 | SD in Original Scale | 0.193 | SD in Log Scale | 1.326 |
| 106 | 95% t UCL (Assumes normality) | 0.238 | 95% H-Stat UCL | 0.564 |
| 107 | **DL/2 is not a recommended method, provided for comparisons and historical reasons** | | | |
| 108 | | | | |
| 109 | **Nonparametric Distribution Free UCL Statistics** | | | |
| 110 | **Detected Data appear Gamma Distributed at 5% Significance Level** | | | |
| 111 | | | | |
| 112 | **Suggested UCL to Use** | | | |
| 113 | 95% KM Adjusted Gamma UCL | 0.32 | 95% GROS Adjusted Gamma UCL | 0.295 |
| 114 | | | | |
| 115 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 116 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 117 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 118 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 119 | | | | |
| 120 | **1-Meth** | | | |
| 121 | | | | |
| 122 | **General Statistics** | | | |
| 123 | Total Number of Observations | 15 | Number of Distinct Observations | 7 |
| 124 | Number of Detects | 9 | Number of Non-Detects | 6 |
| 125 | Number of Distinct Detects | 7 | Number of Distinct Non-Detects | 1 |
| 126 | Minimum Detect | 0.05 | Minimum Non-Detect | 0.05 |
| 127 | Maximum Detect | 0.27 | Maximum Non-Detect | 0.05 |
| 128 | Variance Detects | 0.00644 | Percent Non-Detects | 40% |
| 129 | Mean Detects | 0.122 | SD Detects | 0.0803 |
| 130 | Median Detects | 0.08 | CV Detects | 0.657 |
| 131 | Skewness Detects | 0.96 | Kurtosis Detects | -0.586 |
| 132 | Mean of Logged Detects | -2.283 | SD of Logged Detects | 0.626 |
| 133 | | | | |
| 134 | **Normal GOF Test on Detects Only** | | | |
| 135 | Shapiro Wilk Test Statistic | 0.826 | **Shapiro Wilk GOF Test** | |
| 136 | 5% Shapiro Wilk Critical Value | 0.829 | Detected Data Not Normal at 5% Significance Level | |
| 137 | Lilliefors Test Statistic | 0.256 | **Lilliefors GOF Test** | |
| 138 | 5% Lilliefors Critical Value | 0.274 | Detected Data appear Normal at 5% Significance Level | |
| 139 | **Detected Data appear Approximate Normal at 5% Significance Level** | | | |
| 140 | | | | |
| 141 | **Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs** | | | |
| 142 | KM Mean | 0.0933 | KM Standard Error of Mean | 0.0188 |
| 143 | KM SD | 0.0685 | 95% KM (BCA) UCL | 0.122 |
| 144 | 95% KM (t) UCL | 0.126 | 95% KM (Percentile Bootstrap) UCL | 0.125 |
| 145 | 95% KM (z) UCL | 0.124 | 95% KM Bootstrap t UCL | 0.144 |
| 146 | 90% KM Chebyshev UCL | 0.15 | 95% KM Chebyshev UCL | 0.175 |
| 147 | 97.5% KM Chebyshev UCL | 0.21 | 99% KM Chebyshev UCL | 0.28 |
| 148 | | | | |
| 149 | **Gamma GOF Tests on Detected Observations Only** | | | |
| 150 | A-D Test Statistic | 0.625 | **Anderson-Darling GOF Test** | |
| 151 | 5% A-D Critical Value | 0.727 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 152 | K-S Test Statistic | 0.238 | **Kolmogorov-Smirnov GOF** | |
| 153 | 5% K-S Critical Value | 0.281 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 154 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 155 | | | | |
| 156 | **Gamma Statistics on Detected Data Only** | | | |
| 157 | k hat (MLE) | 2.924 | k star (bias corrected MLE) | 2.023 |
| 158 | Theta hat (MLE) | 0.0418 | Theta star (bias corrected MLE) | 0.0604 |
| 159 | nu hat (MLE) | 52.63 | nu star (bias corrected) | 36.42 |
| 160 | Mean (detects) | 0.122 | | |
| 161 | | | | |
| 162 | **Gamma ROS Statistics using Imputed Non-Detects** | | | |
| 163 | GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| 164 | GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| 165 | For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| 166 | This is especially true when the sample size is small. | | | |
| 167 | For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| 168 | Minimum | 0.01 | Mean | 0.0773 |
| 169 | Maximum | 0.27 | Median | 0.06 |
| 170 | SD | 0.0832 | CV | 1.076 |
| 171 | k hat (MLE) | 0.897 | k star (bias corrected MLE) | 0.762 |
| 172 | Theta hat (MLE) | 0.0862 | Theta star (bias corrected MLE) | 0.101 |
| 173 | nu hat (MLE) | 26.91 | nu star (bias corrected) | 22.86 |
| 174 | Adjusted Level of Significance (β) | 0.0324 | | |
| 175 | Approximate Chi Square Value (22.86, α) | 12.99 | Adjusted Chi Square Value (22.86, β) | 12.08 |
| 176 | 95% Gamma Approximate UCL (use when n>=50) | 0.136 | 95% Gamma Adjusted UCL (use when n<50) | 0.146 |
| 177 | | | | |
| 178 | **Estimates of Gamma Parameters using KM Estimates** | | | |
| 179 | Mean (KM) | 0.0933 | SD (KM) | 0.0685 |
| 180 | Variance (KM) | 0.00469 | SE of Mean (KM) | 0.0188 |
| 181 | k hat (KM) | 1.858 | k star (KM) | 1.531 |
| 182 | nu hat (KM) | 55.73 | nu star (KM) | 45.92 |
| 183 | theta hat (KM) | 0.0502 | theta star (KM) | 0.061 |
| 184 | 80% gamma percentile (KM) | 0.144 | 90% gamma percentile (KM) | 0.194 |
| 185 | 95% gamma percentile (KM) | 0.241 | 99% gamma percentile (KM) | 0.35 |
| 186 | | | | |
| 187 | **Gamma Kaplan-Meier (KM) Statistics** | | | |
| 188 | Approximate Chi Square Value (45.92, α) | 31.37 | Adjusted Chi Square Value (45.92, β) | 29.9 |
| 189 | 95% Gamma Approximate KM-UCL (use when n>=50) | 0.137 | 95% Gamma Adjusted KM-UCL (use when n<50) | 0.143 |
| 190 | | | | |
| 191 | **Lognormal GOF Test on Detected Observations Only** | | | |
| 192 | Shapiro Wilk Test Statistic | 0.884 | **Shapiro Wilk GOF Test** | |
| 193 | 5% Shapiro Wilk Critical Value | 0.829 | Detected Data appear Lognormal at 5% Significance Level | |
| 194 | Lilliefors Test Statistic | 0.207 | **Lilliefors GOF Test** | |
| 195 | 5% Lilliefors Critical Value | 0.274 | Detected Data appear Lognormal at 5% Significance Level | |
| 196 | **Detected Data appear Lognormal at 5% Significance Level** | | | |
| 197 | | | | |
| 198 | **Lognormal ROS Statistics Using Imputed Non-Detects** | | | |
| 199 | Mean in Original Scale | 0.0816 | Mean in Log Scale | -2.956 |
| 200 | SD in Original Scale | 0.0798 | SD in Log Scale | 1.018 |
| 201 | 95% t UCL (assumes normality of ROS data) | 0.118 | 95% Percentile Bootstrap UCL | 0.116 |
| 202 | 95% BCA Bootstrap UCL | 0.12 | 95% Bootstrap t UCL | 0.132 |
| 203 | 95% H-UCL (Log ROS) | 0.186 | | |
| 204 | | | | |
| 205 | **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | |
| 206 | KM Mean (logged) | -2.568 | KM Geo Mean | 0.0767 |
| 207 | KM SD (logged) | 0.575 | 95% Critical H Value (KM-Log) | 2.152 |
| 208 | KM Standard Error of Mean (logged) | 0.158 | 95% H-UCL (KM -Log) | 0.126 |
| 209 | KM SD (logged) | 0.575 | 95% Critical H Value (KM-Log) | 2.152 |
| 210 | KM Standard Error of Mean (logged) | 0.158 | | |

**DL/2 Statistics**

| DL/2 Normal | | DL/2 Log-Transformed | |
|---|---|---|---|
| Mean in Original Scale | 0.0833 | Mean in Log Scale | -2.845 |
| SD in Original Scale | 0.0782 | SD in Log Scale | 0.856 |
| 95% t UCL (Assumes normality) | 0.119 | 95% H-Stat UCL | 0.149 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Detected Data appear Approximate Normal Distributed at 5% Significance Level**

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% KM (t) UCL | 0.126 | | |

When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test

When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**2-Meth**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 11 |
| Number of Detects | 14 | Number of Non-Detects | 1 |
| Number of Distinct Detects | 11 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | 0.01 | Minimum Non-Detect | 0.01 |
| Maximum Detect | 0.38 | Maximum Non-Detect | 0.01 |
| Variance Detects | 0.0107 | Percent Non-Detects | 6.667% |
| Mean Detects | 0.105 | SD Detects | 0.103 |
| Median Detects | 0.07 | CV Detects | 0.985 |
| Skewness Detects | 1.736 | Kurtosis Detects | 2.945 |
| Mean of Logged Detects | -2.688 | SD of Logged Detects | 1.014 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.806 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.874 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.272 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.226 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| KM Mean | 0.0987 | KM Standard Error of Mean | 0.0266 |
| KM SD | 0.0992 | 95% KM (BCA) UCL | 0.144 |
| 95% KM (t) UCL | 0.145 | 95% KM (Percentile Bootstrap) UCL | 0.145 |
| 95% KM (z) UCL | 0.142 | 95% KM Bootstrap t UCL | 0.181 |
| 90% KM Chebyshev UCL | 0.178 | 95% KM Chebyshev UCL | 0.215 |
| 97.5% KM Chebyshev UCL | 0.265 | 99% KM Chebyshev UCL | 0.363 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 0.251 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.755 | Detected data appear Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.163 | **Kolmogorov-Smirnov GOF** |
| 5% K-S Critical Value | 0.234 | Detected data appear Gamma Distributed at 5% Significance Level |

**Detected data appear Gamma Distributed at 5% Significance Level**

| | | | |
|---|---|---|---|
| **Gamma Statistics on Detected Data Only** | | | |
| k hat (MLE) | 1.292 | k star (bias corrected MLE) | 1.063 |
| Theta hat (MLE) | 0.0813 | Theta star (bias corrected MLE) | 0.0988 |
| nu hat (MLE) | 36.18 | nu star (bias corrected) | 29.76 |
| Mean (detects) | 0.105 | | |
| | | | |
| **Gamma ROS Statistics using Imputed Non-Detects** | | | |
| GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| This is especially true when the sample size is small. | | | |
| For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| Minimum | 0.01 | Mean | 0.0987 |
| Maximum | 0.38 | Median | 0.07 |
| SD | 0.103 | CV | 1.041 |
| k hat (MLE) | 1.138 | k star (bias corrected MLE) | 0.955 |
| Theta hat (MLE) | 0.0867 | Theta star (bias corrected MLE) | 0.103 |
| nu hat (MLE) | 34.13 | nu star (bias corrected) | 28.64 |
| Adjusted Level of Significance (β) | 0.0324 | | |
| Approximate Chi Square Value (28.64, α) | 17.42 | Adjusted Chi Square Value (28.64, β) | 16.35 |
| 95% Gamma Approximate UCL (use when n>=50) | 0.162 | 95% Gamma Adjusted UCL (use when n<50) | 0.173 |
| | | | |
| **Estimates of Gamma Parameters using KM Estimates** | | | |
| Mean (KM) | 0.0987 | SD (KM) | 0.0992 |
| Variance (KM) | 0.00984 | SE of Mean (KM) | 0.0266 |
| k hat (KM) | 0.99 | k star (KM) | 0.836 |
| nu hat (KM) | 29.69 | nu star (KM) | 25.08 |
| theta hat (KM) | 0.0997 | theta star (KM) | 0.118 |
| 80% gamma percentile (KM) | 0.161 | 90% gamma percentile (KM) | 0.237 |
| 95% gamma percentile (KM) | 0.315 | 99% gamma percentile (KM) | 0.498 |
| | | | |
| **Gamma Kaplan-Meier (KM) Statistics** | | | |
| Approximate Chi Square Value (25.08, α) | 14.67 | Adjusted Chi Square Value (25.08, β) | 13.7 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 0.169 | 95% Gamma Adjusted KM-UCL (use when n<50) | 0.181 |
| | | | |
| **Lognormal GOF Test on Detected Observations Only** | | | |
| Shapiro Wilk Test Statistic | 0.979 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.874 | Detected Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.105 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.226 | Detected Data appear Lognormal at 5% Significance Level | |
| **Detected Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal ROS Statistics Using Imputed Non-Detects** | | | |
| Mean in Original Scale | 0.0984 | Mean in Log Scale | -2.854 |
| SD in Original Scale | 0.103 | SD in Log Scale | 1.169 |
| 95% t UCL (assumes normality of ROS data) | 0.145 | 95% Percentile Bootstrap UCL | 0.143 |
| 95% BCA Bootstrap UCL | 0.157 | 95% Bootstrap t UCL | 0.181 |
| 95% H-UCL (Log ROS) | 0.293 | | |
| | | | |
| **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | |
| KM Mean (logged) | -2.816 | KM Geo Mean | 0.0598 |
| KM SD (logged) | 1.058 | 95% Critical H Value (KM-Log) | 2.837 |
| KM Standard Error of Mean (logged) | 0.283 | 95% H-UCL (KM -Log) | 0.234 |
| KM SD (logged) | 1.058 | 95% Critical H Value (KM-Log) | 2.837 |
| KM Standard Error of Mean (logged) | 0.283 | | |
| | | | |
| **DL/2 Statistics** | | | |
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 0.0983 | Mean in Log Scale | -2.862 |
| SD in Original Scale | 0.103 | SD in Log Scale | 1.187 |
| 95% t UCL (Assumes normality) | 0.145 | 95% H-Stat UCL | 0.304 |
| **DL/2 is not a recommended method, provided for comparisons and historical reasons** | | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Detected Data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% KM Adjusted Gamma UCL | 0.181 | 95% GROS Adjusted Gamma UCL | 0.173 |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 337 | | | | |
| 338 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 339 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 340 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 341 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 342 | | | | |
| 343 | **Acenaphthene** | | | |
| 344 | | | | |
| 345 | **General Statistics** | | | |
| 346 | Total Number of Observations | 15 | Number of Distinct Observations | 13 |
| 347 | Number of Detects | 12 | Number of Non-Detects | 3 |
| 348 | Number of Distinct Detects | 12 | Number of Distinct Non-Detects | 1 |
| 349 | Minimum Detect | 0.0478 | Minimum Non-Detect | 0.00671 |
| 350 | Maximum Detect | 0.728 | Maximum Non-Detect | 0.00671 |
| 351 | Variance Detects | 0.0357 | Percent Non-Detects | 20% |
| 352 | Mean Detects | 0.245 | SD Detects | 0.189 |
| 353 | Median Detects | 0.194 | CV Detects | 0.772 |
| 354 | Skewness Detects | 1.79 | Kurtosis Detects | 3.424 |
| 355 | Mean of Logged Detects | -1.646 | SD of Logged Detects | 0.729 |
| 356 | | | | |
| 357 | **Normal GOF Test on Detects Only** | | | |
| 358 | Shapiro Wilk Test Statistic | 0.82 | **Shapiro Wilk GOF Test** | |
| 359 | 5% Shapiro Wilk Critical Value | 0.859 | Detected Data Not Normal at 5% Significance Level | |
| 360 | Lilliefors Test Statistic | 0.261 | **Lilliefors GOF Test** | |
| 361 | 5% Lilliefors Critical Value | 0.243 | Detected Data Not Normal at 5% Significance Level | |
| 362 | **Detected Data Not Normal at 5% Significance Level** | | | |
| 363 | | | | |
| 364 | **Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs** | | | |
| 365 | KM Mean | 0.197 | KM Standard Error of Mean | 0.0506 |
| 366 | KM SD | 0.188 | 95% KM (BCA) UCL | 0.283 |
| 367 | 95% KM (t) UCL | 0.286 | 95% KM (Percentile Bootstrap) UCL | 0.284 |
| 368 | 95% KM (z) UCL | 0.28 | 95% KM Bootstrap t UCL | 0.343 |
| 369 | 90% KM Chebyshev UCL | 0.349 | 95% KM Chebyshev UCL | 0.418 |
| 370 | 97.5% KM Chebyshev UCL | 0.513 | 99% KM Chebyshev UCL | 0.701 |
| 371 | | | | |
| 372 | **Gamma GOF Tests on Detected Observations Only** | | | |
| 373 | A-D Test Statistic | 0.268 | **Anderson-Darling GOF Test** | |
| 374 | 5% A-D Critical Value | 0.741 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 375 | K-S Test Statistic | 0.17 | **Kolmogorov-Smirnov GOF** | |
| 376 | 5% K-S Critical Value | 0.248 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 377 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| 378 | | | | |

| | | | |
|---|---|---|---|
| **Gamma Statistics on Detected Data Only** | | | |
| k hat (MLE) | 2.248 | k star (bias corrected MLE) | 1.741 |
| Theta hat (MLE) | 0.109 | Theta star (bias corrected MLE) | 0.141 |
| nu hat (MLE) | 53.95 | nu star (bias corrected) | 41.79 |
| Mean (detects) | 0.245 | | |
| | | | |
| **Gamma ROS Statistics using Imputed Non-Detects** | | | |
| GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| This is especially true when the sample size is small. | | | |
| For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| Minimum | 0.01 | Mean | 0.198 |
| Maximum | 0.728 | Median | 0.168 |
| SD | 0.194 | CV | 0.979 |
| k hat (MLE) | 0.942 | k star (bias corrected MLE) | 0.798 |
| Theta hat (MLE) | 0.21 | Theta star (bias corrected MLE) | 0.248 |
| nu hat (MLE) | 28.25 | nu star (bias corrected) | 23.93 |
| Adjusted Level of Significance (β) | 0.0324 | | |
| Approximate Chi Square Value (23.93, α) | 13.8 | Adjusted Chi Square Value (23.93, β) | 12.86 |
| 95% Gamma Approximate UCL (use when n>=50) | 0.343 | 95% Gamma Adjusted UCL (use when n<50) | 0.368 |
| | | | |
| **Estimates of Gamma Parameters using KM Estimates** | | | |
| Mean (KM) | 0.197 | SD (KM) | 0.188 |
| Variance (KM) | 0.0352 | SE of Mean (KM) | 0.0506 |
| k hat (KM) | 1.104 | k star (KM) | 0.927 |
| nu hat (KM) | 33.11 | nu star (KM) | 27.82 |
| theta hat (KM) | 0.179 | theta star (KM) | 0.213 |
| 80% gamma percentile (KM) | 0.319 | 90% gamma percentile (KM) | 0.462 |
| 95% gamma percentile (KM) | 0.607 | 99% gamma percentile (KM) | 0.943 |
| | | | |
| **Gamma Kaplan-Meier (KM) Statistics** | | | |
| Approximate Chi Square Value (27.82, α) | 16.79 | Adjusted Chi Square Value (27.82, β) | 15.74 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 0.327 | 95% Gamma Adjusted KM-UCL (use when n<50) | 0.348 |
| | | | |
| **Lognormal GOF Test on Detected Observations Only** | | | |
| Shapiro Wilk Test Statistic | 0.984 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.859 | Detected Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.139 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.243 | Detected Data appear Lognormal at 5% Significance Level | |
| **Detected Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal ROS Statistics Using Imputed Non-Detects** | | | |
| Mean in Original Scale | 0.203 | Mean in Log Scale | -1.993 |
| SD in Original Scale | 0.189 | SD in Log Scale | 0.973 |
| 95% t UCL (assumes normality of ROS data) | 0.289 | 95% Percentile Bootstrap UCL | 0.284 |
| 95% BCA Bootstrap UCL | 0.304 | 95% Bootstrap t UCL | 0.346 |
| 95% H-UCL (Log ROS) | 0.442 | | |
| | | | |
| **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | |
| KM Mean (logged) | -2.318 | KM Geo Mean | 0.0985 |
| KM SD (logged) | 1.481 | 95% Critical H Value (KM-Log) | 3.577 |
| KM Standard Error of Mean (logged) | 0.399 | 95% H-UCL (KM -Log) | 1.215 |
| KM SD (logged) | 1.481 | 95% Critical H Value (KM-Log) | 3.577 |
| KM Standard Error of Mean (logged) | 0.399 | | |
| | | | |

| | | | | |
|---|---|---|---|---|
| 435 | DL/2 Statistics | | | |
| 436 | DL/2 Normal | | DL/2 Log-Transformed | |
| 437 | Mean in Original Scale | 0.196 | Mean in Log Scale | -2.456 |
| 438 | SD in Original Scale | 0.195 | SD in Log Scale | 1.797 |
| 439 | 95% t UCL (Assumes normality) | 0.285 | 95% H-Stat UCL | 3.199 |
| 440 | DL/2 is not a recommended method, provided for comparisons and historical reasons | | | |
| 441 | | | | |
| 442 | Nonparametric Distribution Free UCL Statistics | | | |
| 443 | Detected Data appear Gamma Distributed at 5% Significance Level | | | |
| 444 | | | | |
| 445 | Suggested UCL to Use | | | |
| 446 | 95% KM Adjusted Gamma UCL | 0.348 | 95% GROS Adjusted Gamma UCL | 0.368 |
| 447 | | | | |
| 448 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 449 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 450 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 451 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 452 | | | | |
| 453 | Acenaphthylene | | | |
| 454 | | | | |
| 455 | General Statistics | | | |
| 456 | Total Number of Observations | 15 | Number of Distinct Observations | 14 |
| 457 | Number of Detects | 14 | Number of Non-Detects | 1 |
| 458 | Number of Distinct Detects | 13 | Number of Distinct Non-Detects | 1 |
| 459 | Minimum Detect | 0.02 | Minimum Non-Detect | 0.004 |
| 460 | Maximum Detect | 0.465 | Maximum Non-Detect | 0.004 |
| 461 | Variance Detects | 0.0124 | Percent Non-Detects | 6.667% |
| 462 | Mean Detects | 0.0856 | SD Detects | 0.111 |
| 463 | Median Detects | 0.059 | CV Detects | 1.302 |
| 464 | Skewness Detects | 3.493 | Kurtosis Detects | 12.67 |
| 465 | Mean of Logged Detects | -2.805 | SD of Logged Detects | 0.729 |
| 466 | | | | |
| 467 | Normal GOF Test on Detects Only | | | |
| 468 | Shapiro Wilk Test Statistic | 0.484 | Shapiro Wilk GOF Test | |
| 469 | 5% Shapiro Wilk Critical Value | 0.874 | Detected Data Not Normal at 5% Significance Level | |
| 470 | Lilliefors Test Statistic | 0.395 | Lilliefors GOF Test | |
| 471 | 5% Lilliefors Critical Value | 0.226 | Detected Data Not Normal at 5% Significance Level | |
| 472 | Detected Data Not Normal at 5% Significance Level | | | |
| 473 | | | | |
| 474 | Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs | | | |
| 475 | KM Mean | 0.0801 | KM Standard Error of Mean | 0.0283 |
| 476 | KM SD | 0.106 | 95% KM (BCA) UCL | 0.137 |
| 477 | 95% KM (t) UCL | 0.13 | 95% KM (Percentile Bootstrap) UCL | 0.135 |
| 478 | 95% KM (z) UCL | 0.127 | 95% KM Bootstrap t UCL | 0.243 |
| 479 | 90% KM Chebyshev UCL | 0.165 | 95% KM Chebyshev UCL | 0.204 |
| 480 | 97.5% KM Chebyshev UCL | 0.257 | 99% KM Chebyshev UCL | 0.362 |
| 481 | | | | |
| 482 | Gamma GOF Tests on Detected Observations Only | | | |
| 483 | A-D Test Statistic | 1.349 | Anderson-Darling GOF Test | |
| 484 | 5% A-D Critical Value | 0.75 | Detected Data Not Gamma Distributed at 5% Significance Level | |
| 485 | K-S Test Statistic | 0.273 | Kolmogorov-Smirnov GOF | |
| 486 | 5% K-S Critical Value | 0.233 | Detected Data Not Gamma Distributed at 5% Significance Level | |
| 487 | Detected Data Not Gamma Distributed at 5% Significance Level | | | |
| 488 | | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 489 | **Gamma Statistics on Detected Data Only** | | | | | | | | | | | |
| 490 | | | | | k hat (MLE) | 1.59 | | | | | k star (bias corrected MLE) | 1.297 |
| 491 | | | | | Theta hat (MLE) | 0.0538 | | | | | Theta star (bias corrected MLE) | 0.066 |
| 492 | | | | | nu hat (MLE) | 44.51 | | | | | nu star (bias corrected) | 36.31 |
| 493 | | | | | Mean (detects) | 0.0856 | | | | | | |
| 494 | | | | | | | | | | | | |
| 495 | **Gamma ROS Statistics using Imputed Non-Detects** | | | | | | | | | | | |
| 496 | GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | | | | | | | | | |
| 497 | GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | | | | | | | | | |
| 498 | For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | | | | | | | | | |
| 499 | This is especially true when the sample size is small. | | | | | | | | | | | |
| 500 | For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | | | | | | | | | |
| 501 | | | | | Minimum | 0.01 | | | | | Mean | 0.0805 |
| 502 | | | | | Maximum | 0.465 | | | | | Median | 0.058 |
| 503 | | | | | SD | 0.109 | | | | | CV | 1.355 |
| 504 | | | | | k hat (MLE) | 1.375 | | | | | k star (bias corrected MLE) | 1.145 |
| 505 | | | | | Theta hat (MLE) | 0.0586 | | | | | Theta star (bias corrected MLE) | 0.0704 |
| 506 | | | | | nu hat (MLE) | 41.26 | | | | | nu star (bias corrected) | 34.34 |
| 507 | | | | | Adjusted Level of Significance (β) | 0.0324 | | | | | | |
| 508 | | | | | Approximate Chi Square Value (34.34, α) | 21.94 | | | | | Adjusted Chi Square Value (34.34, β) | 20.72 |
| 509 | | | | | 95% Gamma Approximate UCL (use when n>=50) | 0.126 | | | | | 95% Gamma Adjusted UCL (use when n<50) | 0.133 |
| 510 | | | | | | | | | | | | |
| 511 | **Estimates of Gamma Parameters using KM Estimates** | | | | | | | | | | | |
| 512 | | | | | Mean (KM) | 0.0801 | | | | | SD (KM) | 0.106 |
| 513 | | | | | Variance (KM) | 0.0112 | | | | | SE of Mean (KM) | 0.0283 |
| 514 | | | | | k hat (KM) | 0.575 | | | | | k star (KM) | 0.505 |
| 515 | | | | | nu hat (KM) | 17.25 | | | | | nu star (KM) | 15.14 |
| 516 | | | | | theta hat (KM) | 0.139 | | | | | theta star (KM) | 0.159 |
| 517 | | | | | 80% gamma percentile (KM) | 0.132 | | | | | 90% gamma percentile (KM) | 0.216 |
| 518 | | | | | 95% gamma percentile (KM) | 0.307 | | | | | 99% gamma percentile (KM) | 0.529 |
| 519 | | | | | | | | | | | | |
| 520 | **Gamma Kaplan-Meier (KM) Statistics** | | | | | | | | | | | |
| 521 | | | | | Approximate Chi Square Value (15.14, α) | 7.356 | | | | | Adjusted Chi Square Value (15.14, β) | 6.697 |
| 522 | | | | | 95% Gamma Approximate KM-UCL (use when n>=50) | 0.165 | | | | | 95% Gamma Adjusted KM-UCL (use when n<50) | 0.181 |
| 523 | | | | | | | | | | | | |
| 524 | **Lognormal GOF Test on Detected Observations Only** | | | | | | | | | | | |
| 525 | | | | | Shapiro Wilk Test Statistic | 0.868 | **Shapiro Wilk GOF Test** | | | | | |
| 526 | | | | | 5% Shapiro Wilk Critical Value | 0.874 | Detected Data Not Lognormal at 5% Significance Level | | | | | |
| 527 | | | | | Lilliefors Test Statistic | 0.197 | **Lilliefors GOF Test** | | | | | |
| 528 | | | | | 5% Lilliefors Critical Value | 0.226 | Detected Data appear Lognormal at 5% Significance Level | | | | | |
| 529 | **Detected Data appear Approximate Lognormal at 5% Significance Level** | | | | | | | | | | | |
| 530 | | | | | | | | | | | | |
| 531 | **Lognormal ROS Statistics Using Imputed Non-Detects** | | | | | | | | | | | |
| 532 | | | | | Mean in Original Scale | 0.0806 | | | | | Mean in Log Scale | -2.916 |
| 533 | | | | | SD in Original Scale | 0.109 | | | | | SD in Log Scale | 0.824 |
| 534 | | | | | 95% t UCL (assumes normality of ROS data) | 0.13 | | | | | 95% Percentile Bootstrap UCL | 0.135 |
| 535 | | | | | 95% BCA Bootstrap UCL | 0.164 | | | | | 95% Bootstrap t UCL | 0.254 |
| 536 | | | | | 95% H-UCL (Log ROS) | 0.131 | | | | | | |
| 537 | | | | | | | | | | | | |
| 538 | **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | | | | | | | | | |
| 539 | | | | | KM Mean (logged) | -2.986 | | | | | KM Geo Mean | 0.0505 |
| 540 | | | | | KM SD (logged) | 0.959 | | | | | 95% Critical H Value (KM-Log) | 2.68 |
| 541 | | | | | KM Standard Error of Mean (logged) | 0.257 | | | | | 95% H-UCL (KM -Log) | 0.159 |
| 542 | | | | | KM SD (logged) | 0.959 | | | | | 95% Critical H Value (KM-Log) | 2.68 |
| 543 | | | | | KM Standard Error of Mean (logged) | 0.257 | | | | | | |
| 544 | | | | | | | | | | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 545 | DL/2 Statistics | | | |
| 546 | DL/2 Normal | | DL/2 Log-Transformed | |
| 547 | Mean in Original Scale | 0.08 | Mean in Log Scale | -3.032 |
| 548 | SD in Original Scale | 0.109 | SD in Log Scale | 1.127 |
| 549 | 95% t UCL (Assumes normality) | 0.13 | 95% H-Stat UCL | 0.221 |
| 550 | **DL/2 is not a recommended method, provided for comparisons and historical reasons** | | | |
| 551 | | | | |
| 552 | **Nonparametric Distribution Free UCL Statistics** | | | |
| 553 | **Detected Data appear Approximate Lognormal Distributed at 5% Significance Level** | | | |
| 554 | | | | |
| 555 | **Suggested UCL to Use** | | | |
| 556 | KM H-UCL | 0.159 | | |
| 557 | | | | |
| 558 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 559 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 560 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 561 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 562 | | | | |
| 563 | Acridine | | | |
| 564 | | | | |
| 565 | **General Statistics** | | | |
| 566 | Total Number of Observations | 15 | Number of Distinct Observations | 2 |
| 567 | Number of Detects | 1 | Number of Non-Detects | 14 |
| 568 | Number of Distinct Detects | 1 | Number of Distinct Non-Detects | 1 |
| 569 | | | | |
| 570 | **Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!** | | | |
| 571 | **It is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).** | | | |
| 572 | | | | |
| 573 | **The data set for variable Acridine was not processed!** | | | |
| 574 | | | | |
| 575 | | | | |
| 576 | | | | |
| 577 | Anth | | | |
| 578 | | | | |
| 579 | **General Statistics** | | | |
| 580 | Total Number of Observations | 15 | Number of Distinct Observations | 15 |
| 581 | | | Number of Missing Observations | 0 |
| 582 | Minimum | 0.05 | Mean | 0.363 |
| 583 | Maximum | 1.01 | Median | 0.28 |
| 584 | SD | 0.249 | Std. Error of Mean | 0.0643 |
| 585 | Coefficient of Variation | 0.687 | Skewness | 1.439 |
| 586 | | | | |
| 587 | **Normal GOF Test** | | | |
| 588 | Shapiro Wilk Test Statistic | 0.877 | **Shapiro Wilk GOF Test** | |
| 589 | 5% Shapiro Wilk Critical Value | 0.881 | Data Not Normal at 5% Significance Level | |
| 590 | Lilliefors Test Statistic | 0.219 | **Lilliefors GOF Test** | |
| 591 | 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |
| 592 | **Data appear Approximate Normal at 5% Significance Level** | | | |
| 593 | | | | |
| 594 | **Assuming Normal Distribution** | | | |
| 595 | **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 596 | 95% Student's-t UCL | 0.476 | 95% Adjusted-CLT UCL (Chen-1995) | 0.494 |
| 597 | | | 95% Modified-t UCL (Johnson-1978) | 0.48 |
| 598 | | | | |
| 599 | **Gamma GOF Test** | | | |
| 600 | A-D Test Statistic | 0.239 | **Anderson-Darling Gamma GOF Test** | |
| 601 | 5% A-D Critical Value | 0.746 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 602 | K-S Test Statistic | 0.138 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 603 | 5% K-S Critical Value | 0.224 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 604 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 605 | | | | | | | | | | | | |
| 606 | **Gamma Statistics** | | | | | | | | | | | |
| 607 | | | | | k hat (MLE) | 2.438 | | | | | k star (bias corrected MLE) | 1.995 |
| 608 | | | | | Theta hat (MLE) | 0.149 | | | | | Theta star (bias corrected MLE) | 0.182 |
| 609 | | | | | nu hat (MLE) | 73.15 | | | | | nu star (bias corrected) | 59.85 |
| 610 | | | | | MLE Mean (bias corrected) | 0.363 | | | | | MLE Sd (bias corrected) | 0.257 |
| 611 | | | | | | | | | | | Approximate Chi Square Value (0.05) | 43.06 |
| 612 | | | | | Adjusted Level of Significance | 0.0324 | | | | | Adjusted Chi Square Value | 41.31 |
| 613 | | | | | | | | | | | | |
| 614 | **Assuming Gamma Distribution** | | | | | | | | | | | |
| 615 | | | | | 95% Approximate Gamma UCL (use when n>=50)) | 0.504 | | | | | 95% Adjusted Gamma UCL (use when n<50) | 0.525 |
| 616 | | | | | | | | | | | | |
| 617 | **Lognormal GOF Test** | | | | | | | | | | | |
| 618 | | | | | Shapiro Wilk Test Statistic | 0.959 | **Shapiro Wilk Lognormal GOF Test** | | | | | |
| 619 | | | | | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | | | | | |
| 620 | | | | | Lilliefors Test Statistic | 0.137 | **Lilliefors Lognormal GOF Test** | | | | | |
| 621 | | | | | 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | | | | | |
| 622 | **Data appear Lognormal at 5% Significance Level** | | | | | | | | | | | |
| 623 | | | | | | | | | | | | |
| 624 | **Lognormal Statistics** | | | | | | | | | | | |
| 625 | | | | | Minimum of Logged Data | -2.996 | | | | | Mean of logged Data | -1.233 |
| 626 | | | | | Maximum of Logged Data | 0.00995 | | | | | SD of logged Data | 0.723 |
| 627 | | | | | | | | | | | | |
| 628 | **Assuming Lognormal Distribution** | | | | | | | | | | | |
| 629 | | | | | 95% H-UCL | 0.594 | | | | | 90% Chebyshev (MVUE) UCL | 0.59 |
| 630 | | | | | 95% Chebyshev (MVUE) UCL | 0.689 | | | | | 97.5% Chebyshev (MVUE) UCL | 0.827 |
| 631 | | | | | 99% Chebyshev (MVUE) UCL | 1.097 | | | | | | |
| 632 | | | | | | | | | | | | |
| 633 | **Nonparametric Distribution Free UCL Statistics** | | | | | | | | | | | |
| 634 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | | | | | | | | | |
| 635 | | | | | | | | | | | | |
| 636 | **Nonparametric Distribution Free UCLs** | | | | | | | | | | | |
| 637 | | | | | 95% CLT UCL | 0.468 | | | | | 95% Jackknife UCL | 0.476 |
| 638 | | | | | 95% Standard Bootstrap UCL | 0.466 | | | | | 95% Bootstrap-t UCL | 0.524 |
| 639 | | | | | 95% Hall's Bootstrap UCL | 0.586 | | | | | 95% Percentile Bootstrap UCL | 0.475 |
| 640 | | | | | 95% BCA Bootstrap UCL | 0.495 | | | | | | |
| 641 | | | | | 90% Chebyshev(Mean, Sd) UCL | 0.556 | | | | | 95% Chebyshev(Mean, Sd) UCL | 0.643 |
| 642 | | | | | 97.5% Chebyshev(Mean, Sd) UCL | 0.764 | | | | | 99% Chebyshev(Mean, Sd) UCL | 1.002 |
| 643 | | | | | | | | | | | | |
| 644 | **Suggested UCL to Use** | | | | | | | | | | | |
| 645 | | | | | 95% Student's-t UCL | 0.476 | | | | | | |
| 646 | | | | | | | | | | | | |
| 647 | When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test | | | | | | | | | | | |
| 648 | When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL | | | | | | | | | | | |
| 649 | | | | | | | | | | | | |
| 650 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | | | | | | | | | |
| 651 | Recommendations are based upon data size, data distribution, and skewness. | | | | | | | | | | | |
| 652 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | | | | | | | | | |
| 653 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | | | | | | | | | |
| 654 | | | | | | | | | | | | |
| 655 | | | | | | | | | | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 656 | B(a)A | | | |
| 657 | | | | |
| 658 | **General Statistics** | | | |
| 659 | Total Number of Observations | 15 | Number of Distinct Observations | 14 |
| 660 | | | Number of Missing Observations | 0 |
| 661 | Minimum | 0.11 | Mean | 0.675 |
| 662 | Maximum | 1.55 | Median | 0.58 |
| 663 | SD | 0.447 | Std. Error of Mean | 0.115 |
| 664 | Coefficient of Variation | 0.662 | Skewness | 0.949 |
| 665 | | | | |
| 666 | **Normal GOF Test** | | | |
| 667 | Shapiro Wilk Test Statistic | 0.868 | **Shapiro Wilk GOF Test** | |
| 668 | 5% Shapiro Wilk Critical Value | 0.881 | Data Not Normal at 5% Significance Level | |
| 669 | Lilliefors Test Statistic | 0.242 | **Lilliefors GOF Test** | |
| 670 | 5% Lilliefors Critical Value | 0.22 | Data Not Normal at 5% Significance Level | |
| 671 | **Data Not Normal at 5% Significance Level** | | | |
| 672 | | | | |
| 673 | **Assuming Normal Distribution** | | | |
| 674 | **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 675 | 95% Student's-t UCL | 0.879 | 95% Adjusted-CLT UCL (Chen-1995) | 0.895 |
| 676 | | | 95% Modified-t UCL (Johnson-1978) | 0.883 |
| 677 | | | | |
| 678 | **Gamma GOF Test** | | | |
| 679 | A-D Test Statistic | 0.436 | **Anderson-Darling Gamma GOF Test** | |
| 680 | 5% A-D Critical Value | 0.746 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 681 | K-S Test Statistic | 0.164 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 682 | 5% K-S Critical Value | 0.224 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 683 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| 684 | | | | |
| 685 | **Gamma Statistics** | | | |
| 686 | k hat (MLE) | 2.501 | k star (bias corrected MLE) | 2.045 |
| 687 | Theta hat (MLE) | 0.27 | Theta star (bias corrected MLE) | 0.33 |
| 688 | nu hat (MLE) | 75.04 | nu star (bias corrected) | 61.36 |
| 689 | MLE Mean (bias corrected) | 0.675 | MLE Sd (bias corrected) | 0.472 |
| 690 | | | Approximate Chi Square Value (0.05) | 44.35 |
| 691 | Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 42.57 |
| 692 | | | | |
| 693 | **Assuming Gamma Distribution** | | | |
| 694 | 95% Approximate Gamma UCL (use when n>=50) | 0.934 | 95% Adjusted Gamma UCL (use when n<50) | 0.973 |
| 695 | | | | |
| 696 | **Lognormal GOF Test** | | | |
| 697 | Shapiro Wilk Test Statistic | 0.943 | **Shapiro Wilk Lognormal GOF Test** | |
| 698 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| 699 | Lilliefors Test Statistic | 0.131 | **Lilliefors Lognormal GOF Test** | |
| 700 | 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| 701 | **Data appear Lognormal at 5% Significance Level** | | | |
| 702 | | | | |
| 703 | **Lognormal Statistics** | | | |
| 704 | Minimum of Logged Data | -2.207 | Mean of logged Data | -0.606 |
| 705 | Maximum of Logged Data | 0.438 | SD of logged Data | 0.704 |
| 706 | | | | |
| 707 | **Assuming Lognormal Distribution** | | | |
| 708 | 95% H-UCL | 1.081 | 90% Chebyshev (MVUE) UCL | 1.08 |
| 709 | 95% Chebyshev (MVUE) UCL | 1.259 | 97.5% Chebyshev (MVUE) UCL | 1.507 |
| 710 | 99% Chebyshev (MVUE) UCL | 1.994 | | |
| 711 | | | | |
| 712 | **Nonparametric Distribution Free UCL Statistics** | | | |
| 713 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| 714 | | | | |

**Nonparametric Distribution Free UCLs**

| | | | |
|---|---|---|---|
| 95% CLT UCL | 0.865 | 95% Jackknife UCL | 0.879 |
| 95% Standard Bootstrap UCL | 0.86 | 95% Bootstrap-t UCL | 0.939 |
| 95% Hall's Bootstrap UCL | 0.883 | 95% Percentile Bootstrap UCL | 0.875 |
| 95% BCA Bootstrap UCL | 0.894 | | |
| 90% Chebyshev(Mean, Sd) UCL | 1.022 | 95% Chebyshev(Mean, Sd) UCL | 1.179 |
| 97.5% Chebyshev(Mean, Sd) UCL | 1.396 | 99% Chebyshev(Mean, Sd) UCL | 1.824 |

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% Adjusted Gamma UCL | 0.973 | | |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

B(a)P

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 15 |
| | | Number of Missing Observations | 0 |
| Minimum | 0.1 | Mean | 0.625 |
| Maximum | 1.42 | Median | 0.52 |
| SD | 0.405 | Std. Error of Mean | 0.105 |
| Coefficient of Variation | 0.648 | Skewness | 0.879 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.896 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.199 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level |

**Data appear Normal at 5% Significance Level**

**Assuming Normal Distribution**

| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
|---|---|---|---|
| 95% Student's-t UCL | 0.81 | 95% Adjusted-CLT UCL (Chen-1995) | 0.823 |
| | | 95% Modified-t UCL (Johnson-1978) | 0.814 |

**Gamma GOF Test**

| | | |
|---|---|---|
| A-D Test Statistic | 0.26 | **Anderson-Darling Gamma GOF Test** |
| 5% A-D Critical Value | 0.746 | Detected data appear Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.127 | **Kolmogorov-Smirnov Gamma GOF Test** |
| 5% K-S Critical Value | 0.224 | Detected data appear Gamma Distributed at 5% Significance Level |

**Detected data appear Gamma Distributed at 5% Significance Level**

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 2.492 | k star (bias corrected MLE) | 2.038 |
| Theta hat (MLE) | 0.251 | Theta star (bias corrected MLE) | 0.307 |
| nu hat (MLE) | 74.76 | nu star (bias corrected) | 61.14 |
| MLE Mean (bias corrected) | 0.625 | MLE Sd (bias corrected) | 0.438 |
| | | Approximate Chi Square Value (0.05) | 44.16 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 42.38 |

**Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Approximate Gamma UCL (use when n>=50)) | 0.866 | 95% Adjusted Gamma UCL (use when n<50) | 0.902 |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 772 | **Lognormal GOF Test** | | | | | | | | | | | |
| 773 | Shapiro Wilk Test Statistic | | | | | 0.959 | **Shapiro Wilk Lognormal GOF Test** | | | | | |
| 774 | 5% Shapiro Wilk Critical Value | | | | | 0.881 | Data appear Lognormal at 5% Significance Level | | | | | |
| 775 | Lilliefors Test Statistic | | | | | 0.11 | **Lilliefors Lognormal GOF Test** | | | | | |
| 776 | 5% Lilliefors Critical Value | | | | | 0.22 | Data appear Lognormal at 5% Significance Level | | | | | |
| 777 | **Data appear Lognormal at 5% Significance Level** | | | | | | | | | | | |
| 778 | | | | | | | | | | | | |
| 779 | **Lognormal Statistics** | | | | | | | | | | | |
| 780 | Minimum of Logged Data | | | | | -2.303 | Mean of logged Data | | | | | -0.683 |
| 781 | Maximum of Logged Data | | | | | 0.351 | SD of logged Data | | | | | 0.715 |
| 782 | | | | | | | | | | | | |
| 783 | **Assuming Lognormal Distribution** | | | | | | | | | | | |
| 784 | 95% H-UCL | | | | | 1.017 | 90% Chebyshev (MVUE) UCL | | | | | 1.013 |
| 785 | 95% Chebyshev (MVUE) UCL | | | | | 1.182 | 97.5% Chebyshev (MVUE) UCL | | | | | 1.417 |
| 786 | 99% Chebyshev (MVUE) UCL | | | | | 1.879 | | | | | | |
| 787 | | | | | | | | | | | | |
| 788 | **Nonparametric Distribution Free UCL Statistics** | | | | | | | | | | | |
| 789 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | | | | | | | | | |
| 790 | | | | | | | | | | | | |
| 791 | **Nonparametric Distribution Free UCLs** | | | | | | | | | | | |
| 792 | 95% CLT UCL | | | | | 0.798 | 95% Jackknife UCL | | | | | 0.81 |
| 793 | 95% Standard Bootstrap UCL | | | | | 0.793 | 95% Bootstrap-t UCL | | | | | 0.847 |
| 794 | 95% Hall's Bootstrap UCL | | | | | 0.813 | 95% Percentile Bootstrap UCL | | | | | 0.798 |
| 795 | 95% BCA Bootstrap UCL | | | | | 0.806 | | | | | | |
| 796 | 90% Chebyshev(Mean, Sd) UCL | | | | | 0.939 | 95% Chebyshev(Mean, Sd) UCL | | | | | 1.082 |
| 797 | 97.5% Chebyshev(Mean, Sd) UCL | | | | | 1.279 | 99% Chebyshev(Mean, Sd) UCL | | | | | 1.667 |
| 798 | | | | | | | | | | | | |
| 799 | **Suggested UCL to Use** | | | | | | | | | | | |
| 800 | 95% Student's-t UCL | | | | | 0.81 | | | | | | |
| 801 | | | | | | | | | | | | |
| 802 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | | | | | | | | | |
| 803 | Recommendations are based upon data size, data distribution, and skewness. | | | | | | | | | | | |
| 804 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | | | | | | | | | |
| 805 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | | | | | | | | | |
| 806 | | | | | | | | | | | | |
| 807 | | | | | | | | | | | | |
| 808 | B(b)F | | | | | | | | | | | |
| 809 | | | | | | | | | | | | |
| 810 | **General Statistics** | | | | | | | | | | | |
| 811 | Total Number of Observations | | | | | 15 | Number of Distinct Observations | | | | | 14 |
| 812 | | | | | | | Number of Missing Observations | | | | | 0 |
| 813 | Minimum | | | | | 0.11 | Mean | | | | | 0.587 |
| 814 | Maximum | | | | | 1.23 | Median | | | | | 0.49 |
| 815 | SD | | | | | 0.357 | Std. Error of Mean | | | | | 0.0921 |
| 816 | Coefficient of Variation | | | | | 0.607 | Skewness | | | | | 0.748 |
| 817 | | | | | | | | | | | | |
| 818 | **Normal GOF Test** | | | | | | | | | | | |
| 819 | Shapiro Wilk Test Statistic | | | | | 0.895 | **Shapiro Wilk GOF Test** | | | | | |
| 820 | 5% Shapiro Wilk Critical Value | | | | | 0.881 | Data appear Normal at 5% Significance Level | | | | | |
| 821 | Lilliefors Test Statistic | | | | | 0.197 | **Lilliefors GOF Test** | | | | | |
| 822 | 5% Lilliefors Critical Value | | | | | 0.22 | Data appear Normal at 5% Significance Level | | | | | |
| 823 | **Data appear Normal at 5% Significance Level** | | | | | | | | | | | |
| 824 | | | | | | | | | | | | |
| 825 | **Assuming Normal Distribution** | | | | | | | | | | | |
| 826 | **95% Normal UCL** | | | | | | **95% UCLs (Adjusted for Skewness)** | | | | | |
| 827 | 95% Student's-t UCL | | | | | 0.749 | 95% Adjusted-CLT UCL (Chen-1995) | | | | | 0.758 |
| 828 | | | | | | | 95% Modified-t UCL (Johnson-1978) | | | | | 0.752 |
| 829 | | | | | | | | | | | | |

| | | | | |
|---|---|---|---|---|
| 830 | **Gamma GOF Test** | | | |
| 831 | A-D Test Statistic | 0.307 | **Anderson-Darling Gamma GOF Test** | |
| 832 | 5% A-D Critical Value | 0.745 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 833 | K-S Test Statistic | 0.146 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 834 | 5% K-S Critical Value | 0.223 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 835 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| 836 | | | | |
| 837 | **Gamma Statistics** | | | |
| 838 | k hat (MLE) | 2.814 | k star (bias corrected MLE) | 2.296 |
| 839 | Theta hat (MLE) | 0.209 | Theta star (bias corrected MLE) | 0.256 |
| 840 | nu hat (MLE) | 84.43 | nu star (bias corrected) | 68.88 |
| 841 | MLE Mean (bias corrected) | 0.587 | MLE Sd (bias corrected) | 0.388 |
| 842 | | | Approximate Chi Square Value (0.05) | 50.77 |
| 843 | Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 48.86 |
| 844 | | | | |
| 845 | **Assuming Gamma Distribution** | | | |
| 846 | 95% Approximate Gamma UCL (use when n>=50)) | 0.797 | 95% Adjusted Gamma UCL (use when n<50) | 0.828 |
| 847 | | | | |
| 848 | **Lognormal GOF Test** | | | |
| 849 | Shapiro Wilk Test Statistic | 0.953 | **Shapiro Wilk Lognormal GOF Test** | |
| 850 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| 851 | Lilliefors Test Statistic | 0.127 | **Lilliefors Lognormal GOF Test** | |
| 852 | 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| 853 | **Data appear Lognormal at 5% Significance Level** | | | |
| 854 | | | | |
| 855 | **Lognormal Statistics** | | | |
| 856 | Minimum of Logged Data | -2.207 | Mean of logged Data | -0.72 |
| 857 | Maximum of Logged Data | 0.207 | SD of logged Data | 0.667 |
| 858 | | | | |
| 859 | **Assuming Lognormal Distribution** | | | |
| 860 | 95% H-UCL | 0.909 | 90% Chebyshev (MVUE) UCL | 0.921 |
| 861 | 95% Chebyshev (MVUE) UCL | 1.068 | 97.5% Chebyshev (MVUE) UCL | 1.271 |
| 862 | 99% Chebyshev (MVUE) UCL | 1.671 | | |
| 863 | | | | |
| 864 | **Nonparametric Distribution Free UCL Statistics** | | | |
| 865 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| 866 | | | | |
| 867 | **Nonparametric Distribution Free UCLs** | | | |
| 868 | 95% CLT UCL | 0.739 | 95% Jackknife UCL | 0.749 |
| 869 | 95% Standard Bootstrap UCL | 0.73 | 95% Bootstrap-t UCL | 0.79 |
| 870 | 95% Hall's Bootstrap UCL | 0.74 | 95% Percentile Bootstrap UCL | 0.733 |
| 871 | 95% BCA Bootstrap UCL | 0.759 | | |
| 872 | 90% Chebyshev(Mean, Sd) UCL | 0.864 | 95% Chebyshev(Mean, Sd) UCL | 0.989 |
| 873 | 97.5% Chebyshev(Mean, Sd) UCL | 1.162 | 99% Chebyshev(Mean, Sd) UCL | 1.503 |
| 874 | | | | |
| 875 | **Suggested UCL to Use** | | | |
| 876 | 95% Student's-t UCL | 0.749 | | |
| 877 | | | | |
| 878 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 879 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 880 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 881 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 882 | | | | |
| 883 | | | | |

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| | | | |
|---|---|---|---|
| **General Statistics** | | | |
| Total Number of Observations | 15 | Number of Distinct Observations | 15 |
| | | Number of Missing Observations | 0 |
| Minimum | 0.17 | Mean | 0.874 |
| Maximum | 1.96 | Median | 0.8 |
| SD | 0.54 | Std. Error of Mean | 0.139 |
| Coefficient of Variation | 0.617 | Skewness | 0.828 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.914 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.185 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |
| **Data appear Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 1.119 | 95% Adjusted-CLT UCL (Chen-1995) | 1.135 |
| | | 95% Modified-t UCL (Johnson-1978) | 1.124 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.219 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.745 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.115 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.224 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 2.744 | k star (bias corrected MLE) | 2.239 |
| Theta hat (MLE) | 0.319 | Theta star (bias corrected MLE) | 0.39 |
| nu hat (MLE) | 82.31 | nu star (bias corrected) | 67.18 |
| MLE Mean (bias corrected) | 0.874 | MLE Sd (bias corrected) | 0.584 |
| | | Approximate Chi Square Value (0.05) | 49.32 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 47.44 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50)) | 1.191 | 95% Adjusted Gamma UCL (use when n<50) | 1.238 |
| | | | |
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.967 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.102 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| **Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | -1.772 | Mean of logged Data | -0.328 |
| Maximum of Logged Data | 0.673 | SD of logged Data | 0.674 |
| | | | |
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 1.362 | 90% Chebyshev (MVUE) UCL | 1.376 |
| 95% Chebyshev (MVUE) UCL | 1.596 | 97.5% Chebyshev (MVUE) UCL | 1.903 |
| 99% Chebyshev (MVUE) UCL | 2.505 | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |

| | | | |
|---|---|---|---|
| **Nonparametric Distribution Free UCLs** | | | |
| 95% CLT UCL | 1.103 | 95% Jackknife UCL | 1.119 |
| 95% Standard Bootstrap UCL | 1.094 | 95% Bootstrap-t UCL | 1.167 |
| 95% Hall's Bootstrap UCL | 1.132 | 95% Percentile Bootstrap UCL | 1.105 |
| 95% BCA Bootstrap UCL | 1.122 | | |
| 90% Chebyshev(Mean, Sd) UCL | 1.292 | 95% Chebyshev(Mean, Sd) UCL | 1.481 |
| 97.5% Chebyshev(Mean, Sd) UCL | 1.744 | 99% Chebyshev(Mean, Sd) UCL | 2.26 |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% Student's-t UCL | 1.119 | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| | | | |
| | | | |
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| | | | |
| **General Statistics** | | | |
| Total Number of Observations | 15 | Number of Distinct Observations | 13 |
| | | Number of Missing Observations | 0 |
| Minimum | 0.08 | Mean | 0.45 |
| Maximum | 0.93 | Median | 0.37 |
| SD | 0.26 | Std. Error of Mean | 0.0671 |
| Coefficient of Variation | 0.577 | Skewness | 0.692 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.911 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.197 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |
| **Data appear Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 0.568 | 95% Adjusted-CLT UCL (Chen-1995) | 0.573 |
| | | 95% Modified-t UCL (Johnson-1978) | 0.57 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.317 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.745 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.135 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.223 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 2.969 | k star (bias corrected MLE) | 2.419 |
| Theta hat (MLE) | 0.152 | Theta star (bias corrected MLE) | 0.186 |
| nu hat (MLE) | 89.06 | nu star (bias corrected) | 72.58 |
| MLE Mean (bias corrected) | 0.45 | MLE Sd (bias corrected) | 0.289 |
| | | Approximate Chi Square Value (0.05) | 53.96 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 51.99 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50)) | 0.605 | 95% Adjusted Gamma UCL (use when n<50) | 0.628 |

**Lognormal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.939 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.165 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |

**Data appear Lognormal at 5% Significance Level**

**Lognormal Statistics**

| | | | |
|---|---|---|---|
| Minimum of Logged Data | -2.526 | Mean of logged Data | -0.976 |
| Maximum of Logged Data | -0.0726 | SD of logged Data | 0.66 |

**Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% H-UCL | 0.697 | 90% Chebyshev (MVUE) UCL | 0.707 |
| 95% Chebyshev (MVUE) UCL | 0.819 | 97.5% Chebyshev (MVUE) UCL | 0.974 |
| 99% Chebyshev (MVUE) UCL | 1.279 | | |

**Nonparametric Distribution Free UCL Statistics**

**Data appear to follow a Discernible Distribution at 5% Significance Level**

**Nonparametric Distribution Free UCLs**

| | | | |
|---|---|---|---|
| 95% CLT UCL | 0.56 | 95% Jackknife UCL | 0.568 |
| 95% Standard Bootstrap UCL | 0.557 | 95% Bootstrap-t UCL | 0.584 |
| 95% Hall's Bootstrap UCL | 0.569 | 95% Percentile Bootstrap UCL | 0.561 |
| 95% BCA Bootstrap UCL | 0.565 | | |
| 90% Chebyshev(Mean, Sd) UCL | 0.651 | 95% Chebyshev(Mean, Sd) UCL | 0.742 |
| 97.5% Chebyshev(Mean, Sd) UCL | 0.869 | 99% Chebyshev(Mean, Sd) UCL | 1.118 |

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% Student's-t UCL | 0.568 | | |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

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**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 11 |
| Number of Detects | 10 | Number of Non-Detects | 5 |
| Number of Distinct Detects | 10 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | 0.28 | Minimum Non-Detect | 0.01 |
| Maximum Detect | 0.86 | Maximum Non-Detect | 0.01 |
| Variance Detects | 0.0452 | Percent Non-Detects | 33.33% |
| Mean Detects | 0.502 | SD Detects | 0.213 |
| Median Detects | 0.405 | CV Detects | 0.423 |
| Skewness Detects | 0.596 | Kurtosis Detects | -1.326 |
| Mean of Logged Detects | -0.768 | SD of Logged Detects | 0.417 |

**Normal GOF Test on Detects Only**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.876 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.842 | Detected Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.267 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.262 | Detected Data Not Normal at 5% Significance Level | |

**Detected Data appear Approximate Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| KM Mean | 0.338 | KM Standard Error of Mean | 0.0774 |
| KM SD | 0.284 | 95% KM (BCA) UCL | 0.459 |
| 95% KM (t) UCL | 0.474 | 95% KM (Percentile Bootstrap) UCL | 0.469 |
| 95% KM (z) UCL | 0.465 | 95% KM Bootstrap t UCL | 0.478 |
| 90% KM Chebyshev UCL | 0.57 | 95% KM Chebyshev UCL | 0.675 |
| 97.5% KM Chebyshev UCL | 0.821 | 99% KM Chebyshev UCL | 1.108 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 0.533 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.728 | Detected data appear Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.242 | **Kolmogorov-Smirnov GOF** |
| 5% K-S Critical Value | 0.267 | Detected data appear Gamma Distributed at 5% Significance Level |

**Detected data appear Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 6.48 | k star (bias corrected MLE) | 4.603 |
| Theta hat (MLE) | 0.0775 | Theta star (bias corrected MLE) | 0.109 |
| nu hat (MLE) | 129.6 | nu star (bias corrected) | 92.05 |
| Mean (detects) | 0.502 | | |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 0.36 |
| Maximum | 0.86 | Median | 0.32 |
| SD | 0.271 | CV | 0.755 |
| k hat (MLE) | 1.101 | k star (bias corrected MLE) | 0.925 |
| Theta hat (MLE) | 0.327 | Theta star (bias corrected MLE) | 0.389 |
| nu hat (MLE) | 33.02 | nu star (bias corrected) | 27.75 |
| Adjusted Level of Significance (β) | 0.0324 | | |
| Approximate Chi Square Value (27.75, α) | 16.74 | Adjusted Chi Square Value (27.75, β) | 15.69 |
| 95% Gamma Approximate UCL (use when n>=50) | 0.596 | 95% Gamma Adjusted UCL (use when n<50) | 0.636 |

**Estimates of Gamma Parameters using KM Estimates**

| | | | |
|---|---|---|---|
| Mean (KM) | 0.338 | SD (KM) | 0.284 |
| Variance (KM) | 0.0809 | SE of Mean (KM) | 0.0774 |
| k hat (KM) | 1.412 | k star (KM) | 1.174 |
| nu hat (KM) | 42.37 | nu star (KM) | 35.23 |
| theta hat (KM) | 0.239 | theta star (KM) | 0.288 |
| 80% gamma percentile (KM) | 0.536 | 90% gamma percentile (KM) | 0.748 |
| 95% gamma percentile (KM) | 0.957 | 99% gamma percentile (KM) | 1.437 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| Approximate Chi Square Value (35.23, α) | 22.65 | Adjusted Chi Square Value (35.23, β) | 21.41 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 0.526 | 95% Gamma Adjusted KM-UCL (use when n<50) | 0.556 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.901 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.842 | Detected Data appear Lognormal at 5% Significance Level |
| Lilliefors Test Statistic | 0.216 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.262 | Detected Data appear Lognormal at 5% Significance Level |

**Detected Data appear Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 0.389 | Mean in Log Scale | -1.124 |
| SD in Original Scale | 0.238 | SD in Log Scale | 0.636 |
| 95% t UCL (assumes normality of ROS data) | 0.498 | 95% Percentile Bootstrap UCL | 0.489 |
| 95% BCA Bootstrap UCL | 0.492 | 95% Bootstrap t UCL | 0.518 |
| 95% H-UCL (Log ROS) | 0.58 | | |

**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| KM Mean (logged) | -2.047 | KM Geo Mean | 0.129 |
| KM SD (logged) | 1.837 | 95% Critical H Value (KM-Log) | 4.248 |
| KM Standard Error of Mean (logged) | 0.5 | 95% H-UCL (KM -Log) | 5.622 |
| KM SD (logged) | 1.837 | 95% Critical H Value (KM-Log) | 4.248 |
| KM Standard Error of Mean (logged) | 0.5 | | |

| | | | |
|---|---|---|---|
| **DL/2 Statistics** | | | |
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 0.336 | Mean in Log Scale | -2.278 |
| SD in Original Scale | 0.296 | SD in Log Scale | 2.236 |
| 95% t UCL (Assumes normality) | 0.471 | 95% H-Stat UCL | 25.14 |
| **DL/2 is not a recommended method, provided for comparisons and historical reasons** | | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Detected Data appear Approximate Normal Distributed at 5% Significance Level** | | | |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% KM (t) UCL | 0.474 | | |
| | | | |
| When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test | | | |
| When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL | | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| | | | |
| | | | |
| **B(k)F** | | | |
| | | | |
| **General Statistics** | | | |
| Total Number of Observations | 15 | Number of Distinct Observations | 14 |
| | | Number of Missing Observations | 0 |
| Minimum | 0.05 | Mean | 0.325 |
| Maximum | 0.72 | Median | 0.29 |
| SD | 0.182 | Std. Error of Mean | 0.0469 |
| Coefficient of Variation | 0.558 | Skewness | 0.722 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.958 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.134 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |
| **Data appear Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 0.408 | 95% Adjusted-CLT UCL (Chen-1995) | 0.412 |
| | | 95% Modified-t UCL (Johnson-1978) | 0.409 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.171 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.745 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.124 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.223 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 2.991 | k star (bias corrected MLE) | 2.438 |
| Theta hat (MLE) | 0.109 | Theta star (bias corrected MLE) | 0.133 |
| nu hat (MLE) | 89.74 | nu star (bias corrected) | 73.13 |
| MLE Mean (bias corrected) | 0.325 | MLE Sd (bias corrected) | 0.208 |
| | | Approximate Chi Square Value (0.05) | 54.43 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 52.45 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50)) | 0.437 | 95% Adjusted Gamma UCL (use when n<50) | 0.454 |
| | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 1189 | Lognormal GOF Test | | | |
| 1190 | Shapiro Wilk Test Statistic | 0.936 | **Shapiro Wilk Lognormal GOF Test** | |
| 1191 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| 1192 | Lilliefors Test Statistic | 0.163 | **Lilliefors Lognormal GOF Test** | |
| 1193 | 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| 1194 | **Data appear Lognormal at 5% Significance Level** | | | |
| 1195 | | | | |
| 1196 | **Lognormal Statistics** | | | |
| 1197 | Minimum of Logged Data | -2.996 | Mean of logged Data | -1.299 |
| 1198 | Maximum of Logged Data | -0.329 | SD of logged Data | 0.675 |
| 1199 | | | | |
| 1200 | **Assuming Lognormal Distribution** | | | |
| 1201 | 95% H-UCL | 0.516 | 90% Chebyshev (MVUE) UCL | 0.521 |
| 1202 | 95% Chebyshev (MVUE) UCL | 0.605 | 97.5% Chebyshev (MVUE) UCL | 0.721 |
| 1203 | 99% Chebyshev (MVUE) UCL | 0.95 | | |
| 1204 | | | | |
| 1205 | **Nonparametric Distribution Free UCL Statistics** | | | |
| 1206 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| 1207 | | | | |
| 1208 | **Nonparametric Distribution Free UCLs** | | | |
| 1209 | 95% CLT UCL | 0.402 | 95% Jackknife UCL | 0.408 |
| 1210 | 95% Standard Bootstrap UCL | 0.397 | 95% Bootstrap-t UCL | 0.424 |
| 1211 | 95% Hall's Bootstrap UCL | 0.424 | 95% Percentile Bootstrap UCL | 0.402 |
| 1212 | 95% BCA Bootstrap UCL | 0.41 | | |
| 1213 | 90% Chebyshev(Mean, Sd) UCL | 0.466 | 95% Chebyshev(Mean, Sd) UCL | 0.53 |
| 1214 | 97.5% Chebyshev(Mean, Sd) UCL | 0.618 | 99% Chebyshev(Mean, Sd) UCL | 0.792 |
| 1215 | | | | |
| 1216 | **Suggested UCL to Use** | | | |
| 1217 | 95% Student's-t UCL | 0.408 | | |
| 1218 | | | | |
| 1219 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 1220 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 1221 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 1222 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 1223 | | | | |
| 1224 | | | | |
| 1225 | Chry | | | |
| 1226 | | | | |
| 1227 | **General Statistics** | | | |
| 1228 | Total Number of Observations | 15 | Number of Distinct Observations | 15 |
| 1229 | | | Number of Missing Observations | 0 |
| 1230 | Minimum | 0.14 | Mean | 0.769 |
| 1231 | Maximum | 1.7 | Median | 0.66 |
| 1232 | SD | 0.482 | Std. Error of Mean | 0.124 |
| 1233 | Coefficient of Variation | 0.627 | Skewness | 0.918 |
| 1234 | | | | |
| 1235 | **Normal GOF Test** | | | |
| 1236 | Shapiro Wilk Test Statistic | 0.884 | **Shapiro Wilk GOF Test** | |
| 1237 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| 1238 | Lilliefors Test Statistic | 0.223 | **Lilliefors GOF Test** | |
| 1239 | 5% Lilliefors Critical Value | 0.22 | Data Not Normal at 5% Significance Level | |
| 1240 | **Data appear Approximate Normal at 5% Significance Level** | | | |
| 1241 | | | | |
| 1242 | **Assuming Normal Distribution** | | | |
| 1243 | **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 1244 | 95% Student's-t UCL | 0.988 | 95% Adjusted-CLT UCL (Chen-1995) | 1.005 |
| 1245 | | | 95% Modified-t UCL (Johnson-1978) | 0.993 |
| 1246 | | | | |
| 1247 | **Gamma GOF Test** | | | |
| 1248 | A-D Test Statistic | 0.332 | **Anderson-Darling Gamma GOF Test** | |
| 1249 | 5% A-D Critical Value | 0.745 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 1250 | K-S Test Statistic | 0.147 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 1251 | 5% K-S Critical Value | 0.224 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 1252 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | |

| Row | A–E | F | G–K | L |
|---|---|---|---|---|
| 1253 | | | | |
| 1254 | **Gamma Statistics** | | | |
| 1255 | k hat (MLE) | 2.763 | k star (bias corrected MLE) | 2.255 |
| 1256 | Theta hat (MLE) | 0.278 | Theta star (bias corrected MLE) | 0.341 |
| 1257 | nu hat (MLE) | 82.9 | nu star (bias corrected) | 67.65 |
| 1258 | MLE Mean (bias corrected) | 0.769 | MLE Sd (bias corrected) | 0.512 |
| 1259 | | | Approximate Chi Square Value (0.05) | 49.72 |
| 1260 | Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 47.83 |
| 1261 | | | | |
| 1262 | **Assuming Gamma Distribution** | | | |
| 1263 | 95% Approximate Gamma UCL (use when n>=50)) | 1.046 | 95% Adjusted Gamma UCL (use when n<50) | 1.087 |
| 1264 | | | | |
| 1265 | **Lognormal GOF Test** | | | |
| 1266 | Shapiro Wilk Test Statistic | 0.955 | **Shapiro Wilk Lognormal GOF Test** | |
| 1267 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| 1268 | Lilliefors Test Statistic | 0.108 | **Lilliefors Lognormal GOF Test** | |
| 1269 | 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| 1270 | **Data appear Lognormal at 5% Significance Level** | | | |
| 1271 | | | | |
| 1272 | **Lognormal Statistics** | | | |
| 1273 | Minimum of Logged Data | -1.966 | Mean of logged Data | -0.455 |
| 1274 | Maximum of Logged Data | 0.531 | SD of logged Data | 0.668 |
| 1275 | | | | |
| 1276 | **Assuming Lognormal Distribution** | | | |
| 1277 | 95% H-UCL | 1.188 | 90% Chebyshev (MVUE) UCL | 1.203 |
| 1278 | 95% Chebyshev (MVUE) UCL | 1.394 | 97.5% Chebyshev (MVUE) UCL | 1.66 |
| 1279 | 99% Chebyshev (MVUE) UCL | 2.183 | | |
| 1280 | | | | |
| 1281 | **Nonparametric Distribution Free UCL Statistics** | | | |
| 1282 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| 1283 | | | | |
| 1284 | **Nonparametric Distribution Free UCLs** | | | |
| 1285 | 95% CLT UCL | 0.973 | 95% Jackknife UCL | 0.988 |
| 1286 | 95% Standard Bootstrap UCL | 0.971 | 95% Bootstrap-t UCL | 1.054 |
| 1287 | 95% Hall's Bootstrap UCL | 0.996 | 95% Percentile Bootstrap UCL | 0.983 |
| 1288 | 95% BCA Bootstrap UCL | 1.007 | | |
| 1289 | 90% Chebyshev(Mean, Sd) UCL | 1.142 | 95% Chebyshev(Mean, Sd) UCL | 1.311 |
| 1290 | 97.5% Chebyshev(Mean, Sd) UCL | 1.546 | 99% Chebyshev(Mean, Sd) UCL | 2.007 |
| 1291 | | | | |
| 1292 | **Suggested UCL to Use** | | | |
| 1293 | 95% Student's-t UCL | 0.988 | | |
| 1294 | | | | |
| 1295 | When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test | | | |
| 1296 | When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL | | | |
| 1297 | | | | |
| 1298 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 1299 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 1300 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 1301 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 1302 | | | | |
| 1303 | **Dibenz** | | | |
| 1304 | | | | |
| 1305 | **General Statistics** | | | |
| 1306 | Total Number of Observations | 15 | Number of Distinct Observations | 1 |
| 1307 | Number of Detects | 0 | Number of Non-Detects | 15 |
| 1308 | Number of Distinct Detects | 0 | Number of Distinct Non-Detects | 1 |
| 1309 | | | | |
| 1310 | **Warning: All observations are Non-Detects (NDs), therefore all statistics and estimates should also be NDs!** | | | |
| 1311 | **Specifically, sample mean, UCLs, UPLs, and other statistics are also NDs lying below the largest detection limit!** | | | |
| 1312 | **The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).** | | | |
| 1313 | | | | |
| 1314 | **The data set for variable Dibenz was not processed!** | | | |
| 1315 | | | | |
| 1316 | | | | |

**Fluoranthene**

| | | | |
|---|---|---|---|
| **General Statistics** | | | |
| Total Number of Observations | 15 | Number of Distinct Observations | 14 |
| | | Number of Missing Observations | 0 |
| Minimum | 0.3 | Mean | 1.669 |
| Maximum | 3.93 | Median | 1.37 |
| SD | 1.137 | Std. Error of Mean | 0.294 |
| Coefficient of Variation | 0.682 | Skewness | 0.859 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.901 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.173 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |
| **Data appear Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 2.186 | 95% Adjusted-CLT UCL (Chen-1995) | 2.221 |
| | | 95% Modified-t UCL (Johnson-1978) | 2.197 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.216 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.746 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.117 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.224 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 2.256 | k star (bias corrected MLE) | 1.849 |
| Theta hat (MLE) | 0.74 | Theta star (bias corrected MLE) | 0.903 |
| nu hat (MLE) | 67.67 | nu star (bias corrected) | 55.47 |
| MLE Mean (bias corrected) | 1.669 | MLE Sd (bias corrected) | 1.227 |
| | | Approximate Chi Square Value (0.05) | 39.35 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 37.69 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50)) | 2.352 | 95% Adjusted Gamma UCL (use when n<50) | 2.456 |
| | | | |
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.968 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.116 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| **Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | -1.204 | Mean of logged Data | 0.274 |
| Maximum of Logged Data | 1.369 | SD of logged Data | 0.749 |
| | | | |
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 2.799 | 90% Chebyshev (MVUE) UCL | 2.749 |
| 95% Chebyshev (MVUE) UCL | 3.223 | 97.5% Chebyshev (MVUE) UCL | 3.881 |
| 99% Chebyshev (MVUE) UCL | 5.174 | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 1377 | **Nonparametric Distribution Free UCLs** | | | |
| 1378 | 95% CLT UCL | 2.152 | 95% Jackknife UCL | 2.186 |
| 1379 | 95% Standard Bootstrap UCL | 2.136 | 95% Bootstrap-t UCL | 2.282 |
| 1380 | 95% Hall's Bootstrap UCL | 2.212 | 95% Percentile Bootstrap UCL | 2.153 |
| 1381 | 95% BCA Bootstrap UCL | 2.183 | | |
| 1382 | 90% Chebyshev(Mean, Sd) UCL | 2.55 | 95% Chebyshev(Mean, Sd) UCL | 2.949 |
| 1383 | 97.5% Chebyshev(Mean, Sd) UCL | 3.503 | 99% Chebyshev(Mean, Sd) UCL | 4.591 |
| 1384 | | | | |
| 1385 | **Suggested UCL to Use** | | | |
| 1386 | 95% Student's-t UCL | 2.186 | | |
| 1387 | | | | |
| 1388 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 1389 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 1390 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 1391 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 1392 | | | | |
| 1393 | | | | |
| 1394 | Fluorene | | | |
| 1395 | | | | |
| 1396 | **General Statistics** | | | |
| 1397 | Total Number of Observations | 15 | Number of Distinct Observations | 14 |
| 1398 | | | Number of Missing Observations | 0 |
| 1399 | Minimum | 0.03 | Mean | 0.251 |
| 1400 | Maximum | 0.94 | Median | 0.19 |
| 1401 | SD | 0.23 | Std. Error of Mean | 0.0593 |
| 1402 | Coefficient of Variation | 0.916 | Skewness | 2.17 |
| 1403 | | | | |
| 1404 | **Normal GOF Test** | | | |
| 1405 | Shapiro Wilk Test Statistic | 0.78 | **Shapiro Wilk GOF Test** | |
| 1406 | 5% Shapiro Wilk Critical Value | 0.881 | Data Not Normal at 5% Significance Level | |
| 1407 | Lilliefors Test Statistic | 0.217 | **Lilliefors GOF Test** | |
| 1408 | 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |
| 1409 | **Data appear Approximate Normal at 5% Significance Level** | | | |
| 1410 | | | | |
| 1411 | **Assuming Normal Distribution** | | | |
| 1412 | **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 1413 | 95% Student's-t UCL | 0.355 | 95% Adjusted-CLT UCL (Chen-1995) | 0.384 |
| 1414 | | | 95% Modified-t UCL (Johnson-1978) | 0.361 |
| 1415 | | | | |
| 1416 | **Gamma GOF Test** | | | |
| 1417 | A-D Test Statistic | 0.206 | **Anderson-Darling Gamma GOF Test** | |
| 1418 | 5% A-D Critical Value | 0.752 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 1419 | K-S Test Statistic | 0.112 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 1420 | 5% K-S Critical Value | 0.225 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 1421 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| 1422 | | | | |
| 1423 | **Gamma Statistics** | | | |
| 1424 | k hat (MLE) | 1.644 | k star (bias corrected MLE) | 1.359 |
| 1425 | Theta hat (MLE) | 0.153 | Theta star (bias corrected MLE) | 0.184 |
| 1426 | nu hat (MLE) | 49.31 | nu star (bias corrected) | 40.78 |
| 1427 | MLE Mean (bias corrected) | 0.251 | MLE Sd (bias corrected) | 0.215 |
| 1428 | | | Approximate Chi Square Value (0.05) | 27.15 |
| 1429 | Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 25.78 |
| 1430 | | | | |
| 1431 | **Assuming Gamma Distribution** | | | |
| 1432 | 95% Approximate Gamma UCL (use when n>=50)) | 0.377 | 95% Adjusted Gamma UCL (use when n<50) | 0.396 |
| 1433 | | | | |
| 1434 | **Lognormal GOF Test** | | | |
| 1435 | Shapiro Wilk Test Statistic | 0.989 | **Shapiro Wilk Lognormal GOF Test** | |
| 1436 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| 1437 | Lilliefors Test Statistic | 0.0888 | **Lilliefors Lognormal GOF Test** | |
| 1438 | 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| 1439 | **Data appear Lognormal at 5% Significance Level** | | | |

| | | | |
|---|---|---|---|
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | -3.507 | Mean of logged Data | -1.718 |
| Maximum of Logged Data | -0.0619 | SD of logged Data | 0.871 |
| | | | |
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 0.474 | 90% Chebyshev (MVUE) UCL | 0.438 |
| 95% Chebyshev (MVUE) UCL | 0.521 | 97.5% Chebyshev (MVUE) UCL | 0.637 |
| 99% Chebyshev (MVUE) UCL | 0.864 | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| | | | |
| **Nonparametric Distribution Free UCLs** | | | |
| 95% CLT UCL | 0.348 | 95% Jackknife UCL | 0.355 |
| 95% Standard Bootstrap UCL | 0.345 | 95% Bootstrap-t UCL | 0.44 |
| 95% Hall's Bootstrap UCL | 0.836 | 95% Percentile Bootstrap UCL | 0.361 |
| 95% BCA Bootstrap UCL | 0.386 | | |
| 90% Chebyshev(Mean, Sd) UCL | 0.428 | 95% Chebyshev(Mean, Sd) UCL | 0.509 |
| 97.5% Chebyshev(Mean, Sd) UCL | 0.621 | 99% Chebyshev(Mean, Sd) UCL | 0.84 |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% Student's-t UCL | 0.355 | | |
| | | | |
| When a data set follows an approximate (e.g., normal) distribution passing one of the GOF test | | | |
| When applicable, it is suggested to use a UCL based upon a distribution (e.g., gamma) passing both GOF tests in ProUCL | | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| | | | |
| **Indeno** | | | |
| | | | |
| **General Statistics** | | | |
| Total Number of Observations | 15 | Number of Distinct Observations | 10 |
| Number of Detects | 9 | Number of Non-Detects | 6 |
| Number of Distinct Detects | 9 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | 0.29 | Minimum Non-Detect | 0.01 |
| Maximum Detect | 1.13 | Maximum Non-Detect | 0.01 |
| Variance Detects | 0.0952 | Percent Non-Detects | 40% |
| Mean Detects | 0.652 | SD Detects | 0.309 |
| Median Detects | 0.53 | CV Detects | 0.473 |
| Skewness Detects | 0.647 | Kurtosis Detects | -1.105 |
| Mean of Logged Detects | -0.527 | SD of Logged Detects | 0.475 |
| | | | |
| **Normal GOF Test on Detects Only** | | | |
| Shapiro Wilk Test Statistic | 0.898 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.829 | Detected Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.21 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.274 | Detected Data appear Normal at 5% Significance Level | |
| **Detected Data appear Normal at 5% Significance Level** | | | |
| | | | |
| **Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs** | | | |
| KM Mean | 0.395 | KM Standard Error of Mean | 0.106 |
| KM SD | 0.387 | 95% KM (BCA) UCL | 0.565 |
| 95% KM (t) UCL | 0.582 | 95% KM (Percentile Bootstrap) UCL | 0.564 |
| 95% KM (z) UCL | 0.57 | 95% KM Bootstrap t UCL | 0.592 |
| 90% KM Chebyshev UCL | 0.713 | 95% KM Chebyshev UCL | 0.857 |
| 97.5% KM Chebyshev UCL | 1.057 | 99% KM Chebyshev UCL | 1.45 |
| | | | |
| **Gamma GOF Tests on Detected Observations Only** | | | |
| A-D Test Statistic | 0.305 | **Anderson-Darling GOF Test** | |
| 5% A-D Critical Value | 0.723 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.176 | **Kolmogorov-Smirnov GOF** | |
| 5% K-S Critical Value | 0.28 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 5.18 | k star (bias corrected MLE) | 3.528 |
| Theta hat (MLE) | 0.126 | Theta star (bias corrected MLE) | 0.185 |
| nu hat (MLE) | 93.25 | nu star (bias corrected) | 63.5 |
| Mean (detects) | 0.652 | | |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 0.414 |
| Maximum | 1.13 | Median | 0.38 |
| SD | 0.384 | CV | 0.928 |
| k hat (MLE) | 0.714 | k star (bias corrected MLE) | 0.615 |
| Theta hat (MLE) | 0.58 | Theta star (bias corrected MLE) | 0.672 |
| nu hat (MLE) | 21.41 | nu star (bias corrected) | 18.46 |
| Adjusted Level of Significance (β) | 0.0324 | | |
| Approximate Chi Square Value (18.46, α) | 9.726 | Adjusted Chi Square Value (18.46, β) | 8.953 |
| 95% Gamma Approximate UCL (use when n>=50) | 0.785 | 95% Gamma Adjusted UCL (use when n<50) | 0.853 |

**Estimates of Gamma Parameters using KM Estimates**

| | | | |
|---|---|---|---|
| Mean (KM) | 0.395 | SD (KM) | 0.387 |
| Variance (KM) | 0.15 | SE of Mean (KM) | 0.106 |
| k hat (KM) | 1.044 | k star (KM) | 0.879 |
| nu hat (KM) | 31.31 | nu star (KM) | 26.38 |
| theta hat (KM) | 0.379 | theta star (KM) | 0.45 |
| 80% gamma percentile (KM) | 0.642 | 90% gamma percentile (KM) | 0.939 |
| 95% gamma percentile (KM) | 1.24 | 99% gamma percentile (KM) | 1.944 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| Approximate Chi Square Value (26.38, α) | 15.67 | Adjusted Chi Square Value (26.38, β) | 14.66 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 0.665 | 95% Gamma Adjusted KM-UCL (use when n<50) | 0.711 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.95 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.829 | Detected Data appear Lognormal at 5% Significance Level |
| Lilliefors Test Statistic | 0.145 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.274 | Detected Data appear Lognormal at 5% Significance Level |

**Detected Data appear Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 0.46 | Mean in Log Scale | -1.042 |
| SD in Original Scale | 0.339 | SD in Log Scale | 0.777 |
| 95% t UCL (assumes normality of ROS data) | 0.614 | 95% Percentile Bootstrap UCL | 0.605 |
| 95% BCA Bootstrap UCL | 0.617 | 95% Bootstrap t UCL | 0.653 |
| 95% H-UCL (Log ROS) | 0.787 | | |

**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| KM Mean (logged) | -2.158 | KM Geo Mean | 0.116 |
| KM SD (logged) | 2.028 | 95% Critical H Value (KM-Log) | 4.618 |
| KM Standard Error of Mean (logged) | 0.555 | 95% H-UCL (KM -Log) | 11.03 |
| KM SD (logged) | 2.028 | 95% Critical H Value (KM-Log) | 4.618 |
| KM Standard Error of Mean (logged) | 0.555 | | |

**DL/2 Statistics**

| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
|---|---|---|---|
| Mean in Original Scale | 0.393 | Mean in Log Scale | -2.436 |
| SD in Original Scale | 0.403 | SD in Log Scale | 2.446 |
| 95% t UCL (Assumes normality) | 0.576 | 95% H-Stat UCL | 61.41 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Detected Data appear Normal Distributed at 5% Significance Level**

**Suggested UCL to Use**

| | |
|---|---|
| 95% KM (t) UCL | 0.582 |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Naphthalene**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 4 |
| Number of Detects | 4 | Number of Non-Detects | 11 |
| Number of Distinct Detects | 3 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | 0.02 | Minimum Non-Detect | 0.01 |
| Maximum Detect | 0.62 | Maximum Non-Detect | 0.01 |
| Variance Detects | 0.06 | Percent Non-Detects | 73.33% |
| Mean Detects | 0.32 | SD Detects | 0.245 |
| Median Detects | 0.32 | CV Detects | 0.765 |
| Skewness Detects | 0 | Kurtosis Detects | 1.5 |
| Mean of Logged Detects | -1.667 | SD of Logged Detects | 1.529 |

**Normal GOF Test on Detects Only**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.944 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.748 | Detected Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.25 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.375 | Detected Data appear Normal at 5% Significance Level | |

**Detected Data appear Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| KM Mean | 0.0927 | KM Standard Error of Mean | 0.0523 |
| KM SD | 0.175 | 95% KM (BCA) UCL | N/A |
| 95% KM (t) UCL | 0.185 | 95% KM (Percentile Bootstrap) UCL | N/A |
| 95% KM (z) UCL | 0.179 | 95% KM Bootstrap t UCL | N/A |
| 90% KM Chebyshev UCL | 0.25 | 95% KM Chebyshev UCL | 0.321 |
| 97.5% KM Chebyshev UCL | 0.419 | 99% KM Chebyshev UCL | 0.613 |

**Gamma GOF Tests on Detected Observations Only**

| | | | |
|---|---|---|---|
| A-D Test Statistic | 0.499 | **Anderson-Darling GOF Test** | |
| 5% A-D Critical Value | 0.666 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.377 | **Kolmogorov-Smirnov GOF** | |
| 5% K-S Critical Value | 0.402 | Detected data appear Gamma Distributed at 5% Significance Level | |

**Detected data appear Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 1.084 | k star (bias corrected MLE) | 0.438 |
| Theta hat (MLE) | 0.295 | Theta star (bias corrected MLE) | 0.731 |
| nu hat (MLE) | 8.669 | nu star (bias corrected) | 3.501 |
| Mean (detects) | 0.32 | | |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs
GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)
For such situations, GROS method may yield incorrect values of UCLs and BTVs
This is especially true when the sample size is small.
For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 0.0927 |
| Maximum | 0.62 | Median | 0.01 |
| SD | 0.182 | CV | 1.96 |
| k hat (MLE) | 0.448 | k star (bias corrected MLE) | 0.403 |
| Theta hat (MLE) | 0.207 | Theta star (bias corrected MLE) | 0.23 |
| nu hat (MLE) | 13.44 | nu star (bias corrected) | 12.08 |
| Adjusted Level of Significance (β) | 0.0324 | | |
| Approximate Chi Square Value (12.08, α) | 5.281 | Adjusted Chi Square Value (12.08, β) | 4.738 |
| 95% Gamma Approximate UCL (use when n>=50) | 0.212 | 95% Gamma Adjusted UCL (use when n<50) | N/A |

**Estimates of Gamma Parameters using KM Estimates**

| | | | |
|---|---|---|---|
| Mean (KM) | 0.0927 | SD (KM) | 0.175 |
| Variance (KM) | 0.0308 | SE of Mean (KM) | 0.0523 |
| k hat (KM) | 0.279 | k star (KM) | 0.268 |
| nu hat (KM) | 8.366 | nu star (KM) | 8.026 |
| theta hat (KM) | 0.332 | theta star (KM) | 0.346 |
| 80% gamma percentile (KM) | 0.138 | 90% gamma percentile (KM) | 0.277 |
| 95% gamma percentile (KM) | 0.439 | 99% gamma percentile (KM) | 0.869 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| Approximate Chi Square Value (8.03, α) | 2.75 | Adjusted Chi Square Value (8.03, β) | 2.384 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 0.27 | 95% Gamma Adjusted KM-UCL (use when n<50) | 0.312 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.794 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.748 | Detected Data appear Lognormal at 5% Significance Level |
| Lilliefors Test Statistic | 0.385 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.375 | Detected Data Not Lognormal at 5% Significance Level |

**Detected Data appear Approximate Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 0.0877 | Mean in Log Scale | -5.73 |
| SD in Original Scale | 0.184 | SD in Log Scale | 3.222 |
| 95% t UCL (assumes normality of ROS data) | 0.171 | 95% Percentile Bootstrap UCL | 0.171 |
| 95% BCA Bootstrap UCL | 0.208 | 95% Bootstrap t UCL | 0.23 |
| 95% H-UCL (Log ROS) | 245.8 | | |

**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| KM Mean (logged) | -3.822 | KM Geo Mean | 0.0219 |
| KM SD (logged) | 1.468 | 95% Critical H Value (KM-Log) | 3.553 |
| KM Standard Error of Mean (logged) | 0.438 | 95% H-UCL (KM -Log) | 0.259 |
| KM SD (logged) | 1.468 | 95% Critical H Value (KM-Log) | 3.553 |
| KM Standard Error of Mean (logged) | 0.438 | | |

**DL/2 Statistics**

| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
|---|---|---|---|
| Mean in Original Scale | 0.089 | Mean in Log Scale | -4.33 |
| SD in Original Scale | 0.183 | SD in Log Scale | 1.806 |
| 95% t UCL (Assumes normality) | 0.172 | 95% H-Stat UCL | 0.509 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Detected Data appear Normal Distributed at 5% Significance Level**

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% KM (t) UCL | 0.185 | | |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Perylene**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 10 |
| Number of Detects | 10 | Number of Non-Detects | 5 |
| Number of Distinct Detects | 9 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | 0.11 | Minimum Non-Detect | 0.05 |
| Maximum Detect | 0.41 | Maximum Non-Detect | 0.05 |
| Variance Detects | 0.0106 | Percent Non-Detects | 33.33% |
| Mean Detects | 0.212 | SD Detects | 0.103 |
| Median Detects | 0.165 | CV Detects | 0.485 |
| Skewness Detects | 0.901 | Kurtosis Detects | -0.368 |
| Mean of Logged Detects | -1.65 | SD of Logged Detects | 0.462 |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 1706 | Normal GOF Test on Detects Only | | | |
| 1707 | Shapiro Wilk Test Statistic | 0.879 | Shapiro Wilk GOF Test | |
| 1708 | 5% Shapiro Wilk Critical Value | 0.842 | Detected Data appear Normal at 5% Significance Level | |
| 1709 | Lilliefors Test Statistic | 0.227 | Lilliefors GOF Test | |
| 1710 | 5% Lilliefors Critical Value | 0.262 | Detected Data appear Normal at 5% Significance Level | |
| 1711 | Detected Data appear Normal at 5% Significance Level | | | |
| 1712 | | | | |
| 1713 | Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs | | | |
| 1714 | KM Mean | 0.158 | KM Standard Error of Mean | 0.03 |
| 1715 | KM SD | 0.11 | 95% KM (BCA) UCL | 0.209 |
| 1716 | 95% KM (t) UCL | 0.211 | 95% KM (Percentile Bootstrap) UCL | 0.205 |
| 1717 | 95% KM (z) UCL | 0.207 | 95% KM Bootstrap t UCL | 0.219 |
| 1718 | 90% KM Chebyshev UCL | 0.248 | 95% KM Chebyshev UCL | 0.289 |
| 1719 | 97.5% KM Chebyshev UCL | 0.345 | 99% KM Chebyshev UCL | 0.457 |
| 1720 | | | | |
| 1721 | Gamma GOF Tests on Detected Observations Only | | | |
| 1722 | A-D Test Statistic | 0.452 | Anderson-Darling GOF Test | |
| 1723 | 5% A-D Critical Value | 0.729 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 1724 | K-S Test Statistic | 0.225 | Kolmogorov-Smirnov GOF | |
| 1725 | 5% K-S Critical Value | 0.267 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 1726 | Detected data appear Gamma Distributed at 5% Significance Level | | | |
| 1727 | | | | |
| 1728 | Gamma Statistics on Detected Data Only | | | |
| 1729 | k hat (MLE) | 5.214 | k star (bias corrected MLE) | 3.716 |
| 1730 | Theta hat (MLE) | 0.0407 | Theta star (bias corrected MLE) | 0.057 |
| 1731 | nu hat (MLE) | 104.3 | nu star (bias corrected) | 74.33 |
| 1732 | Mean (detects) | 0.212 | | |
| 1733 | | | | |
| 1734 | Gamma ROS Statistics using Imputed Non-Detects | | | |
| 1735 | GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| 1736 | GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| 1737 | For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| 1738 | This is especially true when the sample size is small. | | | |
| 1739 | For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| 1740 | Minimum | 0.01 | Mean | 0.148 |
| 1741 | Maximum | 0.41 | Median | 0.13 |
| 1742 | SD | 0.125 | CV | 0.84 |
| 1743 | k hat (MLE) | 1.036 | k star (bias corrected MLE) | 0.873 |
| 1744 | Theta hat (MLE) | 0.143 | Theta star (bias corrected MLE) | 0.17 |
| 1745 | nu hat (MLE) | 31.07 | nu star (bias corrected) | 26.19 |
| 1746 | Adjusted Level of Significance (β) | 0.0324 | | |
| 1747 | Approximate Chi Square Value (26.19, α) | 15.53 | Adjusted Chi Square Value (26.19, β) | 14.52 |
| 1748 | 95% Gamma Approximate UCL (use when n>=50) | 0.25 | 95% Gamma Adjusted UCL (use when n<50) | 0.268 |
| 1749 | | | | |
| 1750 | Estimates of Gamma Parameters using KM Estimates | | | |
| 1751 | Mean (KM) | 0.158 | SD (KM) | 0.11 |
| 1752 | Variance (KM) | 0.0122 | SE of Mean (KM) | 0.03 |
| 1753 | k hat (KM) | 2.053 | k star (KM) | 1.686 |
| 1754 | nu hat (KM) | 61.58 | nu star (KM) | 50.59 |
| 1755 | theta hat (KM) | 0.077 | theta star (KM) | 0.0937 |
| 1756 | 80% gamma percentile (KM) | 0.241 | 90% gamma percentile (KM) | 0.32 |
| 1757 | 95% gamma percentile (KM) | 0.396 | 99% gamma percentile (KM) | 0.566 |
| 1758 | | | | |
| 1759 | Gamma Kaplan-Meier (KM) Statistics | | | |
| 1760 | Approximate Chi Square Value (50.59, α) | 35.26 | Adjusted Chi Square Value (50.59, β) | 33.69 |
| 1761 | 95% Gamma Approximate KM-UCL (use when n>=50) | 0.227 | 95% Gamma Adjusted KM-UCL (use when n<50) | 0.237 |
| 1762 | | | | |
| 1763 | Lognormal GOF Test on Detected Observations Only | | | |
| 1764 | Shapiro Wilk Test Statistic | 0.922 | Shapiro Wilk GOF Test | |
| 1765 | 5% Shapiro Wilk Critical Value | 0.842 | Detected Data appear Lognormal at 5% Significance Level | |
| 1766 | Lilliefors Test Statistic | 0.204 | Lilliefors GOF Test | |
| 1767 | 5% Lilliefors Critical Value | 0.262 | Detected Data appear Lognormal at 5% Significance Level | |
| 1768 | Detected Data appear Lognormal at 5% Significance Level | | | |
| 1769 | | | | |

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 0.161 | Mean in Log Scale | -2.049 |
| SD in Original Scale | 0.111 | SD in Log Scale | 0.711 |
| 95% t UCL (assumes normality of ROS data) | 0.212 | 95% Percentile Bootstrap UCL | 0.21 |
| 95% BCA Bootstrap UCL | 0.213 | 95% Bootstrap t UCL | 0.228 |
| 95% H-UCL (Log ROS) | 0.258 | | |

**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| KM Mean (logged) | -2.099 | KM Geo Mean | 0.123 |
| KM SD (logged) | 0.728 | 95% Critical H Value (KM-Log) | 2.343 |
| KM Standard Error of Mean (logged) | 0.198 | 95% H-UCL (KM -Log) | 0.252 |
| KM SD (logged) | 0.728 | 95% Critical H Value (KM-Log) | 2.343 |
| KM Standard Error of Mean (logged) | 0.198 | | |

**DL/2 Statistics**

| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
|---|---|---|---|
| Mean in Original Scale | 0.15 | Mean in Log Scale | -2.33 |
| SD in Original Scale | 0.123 | SD in Log Scale | 1.061 |
| 95% t UCL (Assumes normality) | 0.206 | 95% H-Stat UCL | 0.383 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Detected Data appear Normal Distributed at 5% Significance Level**

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% KM (t) UCL | 0.211 | | |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Phenanthrene**

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 15 |
| | | Number of Missing Observations | 0 |
| Minimum | 0.22 | Mean | 1.424 |
| Maximum | 4.05 | Median | 1.26 |
| SD | 1.02 | Std. Error of Mean | 0.263 |
| Coefficient of Variation | 0.717 | Skewness | 1.333 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.89 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.205 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level |

**Data appear Normal at 5% Significance Level**

**Assuming Normal Distribution**

| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
|---|---|---|---|
| 95% Student's-t UCL | 1.888 | 95% Adjusted-CLT UCL (Chen-1995) | 1.954 |
| | | 95% Modified-t UCL (Johnson-1978) | 1.903 |

**Gamma GOF Test**

| | | |
|---|---|---|
| A-D Test Statistic | 0.207 | **Anderson-Darling Gamma GOF Test** |
| 5% A-D Critical Value | 0.747 | Detected data appear Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.121 | **Kolmogorov-Smirnov Gamma GOF Test** |
| 5% K-S Critical Value | 0.224 | Detected data appear Gamma Distributed at 5% Significance Level |

**Detected data appear Gamma Distributed at 5% Significance Level**

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 2.096 | k star (bias corrected MLE) | 1.721 |
| Theta hat (MLE) | 0.679 | Theta star (bias corrected MLE) | 0.827 |
| nu hat (MLE) | 62.89 | nu star (bias corrected) | 51.64 |
| MLE Mean (bias corrected) | 1.424 | MLE Sd (bias corrected) | 1.085 |
| | | Approximate Chi Square Value (0.05) | 36.14 |
| Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 34.55 |

**Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Approximate Gamma UCL (use when n>=50)) | 2.035 | 95% Adjusted Gamma UCL (use when n<50) | 2.129 |

**Lognormal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.961 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.138 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |

**Data appear Lognormal at 5% Significance Level**

**Lognormal Statistics**

| | | | |
|---|---|---|---|
| Minimum of Logged Data | -1.514 | Mean of logged Data | 0.0964 |
| Maximum of Logged Data | 1.399 | SD of logged Data | 0.793 |

**Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% H-UCL | 2.525 | 90% Chebyshev (MVUE) UCL | 2.431 |
| 95% Chebyshev (MVUE) UCL | 2.866 | 97.5% Chebyshev (MVUE) UCL | 3.471 |
| 99% Chebyshev (MVUE) UCL | 4.658 | | |

**Nonparametric Distribution Free UCL Statistics**

**Data appear to follow a Discernible Distribution at 5% Significance Level**

**Nonparametric Distribution Free UCLs**

| | | | |
|---|---|---|---|
| 95% CLT UCL | 1.857 | 95% Jackknife UCL | 1.888 |
| 95% Standard Bootstrap UCL | 1.836 | 95% Bootstrap-t UCL | 2.099 |
| 95% Hall's Bootstrap UCL | 2.248 | 95% Percentile Bootstrap UCL | 1.885 |
| 95% BCA Bootstrap UCL | 1.945 | | |
| 90% Chebyshev(Mean, Sd) UCL | 2.214 | 95% Chebyshev(Mean, Sd) UCL | 2.572 |
| 97.5% Chebyshev(Mean, Sd) UCL | 3.069 | 99% Chebyshev(Mean, Sd) UCL | 4.046 |

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% Student's-t UCL | 1.888 | | |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Pyrene

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 15 | Number of Distinct Observations | 15 |
| | | Number of Missing Observations | 0 |
| Minimum | 0.24 | Mean | 1.307 |
| Maximum | 2.98 | Median | 1.13 |
| SD | 0.833 | Std. Error of Mean | 0.215 |
| Coefficient of Variation | 0.637 | Skewness | 0.778 |

**Normal GOF Test**

| | | | |
|---|---|---|---|
| Shapiro Wilk Test Statistic | 0.918 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.881 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.184 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.22 | Data appear Normal at 5% Significance Level | |

**Data appear Normal at 5% Significance Level**

**Assuming Normal Distribution**

| | | | |
|---|---|---|---|
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 1.685 | 95% Adjusted-CLT UCL (Chen-1995) | 1.707 |
| | | 95% Modified-t UCL (Johnson-1978) | 1.693 |

**Gamma GOF Test**

| | | | |
|---|---|---|---|
| A-D Test Statistic | 0.202 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.746 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.119 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.224 | Detected data appear Gamma Distributed at 5% Significance Level | |

**Detected data appear Gamma Distributed at 5% Significance Level**

| Row | | F | | L |
|---|---|---|---|---|
| 1908 | **Gamma Statistics** | | | |
| 1909 | k hat (MLE) | 2.519 | k star (bias corrected MLE) | 2.059 |
| 1910 | Theta hat (MLE) | 0.519 | Theta star (bias corrected MLE) | 0.635 |
| 1911 | nu hat (MLE) | 75.56 | nu star (bias corrected) | 61.78 |
| 1912 | MLE Mean (bias corrected) | 1.307 | MLE Sd (bias corrected) | 0.911 |
| 1913 | | | Approximate Chi Square Value (0.05) | 44.7 |
| 1914 | Adjusted Level of Significance | 0.0324 | Adjusted Chi Square Value | 42.91 |
| 1915 | | | | |
| 1916 | **Assuming Gamma Distribution** | | | |
| 1917 | 95% Approximate Gamma UCL (use when n>=50)) | 1.806 | 95% Adjusted Gamma UCL (use when n<50) | 1.881 |
| 1918 | | | | |
| 1919 | **Lognormal GOF Test** | | | |
| 1920 | Shapiro Wilk Test Statistic | 0.967 | **Shapiro Wilk Lognormal GOF Test** | |
| 1921 | 5% Shapiro Wilk Critical Value | 0.881 | Data appear Lognormal at 5% Significance Level | |
| 1922 | Lilliefors Test Statistic | 0.121 | **Lilliefors Lognormal GOF Test** | |
| 1923 | 5% Lilliefors Critical Value | 0.22 | Data appear Lognormal at 5% Significance Level | |
| 1924 | **Data appear Lognormal at 5% Significance Level** | | | |
| 1925 | | | | |
| 1926 | **Lognormal Statistics** | | | |
| 1927 | Minimum of Logged Data | -1.427 | Mean of logged Data | 0.056 |
| 1928 | Maximum of Logged Data | 1.092 | SD of logged Data | 0.71 |
| 1929 | | | | |
| 1930 | **Assuming Lognormal Distribution** | | | |
| 1931 | 95% H-UCL | 2.114 | 90% Chebyshev (MVUE) UCL | 2.109 |
| 1932 | 95% Chebyshev (MVUE) UCL | 2.46 | 97.5% Chebyshev (MVUE) UCL | 2.947 |
| 1933 | 99% Chebyshev (MVUE) UCL | 3.903 | | |
| 1934 | | | | |
| 1935 | **Nonparametric Distribution Free UCL Statistics** | | | |
| 1936 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| 1937 | | | | |
| 1938 | **Nonparametric Distribution Free UCLs** | | | |
| 1939 | 95% CLT UCL | 1.66 | 95% Jackknife UCL | 1.685 |
| 1940 | 95% Standard Bootstrap UCL | 1.651 | 95% Bootstrap-t UCL | 1.799 |
| 1941 | 95% Hall's Bootstrap UCL | 1.695 | 95% Percentile Bootstrap UCL | 1.649 |
| 1942 | 95% BCA Bootstrap UCL | 1.679 | | |
| 1943 | 90% Chebyshev(Mean, Sd) UCL | 1.952 | 95% Chebyshev(Mean, Sd) UCL | 2.244 |
| 1944 | 97.5% Chebyshev(Mean, Sd) UCL | 2.649 | 99% Chebyshev(Mean, Sd) UCL | 3.446 |
| 1945 | | | | |
| 1946 | **Suggested UCL to Use** | | | |
| 1947 | 95% Student's-t UCL | 1.685 | | |
| 1948 | | | | |
| 1949 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 1950 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 1951 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 1952 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 1953 | | | | |
| 1954 | Quinoline | | | |
| 1955 | | | | |
| 1956 | **General Statistics** | | | |
| 1957 | Total Number of Observations | 15 | Number of Distinct Observations | 1 |
| 1958 | Number of Detects | 0 | Number of Non-Detects | 15 |
| 1959 | Number of Distinct Detects | 0 | Number of Distinct Non-Detects | 1 |
| 1960 | | | | |
| 1961 | **Warning: All observations are Non-Detects (NDs), therefore all statistics and estimates should also be NDs!** | | | |
| 1962 | **Specifically, sample mean, UCLs, UPLs, and other statistics are also NDs lying below the largest detection limit!** | | | |
| 1963 | **The Project Team may decide to use alternative site specific values to estimate environmental parameters (e.g., EPC, BTV).** | | | |
| 1964 | | | | |
| 1965 | **The data set for variable Quinoline was not processed!** | | | |
| 1966 | | | | |
| 1967 | | | | |

UCL Statistics for Data Sets with Non-Detects

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | ProUCL 5.111/14/2018 4:02:11 PM |
| From File | WorkSheet_b.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

F2

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 14 | Number of Distinct Observations | 11 |
| Number of Detects | 10 | Number of Non-Detects | 4 |
| Number of Distinct Detects | 10 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | 0.06 | Minimum Non-Detect | 0.05 |
| Maximum Detect | 230 | Maximum Non-Detect | 0.05 |
| Variance Detects | 5228 | Percent Non-Detects | 28.57% |
| Mean Detects | 24.28 | SD Detects | 72.31 |
| Median Detects | 0.86 | CV Detects | 2.978 |
| Skewness Detects | 3.158 | Kurtosis Detects | 9.98 |
| Mean of Logged Detects | 0.0369 | SD of Logged Detects | 2.387 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.385 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.842 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.497 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.262 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| KM Mean | 17.36 | KM Standard Error of Mean | 16.62 |
| KM SD | 59 | 95% KM (BCA) UCL | 50.02 |
| 95% KM (t) UCL | 46.79 | 95% KM (Percentile Bootstrap) UCL | 49.73 |
| 95% KM (z) UCL | 44.7 | 95% KM Bootstrap t UCL | 1482 |
| 90% KM Chebyshev UCL | 67.22 | 95% KM Chebyshev UCL | 89.81 |
| 97.5% KM Chebyshev UCL | 121.2 | 99% KM Chebyshev UCL | 182.7 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 1.492 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.843 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.359 | **Kolmogorov-Smirnov GOF** |
| 5% K-S Critical Value | 0.293 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.229 | k star (bias corrected MLE) | 0.227 |
| Theta hat (MLE) | 106.2 | Theta star (bias corrected MLE) | 107.1 |
| nu hat (MLE) | 4.571 | nu star (bias corrected) | 4.533 |
| Mean (detects) | 24.28 | | |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 17.35 |
| Maximum | 230 | Median | 0.28 |
| SD | 61.23 | CV | 3.53 |
| k hat (MLE) | 0.18 | k star (bias corrected MLE) | 0.189 |
| Theta hat (MLE) | 96.12 | Theta star (bias corrected MLE) | 91.58 |
| nu hat (MLE) | 5.053 | nu star (bias corrected) | 5.304 |
| Adjusted Level of Significance (β) | 0.0312 | | |
| Approximate Chi Square Value (5.30, α) | 1.295 | Adjusted Chi Square Value (5.30, β) | 1.054 |
| 95% Gamma Approximate UCL (use when n>=50) | 71.05 | 95% Gamma Adjusted UCL (use when n<50) | 87.33 |

**Estimates of Gamma Parameters using KM Estimates**

| | | | |
|---|---|---|---|
| Mean (KM) | 17.36 | SD (KM) | 59 |
| Variance (KM) | 3481 | SE of Mean (KM) | 16.62 |
| k hat (KM) | 0.0866 | k star (KM) | 0.116 |
| nu hat (KM) | 2.424 | nu star (KM) | 3.238 |
| theta hat (KM) | 200.5 | theta star (KM) | 150.1 |
| 80% gamma percentile (KM) | 14.58 | 90% gamma percentile (KM) | 48.66 |
| 95% gamma percentile (KM) | 99.5 | 99% gamma percentile (KM) | 256.1 |

**Gamma Kaplan-Meier (KM) Statistics**

| | | | |
|---|---|---|---|
| Approximate Chi Square Value (3.24, α) | 0.446 | Adjusted Chi Square Value (3.24, β) | 0.337 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 126 | 95% Gamma Adjusted KM-UCL (use when n<50) | 166.7 |

**Lognormal GOF Test on Detected Observations Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.907 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.842 | Detected Data appear Lognormal at 5% Significance Level |
| Lilliefors Test Statistic | 0.192 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.262 | Detected Data appear Lognormal at 5% Significance Level |

**Detected Data appear Lognormal at 5% Significance Level**

**Lognormal ROS Statistics Using Imputed Non-Detects**

| | | | |
|---|---|---|---|
| Mean in Original Scale | 17.35 | Mean in Log Scale | -1.645 |
| SD in Original Scale | 61.23 | SD in Log Scale | 3.463 |
| 95% t UCL (assumes normality of ROS data) | 46.33 | 95% Percentile Bootstrap UCL | 50.06 |
| 95% BCA Bootstrap UCL | 66.55 | 95% Bootstrap t UCL | 1488 |
| 95% H-UCL (Log ROS) | 128575 | | |

**Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| KM Mean (logged) | -0.83 | KM Geo Mean | 0.436 |
| KM SD (logged) | 2.354 | 95% Critical H Value (KM-Log) | 5.395 |
| KM Standard Error of Mean (logged) | 0.663 | 95% H-UCL (KM -Log) | 235.6 |
| KM SD (logged) | 2.354 | 95% Critical H Value (KM-Log) | 5.395 |
| KM Standard Error of Mean (logged) | 0.663 | | |

**DL/2 Statistics**

| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
|---|---|---|---|
| Mean in Original Scale | 17.35 | Mean in Log Scale | -1.028 |
| SD in Original Scale | 61.23 | SD in Log Scale | 2.645 |
| 95% t UCL (Assumes normality) | 46.33 | 95% H-Stat UCL | 963.1 |

**DL/2 is not a recommended method, provided for comparisons and historical reasons**

**Nonparametric Distribution Free UCL Statistics**

**Detected Data appear Lognormal Distributed at 5% Significance Level**

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 99% KM (Chebyshev) UCL | 182.7 | | |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

| | | | |
|---|---|---|---|
| **F3** | | | |
| **General Statistics** | | | |
| Total Number of Observations | 14 | Number of Distinct Observations | 11 |
| Number of Detects | 10 | Number of Non-Detects | 4 |
| Number of Distinct Detects | 10 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | 0.02 | Minimum Non-Detect | 0.1 |
| Maximum Detect | 216 | Maximum Non-Detect | 0.1 |
| Variance Detects | 4588 | Percent Non-Detects | 28.57% |
| Mean Detects | 23.31 | SD Detects | 67.73 |
| Median Detects | 1.355 | CV Detects | 2.906 |
| Skewness Detects | 3.158 | Kurtosis Detects | 9.978 |
| Mean of Logged Detects | 0.294 | SD of Logged Detects | 2.473 |
| | | | |
| **Normal GOF Test on Detects Only** | | | |
| Shapiro Wilk Test Statistic | 0.39 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.842 | Detected Data Not Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.503 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.262 | Detected Data Not Normal at 5% Significance Level | |
| **Detected Data Not Normal at 5% Significance Level** | | | |
| | | | |
| **Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs** | | | |
| KM Mean | 16.66 | KM Standard Error of Mean | 15.58 |
| KM SD | 55.32 | 95% KM (BCA) UCL | 47.61 |
| 95% KM (t) UCL | 44.25 | 95% KM (Percentile Bootstrap) UCL | 47.13 |
| 95% KM (z) UCL | 42.29 | 95% KM Bootstrap t UCL | 669 |
| 90% KM Chebyshev UCL | 63.41 | 95% KM Chebyshev UCL | 84.58 |
| 97.5% KM Chebyshev UCL | 114 | 99% KM Chebyshev UCL | 171.7 |
| | | | |
| **Gamma GOF Tests on Detected Observations Only** | | | |
| A-D Test Statistic | 1.2 | **Anderson-Darling GOF Test** | |
| 5% A-D Critical Value | 0.835 | Detected Data Not Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.36 | **Kolmogorov-Smirnov GOF** | |
| 5% K-S Critical Value | 0.291 | Detected Data Not Gamma Distributed at 5% Significance Level | |
| **Detected Data Not Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics on Detected Data Only** | | | |
| k hat (MLE) | 0.249 | k star (bias corrected MLE) | 0.241 |
| Theta hat (MLE) | 93.63 | Theta star (bias corrected MLE) | 96.75 |
| nu hat (MLE) | 4.979 | nu star (bias corrected) | 4.819 |
| Mean (detects) | 23.31 | | |
| | | | |
| **Gamma ROS Statistics using Imputed Non-Detects** | | | |
| GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| This is especially true when the sample size is small. | | | |
| For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| Minimum | 0.01 | Mean | 16.65 |
| Maximum | 216 | Median | 0.505 |
| SD | 57.4 | CV | 3.447 |
| k hat (MLE) | 0.189 | k star (bias corrected MLE) | 0.196 |
| Theta hat (MLE) | 87.92 | Theta star (bias corrected MLE) | 84.77 |
| nu hat (MLE) | 5.303 | nu star (bias corrected) | 5.5 |
| Adjusted Level of Significance (β) | 0.0312 | | |
| Approximate Chi Square Value (5.50, α) | 1.39 | Adjusted Chi Square Value (5.50, β) | 1.137 |
| 95% Gamma Approximate UCL (use when n>=50) | 65.89 | 95% Gamma Adjusted UCL (use when n<50) | 80.57 |
| | | | |
| **Estimates of Gamma Parameters using KM Estimates** | | | |
| Mean (KM) | 16.66 | SD (KM) | 55.32 |
| Variance (KM) | 3060 | SE of Mean (KM) | 15.58 |
| k hat (KM) | 0.0907 | k star (KM) | 0.119 |
| nu hat (KM) | 2.539 | nu star (KM) | 3.328 |
| theta hat (KM) | 183.7 | theta star (KM) | 140.1 |
| 80% gamma percentile (KM) | 14.45 | 90% gamma percentile (KM) | 47.06 |
| 95% gamma percentile (KM) | 95.16 | 99% gamma percentile (KM) | 242.3 |
| | | | |
| **Gamma Kaplan-Meier (KM) Statistics** | | | |
| Approximate Chi Square Value (3.33, α) | 0.476 | Adjusted Chi Square Value (3.33, β) | 0.361 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 116.5 | 95% Gamma Adjusted KM-UCL (use when n<50) | 153.7 |
| | | | |
| **Lognormal GOF Test on Detected Observations Only** | | | |
| Shapiro Wilk Test Statistic | 0.96 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.842 | Detected Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.183 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.262 | Detected Data appear Lognormal at 5% Significance Level | |
| **Detected Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal ROS Statistics Using Imputed Non-Detects** | | | |
| Mean in Original Scale | 16.66 | Mean in Log Scale | -1.034 |
| SD in Original Scale | 57.4 | SD in Log Scale | 3.063 |
| 95% t UCL (assumes normality of ROS data) | 43.83 | 95% Percentile Bootstrap UCL | 47.11 |
| 95% BCA Bootstrap UCL | 63.27 | 95% Bootstrap t UCL | 684.2 |
| 95% H-UCL (Log ROS) | 13376 | | |
| | | | |
| **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | |
| KM Mean (logged) | -0.908 | KM Geo Mean | 0.403 |
| KM SD (logged) | 2.746 | 95% Critical H Value (KM-Log) | 6.21 |
| KM Standard Error of Mean (logged) | 0.774 | 95% H-UCL (KM -Log) | 1987 |
| KM SD (logged) | 2.746 | 95% Critical H Value (KM-Log) | 6.21 |
| KM Standard Error of Mean (logged) | 0.774 | | |
| | | | |
| **DL/2 Statistics** | | | |
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 16.66 | Mean in Log Scale | -0.646 |
| SD in Original Scale | 57.4 | SD in Log Scale | 2.572 |
| 95% t UCL (Assumes normality) | 43.83 | 95% H-Stat UCL | 926.1 |
| **DL/2 is not a recommended method, provided for comparisons and historical reasons** | | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Detected Data appear Lognormal Distributed at 5% Significance Level** | | | |
| | | | |
| **Suggested UCL to Use** | | | |
| 99% KM (Chebyshev) UCL | 171.7 | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |

| | | | |
|---|---|---|---|
| **mTPH** | | | |
| **General Statistics** | | | |
| Total Number of Observations | 14 | Number of Distinct Observations | 10 |
| Number of Detects | 9 | Number of Non-Detects | 5 |
| Number of Distinct Detects | 9 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | 0.3 | Minimum Non-Detect | 0.1 |
| Maximum Detect | 447 | Maximum Non-Detect | 0.1 |
| Variance Detects | 21838 | Percent Non-Detects | 35.71% |
| Mean Detects | 53.06 | SD Detects | 147.8 |
| Median Detects | 3.3 | CV Detects | 2.785 |
| Skewness Detects | 2.996 | Kurtosis Detects | 8.983 |
| Mean of Logged Detects | 1.325 | SD of Logged Detects | 2.161 |
| **Normal GOF Test on Detects Only** | | | |
| Shapiro Wilk Test Statistic | 0.412 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.829 | Detected Data Not Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.498 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.274 | Detected Data Not Normal at 5% Significance Level | |
| **Detected Data Not Normal at 5% Significance Level** | | | |
| **Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs** | | | |
| KM Mean | 34.14 | KM Standard Error of Mean | 32.47 |
| KM SD | 114.6 | 95% KM (BCA) UCL | 97.91 |
| 95% KM (t) UCL | 91.65 | 95% KM (Percentile Bootstrap) UCL | 97.51 |
| 95% KM (z) UCL | 87.56 | 95% KM Bootstrap t UCL | 1964 |
| 90% KM Chebyshev UCL | 131.6 | 95% KM Chebyshev UCL | 175.7 |
| 97.5% KM Chebyshev UCL | 236.9 | 99% KM Chebyshev UCL | 357.2 |
| **Gamma GOF Tests on Detected Observations Only** | | | |
| A-D Test Statistic | 1.365 | **Anderson-Darling GOF Test** | |
| 5% A-D Critical Value | 0.821 | Detected Data Not Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.368 | **Kolmogorov-Smirnov GOF** | |
| 5% K-S Critical Value | 0.304 | Detected Data Not Gamma Distributed at 5% Significance Level | |
| **Detected Data Not Gamma Distributed at 5% Significance Level** | | | |
| **Gamma Statistics on Detected Data Only** | | | |
| k hat (MLE) | 0.266 | k star (bias corrected MLE) | 0.251 |
| Theta hat (MLE) | 199.6 | Theta star (bias corrected MLE) | 211.2 |
| nu hat (MLE) | 4.784 | nu star (bias corrected) | 4.522 |
| Mean (detects) | 53.06 | | |
| **Gamma ROS Statistics using Imputed Non-Detects** | | | |
| GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| This is especially true when the sample size is small. | | | |
| For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| Minimum | 0.01 | Mean | 34.11 |
| Maximum | 447 | Median | 0.85 |
| SD | 118.9 | CV | 3.485 |
| k hat (MLE) | 0.174 | k star (bias corrected MLE) | 0.184 |
| Theta hat (MLE) | 196.1 | Theta star (bias corrected MLE) | 185.1 |
| nu hat (MLE) | 4.87 | nu star (bias corrected) | 5.16 |
| Adjusted Level of Significance (β) | 0.0312 | | |
| Approximate Chi Square Value (5.16, α) | 1.227 | Adjusted Chi Square Value (5.16, β) | 0.994 |
| 95% Gamma Approximate UCL (use when n>=50) | 143.5 | 95% Gamma Adjusted UCL (use when n<50) | 177.1 |
| **Estimates of Gamma Parameters using KM Estimates** | | | |
| Mean (KM) | 34.14 | SD (KM) | 114.6 |
| Variance (KM) | 13123 | SE of Mean (KM) | 32.47 |
| k hat (KM) | 0.0888 | k star (KM) | 0.117 |
| nu hat (KM) | 2.487 | nu star (KM) | 3.288 |
| theta hat (KM) | 384.4 | theta star (KM) | 290.8 |
| 80% gamma percentile (KM) | 29.21 | 90% gamma percentile (KM) | 96.14 |
| 95% gamma percentile (KM) | 195.4 | 99% gamma percentile (KM) | 499.8 |
| **Gamma Kaplan-Meier (KM) Statistics** | | | |
| Approximate Chi Square Value (3.29, α) | 0.462 | Adjusted Chi Square Value (3.29, β) | 0.35 |
| 95% Gamma Approximate KM-UCL (use when n>=50) | 242.7 | 95% Gamma Adjusted KM-UCL (use when n<50) | 320.6 |
| **Lognormal GOF Test on Detected Observations Only** | | | |
| Shapiro Wilk Test Statistic | 0.897 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.829 | Detected Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.192 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.274 | Detected Data appear Lognormal at 5% Significance Level | |
| **Detected Data appear Lognormal at 5% Significance Level** | | | |
| **Lognormal ROS Statistics Using Imputed Non-Detects** | | | |
| Mean in Original Scale | 34.12 | Mean in Log Scale | -0.66 |
| SD in Original Scale | 118.9 | SD in Log Scale | 3.344 |
| 95% t UCL (assumes normality of ROS data) | 90.39 | 95% Percentile Bootstrap UCL | 97.32 |
| 95% BCA Bootstrap UCL | 130.2 | 95% Bootstrap t UCL | 1979 |
| 95% H-UCL (Log ROS) | 141032 | | |
| **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | |
| KM Mean (logged) | 0.0294 | KM Geo Mean | 1.03 |
| KM SD (logged) | 2.385 | 95% Critical H Value (KM-Log) | 5.46 |
| KM Standard Error of Mean (logged) | 0.676 | 95% H-UCL (KM -Log) | 656.3 |
| KM SD (logged) | 2.385 | 95% Critical H Value (KM-Log) | 5.46 |
| KM Standard Error of Mean (logged) | 0.676 | | |
| **DL/2 Statistics** | | | |
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 34.13 | Mean in Log Scale | -0.218 |
| SD in Original Scale | 118.9 | SD in Log Scale | 2.737 |
| 95% t UCL (Assumes normality) | 90.39 | 95% H-Stat UCL | 3733 |
| **DL/2 is not a recommended method, provided for comparisons and historical reasons** | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Detected Data appear Lognormal Distributed at 5% Significance Level** | | | |
| **Suggested UCL to Use** | | | |
| 99% KM (Chebyshev) UCL | 357.2 | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |

# UCL Statistics for Data Sets with Non-Detects

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | ProUCL 5.11/30/2019 3:30:26 PM |
| From File | WorkSheet_b.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Number of Bootstrap Operations | 2000 |

As

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 12 | Number of Distinct Observations | 3 |
| | | Number of Missing Observations | 0 |
| Minimum | 2 | Mean | 3 |
| Maximum | 4 | Median | 3 |
| SD | 0.603 | Std. Error of Mean | 0.174 |
| Coefficient of Variation | 0.201 | Skewness | 0 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.774 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.859 | Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.333 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.243 | Data Not Normal at 5% Significance Level |

**Data Not Normal at 5% Significance Level**

**Assuming Normal Distribution**

| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
|---|---|---|---|
| 95% Student's-t UCL | 3.313 | 95% Adjusted-CLT UCL (Chen-1995) | 3.286 |
| | | 95% Modified-t UCL (Johnson-1978) | 3.313 |

**Gamma GOF Test**

| | | |
|---|---|---|
| A-D Test Statistic | 1.554 | **Anderson-Darling Gamma GOF Test** |
| 5% A-D Critical Value | 0.731 | Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.36 | **Kolmogorov-Smirnov Gamma GOF Test** |
| 5% K-S Critical Value | 0.245 | Data Not Gamma Distributed at 5% Significance Level |

**Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 25.64 | k star (bias corrected MLE) | 19.28 |
| Theta hat (MLE) | 0.117 | Theta star (bias corrected MLE) | 0.156 |
| nu hat (MLE) | 615.3 | nu star (bias corrected) | 462.8 |
| MLE Mean (bias corrected) | 3 | MLE Sd (bias corrected) | 0.683 |
| | | Approximate Chi Square Value (0.05) | 413.9 |
| Adjusted Level of Significance | 0.029 | Adjusted Chi Square Value | 406.8 |

**Assuming Gamma Distribution**

| | | | |
|---|---|---|---|
| 95% Approximate Gamma UCL (use when n>=50)) | 3.354 | 95% Adjusted Gamma UCL (use when n<50) | 3.412 |

| | A B C D E | F | G H I J K | L |
|---|---|---|---|---|
| 51 | **Lognormal GOF Test** | | | |
| 52 | Shapiro Wilk Test Statistic | 0.76 | **Shapiro Wilk Lognormal GOF Test** | |
| 53 | 5% Shapiro Wilk Critical Value | 0.859 | Data Not Lognormal at 5% Significance Level | |
| 54 | Lilliefors Test Statistic | 0.37 | **Lilliefors Lognormal GOF Test** | |
| 55 | 5% Lilliefors Critical Value | 0.243 | Data Not Lognormal at 5% Significance Level | |
| 56 | **Data Not Lognormal at 5% Significance Level** | | | |
| 57 | | | | |
| 58 | **Lognormal Statistics** | | | |
| 59 | Minimum of Logged Data | 0.693 | Mean of logged Data | 1.079 |
| 60 | Maximum of Logged Data | 1.386 | SD of logged Data | 0.211 |
| 61 | | | | |
| 62 | **Assuming Lognormal Distribution** | | | |
| 63 | 95% H-UCL | 3.384 | 90% Chebyshev (MVUE) UCL | 3.553 |
| 64 | 95% Chebyshev (MVUE) UCL | 3.803 | 97.5% Chebyshev (MVUE) UCL | 4.149 |
| 65 | 99% Chebyshev (MVUE) UCL | 4.83 | | |
| 66 | | | | |
| 67 | **Nonparametric Distribution Free UCL Statistics** | | | |
| 68 | **Data do not follow a Discernible Distribution (0.05)** | | | |
| 69 | | | | |
| 70 | **Nonparametric Distribution Free UCLs** | | | |
| 71 | 95% CLT UCL | 3.286 | 95% Jackknife UCL | 3.313 |
| 72 | 95% Standard Bootstrap UCL | N/A | 95% Bootstrap-t UCL | N/A |
| 73 | 95% Hall's Bootstrap UCL | N/A | 95% Percentile Bootstrap UCL | N/A |
| 74 | 95% BCA Bootstrap UCL | N/A | | |
| 75 | 90% Chebyshev(Mean, Sd) UCL | 3.522 | 95% Chebyshev(Mean, Sd) UCL | 3.759 |
| 76 | 97.5% Chebyshev(Mean, Sd) UCL | 4.087 | 99% Chebyshev(Mean, Sd) UCL | 4.732 |
| 77 | | | | |
| 78 | **Suggested UCL to Use** | | | |
| 79 | 95% Student's-t UCL | 3.313 | or 95% Modified-t UCL | 3.313 |
| 80 | | | | |
| 81 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 82 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 83 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 84 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 85 | | | | |
| 86 | B | | | |
| 87 | | | | |
| 88 | **General Statistics** | | | |
| 89 | Total Number of Observations | 12 | Number of Distinct Observations | 4 |
| 90 | Number of Detects | 9 | Number of Non-Detects | 3 |
| 91 | Number of Distinct Detects | 3 | Number of Distinct Non-Detects | 1 |
| 92 | Minimum Detect | 4 | Minimum Non-Detect | 2 |
| 93 | Maximum Detect | 6 | Maximum Non-Detect | 2 |
| 94 | Variance Detects | 0.361 | Percent Non-Detects | 25% |
| 95 | Mean Detects | 4.889 | SD Detects | 0.601 |
| 96 | Median Detects | 5 | CV Detects | 0.123 |
| 97 | Skewness Detects | -0.0183 | Kurtosis Detects | 1.126 |
| 98 | Mean of Logged Detects | 1.58 | SD of Logged Detects | 0.125 |
| 99 | | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 100 | Normal GOF Test on Detects Only | | | |
| 101 | Shapiro Wilk Test Statistic | 0.781 | **Shapiro Wilk GOF Test** | |
| 102 | 5% Shapiro Wilk Critical Value | 0.829 | Detected Data Not Normal at 5% Significance Level | |
| 103 | Lilliefors Test Statistic | 0.351 | **Lilliefors GOF Test** | |
| 104 | 5% Lilliefors Critical Value | 0.274 | Detected Data Not Normal at 5% Significance Level | |
| 105 | **Detected Data Not Normal at 5% Significance Level** | | | |
| 106 | | | | |
| 107 | **Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs** | | | |
| 108 | KM Mean | 4.167 | KM Standard Error of Mean | 0.411 |
| 109 | KM SD | 1.344 | 95% KM (BCA) UCL | N/A |
| 110 | 95% KM (t) UCL | 4.906 | 95% KM (Percentile Bootstrap) UCL | N/A |
| 111 | 95% KM (z) UCL | 4.843 | 95% KM Bootstrap t UCL | N/A |
| 112 | 90% KM Chebyshev UCL | 5.401 | 95% KM Chebyshev UCL | 5.96 |
| 113 | 97.5% KM Chebyshev UCL | 6.736 | 99% KM Chebyshev UCL | 8.26 |
| 114 | | | | |
| 115 | **Gamma GOF Tests on Detected Observations Only** | | | |
| 116 | A-D Test Statistic | 1.221 | **Anderson-Darling GOF Test** | |
| 117 | 5% A-D Critical Value | 0.72 | Detected Data Not Gamma Distributed at 5% Significance Level | |
| 118 | K-S Test Statistic | 0.369 | **Kolmogorov-Smirnov GOF** | |
| 119 | 5% K-S Critical Value | 0.279 | Detected Data Not Gamma Distributed at 5% Significance Level | |
| 120 | **Detected Data Not Gamma Distributed at 5% Significance Level** | | | |
| 121 | | | | |
| 122 | **Gamma Statistics on Detected Data Only** | | | |
| 123 | k hat (MLE) | 73.09 | k star (bias corrected MLE) | 48.8 |
| 124 | Theta hat (MLE) | 0.0669 | Theta star (bias corrected MLE) | 0.1 |
| 125 | nu hat (MLE) | 1316 | nu star (bias corrected) | 878.4 |
| 126 | Mean (detects) | 4.889 | | |
| 127 | | | | |
| 128 | **Gamma ROS Statistics using Imputed Non-Detects** | | | |
| 129 | GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| 130 | GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| 131 | For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| 132 | This is especially true when the sample size is small. | | | |
| 133 | For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| 134 | Minimum | 3.432 | Mean | 4.586 |
| 135 | Maximum | 6 | Median | 5 |
| 136 | SD | 0.757 | CV | 0.165 |
| 137 | k hat (MLE) | 39.47 | k star (bias corrected MLE) | 29.66 |
| 138 | Theta hat (MLE) | 0.116 | Theta star (bias corrected MLE) | 0.155 |
| 139 | nu hat (MLE) | 947.3 | nu star (bias corrected) | 711.8 |
| 140 | Adjusted Level of Significance (β) | 0.029 | | |
| 141 | Approximate Chi Square Value (711.78, α) | 650.9 | Adjusted Chi Square Value (711.78, β) | 642 |
| 142 | 95% Gamma Approximate UCL (use when n>=50) | 5.015 | 95% Gamma Adjusted UCL (use when n<50) | 5.085 |
| 143 | | | | |
| 144 | **Estimates of Gamma Parameters using KM Estimates** | | | |
| 145 | Mean (KM) | 4.167 | SD (KM) | 1.344 |
| 146 | Variance (KM) | 1.806 | SE of Mean (KM) | 0.411 |
| 147 | k hat (KM) | 9.615 | k star (KM) | 7.267 |
| 148 | nu hat (KM) | 230.8 | nu star (KM) | 174.4 |
| 149 | theta hat (KM) | 0.433 | theta star (KM) | 0.573 |
| 150 | 80% gamma percentile (KM) | 5.381 | 90% gamma percentile (KM) | 6.229 |
| 151 | 95% gamma percentile (KM) | 6.991 | 99% gamma percentile (KM) | 8.575 |
| 152 | | | | |
| 153 | **Gamma Kaplan-Meier (KM) Statistics** | | | |
| 154 | Approximate Chi Square Value (174.41, α) | 144.9 | Adjusted Chi Square Value (174.41, β) | 140.8 |
| 155 | 95% Gamma Approximate KM-UCL (use when n>=50) | 5.016 | 95% Gamma Adjusted KM-UCL (use when n<50) | 5.163 |
| 156 | | | | |

| | | | |
|---|---|---|---|
| **Lognormal GOF Test on Detected Observations Only** | | | |
| Shapiro Wilk Test Statistic | 0.774 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.829 | Detected Data Not Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.371 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.274 | Detected Data Not Lognormal at 5% Significance Level | |
| **Detected Data Not Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal ROS Statistics Using Imputed Non-Detects** | | | |
| Mean in Original Scale | 4.598 | Mean in Log Scale | 1.514 |
| SD in Original Scale | 0.74 | SD in Log Scale | 0.163 |
| 95% t UCL (assumes normality of ROS data) | 4.981 | 95% Percentile Bootstrap UCL | 4.917 |
| 95% BCA Bootstrap UCL | 4.918 | 95% Bootstrap t UCL | 4.964 |
| 95% H-UCL (Log ROS) | 5.032 | | |
| | | | |
| **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | |
| KM Mean (logged) | 1.358 | KM Geo Mean | 3.89 |
| KM SD (logged) | 0.397 | 95% Critical H Value (KM-Log) | 2.023 |
| KM Standard Error of Mean (logged) | 0.122 | 95% H-UCL (KM -Log) | 5.364 |
| KM SD (logged) | 0.397 | 95% Critical H Value (KM-Log) | 2.023 |
| KM Standard Error of Mean (logged) | 0.122 | | |
| | | | |
| **DL/2 Statistics** | | | |
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 3.917 | Mean in Log Scale | 1.185 |
| SD in Original Scale | 1.832 | SD in Log Scale | 0.723 |
| 95% t UCL (Assumes normality) | 4.866 | 95% H-Stat UCL | 7.239 |
| **DL/2 is not a recommended method, provided for comparisons and historical reasons** | | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data do not follow a Discernible Distribution at 5% Significance Level** | | | |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% KM (t) UCL | 4.906 | KM H-UCL | 5.364 |
| 95% KM (BCA) UCL | N/A | | |
| **Warning: One or more Recommended UCL(s) not available!** | | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 199 | Cd | | | | | | | | | | | |
| 200 | | | | | | | | | | | | |
| 201 | General Statistics | | | | | | | | | | | |
| 202 | Total Number of Observations | | | | | 12 | Number of Distinct Observations | | | | | 12 |
| 203 | | | | | | | Number of Missing Observations | | | | | 0 |
| 204 | Minimum | | | | | 1.3 | Mean | | | | | 6.267 |
| 205 | Maximum | | | | | 17.8 | Median | | | | | 5.8 |
| 206 | SD | | | | | 4.489 | Std. Error of Mean | | | | | 1.296 |
| 207 | Coefficient of Variation | | | | | 0.716 | Skewness | | | | | 1.613 |
| 208 | | | | | | | | | | | | |
| 209 | Normal GOF Test | | | | | | | | | | | |
| 210 | Shapiro Wilk Test Statistic | | | | | 0.86 | Shapiro Wilk GOF Test | | | | | |
| 211 | 5% Shapiro Wilk Critical Value | | | | | 0.859 | Data appear Normal at 5% Significance Level | | | | | |
| 212 | Lilliefors Test Statistic | | | | | 0.22 | Lilliefors GOF Test | | | | | |
| 213 | 5% Lilliefors Critical Value | | | | | 0.243 | Data appear Normal at 5% Significance Level | | | | | |
| 214 | Data appear Normal at 5% Significance Level | | | | | | | | | | | |
| 215 | | | | | | | | | | | | |
| 216 | Assuming Normal Distribution | | | | | | | | | | | |
| 217 | 95% Normal UCL | | | | | | 95% UCLs (Adjusted for Skewness) | | | | | |
| 218 | 95% Student's-t UCL | | | | | 8.594 | 95% Adjusted-CLT UCL (Chen-1995) | | | | | 9.043 |
| 219 | | | | | | | 95% Modified-t UCL (Johnson-1978) | | | | | 8.694 |
| 220 | | | | | | | | | | | | |
| 221 | Gamma GOF Test | | | | | | | | | | | |
| 222 | A-D Test Statistic | | | | | 0.224 | Anderson-Darling Gamma GOF Test | | | | | |
| 223 | 5% A-D Critical Value | | | | | 0.741 | Detected data appear Gamma Distributed at 5% Significance Level | | | | | |
| 224 | K-S Test Statistic | | | | | 0.133 | Kolmogorov-Smirnov Gamma GOF Test | | | | | |
| 225 | 5% K-S Critical Value | | | | | 0.248 | Detected data appear Gamma Distributed at 5% Significance Level | | | | | |
| 226 | Detected data appear Gamma Distributed at 5% Significance Level | | | | | | | | | | | |
| 227 | | | | | | | | | | | | |
| 228 | Gamma Statistics | | | | | | | | | | | |
| 229 | k hat (MLE) | | | | | 2.381 | k star (bias corrected MLE) | | | | | 1.841 |
| 230 | Theta hat (MLE) | | | | | 2.632 | Theta star (bias corrected MLE) | | | | | 3.404 |
| 231 | nu hat (MLE) | | | | | 57.13 | nu star (bias corrected) | | | | | 44.18 |
| 232 | MLE Mean (bias corrected) | | | | | 6.267 | MLE Sd (bias corrected) | | | | | 4.619 |
| 233 | | | | | | | Approximate Chi Square Value (0.05) | | | | | 29.94 |
| 234 | Adjusted Level of Significance | | | | | 0.029 | Adjusted Chi Square Value | | | | | 28.16 |
| 235 | | | | | | | | | | | | |
| 236 | Assuming Gamma Distribution | | | | | | | | | | | |
| 237 | 95% Approximate Gamma UCL (use when n>=50)) | | | | | 9.248 | 95% Adjusted Gamma UCL (use when n<50) | | | | | 9.833 |
| 238 | | | | | | | | | | | | |
| 239 | Lognormal GOF Test | | | | | | | | | | | |
| 240 | Shapiro Wilk Test Statistic | | | | | 0.977 | Shapiro Wilk Lognormal GOF Test | | | | | |
| 241 | 5% Shapiro Wilk Critical Value | | | | | 0.859 | Data appear Lognormal at 5% Significance Level | | | | | |
| 242 | Lilliefors Test Statistic | | | | | 0.145 | Lilliefors Lognormal GOF Test | | | | | |
| 243 | 5% Lilliefors Critical Value | | | | | 0.243 | Data appear Lognormal at 5% Significance Level | | | | | |
| 244 | Data appear Lognormal at 5% Significance Level | | | | | | | | | | | |
| 245 | | | | | | | | | | | | |
| 246 | Lognormal Statistics | | | | | | | | | | | |
| 247 | Minimum of Logged Data | | | | | 0.262 | Mean of logged Data | | | | | 1.611 |
| 248 | Maximum of Logged Data | | | | | 2.879 | SD of logged Data | | | | | 0.72 |
| 249 | | | | | | | | | | | | |

**Assuming Lognormal Distribution**

| | | | |
|---|---|---|---|
| 95% H-UCL | 11.03 | 90% Chebyshev (MVUE) UCL | 10.44 |
| 95% Chebyshev (MVUE) UCL | 12.3 | 97.5% Chebyshev (MVUE) UCL | 14.89 |
| 99% Chebyshev (MVUE) UCL | 19.97 | | |

**Nonparametric Distribution Free UCL Statistics**

**Data appear to follow a Discernible Distribution at 5% Significance Level**

**Nonparametric Distribution Free UCLs**

| | | | |
|---|---|---|---|
| 95% CLT UCL | 8.398 | 95% Jackknife UCL | 8.594 |
| 95% Standard Bootstrap UCL | 8.369 | 95% Bootstrap-t UCL | 9.823 |
| 95% Hall's Bootstrap UCL | 19.27 | 95% Percentile Bootstrap UCL | 8.383 |
| 95% BCA Bootstrap UCL | 8.95 | | |
| 90% Chebyshev(Mean, Sd) UCL | 10.15 | 95% Chebyshev(Mean, Sd) UCL | 11.92 |
| 97.5% Chebyshev(Mean, Sd) UCL | 14.36 | 99% Chebyshev(Mean, Sd) UCL | 19.16 |

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% Student's-t UCL | 8.594 | | |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.

Recommendations are based upon data size, data distribution, and skewness.

These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).

However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

Cu

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 12 | Number of Distinct Observations | 5 |
| Number of Detects | 4 | Number of Non-Detects | 8 |
| Number of Distinct Detects | 4 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | 9 | Minimum Non-Detect | 2 |
| Maximum Detect | 20 | Maximum Non-Detect | 2 |
| Variance Detects | 23.58 | Percent Non-Detects | 66.67% |
| Mean Detects | 15.25 | SD Detects | 4.856 |
| Median Detects | 16 | CV Detects | 0.318 |
| Skewness Detects | -0.688 | Kurtosis Detects | -0.946 |
| Mean of Logged Detects | 2.681 | SD of Logged Detects | 0.355 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.957 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.748 | Detected Data appear Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.214 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.375 | Detected Data appear Normal at 5% Significance Level |

**Detected Data appear Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| KM Mean | 6.417 | KM Standard Error of Mean | 2.234 |
| KM SD | 6.701 | 95% KM (BCA) UCL | N/A |
| 95% KM (t) UCL | 10.43 | 95% KM (Percentile Bootstrap) UCL | N/A |
| 95% KM (z) UCL | 10.09 | 95% KM Bootstrap t UCL | N/A |
| 90% KM Chebyshev UCL | 13.12 | 95% KM Chebyshev UCL | 16.15 |
| 97.5% KM Chebyshev UCL | 20.37 | 99% KM Chebyshev UCL | 28.64 |

| | | | | |
|---|---|---|---|---|
| 303 | **Gamma GOF Tests on Detected Observations Only** | | | |
| 304 | A-D Test Statistic | 0.299 | **Anderson-Darling GOF Test** | |
| 305 | 5% A-D Critical Value | 0.657 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 306 | K-S Test Statistic | 0.25 | **Kolmogorov-Smirnov GOF** | |
| 307 | 5% K-S Critical Value | 0.395 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 308 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| 309 | | | | |
| 310 | **Gamma Statistics on Detected Data Only** | | | |
| 311 | k hat (MLE) | 11.53 | k star (bias corrected MLE) | 3.05 |
| 312 | Theta hat (MLE) | 1.322 | Theta star (bias corrected MLE) | 5 |
| 313 | nu hat (MLE) | 92.26 | nu star (bias corrected) | 24.4 |
| 314 | Mean (detects) | 15.25 | | |
| 315 | | | | |
| 316 | **Gamma ROS Statistics using Imputed Non-Detects** | | | |
| 317 | GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs | | | |
| 318 | GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20) | | | |
| 319 | For such situations, GROS method may yield incorrect values of UCLs and BTVs | | | |
| 320 | This is especially true when the sample size is small. | | | |
| 321 | For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates | | | |
| 322 | Minimum | 0.01 | Mean | 6.273 |
| 323 | Maximum | 20 | Median | 3.533 |
| 324 | SD | 7.364 | CV | 1.174 |
| 325 | k hat (MLE) | 0.319 | k star (bias corrected MLE) | 0.295 |
| 326 | Theta hat (MLE) | 19.64 | Theta star (bias corrected MLE) | 21.25 |
| 327 | nu hat (MLE) | 7.667 | nu star (bias corrected) | 7.084 |
| 328 | Adjusted Level of Significance (β) | 0.029 | | |
| 329 | Approximate Chi Square Value (7.08, α) | 2.217 | Adjusted Chi Square Value (7.08, β) | 1.825 |
| 330 | 95% Gamma Approximate UCL (use when n>=50) | 20.05 | 95% Gamma Adjusted UCL (use when n<50) | N/A |
| 331 | | | | |
| 332 | **Estimates of Gamma Parameters using KM Estimates** | | | |
| 333 | Mean (KM) | 6.417 | SD (KM) | 6.701 |
| 334 | Variance (KM) | 44.91 | SE of Mean (KM) | 2.234 |
| 335 | k hat (KM) | 0.917 | k star (KM) | 0.743 |
| 336 | nu hat (KM) | 22 | nu star (KM) | 17.84 |
| 337 | theta hat (KM) | 6.999 | theta star (KM) | 8.634 |
| 338 | 80% gamma percentile (KM) | 10.52 | 90% gamma percentile (KM) | 15.88 |
| 339 | 95% gamma percentile (KM) | 21.37 | 99% gamma percentile (KM) | 34.43 |
| 340 | | | | |
| 341 | **Gamma Kaplan-Meier (KM) Statistics** | | | |
| 342 | Approximate Chi Square Value (17.84, α) | 9.272 | Adjusted Chi Square Value (17.84, β) | 8.345 |
| 343 | 95% Gamma Approximate KM-UCL (use when n>=50) | 12.34 | 95% Gamma Adjusted KM-UCL (use when n<50) | 13.71 |
| 344 | | | | |
| 345 | **Lognormal GOF Test on Detected Observations Only** | | | |
| 346 | Shapiro Wilk Test Statistic | 0.922 | **Shapiro Wilk GOF Test** | |
| 347 | 5% Shapiro Wilk Critical Value | 0.748 | Detected Data appear Lognormal at 5% Significance Level | |
| 348 | Lilliefors Test Statistic | 0.223 | **Lilliefors GOF Test** | |
| 349 | 5% Lilliefors Critical Value | 0.375 | Detected Data appear Lognormal at 5% Significance Level | |
| 350 | **Detected Data appear Lognormal at 5% Significance Level** | | | |
| 351 | | | | |

| | | | |
|---|---|---|---|
| **Lognormal ROS Statistics Using Imputed Non-Detects** | | | |
| Mean in Original Scale | 7.985 | Mean in Log Scale | 1.809 |
| SD in Original Scale | 6.134 | SD in Log Scale | 0.776 |
| 95% t UCL (assumes normality of ROS data) | 11.17 | 95% Percentile Bootstrap UCL | 10.99 |
| 95% BCA Bootstrap UCL | 11.42 | 95% Bootstrap t UCL | 12.32 |
| 95% H-UCL (Log ROS) | 14.9 | | |
| | | | |
| **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | |
| KM Mean (logged) | 1.356 | KM Geo Mean | 3.879 |
| KM SD (logged) | 0.954 | 95% Critical H Value (KM-Log) | 2.832 |
| KM Standard Error of Mean (logged) | 0.318 | 95% H-UCL (KM -Log) | 13.8 |
| KM SD (logged) | 0.954 | 95% Critical H Value (KM-Log) | 2.832 |
| KM Standard Error of Mean (logged) | 0.318 | | |
| | | | |
| **DL/2 Statistics** | | | |
| **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| Mean in Original Scale | 5.75 | Mean in Log Scale | 0.894 |
| SD in Original Scale | 7.461 | SD in Log Scale | 1.333 |
| 95% t UCL (Assumes normality) | 9.618 | 95% H-Stat UCL | 24.77 |
| **DL/2 is not a recommended method, provided for comparisons and historical reasons** | | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Detected Data appear Normal Distributed at 5% Significance Level** | | | |
| | | | |
| **Suggested UCL to Use** | | | |
| 95% KM (t) UCL | 10.43 | | |
| | | | |
| Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| Recommendations are based upon data size, data distribution, and skewness. | | | |
| These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| | | | |
| Pb | | | |
| | | | |
| **General Statistics** | | | |
| Total Number of Observations | 12 | Number of Distinct Observations | 2 |
| Number of Detects | 1 | Number of Non-Detects | 11 |
| Number of Distinct Detects | 1 | Number of Distinct Non-Detects | 1 |
| | | | |
| **Warning: Only one distinct data value was detected! ProUCL (or any other software) should not be used on such a data set!** | | | |
| **It is suggested to use alternative site specific values determined by the Project Team to estimate environmental parameters (e.g., EPC, BTV).** | | | |
| | | | |
| **The data set for variable Pb was not processed!** | | | |

Sr

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 12 | Number of Distinct Observations | 6 |
| Number of Detects | 10 | Number of Non-Detects | 2 |
| Number of Distinct Detects | 6 | Number of Distinct Non-Detects | 1 |
| Minimum Detect | 5 | Minimum Non-Detect | 5 |
| Maximum Detect | 113 | Maximum Non-Detect | 5 |
| Variance Detects | 1201 | Percent Non-Detects | 16.67% |
| Mean Detects | 26.3 | SD Detects | 34.66 |
| Median Detects | 6 | CV Detects | 1.318 |
| Skewness Detects | 2.033 | Kurtosis Detects | 4.426 |
| Mean of Logged Detects | 2.572 | SD of Logged Detects | 1.211 |

**Normal GOF Test on Detects Only**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.693 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.842 | Detected Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.321 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.262 | Detected Data Not Normal at 5% Significance Level |

**Detected Data Not Normal at 5% Significance Level**

**Kaplan-Meier (KM) Statistics using Normal Critical Values and other Nonparametric UCLs**

| | | | |
|---|---|---|---|
| KM Mean | 22.75 | KM Standard Error of Mean | 9.447 |
| KM SD | 31.05 | 95% KM (BCA) UCL | 41.08 |
| 95% KM (t) UCL | 39.72 | 95% KM (Percentile Bootstrap) UCL | 39.17 |
| 95% KM (z) UCL | 38.29 | 95% KM Bootstrap t UCL | 58.63 |
| 90% KM Chebyshev UCL | 51.09 | 95% KM Chebyshev UCL | 63.93 |
| 97.5% KM Chebyshev UCL | 81.75 | 99% KM Chebyshev UCL | 116.7 |

**Gamma GOF Tests on Detected Observations Only**

| | | |
|---|---|---|
| A-D Test Statistic | 1.121 | **Anderson-Darling GOF Test** |
| 5% A-D Critical Value | 0.754 | Detected Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.358 | **Kolmogorov-Smirnov GOF** |
| 5% K-S Critical Value | 0.275 | Detected Data Not Gamma Distributed at 5% Significance Level |

**Detected Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics on Detected Data Only**

| | | | |
|---|---|---|---|
| k hat (MLE) | 0.845 | k star (bias corrected MLE) | 0.658 |
| Theta hat (MLE) | 31.13 | Theta star (bias corrected MLE) | 39.97 |
| nu hat (MLE) | 16.9 | nu star (bias corrected) | 13.16 |
| Mean (detects) | 26.3 | | |

**Gamma ROS Statistics using Imputed Non-Detects**

GROS may not be used when data set has > 50% NDs with many tied observations at multiple DLs

GROS may not be used when kstar of detects is small such as <1.0, especially when the sample size is small (e.g., <15-20)

For such situations, GROS method may yield incorrect values of UCLs and BTVs

This is especially true when the sample size is small.

For gamma distributed detected data, BTVs and UCLs may be computed using gamma distribution on KM estimates

| | | | |
|---|---|---|---|
| Minimum | 0.01 | Mean | 21.92 |
| Maximum | 113 | Median | 5.5 |
| SD | 32.98 | CV | 1.505 |
| k hat (MLE) | 0.387 | k star (bias corrected MLE) | 0.346 |
| Theta hat (MLE) | 56.69 | Theta star (bias corrected MLE) | 63.44 |
| nu hat (MLE) | 9.279 | nu star (bias corrected) | 8.292 |
| Adjusted Level of Significance (β) | 0.029 | | |
| Approximate Chi Square Value (8.29, α) | 2.905 | Adjusted Chi Square Value (8.29, β) | 2.441 |
| 95% Gamma Approximate UCL (use when n>=50) | 62.56 | 95% Gamma Adjusted UCL (use when n<50) | 74.46 |

| | | | | |
|---|---|---|---|---|
| 455 | **Estimates of Gamma Parameters using KM Estimates** | | | |
| 456 | Mean (KM) | 22.75 | SD (KM) | 31.05 |
| 457 | Variance (KM) | 963.9 | SE of Mean (KM) | 9.447 |
| 458 | k hat (KM) | 0.537 | k star (KM) | 0.458 |
| 459 | nu hat (KM) | 12.89 | nu star (KM) | 11 |
| 460 | theta hat (KM) | 42.37 | theta star (KM) | 49.64 |
| 461 | 80% gamma percentile (KM) | 37.18 | 90% gamma percentile (KM) | 62.64 |
| 462 | 95% gamma percentile (KM) | 90.14 | 99% gamma percentile (KM) | 158.3 |
| 463 | | | | |
| 464 | **Gamma Kaplan-Meier (KM) Statistics** | | | |
| 465 | Approximate Chi Square Value (11.00, α) | 4.575 | Adjusted Chi Square Value (11.00, β) | 3.962 |
| 466 | 95% Gamma Approximate KM-UCL (use when n>=50) | 54.69 | 95% Gamma Adjusted KM-UCL (use when n<50) | 63.15 |
| 467 | | | | |
| 468 | **Lognormal GOF Test on Detected Observations Only** | | | |
| 469 | Shapiro Wilk Test Statistic | 0.774 | **Shapiro Wilk GOF Test** | |
| 470 | 5% Shapiro Wilk Critical Value | 0.842 | Detected Data Not Lognormal at 5% Significance Level | |
| 471 | Lilliefors Test Statistic | 0.34 | **Lilliefors GOF Test** | |
| 472 | 5% Lilliefors Critical Value | 0.262 | Detected Data Not Lognormal at 5% Significance Level | |
| 473 | **Detected Data Not Lognormal at 5% Significance Level** | | | |
| 474 | | | | |
| 475 | **Lognormal ROS Statistics Using Imputed Non-Detects** | | | |
| 476 | Mean in Original Scale | 22.06 | Mean in Log Scale | 2.115 |
| 477 | SD in Original Scale | 32.87 | SD in Log Scale | 1.535 |
| 478 | 95% t UCL (assumes normality of ROS data) | 39.11 | 95% Percentile Bootstrap UCL | 39.22 |
| 479 | 95% BCA Bootstrap UCL | 43.31 | 95% Bootstrap t UCL | 57.81 |
| 480 | 95% H-UCL (Log ROS) | 169.1 | | |
| 481 | | | | |
| 482 | **Statistics using KM estimates on Logged Data and Assuming Lognormal Distribution** | | | |
| 483 | KM Mean (logged) | 2.412 | KM Geo Mean | 11.15 |
| 484 | KM SD (logged) | 1.108 | 95% Critical H Value (KM-Log) | 3.114 |
| 485 | KM Standard Error of Mean (logged) | 0.337 | 95% H-UCL (KM -Log) | 58.32 |
| 486 | KM SD (logged) | 1.108 | 95% Critical H Value (KM-Log) | 3.114 |
| 487 | KM Standard Error of Mean (logged) | 0.337 | | |
| 488 | | | | |
| 489 | **DL/2 Statistics** | | | |
| 490 | **DL/2 Normal** | | **DL/2 Log-Transformed** | |
| 491 | Mean in Original Scale | 22.33 | Mean in Log Scale | 2.296 |
| 492 | SD in Original Scale | 32.69 | SD in Log Scale | 1.271 |
| 493 | 95% t UCL (Assumes normality) | 39.28 | 95% H-Stat UCL | 82.86 |
| 494 | **DL/2 is not a recommended method, provided for comparisons and historical reasons** | | | |
| 495 | | | | |
| 496 | **Nonparametric Distribution Free UCL Statistics** | | | |
| 497 | **Data do not follow a Discernible Distribution at 5% Significance Level** | | | |
| 498 | | | | |
| 499 | **Suggested UCL to Use** | | | |
| 500 | 95% KM (Chebyshev) UCL | 63.93 | | |
| 501 | | | | |
| 502 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 503 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 504 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 505 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 506 | | | | |
| 507 | | | | |

V

| | | | |
|---|---|---|---|
| **General Statistics** | | | |
| Total Number of Observations | 12 | Number of Distinct Observations | 5 |
| | | Number of Missing Observations | 0 |
| Minimum | 2 | Mean | 4.25 |
| Maximum | 6 | Median | 4 |
| SD | 1.215 | Std. Error of Mean | 0.351 |
| Coefficient of Variation | 0.286 | Skewness | -0.205 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.94 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.859 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.169 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.243 | Data appear Normal at 5% Significance Level | |
| **Data appear Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 4.88 | 95% Adjusted-CLT UCL (Chen-1995) | 4.805 |
| | | 95% Modified-t UCL (Johnson-1978) | 4.877 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.443 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.731 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.207 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.245 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 11.8 | k star (bias corrected MLE) | 8.906 |
| Theta hat (MLE) | 0.36 | Theta star (bias corrected MLE) | 0.477 |
| nu hat (MLE) | 283.2 | nu star (bias corrected) | 213.7 |
| MLE Mean (bias corrected) | 4.25 | MLE Sd (bias corrected) | 1.424 |
| | | Approximate Chi Square Value (0.05) | 180.9 |
| Adjusted Level of Significance | 0.029 | Adjusted Chi Square Value | 176.3 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50)) | 5.021 | 95% Adjusted Gamma UCL (use when n<50) | 5.153 |
| | | | |
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.907 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.859 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.228 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.243 | Data appear Lognormal at 5% Significance Level | |
| **Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | 0.693 | Mean of logged Data | 1.404 |
| Maximum of Logged Data | 1.792 | SD of logged Data | 0.319 |
| | | | |
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 5.166 | 90% Chebyshev (MVUE) UCL | 5.456 |
| 95% Chebyshev (MVUE) UCL | 5.996 | 97.5% Chebyshev (MVUE) UCL | 6.744 |
| 99% Chebyshev (MVUE) UCL | 8.215 | | |
| | | | |
| **Nonparametric Distribution Free UCL Statistics** | | | |
| **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |

**Nonparametric Distribution Free UCLs**

| | | | |
|---|---|---|---|
| 95% CLT UCL | 4.827 | 95% Jackknife UCL | 4.88 |
| 95% Standard Bootstrap UCL | 4.806 | 95% Bootstrap-t UCL | 4.88 |
| 95% Hall's Bootstrap UCL | 4.838 | 95% Percentile Bootstrap UCL | 4.833 |
| 95% BCA Bootstrap UCL | 4.667 | | |
| 90% Chebyshev(Mean, Sd) UCL | 5.303 | 95% Chebyshev(Mean, Sd) UCL | 5.779 |
| 97.5% Chebyshev(Mean, Sd) UCL | 6.441 | 99% Chebyshev(Mean, Sd) UCL | 7.741 |

**Suggested UCL to Use**

| | | | |
|---|---|---|---|
| 95% Student's-t UCL | 4.88 | | |

Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL.
Recommendations are based upon data size, data distribution, and skewness.
These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006).
However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician.

**Note: For highly negatively-skewed data, confidence limits (e.g., Chen, Johnson, Lognormal, and Gamma) may not be reliable. Chen's and Johnson's methods provide adjustments for positively skewed data sets.**

Zn

**General Statistics**

| | | | |
|---|---|---|---|
| Total Number of Observations | 12 | Number of Distinct Observations | 8 |
| | | Number of Missing Observations | 0 |
| Minimum | 7 | Mean | 22.33 |
| Maximum | 108 | Median | 11 |
| SD | 28.02 | Std. Error of Mean | 8.088 |
| Coefficient of Variation | 1.255 | Skewness | 3.042 |

**Normal GOF Test**

| | | |
|---|---|---|
| Shapiro Wilk Test Statistic | 0.539 | **Shapiro Wilk GOF Test** |
| 5% Shapiro Wilk Critical Value | 0.859 | Data Not Normal at 5% Significance Level |
| Lilliefors Test Statistic | 0.337 | **Lilliefors GOF Test** |
| 5% Lilliefors Critical Value | 0.243 | Data Not Normal at 5% Significance Level |

**Data Not Normal at 5% Significance Level**

**Assuming Normal Distribution**

| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
|---|---|---|---|
| 95% Student's-t UCL | 36.86 | 95% Adjusted-CLT UCL (Chen-1995) | 43.23 |
| | | 95% Modified-t UCL (Johnson-1978) | 38.04 |

**Gamma GOF Test**

| | | |
|---|---|---|
| A-D Test Statistic | 1.427 | **Anderson-Darling Gamma GOF Test** |
| 5% A-D Critical Value | 0.745 | Data Not Gamma Distributed at 5% Significance Level |
| K-S Test Statistic | 0.324 | **Kolmogorov-Smirnov Gamma GOF Test** |
| 5% K-S Critical Value | 0.25 | Data Not Gamma Distributed at 5% Significance Level |

**Data Not Gamma Distributed at 5% Significance Level**

**Gamma Statistics**

| | | | |
|---|---|---|---|
| k hat (MLE) | 1.502 | k star (bias corrected MLE) | 1.182 |
| Theta hat (MLE) | 14.87 | Theta star (bias corrected MLE) | 18.89 |
| nu hat (MLE) | 36.05 | nu star (bias corrected) | 28.37 |
| MLE Mean (bias corrected) | 22.33 | MLE Sd (bias corrected) | 20.54 |
| | | Approximate Chi Square Value (0.05) | 17.22 |
| Adjusted Level of Significance | 0.029 | Adjusted Chi Square Value | 15.9 |

| Row | A–E | F | G–K | L |
|---|---|---|---|---|
| 624 | **Assuming Gamma Distribution** | | | |
| 625 | 95% Approximate Gamma UCL (use when n>=50)) | 36.8 | 95% Adjusted Gamma UCL (use when n<50) | 39.84 |
| 626 | | | | |
| 627 | **Lognormal GOF Test** | | | |
| 628 | Shapiro Wilk Test Statistic | 0.799 | **Shapiro Wilk Lognormal GOF Test** | |
| 629 | 5% Shapiro Wilk Critical Value | 0.859 | Data Not Lognormal at 5% Significance Level | |
| 630 | Lilliefors Test Statistic | 0.296 | **Lilliefors Lognormal GOF Test** | |
| 631 | 5% Lilliefors Critical Value | 0.243 | Data Not Lognormal at 5% Significance Level | |
| 632 | **Data Not Lognormal at 5% Significance Level** | | | |
| 633 | | | | |
| 634 | **Lognormal Statistics** | | | |
| 635 | Minimum of Logged Data | 1.946 | Mean of logged Data | 2.738 |
| 636 | Maximum of Logged Data | 4.682 | SD of logged Data | 0.768 |
| 637 | | | | |
| 638 | **Assuming Lognormal Distribution** | | | |
| 639 | 95% H-UCL | 37.15 | 90% Chebyshev (MVUE) UCL | 34.17 |
| 640 | 95% Chebyshev (MVUE) UCL | 40.52 | 97.5% Chebyshev (MVUE) UCL | 49.34 |
| 641 | 99% Chebyshev (MVUE) UCL | 66.67 | | |
| 642 | | | | |
| 643 | **Nonparametric Distribution Free UCL Statistics** | | | |
| 644 | **Data do not follow a Discernible Distribution (0.05)** | | | |
| 645 | | | | |
| 646 | **Nonparametric Distribution Free UCLs** | | | |
| 647 | 95% CLT UCL | 35.64 | 95% Jackknife UCL | 36.86 |
| 648 | 95% Standard Bootstrap UCL | 34.93 | 95% Bootstrap-t UCL | 66.94 |
| 649 | 95% Hall's Bootstrap UCL | 79.54 | 95% Percentile Bootstrap UCL | 37.67 |
| 650 | 95% BCA Bootstrap UCL | 45.17 | | |
| 651 | 90% Chebyshev(Mean, Sd) UCL | 46.6 | 95% Chebyshev(Mean, Sd) UCL | 57.59 |
| 652 | 97.5% Chebyshev(Mean, Sd) UCL | 72.84 | 99% Chebyshev(Mean, Sd) UCL | 102.8 |
| 653 | | | | |
| 654 | **Suggested UCL to Use** | | | |
| 655 | 95% Chebyshev (Mean, Sd) UCL | 57.59 | | |
| 656 | | | | |
| 657 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 658 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 659 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 660 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 661 | | | | |
| 662 | | | | |
| 663 | **HMW** | | | |
| 664 | | | | |
| 665 | **General Statistics** | | | |
| 666 | Total Number of Observations | 12 | Number of Distinct Observations | 12 |
| 667 | | | Number of Missing Observations | 0 |
| 668 | Minimum | 3.8 | Mean | 22.26 |
| 669 | Maximum | 58.1 | Median | 21.55 |
| 670 | SD | 15.54 | Std. Error of Mean | 4.487 |
| 671 | Coefficient of Variation | 0.698 | Skewness | 1.059 |
| 672 | | | | |
| 673 | **Normal GOF Test** | | | |
| 674 | Shapiro Wilk Test Statistic | 0.914 | **Shapiro Wilk GOF Test** | |
| 675 | 5% Shapiro Wilk Critical Value | 0.859 | Data appear Normal at 5% Significance Level | |
| 676 | Lilliefors Test Statistic | 0.183 | **Lilliefors GOF Test** | |
| 677 | 5% Lilliefors Critical Value | 0.243 | Data appear Normal at 5% Significance Level | |
| 678 | **Data appear Normal at 5% Significance Level** | | | |
| 679 | | | | |

| | A–E | F | G–K | L |
|---|---|---|---|---|
| 680 | **Assuming Normal Distribution** | | | |
| 681 | **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 682 | 95% Student's-t UCL | 30.32 | 95% Adjusted-CLT UCL (Chen-1995) | 31.1 |
| 683 | | | 95% Modified-t UCL (Johnson-1978) | 30.55 |
| 684 | | | | |
| 685 | **Gamma GOF Test** | | | |
| 686 | A-D Test Statistic | 0.26 | **Anderson-Darling Gamma GOF Test** | |
| 687 | 5% A-D Critical Value | 0.741 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 688 | K-S Test Statistic | 0.158 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 689 | 5% K-S Critical Value | 0.249 | Detected data appear Gamma Distributed at 5% Significance Level | |
| 690 | **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| 691 | | | | |
| 692 | **Gamma Statistics** | | | |
| 693 | k hat (MLE) | 2.027 | k star (bias corrected MLE) | 1.576 |
| 694 | Theta hat (MLE) | 10.98 | Theta star (bias corrected MLE) | 14.13 |
| 695 | nu hat (MLE) | 48.64 | nu star (bias corrected) | 37.81 |
| 696 | MLE Mean (bias corrected) | 22.26 | MLE Sd (bias corrected) | 17.73 |
| 697 | | | Approximate Chi Square Value (0.05) | 24.73 |
| 698 | Adjusted Level of Significance | 0.029 | Adjusted Chi Square Value | 23.13 |
| 699 | | | | |
| 700 | **Assuming Gamma Distribution** | | | |
| 701 | 95% Approximate Gamma UCL (use when n>=50)) | 34.03 | 95% Adjusted Gamma UCL (use when n<50) | 36.39 |
| 702 | | | | |
| 703 | **Lognormal GOF Test** | | | |
| 704 | Shapiro Wilk Test Statistic | 0.928 | **Shapiro Wilk Lognormal GOF Test** | |
| 705 | 5% Shapiro Wilk Critical Value | 0.859 | Data appear Lognormal at 5% Significance Level | |
| 706 | Lilliefors Test Statistic | 0.193 | **Lilliefors Lognormal GOF Test** | |
| 707 | 5% Lilliefors Critical Value | 0.243 | Data appear Lognormal at 5% Significance Level | |
| 708 | **Data appear Lognormal at 5% Significance Level** | | | |
| 709 | | | | |
| 710 | **Lognormal Statistics** | | | |
| 711 | Minimum of Logged Data | 1.335 | Mean of logged Data | 2.836 |
| 712 | Maximum of Logged Data | 4.062 | SD of logged Data | 0.832 |
| 713 | | | | |
| 714 | **Assuming Lognormal Distribution** | | | |
| 715 | 95% H-UCL | 46.57 | 90% Chebyshev (MVUE) UCL | 40.93 |
| 716 | 95% Chebyshev (MVUE) UCL | 48.93 | 97.5% Chebyshev (MVUE) UCL | 60.04 |
| 717 | 99% Chebyshev (MVUE) UCL | 81.87 | | |
| 718 | | | | |
| 719 | **Nonparametric Distribution Free UCL Statistics** | | | |
| 720 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | |
| 721 | | | | |
| 722 | **Nonparametric Distribution Free UCLs** | | | |
| 723 | 95% CLT UCL | 29.64 | 95% Jackknife UCL | 30.32 |
| 724 | 95% Standard Bootstrap UCL | 29.4 | 95% Bootstrap-t UCL | 32.77 |
| 725 | 95% Hall's Bootstrap UCL | 34.44 | 95% Percentile Bootstrap UCL | 29.56 |
| 726 | 95% BCA Bootstrap UCL | 30.71 | | |
| 727 | 90% Chebyshev(Mean, Sd) UCL | 35.72 | 95% Chebyshev(Mean, Sd) UCL | 41.82 |
| 728 | 97.5% Chebyshev(Mean, Sd) UCL | 50.28 | 99% Chebyshev(Mean, Sd) UCL | 66.91 |
| 729 | | | | |
| 730 | **Suggested UCL to Use** | | | |
| 731 | 95% Student's-t UCL | 30.32 | | |
| 732 | | | | |
| 733 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | |
| 734 | Recommendations are based upon data size, data distribution, and skewness. | | | |
| 735 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | |
| 736 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | |
| 737 | | | | |

LMW

| | | | |
|---|---|---|---|
| **General Statistics** | | | |
| Total Number of Observations | 12 | Number of Distinct Observations | 12 |
| | | Number of Missing Observations | 0 |
| Minimum | 64.3 | Mean | 96.83 |
| Maximum | 155.2 | Median | 92.65 |
| SD | 26.37 | Std. Error of Mean | 7.614 |
| Coefficient of Variation | 0.272 | Skewness | 0.931 |
| | | | |
| **Normal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.933 | **Shapiro Wilk GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.859 | Data appear Normal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.14 | **Lilliefors GOF Test** | |
| 5% Lilliefors Critical Value | 0.243 | Data appear Normal at 5% Significance Level | |
| **Data appear Normal at 5% Significance Level** | | | |
| | | | |
| **Assuming Normal Distribution** | | | |
| **95% Normal UCL** | | **95% UCLs (Adjusted for Skewness)** | |
| 95% Student's-t UCL | 110.5 | 95% Adjusted-CLT UCL (Chen-1995) | 111.5 |
| | | 95% Modified-t UCL (Johnson-1978) | 110.8 |
| | | | |
| **Gamma GOF Test** | | | |
| A-D Test Statistic | 0.222 | **Anderson-Darling Gamma GOF Test** | |
| 5% A-D Critical Value | 0.731 | Detected data appear Gamma Distributed at 5% Significance Level | |
| K-S Test Statistic | 0.124 | **Kolmogorov-Smirnov Gamma GOF Test** | |
| 5% K-S Critical Value | 0.245 | Detected data appear Gamma Distributed at 5% Significance Level | |
| **Detected data appear Gamma Distributed at 5% Significance Level** | | | |
| | | | |
| **Gamma Statistics** | | | |
| k hat (MLE) | 15.83 | k star (bias corrected MLE) | 11.93 |
| Theta hat (MLE) | 6.116 | Theta star (bias corrected MLE) | 8.116 |
| nu hat (MLE) | 380 | nu star (bias corrected) | 286.3 |
| MLE Mean (bias corrected) | 96.83 | MLE Sd (bias corrected) | 28.03 |
| | | Approximate Chi Square Value (0.05) | 248.1 |
| Adjusted Level of Significance | 0.029 | Adjusted Chi Square Value | 242.7 |
| | | | |
| **Assuming Gamma Distribution** | | | |
| 95% Approximate Gamma UCL (use when n>=50)) | 111.7 | 95% Adjusted Gamma UCL (use when n<50) | 114.2 |
| | | | |
| **Lognormal GOF Test** | | | |
| Shapiro Wilk Test Statistic | 0.971 | **Shapiro Wilk Lognormal GOF Test** | |
| 5% Shapiro Wilk Critical Value | 0.859 | Data appear Lognormal at 5% Significance Level | |
| Lilliefors Test Statistic | 0.107 | **Lilliefors Lognormal GOF Test** | |
| 5% Lilliefors Critical Value | 0.243 | Data appear Lognormal at 5% Significance Level | |
| **Data appear Lognormal at 5% Significance Level** | | | |
| | | | |
| **Lognormal Statistics** | | | |
| Minimum of Logged Data | 4.164 | Mean of logged Data | 4.541 |
| Maximum of Logged Data | 5.045 | SD of logged Data | 0.261 |
| | | | |
| **Assuming Lognormal Distribution** | | | |
| 95% H-UCL | 112.6 | 90% Chebyshev (MVUE) UCL | 118.7 |
| 95% Chebyshev (MVUE) UCL | 128.7 | 97.5% Chebyshev (MVUE) UCL | 142.5 |
| 99% Chebyshev (MVUE) UCL | 169.7 | | |

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 795 | **Nonparametric Distribution Free UCL Statistics** | | | | | | | | | | | |
| 796 | **Data appear to follow a Discernible Distribution at 5% Significance Level** | | | | | | | | | | | |
| 797 | | | | | | | | | | | | |
| 798 | **Nonparametric Distribution Free UCLs** | | | | | | | | | | | |
| 799 | | | | | 95% CLT UCL | 109.4 | | | | | 95% Jackknife UCL | 110.5 |
| 800 | | | | | 95% Standard Bootstrap UCL | 108.6 | | | | | 95% Bootstrap-t UCL | 114.1 |
| 801 | | | | | 95% Hall's Bootstrap UCL | 116.6 | | | | | 95% Percentile Bootstrap UCL | 109.5 |
| 802 | | | | | 95% BCA Bootstrap UCL | 110.6 | | | | | | |
| 803 | | | | | 90% Chebyshev(Mean, Sd) UCL | 119.7 | | | | | 95% Chebyshev(Mean, Sd) UCL | 130 |
| 804 | | | | | 97.5% Chebyshev(Mean, Sd) UCL | 144.4 | | | | | 99% Chebyshev(Mean, Sd) UCL | 172.6 |
| 805 | | | | | | | | | | | | |
| 806 | **Suggested UCL to Use** | | | | | | | | | | | |
| 807 | | | | | 95% Student's-t UCL | 110.5 | | | | | | |
| 808 | | | | | | | | | | | | |
| 809 | Note: Suggestions regarding the selection of a 95% UCL are provided to help the user to select the most appropriate 95% UCL. | | | | | | | | | | | |
| 810 | Recommendations are based upon data size, data distribution, and skewness. | | | | | | | | | | | |
| 811 | These recommendations are based upon the results of the simulation studies summarized in Singh, Maichle, and Lee (2006). | | | | | | | | | | | |
| 812 | However, simulations results will not cover all Real World data sets; for additional insight the user may want to consult a statistician. | | | | | | | | | | | |
| 813 | | | | | | | | | | | | |

**Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | ProUCL 5.111/16/2018 12:59:44 PM |
| From File | WorkSheet_a.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Substantial Difference | 0.000 |
| Selected Null Hypothesis | Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative) |
| Alternative Hypothesis | Sample 1 Mean/Median <> Sample 2 Mean/Median |

**Sample 1 Data: Arsenic-Site**

**Sample 2 Data: Arsenic-Back**

**Raw Statistics**

| | Sample 1 | Sample 2 |
|---|---|---|
| Number of Valid Observations | 15 | 3 |
| Number of Distinct Observations | 12 | 3 |
| Minimum | 17 | 9 |
| Maximum | 78 | 13 |
| Mean | 31.13 | 11 |
| Median | 24 | 11 |
| SD | 17.76 | 2 |
| SE of Mean | 4.586 | 1.155 |

**Wilcoxon-Mann-Whitney (WMW) Test**

**H0: Mean/Median of Sample 1 = Mean/Median of Sample 2**

| | |
|---|---|
| Sample 1 Rank Sum W-Stat | 165 |
| WMW U-Stat | 45 |
| Mean (U) | 22.5 |
| SD(U) - Adj ties | 8.424 |
| Lower U-Stat Critical Value (0.025) | 6 |
| Upper U-Stat Critical Value (0.975) | 39 |
| Standardized WMW U-Stat | 2.672 |
| Approximate P-Value | 0.00753 |

**Conclusion with Alpha = 0.05**

**Reject H0, Conclude Sample 1 <> Sample 2**

**Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | ProUCL 5.111/16/2018 1:06:30 PM |
| From File | WorkSheet_a.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Substantial Difference | 0.000 |
| Selected Null Hypothesis | Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative) |
| Alternative Hypothesis | Sample 1 Mean/Median <> Sample 2 Mean/Median |

**Sample 1 Data: Chromium-Site**

**Sample 2 Data: Chromium-Back**

**Raw Statistics**

| | Sample 1 | Sample 2 |
|---|---|---|
| Number of Valid Observations | 15 | 3 |
| Number of Distinct Observations | 13 | 3 |
| Minimum | 11 | 11 |
| Maximum | 98 | 22 |
| Mean | 34.4 | 16.33 |
| Median | 31 | 16 |
| SD | 22.64 | 5.508 |
| SE of Mean | 5.846 | 3.18 |

**Wilcoxon-Mann-Whitney (WMW) Test**

**H0: Mean/Median of Sample 1 = Mean/Median of Sample 2**

| | |
|---|---|
| Sample 1 Rank Sum W-Stat | 158.5 |
| WMW U-Stat | 38.5 |
| Mean (U) | 22.5 |
| SD(U) - Adj ties | 8.432 |
| Lower U-Stat Critical Value (0.025) | 6 |
| Upper U-Stat Critical Value (0.975) | 39 |
| Standardized WMW U-Stat | 1.898 |
| Approximate P-Value | 0.0576 |

**Conclusion with Alpha = 0.05**

**Do Not Reject H0, Conclude Sample 1 = Sample 2**

## Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | ProUCL 5.111/16/2018 1:41:07 PM |
| From File | WorkSheet_a.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Substantial Difference | 0.000 |
| Selected Null Hypothesis | Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative) |
| Alternative Hypothesis | Sample 1 Mean/Median <> Sample 2 Mean/Median |

**Sample 1 Data: Chry-Site**

**Sample 2 Data: Chry-Back**

**Raw Statistics**

| | Sample 1 | Sample 2 |
|---|---|---|
| Number of Valid Observations | 15 | 3 |
| Number of Distinct Observations | 15 | 2 |
| Minimum | 0.14 | 0.01 |
| Maximum | 1.7 | 0.03 |
| Mean | 0.769 | 0.0233 |
| Median | 0.66 | 0.03 |
| SD | 0.482 | 0.0115 |
| SE of Mean | 0.124 | 0.00667 |

**Wilcoxon-Mann-Whitney (WMW) Test**

**H0: Mean/Median of Sample 1 = Mean/Median of Sample 2**

| | |
|---|---|
| Sample 1 Rank Sum W-Stat | 165 |
| WMW U-Stat | 45 |
| Mean (U) | 22.5 |
| SD(U) - Adj ties | 8.441 |
| Lower U-Stat Critical Value (0.025) | 6 |
| Upper U-Stat Critical Value (0.975) | 39 |
| Standardized WMW U-Stat | 2.667 |
| Approximate P-Value | 0.00765 |

**Conclusion with Alpha = 0.05**

**Reject H0, Conclude Sample 1 <> Sample 2**

| | | |
|---|---|---|
| Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs | | |
| User Selected Options | | |
| Date/Time of Computation | ProUCL 5.111/16/2018 1:08:29 PM | |
| From File | WorkSheet_a.xls | |
| Full Precision | OFF | |
| Confidence Coefficient | 95% | |
| Substantial Difference | 0.000 | |
| Selected Null Hypothesis | Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative) | |
| Alternative Hypothesis | Sample 1 Mean/Median <> Sample 2 Mean/Median | |

**Sample 1 Data: Cobalt-Site**

**Sample 2 Data: Cobalt-Back**

**Raw Statistics**

| | Sample 1 | Sample 2 |
|---|---|---|
| Number of Valid Observations | 15 | 3 |
| Number of Distinct Observations | 10 | 3 |
| Minimum | 8 | 7 |
| Maximum | 22 | 10 |
| Mean | 13.53 | 8.333 |
| Median | 13 | 8 |
| SD | 3.739 | 1.528 |
| SE of Mean | 0.965 | 0.882 |

**Wilcoxon-Mann-Whitney (WMW) Test**

**H0: Mean/Median of Sample 1 = Mean/Median of Sample 2**

| | |
|---|---|
| Sample 1 Rank Sum W-Stat | 162 |
| WMW U-Stat | 42 |
| Mean (U) | 22.5 |
| SD(U) - Adj ties | 8.375 |
| Lower U-Stat Critical Value (0.025) | 6 |
| Upper U-Stat Critical Value (0.975) | 39 |
| Standardized WMW U-Stat | 2.329 |
| Approximate P-Value | 0.0198 |

**Conclusion with Alpha = 0.05**

**Reject H0, Conclude Sample 1 <> Sample 2**

## Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | ProUCL 5.111/16/2018 1:10:42 PM |
| From File | WorkSheet_a.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Substantial Difference | 0.000 |
| Selected Null Hypothesis | Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative) |
| Alternative Hypothesis | Sample 1 Mean/Median <> Sample 2 Mean/Median |

**Sample 1 Data: Copper-Site**

**Sample 2 Data: Copper-Back**

**Raw Statistics**

| | Sample 1 | Sample 2 |
|---|---|---|
| Number of Valid Observations | 15 | 3 |
| Number of Distinct Observations | 14 | 3 |
| Minimum | 63 | 6 |
| Maximum | 260 | 14 |
| Mean | 145.3 | 9.333 |
| Median | 147 | 8 |
| SD | 50.21 | 4.163 |
| SE of Mean | 12.96 | 2.404 |

**Wilcoxon-Mann-Whitney (WMW) Test**

**H0: Mean/Median of Sample 1 = Mean/Median of Sample 2**

| | |
|---|---|
| Sample 1 Rank Sum W-Stat | 165 |
| WMW U-Stat | 45 |
| Mean (U) | 22.5 |
| SD(U) - Adj ties | 8.441 |
| Lower U-Stat Critical Value (0.025) | 6 |
| Upper U-Stat Critical Value (0.975) | 39 |
| Standardized WMW U-Stat | 2.667 |
| Approximate P-Value | 0.00765 |

**Conclusion with Alpha = 0.05**

**Reject H0, Conclude Sample 1 <> Sample 2**

## Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | ProUCL 5.111/16/2018 1:37:59 PM |
| From File | WorkSheet_a.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Substantial Difference | 0.000 |
| Selected Null Hypothesis | Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative) |
| Alternative Hypothesis | Sample 1 Mean/Median <> Sample 2 Mean/Median |

**Sample 1 Data: F3-Site**

**Sample 2 Data: F3-Back**

**Raw Statistics**

| | Sample 1 | Sample 2 |
|---|---|---|
| Number of Valid Observations | 15 | 3 |
| Number of Distinct Observations | 15 | 2 |
| Minimum | 38 | 15 |
| Maximum | 419 | 22 |
| Mean | 187.9 | 17.33 |
| Median | 200 | 15 |
| SD | 112.2 | 4.041 |
| SE of Mean | 28.96 | 2.333 |

**Wilcoxon-Mann-Whitney (WMW) Test**

**H0: Mean/Median of Sample 1 = Mean/Median of Sample 2**

| | |
|---|---|
| Sample 1 Rank Sum W-Stat | 165 |
| WMW U-Stat | 45 |
| Mean (U) | 22.5 |
| SD(U) - Adj ties | 8.441 |
| Lower U-Stat Critical Value (0.025) | 6 |
| Upper U-Stat Critical Value (0.975) | 39 |
| Standardized WMW U-Stat | 2.667 |
| Approximate P-Value | 0.00765 |

**Conclusion with Alpha = 0.05**

**Reject H0, Conclude Sample 1 <> Sample 2**

## Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | ProUCL 5.111/16/2018 1:46:10 PM |
| From File | WorkSheet_a.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Substantial Difference | 0.000 |
| Selected Null Hypothesis | Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative) |
| Alternative Hypothesis | Sample 1 Mean/Median <> Sample 2 Mean/Median |

**Sample 1 Data: Fluoranthene-Site**

**Sample 2 Data: Fluoranthene-Back**

**Raw Statistics**

| | Sample 1 | Sample 2 |
|---|---|---|
| Number of Valid Observations | 15 | 3 |
| Number of Distinct Observations | 14 | 2 |
| Minimum | 0.3 | 0.05 |
| Maximum | 3.93 | 0.07 |
| Mean | 1.669 | 0.0633 |
| Median | 1.37 | 0.07 |
| SD | 1.137 | 0.0115 |
| SE of Mean | 0.294 | 0.00667 |

**Wilcoxon-Mann-Whitney (WMW) Test**

**H0: Mean/Median of Sample 1 = Mean/Median of Sample 2**

| | |
|---|---|
| Sample 1 Rank Sum W-Stat | 165 |
| WMW U-Stat | 45 |
| Mean (U) | 22.5 |
| SD(U) - Adj ties | 8.437 |
| Lower U-Stat Critical Value (0.025) | 6 |
| Upper U-Stat Critical Value (0.975) | 39 |
| Standardized WMW U-Stat | 2.668 |
| Approximate P-Value | 0.00762 |

**Conclusion with Alpha = 0.05**

**Reject H0, Conclude Sample 1 <> Sample 2**

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | **Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs** | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | User Selected Options | | | | | | | | | | | |
| 4 | Date/Time of Computation | | | ProUCL 5.111/16/2018 1:14:46 PM | | | | | | | | |
| 5 | From File | | | WorkSheet_a.xls | | | | | | | | |
| 6 | Full Precision | | | OFF | | | | | | | | |
| 7 | Confidence Coefficient | | | 95% | | | | | | | | |
| 8 | Substantial Difference | | | 0.000 | | | | | | | | |
| 9 | Selected Null Hypothesis | | | Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative) | | | | | | | | |
| 10 | Alternative Hypothesis | | | Sample 1 Mean/Median <> Sample 2 Mean/Median | | | | | | | | |
| 11 | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | |
| 13 | **Sample 1 Data: Lead-Site** | | | | | | | | | | | |
| 14 | **Sample 2 Data: Lead-Back** | | | | | | | | | | | |
| 15 | | | | | | | | | | | | |
| 16 | | | | **Raw Statistics** | | | | | | | | |
| 17 | | | | | Sample 1 | Sample 2 | | | | | | |
| 18 | Number of Valid Observations | | | | 15 | 3 | | | | | | |
| 19 | Number of Distinct Observations | | | | 13 | 3 | | | | | | |
| 20 | Minimum | | | | 54.4 | 5.9 | | | | | | |
| 21 | Maximum | | | | 728 | 7.4 | | | | | | |
| 22 | Mean | | | | 286.9 | 6.6 | | | | | | |
| 23 | Median | | | | 252 | 6.5 | | | | | | |
| 24 | SD | | | | 165.1 | 0.755 | | | | | | |
| 25 | SE of Mean | | | | 42.62 | 0.436 | | | | | | |
| 26 | | | | | | | | | | | | |
| 27 | | | **Wilcoxon-Mann-Whitney (WMW) Test** | | | | | | | | | |
| 28 | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | |
| 30 | **H0: Mean/Median of Sample 1 = Mean/Median of Sample 2** | | | | | | | | | | | |
| 31 | | | | | | | | | | | | |
| 32 | Sample 1 Rank Sum W-Stat | | | | 165 | | | | | | | |
| 33 | WMW U-Stat | | | | 45 | | | | | | | |
| 34 | Mean (U) | | | | 22.5 | | | | | | | |
| 35 | SD(U) - Adj ties | | | | 8.437 | | | | | | | |
| 36 | Lower U-Stat Critical Value (0.025) | | | | 6 | | | | | | | |
| 37 | Upper U-Stat Critical Value (0.975) | | | | 39 | | | | | | | |
| 38 | Standardized WMW U-Stat | | | | 2.668 | | | | | | | |
| 39 | Approximate P-Value | | | | 0.00762 | | | | | | | |
| 40 | | | | | | | | | | | | |
| 41 | **Conclusion with Alpha = 0.05** | | | | | | | | | | | |
| 42 | **Reject H0, Conclude Sample 1 <> Sample 2** | | | | | | | | | | | |
| 43 | | | | | | | | | | | | |
| 44 | | | | | | | | | | | | |

## Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | ProUCL 5.111/16/2018 1:22:27 PM |
| From File | WorkSheet_a.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Substantial Difference | 0.000 |
| Selected Null Hypothesis | Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative) |
| Alternative Hypothesis | Sample 1 Mean/Median <> Sample 2 Mean/Median |

**Sample 1 Data: Molybdenum-Site**

**Sample 2 Data: Molybdenum-Back**

**Raw Statistics**

| | Sample 1 | Sample 2 |
|---|---|---|
| Number of Valid Observations | 15 | 3 |
| Number of Distinct Observations | 6 | 2 |
| Minimum | 2 | 2 |
| Maximum | 9 | 3 |
| Mean | 4.933 | 2.333 |
| Median | 4 | 2 |
| SD | 2.463 | 0.577 |
| SE of Mean | 0.636 | 0.333 |

**Wilcoxon-Mann-Whitney (WMW) Test**

**H0: Mean/Median of Sample 1 = Mean/Median of Sample 2**

| | |
|---|---|
| Sample 1 Rank Sum W-Stat | 158.5 |
| WMW U-Stat | 38.5 |
| Mean (U) | 22.5 |
| SD(U) - Adj ties | 8.367 |
| Lower U-Stat Critical Value (0.025) | 6 |
| Upper U-Stat Critical Value (0.975) | 39 |
| Standardized WMW U-Stat | 1.933 |
| Approximate P-Value | 0.0533 |

**Conclusion with Alpha = 0.05**

**Do Not Reject H0, Conclude Sample 1 = Sample 2**

## Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | ProUCL 5.111/19/2018 3:01:08 PM |
| From File | WorkSheet.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Substantial Difference | 0.000 |
| Selected Null Hypothesis | Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative) |
| Alternative Hypothesis | Sample 1 Mean/Median <> Sample 2 Mean/Median |

**Sample 1 Data: mTPH-Site**

**Sample 2 Data: mTPH-Back**

**Raw Statistics**

| | Sample 1 | Sample 2 |
|---|---|---|
| Number of Valid Observations | 15 | 3 |
| Number of Distinct Observations | 15 | 2 |
| Minimum | 38 | 20 |
| Maximum | 419 | 22 |
| Mean | 189.2 | 20.67 |
| Median | 200 | 20 |
| SD | 113.1 | 1.155 |
| SE of Mean | 29.2 | 0.667 |

**Wilcoxon-Mann-Whitney (WMW) Test**

**H0: Mean/Median of Sample 1 = Mean/Median of Sample 2**

| | |
|---|---|
| Sample 1 Rank Sum W-Stat | 165 |
| WMW U-Stat | 45 |
| Mean (U) | 22.5 |
| SD(U) - Adj ties | 8.441 |
| Lower U-Stat Critical Value (0.025) | 6 |
| Upper U-Stat Critical Value (0.975) | 39 |
| Standardized WMW U-Stat | 2.667 |
| Approximate P-Value | 0.00765 |

**Conclusion with Alpha = 0.05**

**Reject H0, Conclude Sample 1 <> Sample 2**

**Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs**

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | ProUCL 5.111/16/2018 1:25:19 PM |
| From File | WorkSheet_a.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Substantial Difference | 0.000 |
| Selected Null Hypothesis | Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative) |
| Alternative Hypothesis | Sample 1 Mean/Median <> Sample 2 Mean/Median |

**Sample 1 Data: Nickel-Site**

**Sample 2 Data: Nickel-Back**

**Raw Statistics**

| | Sample 1 | Sample 2 |
|---|---|---|
| Number of Valid Observations | 15 | 3 |
| Number of Distinct Observations | 10 | 3 |
| Minimum | 9 | 11 |
| Maximum | 45 | 18 |
| Mean | 21.73 | 14 |
| Median | 22 | 13 |
| SD | 8.102 | 3.606 |
| SE of Mean | 2.092 | 2.082 |

**Wilcoxon-Mann-Whitney (WMW) Test**

**H0: Mean/Median of Sample 1 = Mean/Median of Sample 2**

| | |
|---|---|
| Sample 1 Rank Sum W-Stat | 157 |
| WMW U-Stat | 37 |
| Mean (U) | 22.5 |
| SD(U) - Adj ties | 8.419 |
| Lower U-Stat Critical Value (0.025) | 6 |
| Upper U-Stat Critical Value (0.975) | 39 |
| Standardized WMW U-Stat | 1.726 |
| Approximate P-Value | 0.0844 |

**Conclusion with Alpha = 0.05**

**Do Not Reject H0, Conclude Sample 1 = Sample 2**

## Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | ProUCL 5.111/16/2018 1:49:50 PM |
| From File | WorkSheet_a.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Substantial Difference | 0.000 |
| Selected Null Hypothesis | Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative) |
| Alternative Hypothesis | Sample 1 Mean/Median <> Sample 2 Mean/Median |

**Sample 1 Data: Phenanthrene-Site**

**Sample 2 Data: Phenanthrene-Back**

**Raw Statistics**

| | Sample 1 | Sample 2 |
|---|---|---|
| Number of Valid Observations | 15 | 3 |
| Number of Distinct Observations | 15 | 3 |
| Minimum | 0.22 | 0.03 |
| Maximum | 4.05 | 0.06 |
| Mean | 1.424 | 0.0433 |
| Median | 1.26 | 0.04 |
| SD | 1.02 | 0.0153 |
| SE of Mean | 0.263 | 0.00882 |

**Wilcoxon-Mann-Whitney (WMW) Test**

**H0: Mean/Median of Sample 1 = Mean/Median of Sample 2**

| | |
|---|---|
| Sample 1 Rank Sum W-Stat | 165 |
| WMW U-Stat | 45 |
| Mean (U) | 22.5 |
| SD(U) - Adj ties | 8.441 |
| Lower U-Stat Critical Value (0.025) | 6 |
| Upper U-Stat Critical Value (0.975) | 39 |
| Standardized WMW U-Stat | 2.606 |
| Approximate P-Value | 0.00915 |

**Conclusion with Alpha = 0.05**

**Reject H0, Conclude Sample 1 <> Sample 2**

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | User Selected Options | | | | | | | | | | | |
| 4 | Date/Time of Computation | | | ProUCL 5.111/16/2018 1:50:59 PM | | | | | | | | |
| 5 | From File | | | WorkSheet_a.xls | | | | | | | | |
| 6 | Full Precision | | | OFF | | | | | | | | |
| 7 | Confidence Coefficient | | | 95% | | | | | | | | |
| 8 | Substantial Difference | | | 0.000 | | | | | | | | |
| 9 | Selected Null Hypothesis | | | Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative) | | | | | | | | |
| 10 | Alternative Hypothesis | | | Sample 1 Mean/Median <> Sample 2 Mean/Median | | | | | | | | |
| 11 | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | |
| 13 | **Sample 1 Data: Pyrene-Site** | | | | | | | | | | | |
| 14 | **Sample 2 Data: Pyrene-Back** | | | | | | | | | | | |
| 15 | | | | | | | | | | | | |
| 16 | | | | **Raw Statistics** | | | | | | | | |
| 17 | | | | | Sample 1 | Sample 2 | | | | | | |
| 18 | Number of Valid Observations | | | | 15 | 3 | | | | | | |
| 19 | Number of Distinct Observations | | | | 15 | 2 | | | | | | |
| 20 | Minimum | | | | 0.24 | 0.05 | | | | | | |
| 21 | Maximum | | | | 2.98 | 0.06 | | | | | | |
| 22 | Mean | | | | 1.307 | 0.0533 | | | | | | |
| 23 | Median | | | | 1.13 | 0.05 | | | | | | |
| 24 | SD | | | | 0.833 | 0.00577 | | | | | | |
| 25 | SE of Mean | | | | 0.215 | 0.00333 | | | | | | |
| 26 | | | | | | | | | | | | |
| 27 | | | | **Wilcoxon-Mann-Whitney (WMW) Test** | | | | | | | | |
| 28 | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | |
| 30 | **H0: Mean/Median of Sample 1 = Mean/Median of Sample 2** | | | | | | | | | | | |
| 31 | | | | | | | | | | | | |
| 32 | Sample 1 Rank Sum W-Stat | | | | 165 | | | | | | | |
| 33 | WMW U-Stat | | | | 45 | | | | | | | |
| 34 | Mean (U) | | | | 22.5 | | | | | | | |
| 35 | SD(U) - Adj ties | | | | 8.441 | | | | | | | |
| 36 | Lower U-Stat Critical Value (0.025) | | | | 6 | | | | | | | |
| 37 | Upper U-Stat Critical Value (0.975) | | | | 39 | | | | | | | |
| 38 | Standardized WMW U-Stat | | | | 2.667 | | | | | | | |
| 39 | Approximate P-Value | | | | 0.00765 | | | | | | | |
| 40 | | | | | | | | | | | | |
| 41 | **Conclusion with Alpha = 0.05** | | | | | | | | | | | |
| 42 | **Reject H0, Conclude Sample 1 <> Sample 2** | | | | | | | | | | | |
| 43 | | | | | | | | | | | | |
| 44 | | | | | | | | | | | | |

## Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | ProUCL 5.111/16/2018 1:31:46 PM |
| From File | WorkSheet_a.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Substantial Difference | 0.000 |
| Selected Null Hypothesis | Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative) |
| Alternative Hypothesis | Sample 1 Mean/Median <> Sample 2 Mean/Median |

**Sample 1 Data: Tin-Site**

**Sample 2 Data: Tin-Back**

**Raw Statistics**

| | Sample 1 | Sample 2 |
|---|---|---|
| Number of Valid Observations | 15 | 3 |
| Number of Distinct Observations | 11 | 2 |
| Minimum | 7 | 3 |
| Maximum | 28 | 4 |
| Mean | 14.73 | 3.333 |
| Median | 13 | 3 |
| SD | 6.617 | 0.577 |
| SE of Mean | 1.708 | 0.333 |

**Wilcoxon-Mann-Whitney (WMW) Test**

**H0: Mean/Median of Sample 1 = Mean/Median of Sample 2**

| | |
|---|---|
| Sample 1 Rank Sum W-Stat | 165 |
| WMW U-Stat | 45 |
| Mean (U) | 22.5 |
| SD(U) - Adj ties | 8.415 |
| Lower U-Stat Critical Value (0.025) | 6 |
| Upper U-Stat Critical Value (0.975) | 39 |
| Standardized WMW U-Stat | 2.675 |
| Approximate P-Value | 0.00747 |

**Conclusion with Alpha = 0.05**

**Reject H0, Conclude Sample 1 <> Sample 2**

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | User Selected Options | | | | | | | | | | | |
| 4 | Date/Time of Computation | | | ProUCL 5.111/16/2018 1:33:00 PM | | | | | | | | |
| 5 | From File | | | WorkSheet_a.xls | | | | | | | | |
| 6 | Full Precision | | | OFF | | | | | | | | |
| 7 | Confidence Coefficient | | | 95% | | | | | | | | |
| 8 | Substantial Difference | | | 0.000 | | | | | | | | |
| 9 | Selected Null Hypothesis | | | Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative) | | | | | | | | |
| 10 | Alternative Hypothesis | | | Sample 1 Mean/Median <> Sample 2 Mean/Median | | | | | | | | |
| 11 | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | |
| 13 | **Sample 1 Data: Uranium-Site** | | | | | | | | | | | |
| 14 | **Sample 2 Data: Uranium-Back** | | | | | | | | | | | |
| 15 | | | | | | | | | | | | |
| 16 | | | | **Raw Statistics** | | | | | | | | |
| 17 | | | | | Sample 1 | Sample 2 | | | | | | |
| 18 | Number of Valid Observations | | | | 15 | 3 | | | | | | |
| 19 | Number of Distinct Observations | | | | 11 | 2 | | | | | | |
| 20 | Minimum | | | | 0.7 | 1.1 | | | | | | |
| 21 | Maximum | | | | 2.5 | 1.4 | | | | | | |
| 22 | Mean | | | | 1.373 | 1.3 | | | | | | |
| 23 | Median | | | | 1.2 | 1.4 | | | | | | |
| 24 | SD | | | | 0.554 | 0.173 | | | | | | |
| 25 | SE of Mean | | | | 0.143 | 0.1 | | | | | | |
| 26 | | | | | | | | | | | | |
| 27 | | | | **Wilcoxon-Mann-Whitney (WMW) Test** | | | | | | | | |
| 28 | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | |
| 30 | **H0: Mean/Median of Sample 1 = Mean/Median of Sample 2** | | | | | | | | | | | |
| 31 | | | | | | | | | | | | |
| 32 | Sample 1 Rank Sum W-Stat | | | | 138.5 | | | | | | | |
| 33 | WMW U-Stat | | | | 18.5 | | | | | | | |
| 34 | Mean (U) | | | | 22.5 | | | | | | | |
| 35 | SD(U) - Adj ties | | | | 8.428 | | | | | | | |
| 36 | Lower U-Stat Critical Value (0.025) | | | | 6 | | | | | | | |
| 37 | Upper U-Stat Critical Value (0.975) | | | | 39 | | | | | | | |
| 38 | Standardized WMW U-Stat | | | | -0.477 | | | | | | | |
| 39 | Approximate P-Value | | | | 0.633 | | | | | | | |
| 40 | | | | | | | | | | | | |
| 41 | **Conclusion with Alpha = 0.05** | | | | | | | | | | | |
| 42 | **Do Not Reject H0, Conclude Sample 1 = Sample 2** | | | | | | | | | | | |
| 43 | | | | | | | | | | | | |
| 44 | | | | | | | | | | | | |

## Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs

| | |
|---|---|
| User Selected Options | |
| Date/Time of Computation | ProUCL 5.111/16/2018 1:34:36 PM |
| From File | WorkSheet_a.xls |
| Full Precision | OFF |
| Confidence Coefficient | 95% |
| Substantial Difference | 0.000 |
| Selected Null Hypothesis | Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative) |
| Alternative Hypothesis | Sample 1 Mean/Median <> Sample 2 Mean/Median |

**Sample 1 Data: Vanadium-Site**

**Sample 2 Data: Vandium-Back**

**Raw Statistics**

| | Sample 1 | Sample 2 |
|---|---|---|
| Number of Valid Observations | 15 | 3 |
| Number of Distinct Observations | 13 | 3 |
| Minimum | 14 | 26 |
| Maximum | 63 | 40 |
| Mean | 40.93 | 33 |
| Median | 45 | 33 |
| SD | 13.61 | 7 |
| SE of Mean | 3.514 | 4.041 |

**Wilcoxon-Mann-Whitney (WMW) Test**

**H0: Mean/Median of Sample 1 = Mean/Median of Sample 2**

| | |
|---|---|
| Sample 1 Rank Sum W-Stat | 154.5 |
| WMW U-Stat | 34.5 |
| Mean (U) | 22.5 |
| SD(U) - Adj ties | 8.432 |
| Lower U-Stat Critical Value (0.025) | 6 |
| Upper U-Stat Critical Value (0.975) | 39 |
| Standardized WMW U-Stat | 1.424 |
| Approximate P-Value | 0.154 |

**Conclusion with Alpha = 0.05**

**Do Not Reject H0, Conclude Sample 1 = Sample 2**

| | A | B | C | D | E | F | G | H | I | J | K | L |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Wilcoxon-Mann-Whitney Sample 1 vs Sample 2 Comparison Test for Uncensor Full Data Sets without NDs | | | | | | | | | | | |
| 2 | | | | | | | | | | | | |
| 3 | User Selected Options | | | | | | | | | | | |
| 4 | Date/Time of Computation | | | ProUCL 5.111/16/2018 1:36:12 PM | | | | | | | | |
| 5 | From File | | | WorkSheet_a.xls | | | | | | | | |
| 6 | Full Precision | | | OFF | | | | | | | | |
| 7 | Confidence Coefficient | | | 95% | | | | | | | | |
| 8 | Substantial Difference | | | 0.000 | | | | | | | | |
| 9 | Selected Null Hypothesis | | | Sample 1 Mean/Median = Sample 2 Mean/Median (Two Sided Alternative) | | | | | | | | |
| 10 | Alternative Hypothesis | | | Sample 1 Mean/Median <> Sample 2 Mean/Median | | | | | | | | |
| 11 | | | | | | | | | | | | |
| 12 | | | | | | | | | | | | |
| 13 | **Sample 1 Data: Zinc-Site** | | | | | | | | | | | |
| 14 | **Sample 2 Data: Zinc-Back** | | | | | | | | | | | |
| 15 | | | | | | | | | | | | |
| 16 | | | | **Raw Statistics** | | | | | | | | |
| 17 | | | | | Sample 1 | Sample 2 | | | | | | |
| 18 | Number of Valid Observations | | | | 15 | 3 | | | | | | |
| 19 | Number of Distinct Observations | | | | 15 | 3 | | | | | | |
| 20 | Minimum | | | | 267 | 30 | | | | | | |
| 21 | Maximum | | | | 5020 | 38 | | | | | | |
| 22 | Mean | | | | 1026 | 34 | | | | | | |
| 23 | Median | | | | 629 | 34 | | | | | | |
| 24 | SD | | | | 1210 | 4 | | | | | | |
| 25 | SE of Mean | | | | 312.5 | 2.309 | | | | | | |
| 26 | | | | | | | | | | | | |
| 27 | | | **Wilcoxon-Mann-Whitney (WMW) Test** | | | | | | | | | |
| 28 | | | | | | | | | | | | |
| 29 | | | | | | | | | | | | |
| 30 | **H0: Mean/Median of Sample 1 = Mean/Median of Sample 2** | | | | | | | | | | | |
| 31 | | | | | | | | | | | | |
| 32 | Sample 1 Rank Sum W-Stat | | | | 165 | | | | | | | |
| 33 | WMW U-Stat | | | | 45 | | | | | | | |
| 34 | Mean (U) | | | | 22.5 | | | | | | | |
| 35 | SD(U) - Adj ties | | | | 8.441 | | | | | | | |
| 36 | Lower U-Stat Critical Value (0.025) | | | | 6 | | | | | | | |
| 37 | Upper U-Stat Critical Value (0.975) | | | | 39 | | | | | | | |
| 38 | Standardized WMW U-Stat | | | | 2.606 | | | | | | | |
| 39 | Approximate P-Value | | | | 0.00915 | | | | | | | |
| 40 | | | | | | | | | | | | |
| 41 | **Conclusion with Alpha = 0.05** | | | | | | | | | | | |
| 42 | **Reject H0, Conclude Sample 1 <> Sample 2** | | | | | | | | | | | |
| 43 | | | | | | | | | | | | |
| 44 | | | | | | | | | | | | |

# Appendix E
# HHRA Supporting Information

**Site-Specific Target Levels for Human Health (Non-Threshold Substances) - Commercial Adult at Marystown Shipyard, Marystown, Newfoundland and Labrador**

**Site Name:** Marystown Shipyard, Marystown, Newfoundland and Labrador
**Receptor:** Adult
**Dust Levels:** Default
**Exposure Scenario:** Commercial

$$SSTL = \frac{TR \times BW \times LE}{ED \times [(AF_{gut} \times SIR \times ET_{ing} \times SF_o) + (AF_{lung} \times IR_{soil} \times ET_{inh} \times SF_i) + (AF_{skin} \times SDR \times ET_{derm} \times SF_o)]} + BSC$$

| **Time on site:** | Default |
|---|---|
| Hours per day (inhalation) | 8 |
| Days per Week | 5 |
| Weeks per Year | 48 |
| Years Exposed | 35 |
| Life Expectancy | 80 |

**Default Scenario?** Yes

| **Compound** | **$SF_o$** $(mg/kg\text{-}d)^{-1}$ | **$SF_i$** $(mg/kg\text{-}d)^{-1}$ | **BSC** (mg/kg) | **$AF_{gut}$** | **$AF_{lung}$** | **$AF_{skin}$** | **SSTL** (mg/kg) |
|---|---|---|---|---|---|---|---|
| **Arsenic** | 1.8 | 27 | 11 | 1 | 1 | 0.03 | 69 |

| Parameter | Definition (units) | Default Value | Reference |
|---|---|---|---|
| **$SF_o$ =** | oral slope factor [ 1/(mg/kg bw-day) ] | chemical specific | Health Canada (2010b) |
| **$SF_i$ =** | inhalation slope factor [ 1/(mg/kg bw-day) ] | chemical specific | Health Canada (2010b) |
| **TR =** | target risk | 0.00001 | Health Canada (2010a) |
| **BSC =** | background sediment concentration | chemical specific | Site-specific - mean concentration |
| **BW =** | body weight (kg) | 70.7 | Health Canada (2010a) - Adult |
| **$AF_{gut}$ =** | absorption factor for gut (unitless) | chemical specific | Assumed 1. |
| **$AF_{lung}$ =** | absorption factor for lung (unitless) | chemical specific | Assumed 1. |
| **$AF_{skin}$ =** | absorption factor skin (unitless) | chemical specific | Health Canada (2010b) |
| **SIR =** | soil ingestion rate (kg/day) | 0.00002 | Health Canada (2010a) - Adult |
| **$IR_{soil}$ =** | soil inhalation rate (kg/day) = CRP ($kg/m^3$) x $IR_{air}$ ($m^3$/day) | 1.2616E-08 | Calculated |
| **SDR =** | soil dermal contact rate (kg/day) = ($SA_{hands}$ x $M_{hands}$) + ($SA_{body}$ x $M_{body}$) x 1E-6 (kg/mg) | 0.000114 | Calculated |
| **$ET_{ing}$ =** | exposure term for soil ingestion pathway (unitless) | 0.659 | Site Specific [ 24 Hours per Day, 5 Days per Week, 48 Weeks per Year] |
| **$ET_{inh}$ =** | exposure term for soil inhalation pathway (unitless) | 0.220 | Site Specific [ 8 Hours per Day, 5 Days per Week, 48 Weeks per Year] |
| **$ET_{derm}$ =** | exposure term for soil dermal contact pathway (unitless) | 0.659 | Site Specific [ 24 Hours per Day, 5 Days per Week, 48 Weeks per Year] |
| **CRP =** | concentration of respirable particles ($kg/m^3$) | 7.60E-10 | Health Canada (2010a) - Default |
| **$IR_{air}$ =** | daily inhalation rate ($m^3$ air/day) | 16.6 | Health Canada (2010a) - Adult |
| **$SA_{hands}$ =** | skin surface area - hands ($cm^2$/day) | 890 | Health Canada (2010a) - Adult |
| **$SA_{body}$ =** | skin surface area - arms ($cm^2$/day) | 2500 | Health Canada (2010a) - Adult |
| **$M_{hands}$ =** | soil to skin adherence factor - hands ($mg/cm^2$) | 0.1 | Health Canada (2010a) - Adult |
| **$M_{body}$ =** | soil to skin adherence factor - rest of body ($mg/cm^2$) | 0.01 | Health Canada (2010a) - Adult |

**Site Specific Target Levels for Human Health (Non-carcinogenic Substances) - Adult at Marystown Shipyard, Marystown, Newfoundland and Labrador**

**Site Name:** Marystown Shipyard, Marystown, Newfoundland and Labrador **Receptor:** Adult **Dust Levels:** Default

**Exposure Scenario:** Commercial

$$SSTL = \frac{HQ \times BW}{((1/(TDI - EDI) \times AF_{gut} \times SIR \times ET_{ing}) + ((1/(TDI - EDI)) \times AF_{lung} \times IR_{soil} \times ET_{inh}) + ((1/(TDI - EDI)) \times AF_{skin} \times SDR \times ET_{derm})} + BSC$$

**Time on site:**

| | |
|---|---|
| Hours per day (inhalation) | 8 |
| Days per Week | 5 |
| Weeks per Year | 52 |

| Compound | TDI (oral) | TDI (inhalation) | EDI | THQ | BSC | $AF_{gut}$ | $AF_{lung}$ | $AF_{skin}$ | SSTL (mg/kg) | Comments |
|---|---|---|---|---|---|---|---|---|---|---|
| Lead | 0.0011 | 0.0011 | | 1 | 6.6 | 0.6 | 1 | 0.006 | 8,588 | Developmental Toxicant. No Amortization. |

| Parameter | Definition (units) | Default Value | Reference |
|---|---|---|---|
| **TDI =** | reference dose (mg/kg bw-day) | chemical specific | Lead - AFWEI (2015) |
| **EDI =** | estimated daily intake (multimedia exposure assessment) (mg/kg bw-day) | chemical specific | Not available. |
| **THQ =** | target hazard quotient (unitless) | chemical specific | Health Canada (2012) |
| **BW =** | body weight (kg) | 70.7 | Health Canada (2012) - Adult |
| **BSC =** | background sediment concentration (mg/kg) | chemical specific | Site-specific - mean concentration |
| **$AF_{gut}$ =** | absorption factor for gut (unitless) | chemical specific | Assumed 1. |
| **$AF_{lung}$ =** | absorption factor for lung (unitless) | chemical specific | Assumed 1. |
| **$AF_{skin}$ =** | absorption factor skin (unitless) | chemical specific | Antimony - Ontario MOECC (2016); Iron - USEPA RSL (2018); Lead - AFWEI (2015) |
| **SIR =** | soil ingestion rate (kg/day) | 0.00002 | Health Canada (2012) - Adult |
| **$IR_{soil}$ =** | soil inhalation rate (kg/day) = CRP (kg/m$^3$) x $IR_{air}$ (m$^3$/day) | 1.3E-08 | Calculated |
| **SDR =** | soil dermal contact rate (kg/day) = ($SA_{hands}$ x $M_{hands}$) + ($SA_{body}$ x $M_{body}$) x 1E-6 (kg/mg) | 0.000114 | Calculated |
| **$ET_{ing}$ =** | exposure term for soil i exposure term for soil ingestion pathway (unitless) | 0.7143 | Site Specific [ 8 Hours per Day, 5 Days per Week, 52 Weeks per Year] |
| **$ET_{inh}$ =** | exposure term for soil i exposure term for soil inhalation pathway (unitless) | 0.2381 | Site Specific [ 8 Hours per Day, 5 Days per Week, 52 Weeks per Year] |
| **$ET_{derm}$ =** | exposure term for soil c exposure term for soil dermal contact pathway (unitless) | 0.7143 | Site Specific [ 8 Hours per Day, 5 Days per Week, 52 Weeks per Year] |
| **$ET_{ing}$ =** | exposure term for soil ingestion pathway (unitless) - developmental toxicant | 0.7143 | Site Specific [ 24 Hours per Day, 5 Days per Week] |
| **$ET_{inh}$ =** | exposure term for soil inhalation pathway (unitless) - developmental toxicant | 0.2381 | Site Specific [ 8 Hours per Day, 5 Days per Week] |
| **$ET_{derm}$ =** | exposure term for soil dermal contact pathway (unitless) - developmental toxicant | 0.7143 | Site Specific [ 24 Hours per Day, 5 Days per Week] |
| **CRP =** | concentration of respirable particles (kg/m$^3$) | 7.60E-10 | Health Canada (2012) - Default |
| **$IR_{air}$ =** | daily inhalation rate (m$^3$/day) | 16.6 | Health Canada (2012) - Adult |
| **$SA_{hands}$ =** | skin surface area - hands (cm$^2$/day) | 890 | Health Canada (2012) - Adult |
| **$SA_{body}$ =** | skin surface area - rest of body (cm$^2$/day) | 2500 | Health Canada (2012) - Adult - arms |
| **$M_{hands}$ =** | soil to skin adherence factor - hands (mg/cm$^2$) | 0.1 | Health Canada (2012) - Adult |
| **$M_{body}$ =** | soil to skin adherence factor - rest of body (mg/cm$^2$) | 0.01 | Health Canada (2012) - Adult |

**Site-Specific Target Levels for Human Health (Non-Carcinogenic Substances) - Recreational/Commercial Fisher Consumption of Shellfish Toddler at Marystown Shipyard, Marystown, Newfoundland and Labrador**

**Site Name:** Marystown Shipyard, Marystown, Newfoundland and Labrador

**Receptor:** Toddler

**Exposure Scenario:** Recreational/Commercial Fisher

**Exposure Pathway:** Consumption of Shellfish

$$SSTL = \frac{TDI \times THQ \times BW}{AF_{gut} \times IR_{fish} \times EF1 \times EF2} + BC$$

| Compound | TDI (mg/kg-d) | $AF_{gut}$ | BC (mg/kg) | SSTL (mg/kg) | EPC (mg/kg) |
|---|---|---|---|---|---|
| Cadmium | 0.001 | 1 | 4.9 | 5.9 | 8.6 |

| Parameter | Definition (units) | Default Value | Reference |
|---|---|---|---|
| **TDI =** | reference dose (mg/kg bw-day) | chemical specific | Health Canada (2010) |
| **THQ =** | target hazard quotient (unitless) | 0.2 | Health Canada (2012) |
| **$AF_{gut}$ =** | absorption factor for gut (unitless) | chemical specific | Assumed 1. |
| **$IR_{fish}$ =** | fish ingestion rate (kg/day) | 0.009 | Health Canada (2007) |
| **EF1 =** | exposure frequency (unitless) | 0.71 | Site-Specific; based on 2 days per week exposed/7 days |
| **EF2 =** | exposure frequency (unitless) | 0.50 | Site-Specific; based on 26 weeks per year exposed/52 weeks |
| **BW =** | body weight (kg) | 16.5 | Health Canada (2012) |
| **BC =** | background concentration (mg/kg) | chemical specific | For cadmium, background concentrations are based on site-specific maximum background shellfish concentrations as indicated in Table 7-5 of the main report. |

**Site-Specific Target Levels for Human Health (Non-Carcinogenic Substances) - Recreational/Commercial Fisher Consumption of Shellfish Adult at Marystown Shipyard, Marystown, Newfoundland and Labrador**

**Site Name:** Marystown Shipyard, Marystown, Newfoundland and Labrador

**Receptor:** Adult

**Exposure Scenario:** Recreational/Commercial Fisher

**Exposure Pathway:** Consumption of Shellfish

$$SSTL = \frac{TDI \times THQ \times BW}{AF_{gut} \times IR_{fish} \times EF1 \times EF2} + BC$$

| Compound | TDI (mg/kg-d) | $AF_{gut}$ | BC (mg/kg) | SSTL (mg/kg) | EPC (mg/kg) |
|---|---|---|---|---|---|
| Cadmium | 0.001 | 1 | 4.9 | 9.3 | 8.6 |

| Parameter | Definition (units) | Default Value | Reference |
|---|---|---|---|
| **TDI =** | reference dose (mg/kg bw-day) | chemical specific | Health Canada (2010) |
| **THQ =** | target hazard quotient (unitless) | 0.2 | Health Canada (2012) |
| **$AF_{gut}$ =** | absorption factor for gut (unitless) | chemical specific | Assumed 1. |
| **$IR_{fish}$ =** | fish ingestion rate (kg/day) | 0.009 | Health Canada (2007) |
| **EF1 =** | exposure frequency (unitless) | 0.71 | Site-Specific; based on 2 days per week exposed/7 days |
| **EF2 =** | exposure frequency (unitless) | 0.50 | Site-Specific; based on 26 weeks per year exposed/52 weeks |
| **BW =** | body weight (kg) | 70.7 | Health Canada (2012) |
| **BC =** | background concentration (mg/kg) | chemical specific | For cadmium, background concentrations are based on site-specific maximum background shellfish concentrations as indicated in Table 7-5 of the main report. |

**Site-Specific Target Levels for Human Health (Non-Carcinogenic Substances) - Recreational/Commercial Fisher - Site Specific Consumption of Shellfish Toddler at Marystown Shipyard, Marystown, Newfoundland and Labrac**

**Site Name:** Marystown Shipyard, Marystown, Newfoundland and Labrador

**Receptor:** Toddler

**Exposure Scenario:** Recreational/Commercial Fisher - Site Specific

**Exposure Pathway:** Consumption of Shellfish

$$SSTL = \frac{TDI \times THQ \times BW}{AF_{gut} \times IR_{fish} \times EF1 \times EF2} + BC$$

| Compound | TDI (mg/kg-d) | $AF_{gut}$ | BC (mg/kg) | SSTL (mg/kg) | EPC (mg/kg) |
|---|---|---|---|---|---|
| Cadmium | 0.001 | 1 | 4.9 | 10.1 | 8.6 |

| Parameter | Definition (units) | Default Value | Reference |
|---|---|---|---|
| **TDI =** | reference dose (mg/kg bw-day) | chemical specific | Health Canada (2010) |
| **THQ =** | target hazard quotient (unitless) | 0.2 | Health Canada (2012) |
| **$AF_{gut}$ =** | absorption factor for gut (unitless) | chemical specific | Assumed 1. |
| **$IR_{fish}$ =** | fish ingestion rate (kg/day) | 0.009 | Health Canada (2007) |
| **EF1 =** | exposure frequency (unitless) | 0.14 | Site-Specific; based on 2 days per week exposed/7 days |
| **EF2 =** | exposure frequency (unitless) | 0.50 | Site-Specific; based on 26 weeks per year exposed/52 weeks |
| **BW =** | body weight (kg) | 16.5 | Health Canada (2012) |
| **BC =** | background concentration (mg/kg) | chemical specific | For cadmium, background concentrations are based on site-specific maximum background shellfish concentrations as indicated in Table 7-5 of the main report. |

# TOXICITY PROFILE

## Arsenic

Arsenic is a natural, ubiquitous element found in soils and minerals. Arsenic can occur in both organic and inorganic forms in the environment with substantially different toxicological effects. For the purposes of this assessment the total concentrations of arsenic are believed to be in the inorganic form.

### Assessment of Carcinogenicity

Exposure to high levels of arsenic has been shown to cause both carcinogenic and non-carcinogenic effects in humans. There is sufficient convincing epidemiological evidences to show that inhalation exposure to inorganic arsenic can increase the risk of developing lung cancer and that the ingestion of inorganic arsenic increases the risk of developing skin cancer, therefore, inorganic arsenic is a known human carcinogen (Environment Canada and Health Canada, 1993; US EPA, 1998; US EPA, 2002). Arsenic is listed as a Group 1 carcinogen by the International Agency for Research on Cancer (IARC, 1987).

### Susceptible Populations

No studies were located regarding unusual susceptibility of any human subpopulation to arsenic; however, since the degree of arsenic toxicity may be influenced by the rate and extent of methylation in the liver, it is likely that members of the population with lower than normal methylating capacity might be more susceptible (ATSDR, 2000).

### Selection of Toxicity Reference Values

A summary of the reviewed studies, and the rationale for the selection of the TRVs used in the HHRA, is outlined below.

**Oral Exposure**

#### Non-Carcinogenic Toxicity Reference Values

Chronic oral exposure to inorganic arsenic in humans has resulted in gastrointestinal effects, anemia, peripheral neuropathy, skin lesions, hyperpigmentation, gangrene of the extremities, vascular lesions, and liver or kidney damage (ATSDR, 2000).

The United States Environmental Protection Agency (US EPA IRIS, 1988, last revised 1993) provides an oral RfD for non-carcinogenic effects from inorganic arsenic of $3 \times 10^{-4}$ mg/kg-day (last revised 1993). This value is based on the extensive data set of both non-cancerous and carcinogenic health effects of Taiwan residents that were exposed to inorganic arsenic (predominately as arsenate (As(V)) in their drinking water. Tseng (1977) studied the prevalence of skin cancer and blackfoot disease in 40,421 inhabitants of an area on the Southwest coast of Taiwan where well water with a high concentration of arsenic was used for over 60 years. The rates of blackfoot disease were recorded for three ranges of arsenic concentrations in well water. The low range (<0.3 ppm arsenic) from the Tseng (1977) study was taken as a LOAEL of 0.17 mg/L (converted to 0.014 mg/kg-day) (Tseng et al., 1968; US EPA 1993).

In an earlier study (Tseng et al., 1968), prevalence of hyperpigmentation, keratosis, skin cancer and blackfoot disease were observed. A control population of 7,500 individuals was also examined. In the control population, 4,978 persons used water with non-detectable levels of arsenic and 2,522 persons used water with 0.001 to 0.017 ppm of arsenic. Not a single case of keratosis, hyperpigmentation or skin cancer was observed in these populations. The US EPA (1993) adopted a NOAEL of 0.009 mg/L based on this study (converted to 0.0008 mg/kg-day).

The RfD was developed based on the NOAEL of 0.8 μg/kg-day of arsenic divided by an uncertainty factor of 3. The uncertainty factor of 3 was to account for both the lack of data to preclude reproductive toxicity as a critical effect and to account for some uncertainty in whether the NOAEL of the critical study accounts for all sensitive individuals; therefore, this RfD is appropriate for comparison to exposures averaged over an entire lifetime (US EPA, 2003). The US EPA weights the selected study as medium given the poor characterization of doses, the presence of other contaminants despite the large sample population (1993).

The World Health Organization (WHO, 1998) provide a provisional Tolerable Daily Intake (TDI) for the dietary ingestion of inorganic arsenic of 2.1 μg/kg-day. The WHO value, however, was developed in the late 1980s and may not be representative of the current knowledge of the health effects related to arsenic exposure.

As arsenic is being assessed on its carcinogenic endpoints via oral exposure, a non-cancer value has not been selected for use in this assessment.

### Cancer Oral Toxicity Reference Values

The US EPA (1998) provides an oral cancer SF of 1.5 $(mg/kg\text{-}day)^{-1}$. The slope factor was based on data provided by the US EPA (2002) from increased incidence of skin cancer in Taiwanese populations orally exposed to arsenic in drinking water (Tseng, 1977; Tseng et al., 1968). These studies did not examine rates of internal cancers (e.g., bladder and lung cancer) and are thus considered to underestimate total carcinogenic risks from arsenic. Arsenic is being reassessed under the Integrated Risk Information System (IRIS) program (US EPA, 1998).

Health Canada (2010) recommends a SF of 1.8 $(mg/kg\text{-}day)^{-1}$. The slope factor was based on an epidemiological study of increased incidence of cancers (bladder, liver, and lung) in Taiwanese populations orally exposed to arsenic in drinking water (Morales, 2000). The TRV was based on the upper end of range of mean unit risks.

The US EPA recently lowered its drinking water standard from 50 µg/L to 10 µg/L (US EPA 2001a; 2002) because of indications that the total carcinogenic risk from arsenic exposure was previously underestimated. New estimates were based solely on Taiwanese mortality data.

Risks presented by the National Research Council (NRC, 2001) indicate an excess lifetime risk of bladder cancer of $7.1 \times 10^{-5}$ per µg/L based on Taiwan data and $1.8 \times 10^{-4}$ per µg/L based on US data (see Table below).

**Summary of NRC (2001) reported unit risks**

| **Bladder Cancer Unit Risk (per µg/L)** | | **Lung Cancer Unit Risk (per µg/L)** | |
|---|---|---|---|
| US Background Rate | Taiwan Background Rate | US Background Rate | Taiwan Background Rate |
| $1.7 \times 10^{-4}$ | $7.1 \times 10^{-5}$ | $1.6 \times 10^{-4}$ | $5.9 \times 10^{-5}$ |

The NRC reviewed the four recent studies conducted since 1999 as cited above and concluded from their review that the risks from arsenic in drinking water are greater than those on which the previous arsenic standard of 50 µg/L was based as well as the risks that the updated standard of 10 µg/L is based on.

The Health Canada (2010) SF of 1.8 $(mg/kg\text{-}day)^{-1}$ has been adopted for use in this assessment.

***Non-Cancer Inhalation Toxicity Reference Values***

Chronic inhalation exposure to inorganic arsenic in humans is associated with irritation of the skin and mucous membranes (dermatitis, conjunctivitis, pharyngitis, and rhinitis) (ATSDR, 2000). The US EPA has not established a RfC for inorganic arsenic (US EPA, 2002).

A non-cancer inhalation TRV has not been selected for this assessment due to the lack of sufficient data and the fact that arsenic is being assessed as a carcinogen.

***Cancer Inhalation Toxicity Reference Values***

The US EPA has developed a unit risk of $4.3 \times 10^{-3}$ per $µg/m_3$ (last revised April 1998) for carcinogenic risk from inhalation of inorganic arsenic. This is based on unit risk estimates derived for the Anaconda, Montana smelter cohort (3 studies yielding average unit risk of $2.6 \times 10^{-3}$ per $µg/m^3$) and the ASARCO (Tacoma, Washington) smelter cohort (average of two estimates of $7.2 \times 10^{-3}$ per $µg/m^3$) (US EPA, 1993). The midpoint of average unit risk estimated for the two cohorts was adopted by the US EPA for use in developing the unit risk.

Health Canada (2004) made $TD_{05}$ estimates for inhalation carcinogenic risk for the Anaconda, Tacoma and Ronnskar (Sweden) cohorts of 7.83, 10.2, and 50.5 $µg/m^3$, respectively. These equate to unit risks of $6.4 \times 10^{-3}$ per $µg/m^3$, of $4.9 \times 10^{-3}$ per $µg/m^3$, and of $0.99 \times 10^{-3}$ per $µg/m^3$ for the Anaconda, Tacoma, and Ronnskar cohorts, respectively. The Health Canada $TD_{05}$ is based on only the Anaconda smelter data as being the most conservative. Recently, Health Canada

(2010) has recommended an inhalation SF of 2.7 x $10^1$ $(mg/kg\text{-}day)^{-1}$. (which equates to an inhalation unit risk of 6.40 x $10^0$) based on a $TC_{05}$ of 7.8 µg/$m^3$ for arsenic and its inorganic compounds (Health Canada, 1996). This value has been adopted for the purposes of this assessment.

## Bioavailability

For this HHRA, the relative oral and inhalation bioavailability factor for soil was conservatively assumed to be 1 (Health Canada, 2010); while the relative dermal absorption fraction (RAF) was set as 0.03 (Health Canada, 2010).

## Conclusion

The following table presents arsenic TRVs selected for use in this risk assessment.

**Table 1 Oral and Inhalation TRVs used in the HHRA**

| COPC | Toxicity Reference Value | Value [a] | Critical Effect | Reference Type | Source |
|---|---|---|---|---|---|
| **Arsenic** | Non-carcinogenic TRV | NE | | | |
| | Carcinogenic Slope Factor – oral | 1.8 | bladder, lung, liver | GCDWQ | Health Canada, 2010 |
| | Carcinogenic Slope Factor - inhalation | 27 | lung cancer | PSL1 | Health Canada, 2010 |

[a] Units: Carcinogenic COPC $(mg/kg/day^{-1})$ , NE – Not Evaluated

## References


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# TOXICITY PROFILE

## Antimony

In humans and animals, the gastrointestinal tract appears to be the primary target for acute and long term oral exposure to antimony. Effects include vomiting and diarrhea. Oral exposure to antimony also may adversely affect the cardiovascular system, blood (for example, increased serum cholesterol levels and decreased glucose levels), and liver. The respiratory tract is the primary target for toxicity of inhaled antimony following acute, sub-chronic, and chronic exposures. Both human and animal data have demonstrated various forms of restrictive airway diseases including: bronchitis pneumoconiosis, emphysema, pulmonary edema, and varying degrees of irritation and inflammation. Inhalation exposure to antimony also may adversely affect the cardiovascular system, kidneys, and reproductive tract. Developmental toxicity is suggested by animal data showing that prenatal and postnatal exposure to antimony may affect cardiovascular functions (ATSDR, 1992).

### Assessment of Carcinogenicity

Animal studies show that there is no evidence of carcinogenicity following oral, dermal or inhalation exposure to antimony.

### Susceptible Populations

An increased incidence of spontaneous abortions, compared to a control group, were reported in women working at an antimony metallurgical plant. The women were exposed to a mixture of antimony trioxide, antimony pentasulphide, and metallic antimony. Women also reported disturbances in their menstrual cycles when exposed to the same antimony compounds (ATSDR, 1992).

### Selection of Toxicity Reference Values

A summary of the reviewed studies, and the rationale for the selection of the TRVs used in the HHRA, is outlined below.

**<u>Oral Exposure</u>**

#### Non-Carcinogenic Toxicity Reference Values

The US EPA (2013) derived a tolerable daily intake (TDI) for antimony of 0.0004 mg/kg-day based on the Schroeder, et al., (1970) study as presented in the Integrated Risk Information System (IRIS) database. An experimental group of 50 male and 50 female rats was administered 5 parts per million (ppm) potassium antimony tartrate in water. Over the period of study, growth rates of treated animals were not affected, but male rats survived 106 and females 107 fewer days than did controls at median life spans. Because there was only one level of antimony administered, a NOEL was not established in this study. Although not precisely stated, the concentration of 5-ppm antimony was expressed as an exposure of 0.35 mg/kg/day.

A UF of 1,000 was applied to the value, 10 for interspecies conversion, 10 to protect sensitive individuals, and 10 because the effect level was a LOAEL of 0.35 mg/kg/day and no NOEL was established.

The US EPA IRIS value of 0.0004 mg/kg-day was used as the exposure limit in this assessment.

**Cancer Oral Toxicity Reference Values**

The lack of suitable positive carcinogenic data precludes the derivation of an oral slope factor for antimony.

**Inhalation Exposure**

**Non-Carcinogenic Toxicity Reference Values**

The derived inhalation tolerable daily intake (TDI) for cobalt of 0.000057 mg/kg-day is based on the OMOE TRV of 0.0002 mg/m$^3$, an inhalation rate of 20 m$^3$/day and a body weight of 70 kg. The OMOE TRV is based on a benchmark concentration of 0.074 mg/m$^3$ for pulmonary toxicity in rats for antimony trioxide converted to human equivalent concentration using benchmark dose modeling as presented by USEPA (1995).

A UF of 300 was applied to the value, 10 for human variability, 10 for extrapolation from sub-chronic to chronic, and 3 for database inadequacies.

**Cancer Inhalation Toxicity Reference Values**

The lack of suitable positive carcinogenic data precludes the derivation of an inhalation slope factor for cobalt.

## Bioavailability

For this HHRA, the relative oral and inhalation bioavailability factor for soil was conservatively assumed to be 1 (Health Canada, 2010); while the relative dermal absorption fraction (RAF) was set as 0.1 (OMOE, 2011).

## Conclusion

The following table presents antimony TRVs selected for use in this risk assessment.

**Table 1 Oral and Inhalation TRVs used in the HHRA**

| COPC | Toxicity Reference Value | Value [a] | Critical Effect | Reference Type | Source |
|---|---|---|---|---|---|
| **Antimony** | Non-carcinogenic TRV | 0.0004 | Longevity, blood glucose, and cholesterol | RfD | IRIS, 1991 |
| | Non-carcinogenic TRV - inhalation | 0.000057 | Pulmonary toxicity, chronic interstitial inflammation | RfC | OMOE, 2011 |
| | Carcinogenic Slope Factor | NE | | | |

[a] Units: Non-carcinogenic COPC (mg/kg/day) , NE – Not Evaluated

## References

ATSDR (Agency for Toxic Substances and Disease Registry), 1992. Toxicological profile for antimony. U.S. Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department Of Health And Human Services, Washington, DC.

Health Canada, 2010. Federal Contaminated Site Risk Assessment in Canada, Part II: Health Canada Toxicological Reference Values (TRVs) and Chemical-Specific Factors, Version 2.0.

IRIS, 1991. Integrated Risk Information System (IRIS), Antimony (CASRN 7440-36-0), February 1991.

OMOE, 2011. Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario, April 15.

Schroeder, H.A., M. Mitchner and A.P. Nasor. 1970. Zirconium, niobium, antimony, vanadium and lead in rats: Life term studies. J. Nutrition. 100: 59-66.

US EPA (United States Environmental Protection Agency), 2013. Integrated Risk Information System (IRIS) Database. Available on-line at: http://www.epa.gov/iris.

# TOXICITY PROFILE

## Cobalt

Effects in humans following acute inhalation, oral and dermal exposures to cobalt have been reported. Occupational exposure of humans to cobalt has reported primarily respiratory effects, including decreased pulmonary function, asthma, interstitial lung disease, wheezing, and dyspnea. Animal studies have further identified respiratory tract hyperplasia, pulmonary fibrosis, and emphysema as sensitive effects of inhaled cobalt. Humans in the workplace have been shown to develop sensitivity to cobalt following inhalation exposures. Exposure to inhaled cobalt aerosols resulted in asthmatic attacks in sensitized individuals. This has been reported to be an allergic reaction within the lungs (ATSDR, 2004).

The most sensitive endpoint following oral exposure appears to be an increase in erythrocyte (polycythemia), hematocrit, and hemoglobin levels in both humans and animals. Following dermal exposure, the most commonly observed effect is dermatitis. Using patch test studies, it has been demonstrated that the dermatitis is most likely caused by an allergic reaction to cobalt with cobalt functioning as a hapten (ATSDR, 2004)

Lethal cardiomyopathy in humans was reported following repeated inhalation of airborne cobalt or ingestion of beer that contained cobalt. Occupational exposure to airborne cobalt is characterized by functional effects on the ventricles and enlargement of the heart, resulting in cardiomyopathy. Exposure of humans to beer containing cobalt as a foam stabilizer resulted in severe effects of the cardiovascular system, including cardiomyopathy and death. As well, gastrointestinal effects including nausea and vomiting and hepatic necrosis were reported (ATSDR, 2004).

### Assessment of Carcinogenicity

Available studies of the carcinogenic effects of cobalt in workers have reported both positive and negative results. Lifetime occupational inhalation studies of cobalt reported increases in lung cancer mortality. As well, animal studies have reported increase in alveolar/bronchiolar neoplasms, with lung tumors occurring with significantly positive trends. USEPA does not report a cancer classification for cobalt (ATSDR, 2004).

### Susceptible Populations

Pregnant women treated with cobalt for hematocrit and hemoglobin levels reported no observable effects to the fetuses. However, animal studies reported stunted fetuses, decrease in the number of litters and average litter weights, and increased mortality (ATSDR, 2004). Following inhalation and oral exposure of male rats to cobalt, adverse effects on the testes were observed (degeneration, atrophy, and decreased weight). An increase in the length of the estrous cycle was also reported in female mice following inhalation exposure (ATSDR, 2004).

### Selection of Toxicity Reference Values

A summary of the reviewed studies, and the rationale for the selection of the TRVs used in the HHRA, is outlined below.

**<u>Oral Exposure</u>**

**Non-Carcinogenic Toxicity Reference Values**

The OMOE (2011) derived an oral tolerable daily intake (TDI) of 0.001 mg/kg-day based on the Davis and Fields (1958) study as presented in the ATSDR (2004) profile for cobalt. Six apparently normal men, ages 20–47, were administered a daily dose of cobalt chloride, administered as a 2% solution diluted in either water or milk, for up to 22 days. Five of the six received 150 mg cobalt chloride per day for the entire exposure period, while the sixth was started on 120 mg/day and later increased to 150 mg/day. Blood samples were obtained daily from free-flowing punctures of fingertips at least 2 hours after eating, and at least 15 hours after the last dosage of cobalt. Blood was analyzed for red blood cell counts, hemoglobin percentage, leukocyte counts, reticulocyte percentages, and thrombocyte counts. Exposure to cobalt resulted in the development of polycythemia in all six subjects. Davis and Fields (1958) identified a LOAEL of 150 mg cobalt chloride per day for increased levels of erythrocytes in volunteers. The dose of 150 mg cobalt chloride/day corresponds to ~1 mg Co/kg/day, assuming a reference body weight of 70 kg.

A UF of 1,000 was applied to the value, 10 for human variability, 10 because the effect level was a LOAEL of 1 mg/kg-day, and 10 for OMOE modification.

The OMOE value of 0.001 mg/kg-day was used as the exposure limit in this assessment.

**Cancer Oral Toxicity Reference Values**

The lack of suitable positive carcinogenic data precludes the derivation of an oral slope factor for cobalt.

**<u>Inhalation Exposure</u>**

**Non-Carcinogenic Toxicity Reference Values**

The derived inhalation tolerable daily intake (TDI) for cobalt of 0.00014 mg/kg-day is based on the OMOE TRV of 0.0005 mg/m$^3$, an inhalation rate of 20 m$^3$/day and a body weight of 70 kg. The OMOE TRV is based on a LOAEL of 0.05 mg/m$^3$ for interstitial lung disease in humans as presented by RIVM (2001).

A UF of 100 was applied to the value, 10 for human variability and 10 for the extrapolation from a LOAEL to a NOAEL.

The OMOE value of 0.0001 mg/kg-day was used as the exposure limit in this assessment.

### Cancer Inhalation Toxicity Reference Values

The lack of suitable positive carcinogenic data precludes the derivation of an inhalation slope factor for cobalt.

## Bioavailability

For this HHRA, the relative oral and inhalation bioavailability factor for soil was conservatively assumed to be 1; while the relative dermal absorption fraction (RAF) was set as 0.01 (OMOE, 2011). For this HHRA, the relative oral bioavailability factor for fish was conservatively assumed to be 1 (Health Canada, 2010).

## Conclusion

The following table presents cobalt TRVs selected for use in this risk assessment.

**Table 1 Oral and Inhalation TRVs used in the HHRA**

| COPC | Toxicity Reference Value | Value [a] | Critical Effect | Reference Type | Source |
|---|---|---|---|---|---|
| Cobalt | Non-carcinogenic TRV – oral | 0.001 | polycythemia | RfD | OMOE, 2011 |
| | Non-carcinogenic TRV - inhalation | 0.00014 | interstitial lung disease | RfC | OMOE, 2011 |
| | Carcinogenic Slope Factor | NE | | | |

[a] Units: Non-carcinogenic COPC (mg/kg/day) , NE – Not Evaluated

## References

ATSDR (Agency for Toxic Substances and Disease Registry), 2004. Toxicological profile for cobalt. U.S. Agency for Toxic Substances and Disease Registry, Public Health Service, U.S. Department Of Health And Human Services, Washington, DC.

OMOE, 2011. Rationale for the Development of Soil and Ground Water Standards for Use at Contaminated Sites in Ontario, April 15.

RIVM, 2001. Re-evaluation of Human-Toxicological Maximum Permissible Risk Levels, RIVM Report 711701 025, March.

# TOXICITY PROFILE

**Lead**

Lead is a naturally occurring element found in the earth's crust. While most of the lead found in the environment is the result of anthropogenic activities, there are significant natural sources as well, including volcanoes, forest fires, sea spray, and weathering of lead-containing minerals (Environment Canada, 1996). The different forms of lead found in the environment are governed by factors such as temperature, pH, and the presence of humic materials. Elemental lead occurs rarely in the ambient environment. The most common form of lead in the environment is Pb2+. Particulate-bound lead emitted from mining operations, smelters, and combustion sources occurs primarily in the form of lead-sulphur compounds such as $PbSO_4$, $PbO{\cdot}PbSO_4$, and PbS (US EPA, 1986). In the ambient atmosphere, lead exists primarily in the form of particulate-bound $PbSO_4$ and $PbCO_3$, and is deposited onto soil and water surfaces in this form (ATSDR, 2007a).

The toxic effects of lead in humans are widely believed to be the same regardless of the route of entry, and are correlated to blood lead (PbB) in the vast majority of studies (ATSDR, 2007b). The effects from chronic exposure to lead in humans and experimental animals are primarily neurological, renal, hematological, reproductive, and developmental (ATSDR, 2007b). Well characterized human health effects include neurotoxicity and renal toxicity, which can be severe at blood lead levels greater than 120 µg/dL (US EPA, 1986). Severe lead exposure in children (PbB above 380 µg/dL) can cause coma, convulsions, and even death.

The most commonly reported and well-studied effects of environmental lead exposure are (1) adverse effects on neurological function and neurobehavioural development in children, and (2) reduced growth rate. However, it remains unclear if lead causes such effects in adults (US EPA, 2004). The effects in children often manifest as decreased IQ and memory, decreased gestation period, and retarded growth rate.

**Assessment of Carcinogenicity**

Epidemiological studies of occupationally exposed adults were not able to demonstrate an increase in cancers among an exposed population compared to a control group. The US EPA (2004) lists lead as a Group 2B, probable human carcinogen, based on sufficient animal evidence but did not recommend derivation of a quantitative estimate of oral carcinogenic risk due to a lack of understanding of the toxicological and pharmacokinetic characteristics of lead.

Health Canada (1992) classified lead as Group IIIB – possibly carcinogenic to humans (inadequate data in humans, limited evidence in animals) according to the classification scheme of the Environmental Health Directorate of Health and Welfare Canada (CCME, 1999). Chemicals classified in Group IIIB are treated as non-carcinogens and are evaluated against a tolerable daily intake (TDI), based on a no observed adverse effects level (NOAEL).

The International Agency for Research on Cancer (IARC) (2006) lists lead and inorganic lead compounds as Group 2A, probably carcinogenic to humans. IARC states that there is limited evidence for the carcinogenicity of inorganic lead compounds in humans.

For this assessment, lead was not assessed as a carcinogen.

**Susceptible Populations**

There is a very large database that documents the effects of acute and chronic lead exposure in adults and children. Extensive summaries of the human health effects of lead are available from a number of sources including ATSDR, 2007b. These reviews show that infants, young children up to the age of six, and developing fetuses in pregnant women are the most susceptible.

**Selection of Toxicity Reference Values**

A summary of the reviewed studies, and the rationale for the selection of the TRVs used in the HHRA, is outlined below.

**<u>Oral Exposure</u>**

**Non-Carcinogenic Toxicity Reference Values**

The 2007 DFO SSC for lead was developed based on a Provisional Tolerable Weekly Intake (PTWI) of 25 µg/kg bw published by the World Health Organization (WHO, 1987). Based on the WHO report, Health Canada published a Tolerable Daily Intake (TDI) for lead of 3.6 µg/kg bw – day and this value was adopted in the derivation of the 2007 DFO SSC. The WHO rescinded their PTWI (WHO, 2011) because they concluded that the PTWI could no longer be considered health protective. In turn, Health Canada withdrew their TDI (3.6 µg/kg bw - day). In December 2009, the Contaminated Sites Division (CSD) of Health Canada published interim guidance on a TRV for lead (Health Canada, 2009) which indicated that until their toxicological review of lead was completed, the Ontario Ministry of the Environment (OMOE, 1994) Intake of Concern (IOC; 1.85 µg/kg bw - day) should be adopted as the TRV for lead, for application in risk assessments at federal contaminated sites. This remains the last guidance published by Health Canada that provides a TRV for lead however it is understood that the Health Canada review is on-going at the time of writing this report.

In the absence of published Health Canada guidance, Amec Foster Wheeler, in collaboration with Dillon Consulting Limited and Stantec Consulting Ltd., has reviewed the recent scientific literature and regulatory guidance and proposed an interim TRV for lead for use in deriving the lead SSC for use at DFO sites in Maritimes and Gulf Region.

Based on the current state of the regulatory guidance published at the time of writing this report, we recommend adopting an interim risk specific dose (RSD) for lead of 1.1 µg/kg-day for all age groups, based on the analysis and discussion presented in Attachment A (i.e., a RSD of 1.1 µg/kg-day was derived for both a toddler and an adult receptor and is considered protective of all other human age classes as well). This approach provides a protective and scientifically sound basis for HHRA of lead at DFO sites in Maritimes and Gulf Region until the draft Health Canada/CCME scientific criteria document has completed public review and is published, or Health Canada releases other guidance or decisions on a lead TRV for use in HHRAs.

While the final form of Health Canada lead guidance is unknown at this time, a preliminary review of the draft CCME scientific criteria document suggests that changes regarding the human health risk assessment of lead may be significant as compared to current CCME guidance. However, the interim lead TRV presented herein is based on a review of current science and the re-assessment being conducted by Health Canada will be based on the same science. Therefore, to the extent possible, we believe that the revised lead SSCs will not be significantly altered by future Health Canada lead guidance. Nevertheless, it is recommended that the DFO SSC for lead be reviewed again after the final Health Canada documentation is published.

**Cancer Oral Toxicity Reference Values**

The lack of suitable positive carcinogenic data precludes the derivation of an oral slope factor for lead.

**Bioavailability**

For this HHRA, the relative oral bioavailability factor for soil was conservatively assumed to be 0.6 (USEPA, 2007); while the relative dermal absorption fraction (RAF) was set as 0.006 (Health Canada, 2008). For this HHRA, the relative oral bioavailability factor for fish was conservatively assumed to be 1 (Health Canada, 2010).

**Conclusion**

The following table presents lead TRVs selected for use in this risk assessment. Note that the oral TRV of 0.001 mg/kg/day was also applied as the inhalation TRV.

**Table 1 Oral TRVs used in the HHRA**

| COPC | Toxicity Reference Value | Value [a] | Critical Effect | Reference Type | Source |
|---|---|---|---|---|---|
| **Lead** | Non-carcinogenic TRV | 0.0011 | Behavioural effects and learning disabilities in children | RSD | AFWEI, 2015 |
| | Carcinogenic Slope Factor | NE | | | |

[a] Units: Non-carcinogenic COPC (mg/kg/day) , NE – Not Evaluated

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# Appendix F
# ERA Supporting Information

**Table F-1**
**Equilibrium Partioning Evaluation - PAHs Sediment**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| Constituent | Units | 18-MNMA-S1 | | | 18-MNMA-S2 | | | 18-MNMA-S3 | | | 18-MNMA-S4 | | | 18-MNMA-S5 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Concentration | Concentration Normalized for TOC | ESBTU | Concentration | Concentration Normalized for TOC | ESBTU | Concentration | Concentration Normalized for TOC | ESBTU | Concentration | Concentration Normalized for TOC | ESBTU | Concentration | Concentration Normalized for TOC | ESBTU |
| Total organic Carbon | g/kg | 19 | | | 62 | | | 57 | | | 57 | | | 49 | | |
| **Fraction Organic Carbon** | | 0.019 | | | 0.062 | | | 0.057 | | | 0.057 | | | 0.049 | | |
| 1-Methylnaphthalene | mg/kg | 0.025 | 1.32 | 3.0E-03 | 0.06 | 0.97 | 2.2E-03 | 0.2 | 3.51 | 7.9E-03 | 0.05 | 0.88 | 2.0E-03 | 0.27 | 5.51 | 1.2E-02 |
| 2-Methylnaphthalene | mg/kg | 0.05 | 2.63 | 5.9E-03 | 0.07 | 1.13 | 2.5E-03 | 0.24 | 4.21 | 9.4E-03 | 0.06 | 1.05 | 2.4E-03 | 0.38 | 7.76 | 1.7E-02 |
| Acenaphthene | mg/kg | 0.122 | 6.42 | 1.3E-02 | 0.146 | 2.35 | 4.8E-03 | 0.279 | 4.89 | 1.0E-02 | 0.168 | 2.95 | 6.0E-03 | 0.728 | 14.86 | 3.0E-02 |
| Acenaphthylene | mg/kg | 0.039 | 2.05 | 4.5E-03 | 0.002 | 0.03 | 7.1E-05 | 0.045 | 0.79 | 1.7E-03 | 0.043 | 0.75 | 1.7E-03 | 0.076 | 1.55 | 3.4E-03 |
| Anthracene | mg/kg | 0.19 | 10.00 | 1.7E-02 | 0.22 | 3.55 | 6.0E-03 | 0.31 | 5.44 | 9.2E-03 | 0.24 | 4.21 | 7.1E-03 | 1.01 | 20.61 | 3.5E-02 |
| Benzo(a)anthracene | mg/kg | 0.36 | 18.95 | 2.3E-02 | 0.42 | 6.77 | 8.1E-03 | 0.58 | 10.18 | 1.2E-02 | 0.43 | 7.54 | 9.0E-03 | 1.55 | 31.63 | 3.8E-02 |
| Benzo(a)pyrene | mg/kg | 0.37 | 19.47 | 2.0E-02 | 0.42 | 6.77 | 7.0E-03 | 0.6 | 10.53 | 1.1E-02 | 0.44 | 7.72 | 8.0E-03 | 1.34 | 27.35 | 2.8E-02 |
| Benzo(b)fluoranthene | mg/kg | 0.36 | 18.95 | 1.9E-02 | 0.39 | 6.29 | 6.4E-03 | 0.55 | 9.65 | 9.9E-03 | 0.41 | 7.19 | 7.3E-03 | 1.23 | 25.10 | 2.6E-02 |
| Benzo(e)pyrene | mg/kg | 0.3 | 15.79 | 1.6E-02 | 0.32 | 5.16 | 5.3E-03 | 0.42 | 7.37 | 7.6E-03 | 0.32 | 5.61 | 5.8E-03 | 0.93 | 18.98 | 2.0E-02 |
| Benzo(g,h,i)perylene | mg/kg | 0.005 | 0.26 | 2.4E-04 | 0.28 | 4.52 | 4.1E-03 | 0.41 | 7.19 | 6.6E-03 | 0.29 | 5.09 | 4.6E-03 | 0.86 | 17.55 | 1.6E-02 |
| Benzo(k)fluoranthene | mg/kg | 0.19 | 10.00 | 1.0E-02 | 0.23 | 3.71 | 3.8E-03 | 0.31 | 5.44 | 5.5E-03 | 0.26 | 4.56 | 4.6E-03 | 0.72 | 14.69 | 1.5E-02 |
| Benzo(j)fluoranthene | mg/kg | 0.21 | 11.05 | 1.1E-02 | 0.21 | 3.39 | 3.5E-03 | 0.35 | 6.14 | 6.3E-03 | 0.23 | 4.04 | 4.1E-03 | 0.73 | 14.90 | 1.5E-02 |
| Chrysene | mg/kg | 0.47 | 24.74 | 2.9E-02 | 0.51 | 8.23 | 9.7E-03 | 0.67 | 11.75 | 1.4E-02 | 0.53 | 9.30 | 1.1E-02 | 1.7 | 34.69 | 4.1E-02 |
| Dibenz(a,h)anthracene | mg/kg | 0.003 | 0.00 | 0.0E+00 | 0.003 | 0.05 | 4.3E-05 | 0.003 | 0.05 | 4.7E-05 | 0.003 | 0.05 | 4.7E-05 | 0.003 | 0.06 | 5.5E-05 |
| Fluoranthene | mg/kg | 0.92 | 48.42 | 6.8E-02 | 0.99 | 0.17 | 2.4E-04 | 1.59 | 27.89 | 3.9E-02 | 1.16 | 20.35 | 2.9E-02 | 3.62 | 73.88 | 1.0E-01 |
| Fluorene | mg/kg | 0.15 | 7.89 | 1.5E-02 | 0.17 | 2.74 | 5.1E-03 | 0.32 | 5.61 | 1.0E-02 | 0.19 | 3.33 | 6.2E-03 | 0.94 | 19.18 | 3.6E-02 |
| Indeno(1,2,3-cd)pyrene | mg/kg | 0.005 | 0.26 | 2.4E-04 | 0.29 | 4.68 | 4.2E-03 | 0.51 | 8.95 | 8.0E-03 | 0.38 | 6.67 | 6.0E-03 | 1.09 | 22.24 | 2.0E-02 |
| Naphthalene | mg/kg | 0.005 | 0.26 | 6.8E-04 | 0.005 | 0.08 | 2.1E-04 | 0.32 | 5.61 | 1.5E-02 | 0.005 | 0.09 | 2.3E-04 | 0.62 | 12.65 | 3.3E-02 |
| Perylene | mg/kg | 0.025 | 1.32 | 1.4E-03 | 0.11 | 1.77 | 1.8E-03 | 0.15 | 2.63 | 2.7E-03 | 0.12 | 2.11 | 2.2E-03 | 0.33 | 6.73 | 7.0E-03 |
| Phenanthrene | mg/kg | 0.91 | 47.89 | 8.0E-02 | 0.94 | 15.16 | 2.5E-02 | 1.67 | 29.30 | 4.9E-02 | 1.12 | 19.65 | 3.3E-02 | 4.05 | 82.65 | 1.4E-01 |
| Pyrene | mg/kg | 0.87 | 45.79 | 6.6E-02 | 0.8 | 12.90 | 1.9E-02 | 1.19 | 20.88 | 3.0E-02 | 0.9 | 15.79 | 2.3E-02 | 2.61 | 53.27 | 7.6E-02 |
| **Total PAH Concentration (not normalized)** | | 5.579 | | | 6.586 | | | 10.717 | | | 7.349 | | | 24.787 | | |
| **Sum ESBTU*** | | 4.0E-01 | | | 1.2E-01 | | | 2.7E-01 | | | 1.7E-01 | | | 7.1E-01 | | |
| **Uncertainty Factor (95 percentile)** | | 4.14 | | | 4.14 | | | 4.14 | | | 4.14 | | | 4.14 | | |
| **Sum ESBTU with Uncertainty Factor*** | | 1.7 | | | 0.49 | | | 1.1 | | | 0.71 | | | 2.9 | | |

Notes:

ESBTU - Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the Final Chronic Value.

COC, PAH FCV - Effect Concentration of a PAH in sediment on an organic carbon basis.

* - Summed ESBTU below 1 represents a low risk to sensitive benthic invertebrates.
* - Summed ESBTU below 3 represents a low risk to common benthic invertebrates.

**Table F-1**
**Equilibrium Partioning Evaluation - PAHs Sediment**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| Constituent | Units | 18-MNMA-S6 | | | 18-MNMA-DUP1 Field Duplicate 18-MNMA-S6 | | | 18-MNMA-S7 | | | 18-MNMA-S8 | | | 18-MNMA-S9 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Concentration | Concentration Normalized for TOC | ESBTU | Concentration | Concentration Normalized for TOC | ESBTU | Concentration | Concentration Normalized for TOC | ESBTU | Concentration | Concentration Normalized for TOC | ESBTU | Concentration | Concentration Normalized for TOC | ESBTU |
| Total organic Carbon | g/kg | 80 | | | 83 | | | 113 | | | 106 | | | 88 | | |
| **Fraction Organic Carbon** | | 0.08 | | | 0.083 | | | 0.113 | | | 0.106 | | | 0.088 | | |
| 1-Methylnaphthalene | mg/kg | 0.06 | 0.75 | 1.7E-03 | 0.025 | 0.30 | 6.8E-04 | 0.025 | 0.22 | 5.0E-04 | 0.025 | 0.24 | 5.3E-04 | 0.2 | 2.27 | 5.10E-03 |
| 2-Methylnaphthalene | mg/kg | 0.07 | 0.88 | 2.0E-03 | 0.03 | 0.36 | 8.1E-04 | 0.005 | 0.04 | 9.9E-05 | 0.04 | 0.38 | 8.4E-04 | 0.2 | 2.27 | 5.08E-03 |
| Acenaphthene | mg/kg | 0.179 | 2.24 | 4.6E-03 | 0.101 | 1.22 | 2.5E-03 | 0.003355 | 0.03 | 6.0E-05 | 0.0831 | 0.78 | 1.6E-03 | 0.226 | 2.57 | 5.23E-03 |
| Acenaphthylene | mg/kg | 0.063 | 0.79 | 1.7E-03 | 0.034 | 0.41 | 9.1E-04 | 0.02 | 0.18 | 3.9E-04 | 0.058 | 0.55 | 1.2E-03 | 0.06 | 0.68 | 1.51E-03 |
| Anthracene | mg/kg | 0.27 | 3.38 | 5.7E-03 | 0.17 | 2.05 | 3.4E-03 | 0.05 | 0.44 | 7.4E-04 | 0.17 | 1.60 | 2.7E-03 | 0.33 | 3.75 | 6.31E-03 |
| Benzo(a)anthracene | mg/kg | 0.59 | 7.38 | 8.8E-03 | 0.29 | 3.49 | 4.2E-03 | 0.11 | 0.97 | 1.2E-03 | 0.35 | 3.30 | 3.9E-03 | 0.59 | 6.70 | 7.97E-03 |
| Benzo(a)pyrene | mg/kg | 0.57 | 7.13 | 7.4E-03 | 0.29 | 3.49 | 3.6E-03 | 0.1 | 0.88 | 9.2E-04 | 0.35 | 3.30 | 3.4E-03 | 0.52 | 5.91 | 6.12E-03 |
| Benzo(b)fluoranthene | mg/kg | 0.56 | 7.00 | 7.2E-03 | 0.27 | 3.25 | 3.3E-03 | 0.11 | 0.97 | 9.9E-04 | 0.35 | 3.30 | 3.4E-03 | 0.49 | 5.57 | 5.69E-03 |
| Benzo(e)pyrene | mg/kg | 0.43 | 5.38 | 5.6E-03 | 0.21 | 2.53 | 2.6E-03 | 0.08 | 0.71 | 7.3E-04 | 0.35 | 3.30 | 3.4E-03 | 0.37 | 4.20 | 4.35E-03 |
| Benzo(g,h,i)perylene | mg/kg | 0.38 | 4.75 | 4.3E-03 | 0.005 | 0.06 | 5.5E-05 | 0.005 | 0.04 | 4.0E-05 | 0.005 | 0.05 | 4.3E-05 | 0.32 | 3.64 | 3.32E-03 |
| Benzo(k)fluoranthene | mg/kg | 0.29 | 3.63 | 3.7E-03 | 0.19 | 2.29 | 2.3E-03 | 0.05 | 0.44 | 4.5E-04 | 0.43 | 4.06 | 4.1E-03 | 0.25 | 2.84 | 2.90E-03 |
| Benzo(j)fluoranthene | mg/kg | 0.24 | 3.00 | 3.1E-03 | 0.12 | 1.45 | 1.5E-03 | 0.06 | 0.53 | 5.4E-04 | 0 | 0.00 | 0.0E+00 | 0.32 | 3.64 | 3.71E-03 |
| Chrysene | mg/kg | 0.7 | 8.75 | 1.0E-02 | 0.33 | 3.98 | 4.7E-03 | 0.14 | 1.24 | 1.5E-03 | 0.41 | 3.87 | 4.6E-03 | 0.66 | 7.50 | 8.89E-03 |
| Dibenz(a,h)anthracene | mg/kg | 0.003 | 0.04 | 3.3E-05 | 0.003 | 0.04 | 3.2E-05 | 0.003 | 0.03 | 2.4E-05 | 0.003 | 0.03 | 2.5E-05 | 0.003 | 0.03 | 3.04E-05 |
| Fluoranthene | mg/kg | 1.37 | 17.13 | 2.4E-02 | 0.8 | 9.64 | 1.4E-02 | 0.3 | 2.65 | 3.8E-03 | 0.92 | 8.68 | 1.2E-02 | 1.67 | 18.98 | 2.68E-02 |
| Fluorene | mg/kg | 0.2 | 2.50 | 4.6E-03 | 0.12 | 1.45 | 2.7E-03 | 0.03 | 0.27 | 4.9E-04 | 0.11 | 1.04 | 1.9E-03 | 0.26 | 2.95 | 5.49E-03 |
| Indeno(1,2,3-cd)pyrene | mg/kg | 0.005 | 0.06 | 5.6E-05 | 0.005 | 0.06 | 5.4E-05 | 0.005 | 0.04 | 4.0E-05 | 0.005 | 0.05 | 4.2E-05 | 0.42 | 4.77 | 4.28E-03 |
| Naphthalene | mg/kg | 0.005 | 0.06 | 1.6E-04 | 0.005 | 0.06 | 1.6E-04 | 0.005 | 0.04 | 1.1E-04 | 0.005 | 0.05 | 1.2E-04 | 0.005 | 0.06 | 1.48E-04 |
| Perylene | mg/kg | 0.15 | 1.88 | 1.9E-03 | 0.025 | 0.30 | 3.1E-04 | 0.025 | 0.22 | 2.3E-04 | 0.025 | 0.24 | 2.4E-04 | 0.13 | 1.48 | 1.53E-03 |
| Phenanthrene | mg/kg | 1.26 | 15.75 | 2.6E-02 | 0.74 | 8.92 | 1.5E-02 | 0.22 | 1.95 | 3.3E-03 | 0.78 | 7.36 | 1.2E-02 | 1.5 | 17.05 | 2.86E-02 |
| Pyrene | mg/kg | 1.13 | 14.13 | 2.0E-02 | 0.57 | 6.87 | 9.9E-03 | 0.24 | 2.12 | 3.0E-03 | 0.76 | 7.17 | 1.0E-02 | 1.27 | 14.43 | 2.07E-02 |
| **Total PAH Concentration (not normalized)** | | 8.525 | | | 4.333 | | | 1.586355 | | | 5.2291 | | | 9.794 | | |
| **Sum ESBTU*** | | 1.4E-01 | | | 7.2E-02 | | | 1.9E-02 | | | 6.7E-02 | | | 1.5E-01 | | |
| **Uncertainty Factor (95 percentile)** | | 4.14 | | | 4.14 | | | 4.14 | | | 4.14 | | | 4.14 | | |
| **Sum ESBTU with Uncertainty Factor*** | | 0.59 | | | 0.30 | | | 0.079 | | | 0.28 | | | 0.64 | | |

Notes:

ESBTU - Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the Final Chronic Value.

COC, PAH FCV - Effect Concentration of a PAH in sediment on an organic carbon basis.

* - Summed ESBTU below 1 represents a low risk to sensitive benthic invertebrates.

* - Summed ESBTU below 3 represents a low risk to common benthic invertebrates.

**Table F-1**
**Equilibrium Partioning Evaluation - PAHs Sediment**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| Constituent | Units | 18-MNMA-S10 | | | 18-MNMA-S11 | | | 18-MNMA-DUP2 Field Duplicate 18-MNMA-S11 | | | 18-MNMA-S12 | | | 18-MNMA-S13 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Concentration | Concentration Normalized for TOC | ESBTU | Concentration | Concentration Normalized for TOC | ESBTU | Concentration | Concentration Normalized for TOC | ESBTU | Concentration | Concentration Normalized for TOC | ESBTU | Concentration | Concentration Normalized for TOC | ESBTU |
| Total organic Carbon | g/kg | 99 | | | 109 | | | 159 | | | 198 | | | 370 | | |
| **Fraction Organic Carbon** | | 0.099 | | | 0.109 | | | 0.159 | | | 0.198 | | | 0.37 | | |
| 1-Methylnaphthalene | mg/kg | 0.07 | 0.71 | 1.6E-03 | 0.025 | 0.23 | 5.1E-04 | 0.025 | 0.16 | 3.5E-04 | 0.025 | 0.13 | 2.8E-04 | 0.025 | 0.07 | 1.51E-04 |
| 2-Methylnaphthalene | mg/kg | 0.09 | 0.91 | 2.0E-03 | 0.02 | 0.18 | 4.1E-04 | 0.02 | 0.13 | 2.8E-04 | 0.02 | 0.10 | 2.3E-04 | 0.01 | 0.03 | 6.05E-05 |
| Acenaphthene | mg/kg | 0.269 | 2.72 | 5.5E-03 | 0.003355 | 0.03 | 6.3E-05 | 0.003355 | 0.02 | 4.3E-05 | 0.003355 | 0.02 | 3.5E-05 | 0.0478 | 0.13 | 2.63E-04 |
| Acenaphthylene | mg/kg | 0.095 | 0.96 | 2.1E-03 | 0.049 | 0.45 | 9.9E-04 | 0.465 | 2.92 | 6.5E-03 | 0.03 | 0.15 | 3.4E-04 | 0.039 | 0.11 | 2.33E-04 |
| Anthracene | mg/kg | 0.49 | 4.95 | 8.3E-03 | 0.12 | 1.10 | 1.9E-03 | 0.56 | 3.52 | 5.9E-03 | 0.28 | 1.41 | 2.4E-03 | 0.16 | 0.43 | 7.28E-04 |
| Benzo(a)anthracene | mg/kg | 1.26 | 12.73 | 1.5E-02 | 0.28 | 2.57 | 3.1E-03 | 1.45 | 9.12 | 1.1E-02 | 0.34 | 1.72 | 2.0E-03 | 0.3 | 0.81 | 9.64E-04 |
| Benzo(a)pyrene | mg/kg | 1.06 | 10.71 | 1.1E-02 | 0.22 | 2.02 | 2.1E-03 | 1.42 | 8.93 | 9.3E-03 | 0.25 | 1.26 | 1.3E-03 | 0.24 | 0.65 | 6.72E-04 |
| Benzo(b)fluoranthene | mg/kg | 1 | 10.10 | 1.0E-02 | 0.23 | 2.11 | 2.2E-03 | 1.2 | 7.55 | 7.7E-03 | 0.26 | 1.31 | 1.3E-03 | 0.24 | 0.65 | 6.63E-04 |
| Benzo(e)pyrene | mg/kg | 0.74 | 7.47 | 7.7E-03 | 0.18 | 1.65 | 1.7E-03 | 0.89 | 5.60 | 5.8E-03 | 0.18 | 0.91 | 9.4E-04 | 0.19 | 0.51 | 5.31E-04 |
| Benzo(g,h,i)perylene | mg/kg | 0.64 | 6.46 | 5.9E-03 | 0.005 | 0.05 | 4.2E-05 | 0.76 | 4.78 | 4.4E-03 | 0.005 | 0.03 | 2.3E-05 | 0.005 | 0.01 | 1.23E-05 |
| Benzo(k)fluoranthene | mg/kg | 0.53 | 5.35 | 5.5E-03 | 0.11 | 1.01 | 1.0E-03 | 0.59 | 3.71 | 3.8E-03 | 0.19 | 0.96 | 9.8E-04 | 0.11 | 0.30 | 3.03E-04 |
| Benzo(j)fluoranthene | mg/kg | 0.41 | 4.14 | 4.2E-03 | 0.15 | 1.38 | 1.4E-03 | 0.6 | 3.77 | 3.8E-03 | 0.13 | 0.66 | 6.7E-04 | 0.14 | 0.38 | 3.86E-04 |
| Chrysene | mg/kg | 1.63 | 16.46 | 2.0E-02 | 0.33 | 3.03 | 3.6E-03 | 1.37 | 8.62 | 1.0E-02 | 0.39 | 1.97 | 2.3E-03 | 0.33 | 0.89 | 1.06E-03 |
| Dibenz(a,h)anthracene | mg/kg | 0.003 | 0.03 | 2.7E-05 | 0.003 | 0.03 | 2.5E-05 | 0.003 | 0.02 | 1.7E-05 | 0.003 | 0.02 | 1.3E-05 | 0.003 | 0.01 | 7.22E-06 |
| Fluoranthene | mg/kg | 2.76 | 27.88 | 3.9E-02 | 1.08 | 9.91 | 1.4E-02 | 3.93 | 24.72 | 3.5E-02 | 0.49 | 2.47 | 3.5E-03 | 0.56 | 1.51 | 2.14E-03 |
| Fluorene | mg/kg | 0.35 | 3.54 | 6.6E-03 | 0.04 | 0.37 | 6.8E-04 | 0.13 | 0.82 | 1.5E-03 | 0.06 | 0.30 | 5.6E-04 | 0.07 | 0.19 | 3.52E-04 |
| Indeno(1,2,3-cd)pyrene | mg/kg | 0.65 | 6.57 | 5.9E-03 | 0.005 | 0.05 | 4.1E-05 | 1.13 | 7.11 | 6.4E-03 | 0.005 | 0.03 | 2.3E-05 | 0.005 | 0.01 | 1.21E-05 |
| Naphthalene | mg/kg | 0.005 | 0.05 | 1.3E-04 | 0.005 | 0.05 | 1.2E-04 | 0.005 | 0.03 | 8.2E-05 | 0.02 | 0.10 | 2.6E-04 | 0.005 | 0.01 | 3.51E-05 |
| Perylene | mg/kg | 0.25 | 2.53 | 2.6E-03 | 0.025 | 0.23 | 2.4E-04 | 0.41 | 2.58 | 2.7E-03 | 0.025 | 0.13 | 1.3E-04 | 0.025 | 0.07 | 6.99E-05 |
| Phenanthrene | mg/kg | 2.41 | 24.34 | 4.1E-02 | 0.32 | 2.94 | 4.9E-03 | 1.42 | 8.93 | 1.5E-02 | 0.33 | 1.67 | 2.8E-03 | 0.42 | 1.14 | 1.90E-03 |
| Pyrene | mg/kg | 2.13 | 21.52 | 3.1E-02 | 0.83 | 7.61 | 1.1E-02 | 2.98 | 18.74 | 2.7E-02 | 0.41 | 2.07 | 3.0E-03 | 0.5 | 1.35 | 1.94E-03 |
| **Total PAH Concentration (not normalized)** | | 16.842 | | | 4.030355 | | | 19.361355 | | | 3.446355 | | | 3.4248 | | |
| **Sum ESBTU*** | | 2.3E-01 | | | 5.0E-02 | | | 1.6E-01 | | | 2.3E-02 | | | 1.2E-02 | | |
| **Uncertainty Factor (95 percentile)** | | 4.14 | | | 4.14 | | | 4.14 | | | 4.14 | | | 4.14 | | |
| **Sum ESBTU with Uncertainty Factor*** | | 0.93 | | | 0.21 | | | 0.65 | | | 0.096 | | | 0.052 | | |

Notes:

ESBTU - Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the Final Chronic Value.

COC, PAH FCV - Effect Concentration of a PAH in sediment on an organic carbon basis.

* - Summed ESBTU below 1 represents a low risk to sensitive benthic invertebrates.

* - Summed ESBTU below 3 represents a low risk to common benthic invertebrates.

**Table F-1**
**Equilibrium Partioning Evaluation - PAHs Sediment**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| Constituent | Units | 18-MNMA-S14 | | | 18-MNMA-S15 | | | 18-MNMA-REF1 | | | 18-MNMA-REF2 | | | 18-MNMA-REF3 | | | COC, PAH FCV |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Concentration | Concentration Normalized for TOC | ESBTU | Concentration | Concentration Normalized for TOC | ESBTU | Concentration | Concentration Normalized for TOC | ESBTU | Concentration | Concentration Normalized for TOC | ESBTU | Concentration | Concentration Normalized for TOC | ESBTU | |
| Total organic Carbon | g/kg | 75 | | | 101 | | | 34 | | | 51 | | | 29 | | | |
| **Fraction Organic Carbon** | | 0.075 | | | 0.101 | | | 0.034 | | | 0.051 | | | 0.029 | | | |
| 1-Methylnaphthalene | mg/kg | 0.11 | 1.47 | 3.3E-03 | 0.08 | 0.79 | 1.8E-03 | 0.025 | 0.74 | 0.002 | 0.025 | 0.49 | 0.001 | 0.025 | 0.86 | 0.002 | 446 |
| 2-Methylnaphthalene | mg/kg | 0.13 | 1.73 | 3.9E-03 | 0.09 | 0.89 | 2.0E-03 | 0.005 | 0.15 | 0.000 | 0.005 | 0.10 | 0.000 | 0.005 | 0.17 | 0.000 | 447 |
| Acenaphthene | mg/kg | 0.48 | 6.40 | 1.3E-02 | 0.209 | 2.07 | 4.2E-03 | 0.003355 | 0.10 | 0.000 | 0.003355 | 0.07 | 0.000 | 0.003355 | 0.12 | 0.000 | 491 |
| Acenaphthylene | mg/kg | 0.084 | 1.12 | 2.5E-03 | 0.081 | 0.80 | 1.8E-03 | 0.002 | 0.06 | 0.000 | 0.002 | 0.04 | 0.000 | 0.002 | 0.07 | 0.000 | 452 |
| Anthracene | mg/kg | 0.72 | 9.60 | 1.6E-02 | 0.44 | 4.36 | 7.3E-03 | 0.015 | 0.44 | 0.001 | 0.015 | 0.29 | 0.000 | 0.015 | 0.52 | 0.001 | 594 |
| Benzo(a)anthracene | mg/kg | 1.08 | 14.40 | 1.7E-02 | 0.72 | 7.13 | 8.5E-03 | 0.03 | 0.88 | 0.001 | 0.02 | 0.39 | 0.000 | 0.005 | 0.17 | 0.000 | 841 |
| Benzo(a)pyrene | mg/kg | 1.04 | 13.87 | 1.4E-02 | 0.66 | 6.53 | 6.8E-03 | 0.005 | 0.15 | 0.000 | 0.005 | 0.10 | 0.000 | 0.005 | 0.17 | 0.000 | 965 |
| Benzo(b)fluoranthene | mg/kg | 1 | 13.33 | 1.4E-02 | 0.66 | 6.53 | 6.7E-03 | 0.025 | 0.74 | 0.001 | 0.025 | 0.49 | 0.001 | 0.025 | 0.86 | 0.001 | 979 |
| Benzo(e)pyrene | mg/kg | 0.74 | 9.87 | 1.0E-02 | 0.49 | 4.85 | 5.0E-03 | 0.025 | 0.74 | 0.001 | 0.025 | 0.49 | 0.001 | 0.025 | 0.86 | 0.001 | 967 |
| Benzo(g,h,i)perylene | mg/kg | 0.68 | 9.07 | 8.3E-03 | 0.4 | 3.96 | 3.6E-03 | 0.005 | 0.15 | 0.000 | 0.005 | 0.10 | 0.000 | 0.005 | 0.17 | 0.000 | 1095 |
| Benzo(k)fluoranthene | mg/kg | 0.38 | 5.07 | 5.2E-03 | 0.35 | 3.47 | 3.5E-03 | 0.02 | 0.59 | 0.001 | 0.005 | 0.10 | 0.000 | 0.005 | 0.17 | 0.000 | 981 |
| Benzo(j)fluoranthene | mg/kg | 0.39 | 5.20 | 5.3E-03 | 0.28 | 2.77 | 2.8E-03 | 0.05 | 1.47 | 0.001 | 0.05 | 0.98 | 0.001 | 0.05 | 1.72 | 0.002 | 981 |
| Chrysene | mg/kg | 1.19 | 15.87 | 1.9E-02 | 0.83 | 8.22 | 9.7E-03 | 0.03 | 0.88 | 0.001 | 0.03 | 0.59 | 0.001 | 0.005 | 0.17 | 0.000 | 844 |
| Dibenz(a,h)anthracene | mg/kg | 0.003 | 0.04 | 3.6E-05 | 0.003 | 0.03 | 2.6E-05 | 0.003 | 0.09 | 0.000 | 0.003 | 0.06 | 0.000 | 0.003 | 0.10 | 0.000 | 1123 |
| Fluoranthene | mg/kg | 2.91 | 38.80 | 5.5E-02 | 1.84 | 18.22 | 2.6E-02 | 0.07 | 2.06 | 0.003 | 0.07 | 1.37 | 0.002 | 0.025 | 0.86 | 0.001 | 707 |
| Fluorene | mg/kg | 0.52 | 6.93 | 1.3E-02 | 0.26 | 2.57 | 4.8E-03 | 0.005 | 0.15 | 0.000 | 0.005 | 0.10 | 0.000 | 0.005 | 0.17 | 0.000 | 538 |
| Indeno(1,2,3-cd)pyrene | mg/kg | 0.87 | 11.60 | 1.0E-02 | 0.53 | 5.25 | 4.7E-03 | 0.005 | 0.15 | 0.000 | 0.005 | 0.10 | 0.000 | 0.005 | 0.17 | 0.000 | 1115 |
| Naphthalene | mg/kg | 0.32 | 4.27 | 1.1E-02 | 0.005 | 0.05 | 1.3E-04 | 0.005 | 0.15 | 0.000 | 0.005 | 0.10 | 0.000 | 0.005 | 0.17 | 0.000 | 385 |
| Perylene | mg/kg | 0.29 | 3.87 | 4.0E-03 | 0.18 | 1.78 | 1.8E-03 | 0.025 | 0.74 | 0.001 | 0.025 | 0.49 | 0.001 | 0.025 | 0.86 | 0.001 | 967 |
| Phenanthrene | mg/kg | 2.82 | 37.60 | 6.3E-02 | 1.51 | 14.95 | 2.5E-02 | 0.06 | 1.76 | 0.003 | 0.04 | 0.78 | 0.001 | 0.015 | 0.52 | 0.001 | 596 |
| Pyrene | mg/kg | 2.27 | 30.27 | 4.3E-02 | 1.54 | 15.25 | 2.2E-02 | 0.05 | 1.47 | 0.002 | 0.06 | 1.18 | 0.002 | 0.025 | 0.86 | 0.001 | 697 |
| **Total PAH Concentration (not normalized)** | | 18.027 | | | 11.158 | | | 0.463355 | | | 0.428355 | | | 0.283355 | | | |
| **Sum ESBTU*** | | 3.3E-01 | | | 1.5E-01 | | | 0.019 | | | 0.012 | | | 0.013 | | | |
| **Uncertainty Factor (95 percentile)** | | 4.14 | | | 4.14 | | | 4.14 | | | 4.14 | | | 4.14 | | | |
| **Sum ESBTU with Uncertainty Factor*** | | 1.4 | | | 0.61 | | | 0.077 | | | 0.048 | | | 0.055 | | | |

Notes:

ESBTU - Equilibrium Partitioning Sediment Benchmark Toxic Unit for PAH based on the Final Chronic Value.

COC, PAH FCV - Effect Concentration of a PAH in sediment on an organic carbon basis.

* - Summed ESBTU below 1 represents a low risk to sensitive benthic invertebrates.

* - Summed ESBTU below 3 represents a low risk to common benthic invertebrates.

**Table F-2**
**Benthic Invertebrate Results**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | Benthic Invertebrate Grab Samples | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Sample/Site ID** | **18-MNMA-BMI-REF2** | **18MNMA-BMI 1** | **18-MNMA-BMI3** | **18-MNMA-BMI5** | **18-MNMA-BMI 6** | **18-MNMA-BMI 11** | **18-MNMA-BMI 12** | **18-MNMA-BMI 14** |
| **Year Sampled** | 2018 | 2018 | 2018 | 2018 | 2018 | 2018 | 2018 | 2018 |
| **Location** | | | | | | | | |
| **Abundance (#/sample)** | 243 | 243 | 7 | 91 | 97 | 28 | 124 | 2 |
| NEMATODA | | | | | | | | |
| Oncholaimellus brevicauda | 223 | 15 | 0 | 0 | 0 | 0 | 0 | 0 |
| POLYCHAETA | | | | | | | | |
| Arabella iricolor | 0 | 3 | 0 | 4 | 6 | 3 | 32 | 0 |
| Arcteobia anticostiensis | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Asabellides oculata | 0 | 4 | 1 | 8 | 28 | 3 | 0 | 0 |
| Brada villosa | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 |
| Capitella capitata | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Chaetozone setosa | 0 | 3 | 0 | 0 | 0 | 0 | 1 | 0 |
| Chone infundibuliformis | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Cistena granulata | 0 | 0 | 0 | 0 | 7 | 0 | 0 | 0 |
| Eteone flava | 0 | 2 | 0 | 5 | 4 | 3 | 1 | 0 |
| Eteone longa | 0 | 2 | 0 | 3 | 3 | 0 | 1 | 0 |
| Eteone trilineata | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| Euchone rubrocincta | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Glycera capitata | 3 | 31 | 0 | 1 | 0 | 0 | 0 | 0 |
| Goniada norvegica | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| Harmothoe extenuata | 0 | 4 | 0 | 1 | 0 | 0 | 1 | 0 |
| Harmothoe imbricata | 0 | 0 | 0 | 0 | 0 | 0 | 6 | 0 |
| Harmothoe nodosa | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Harmothoe oerstedi | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Laonice cirrata | 0 | 20 | 0 | 0 | 0 | 0 | 0 | 0 |
| Lepidonotus squamatus | 0 | 5 | 0 | 0 | 2 | 0 | 2 | 0 |
| Nephtys incisa | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 |
| Nephtys picta | 0 | 8 | 2 | 2 | 1 | 1 | 0 | 0 |
| Nereis diversicolor | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ophelia acuminata | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Ophelina acuminata | 0 | 1 | 0 | 0 | 2 | 0 | 0 | 0 |
| Ophioglycera gigantia | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pherusa plumosa | 0 | 4 | 0 | 3 | 4 | 1 | 0 | 0 |
| Phyllodoce groenlandica | 0 | 3 | 0 | 4 | 4 | 2 | 0 | 0 |
| Praxillella gracilis | 0 | 6 | 1 | 9 | 2 | 0 | 2 | 0 |
| Samytha sexcirrata | 0 | 2 | 0 | 8 | 5 | 0 | 5 | 0 |
| Scolecolepides viridis | 1 | 65 | 0 | 35 | 6 | 8 | 53 | 0 |
| AMPHIPODA | | | | | | | | |
| Aeginina longicornis | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 |
| Calliopius laeviusculus | 0 | 1 | 0 | 0 | 0 | 0 | 2 | 0 |
| Orchomenella groenlandica | 4 | 0 | 0 | 0 | 3 | 0 | 0 | 0 |
| Photis reinhardi | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| Phoxocephalus holbolli | 0 | 4 | 0 | 1 | 1 | 0 | 10 | 0 |

**Table F-2**
**Benthic Invertebrate Results**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | Benthic Invertebrate Grab Samples | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Sample/Site ID** | **18-MNMA-BMI-REF2** | **18MNMA-BMI 1** | **18-MNMA-BMI3** | **18-MNMA-BMI5** | **18-MNMA-BMI 6** | **18-MNMA-BMI 11** | **18-MNMA-BMI 12** | **18-MNMA-BMI 14** |
| **Year Sampled** | 2018 | 2018 | 2018 | 2018 | 2018 | 2018 | 2018 | 2018 |
| **Location** | | | | | | | | |
| **Abundance (#/sample)** | 243 | 243 | 7 | 91 | 97 | 28 | 124 | 2 |
| GASTROPODA | | | | | | | | |
| Buccinum undatum | 1 | 1 | 0 | | | | | |
| BIVALVIA | | | | | | | | |
| Cerastoderma pinnulatum | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 |
| Crenella faba | 0 | 0 | 0 | 0 | 0 | 0 | 4 | 0 |
| Ensis directus | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nucula expansa | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| Yoldia myalis | 10 | 21 | 1 | 3 | 3 | 1 | 1 | 0 |
| Yoldia sapotilla | 0 | 6 | 0 | 0 | 0 | 0 | 0 | 0 |
| OPHIUROIDEA | | | | | | | | |
| Amphiopholis squamata | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| Ophiopholis aculeata | 0 | 0 | 0 | 0 | 5 | 1 | 0 | 0 |
| Ophiura sarsi | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| ANTHOZOA | | | | | | | | |
| Edwardsia elegans | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| Tealia felina | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| HARPACTICOIDEA | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 |
| AMPHINEURA | | | | | | | | |
| Ischochiton ruber | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| Tonicella marmorea | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 |
| HOLOTHUROIDEA | | | | | | | | |
| Molpadia oolitica | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 |
| NEMERTEA | | | | | | | | |
| Amphiporus groenlandicus | 0 | 0 | 0 | 0 | 3 | 1 | 1 | 0 |
| ASTEROIDEA | | | | | | | | |
| Astarias forbesii | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 |
| | | | | | | | | |
| **SUMMARY** | | | | | | | | |
| Abundance (#/sample) | 243 | 243 | 7 | 91 | 97 | 28 | 124 | 2 |
| Taxon Richness (#/sample) | 7 | 32 | 5 | 17 | 24 | 14 | 17 | 1 |
| Shannon Wiener Diversity (ln) | 0.40 | 2.75 | 1.55 | 2.21 | 1.60 | 2.34 | 1.54 | NA |
| Dominant Species | Oncholaimellus brevicauda | Scolecolepides viridis | Nephtys picta & Molpadia oolitica | Scolecolepides viridis | Asabellides oculata | Scolecolepides viridis | Scolecolepides viridis | Goniada norvegica |
| % Dominant Taxa | 91.8 | 26.7 | 28.6 | 38.5 | 28.9 | 28.6 | 42.7 | 100.0 |
| Total Number of Dominant Taxa | 223 | 65 | 2 | 35 | 28 | 8 | 53 | 2 |

**Table F-3**
**Exposure Point Concentrations**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| Parameter | Percent Composition | Measured Sediment Conc. (1) | Surface Water Conc. (2) | Predicted Marine Plant Tissue Conc. | Measured Marine Invertebrate Tissue Conc. | Predicted Marine Fish Tissue Conc. |
|---|---|---|---|---|---|---|
| | | (mg/kg dw) | (mg/L) | (mg/kg ww) | (mg/kg ww) | (mg/kg ww) |
| **Polycyclic Aromatic Hydrocarbons** | | | | | | |
| LMW PAHs | - | 5.9 | 0.0 | 0.090 | 0.10 | 0 |
| HMW PAHs | - | 7.5 | 0.0 | 0.18 | 0.03 | 0 |
| **Polychlorinated Biphenyls** | | | | | | |
| Total PCBs | --- | 0.32 | 0.00 | 0.00043 | 0.50 | 0.50 |
| **Inorganics** | | | | | | |
| Arsenic | --- | 40 | 0.00 | 0.16 | 3.3 | 3.3 |
| Cadmium | --- | 0.56 | 0.00 | 0.068 | 8.60 | 8.60 |
| Copper | - | 168 | 0.011 | 2.3 | 10.3 | 10.3 |
| Lead | - | 362 | 0.00 | 1.1 | 0.7 | 0.7 |
| Mercury (total) | - | 0.16 | 0.00 | 0.020 | 0.050 | 0.050 |
| Mercury (inorganic) | - | 0.16 (a) | 0.00 | 0.020 | 0.025 | 0.009 |
| Mercury (methyl) | - | 0 (a) | 0.00 | 0 | 0.025 | 0.04 |
| Selenium | --- | 1.6 | 0.002 | 0.13 | 0.50 | 0.50 |
| Zinc | - | 1,681 | 0.00 | 44.7 | 57.6 | 57.6 |

(a) The proportion of methylmercury of total mercury in sediment is negligible (0.77%) (Kannan et al. 1998). Therefore, total mercury in sediment is assumed to be entirely made up of inorganic mercury.

(1) Sediment concentrations are based on the 95 percent upper confidence limit (UCL) of the mean, as calculated in USEPA's ProUCL Version 5.1 software.
See ProUCL output sheets.

(2) COPCs not detected in surface water were applied a concentration of "0".
For all other parameters, the maximum detected concentrations were applied as there were insufficient sample numbers to calculate a 95 percent UCL

(3) Invertebrate concentrations based on 95%UCL values measured in Site tissue. Maximums were applied if a 95%UCL could not be calculated. 1/2 method detection limits used for parameters with no detectable concentrations (PCBs, mercury)

**Table F-3**
**Exposure Point Concentrations**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

***Predicted Marine Plant Concentrations***

*Inorganics*

ln(plant tissue)= intercept + slope(ln[$C_{sed}$]) (Efroymson et al., 2001) x dry weight to wet weight conversion (0.15)

Where:

$C_{sed}$ = measured sediment concentration (mg/kg dw)

| | Intercept | Slope | |
|---|---|---|---|
| Arsenic | -1.992 | 0.564 | Efroymson et al., 2001 |
| Cadmium | -0.476 | 0.546 | Efroymson et al., 2001 |
| Copper | 0.699 | 0.394 | Efroymson et al., 2001 |
| Lead | -1.328 | 0.561 | Efroymson et al., 2001 |
| Mercury (total) | -0.996 | 0.544 | Efroymson et al., 2001 |
| Selenium | -0.678 | 1.104 | Efroymson et al., 2001 |
| Zinc | 1.575 | 0.555 | Efroymson et al., 2001 |
| Mercury (inorganic) | calculated | Difference between total mercury and methylmercury | |
| Mercury (methyl) | 0 | Assumed | |

$C_{plant\ tissue} = C_{sed} \times UF_{SP}$ x dry weight to wet weight conversion (0.15)

Where:

| | $UF_{SP}$ = uptake factor | |
|---|---|---|
| Barium | 0.156 | USEPA, 2007 |
| Cobalt | 0.0075 | USEPA, 2007 |
| Tin | 0.03 | Baes et al., 1984 |

*Organics (Polycyclic Aromatic Hydrocarbons)*

| | |
|---|---|
| LMW PAHs | ln(plant tissue) = 0.4544 x ln[Csed] - 1.3205 (USEPA, 2007) x dry weight to wet weight conversion (0.15) |
| HMW PAHs | ln(plant tissue) = 0.9469 x ln[Csed] - 1.7026 (USEPA, 2007) x dry weight to wet weight conversion (0.15) |

*Organics (PCBs)*

$C_{plant\ tissue} = C_{soil} \times UF_{SP}$ x dry weight to wet weight conversion (0.15)

Where:

$UF_{SP} = 10^{1.588 - 0.578 \times logKow}$ (USEPA, 2007; Travis and Arms, 1988)

Where:

| | logKoc (CCME, 2008) | Koc | Kow = Koc / 0.41 | logKow (CCME, 2008; OMOE, 2011) | $UF_{SP}$ |
|---|---|---|---|---|---|
| Total PCBs | - | - | - | 6.29 | 0.009 |

**Table F-3**
**Exposure Point Concentrations**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

***Predicted Marine Fish Concentration***

*Inorganics*
$C_{fish}$ = Measured invertebrate concentration

Methylmercury is assumed to be 83% of the total mercury within fish tissue (Kannan et al., 1998); therefore, the fish tissue methylmercury concentration was calculated by multiplying the total mercury concentration by 0.83.

**Table F-4**
**Input Parameters and Exposure Factors for Modeled Species**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| **Parameters** | **Units** | **Avian Receptors** | **Avian Receptors** |
|---|---|---|---|
| | | **Lesser Scaup** | **Common Loon** |
| | | Insectivore | Piscivore |
| Body Mass | kg | 0.707 | 5.3 |
| Ingestion - Food | kg/day (Wet) | 0.19 | 1 |
| Ingestion - Water | L/day | 0.049 | 0.159 |
| Ingestion - Soil/Sediment | kg/day (Dry) | 0.00099 | 0.0055 |
| Diet | | | |
| Marine Plants | %/100 | 0.1 | 0 |
| Marine Invertebrates | %/100 | 0.9 | 0.1 |
| Marine Fish | %/100 | 0 | 0.9 |
| Foraging Range | ha | 10 | 4.4 |

| **Parameters** | **Units** | **Mammalian Receptors** |
|---|---|---|
| | | **River Otter** |
| | | Piscivore/Insectivore |
| Body Mass | kg | 7.5 |
| Ingestion - Food | kg/day (Wet) | 0.86 |
| Ingestion - Water | L/day | 0.6 |
| Ingestion - Soil/Sediment | kg/day (Dry) | 0.0045 |
| Diet | | |
| Marine Plants | %/100 | 0 |
| Marine Invertebrates | %/100 | 0.2 |
| Marine Fish | %/100 | 0.8 |
| Foraging Range | ha | 900 |

Notes:
All receptor exposure factors and input parameters were obtained from FCSAP (2012; Module 3).
Ingestion rates assumes marine invertebrates are 77% water (average for marine invertebrates), and fish are 72% water (average for bony fishes and herring), as indicated in Sample et al., 1994.

**Table F-5**
**Bird and Mammal TRVs**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| COPC | Avian Wildlife | | Mammalian Wildlife | |
|---|---|---|---|---|
| | LOAEL (mg/kg-day) | Source | LOAEL (mg/kg-day) | Source |
| **Polycyclic Aromatic Hydrocarbons (PAHs)** | | | | |
| LMW PAHs | NA | - | 367 | EcoSSL |
| HMW PAHs | 20 | EcoSSL[a] | 32 | EcoSSL |
| **Polychlorinated Biphenyls (PCBs)** | | | | |
| Total PCBs | 1.8 | Sample et al., 1996 | 0.68 | Sample et al., 1996 |
| **Metals** | | | | |
| Arsenic | 4.5 | EcoSSL | 5.7 | EcoSSL |
| Cadmium | 7.8 | EcoSSL | 7.1 | EcoSSL |
| Cobalt | 18 | EcoSSL | 19 | EcoSSL |
| Copper | 37 | EcoSSL | 74 | EcoSSL |
| Lead | 52 | EcoSSL | 170 | EcoSSL |
| Mercury | 0.9 | Sample et al., 1996 | 10 | Sample et al., 1996[a] |
| Methylmercury | 0.064 | Sample et al., 1996 | 0.16 | Sample et al., 1996 |
| Selenium | 1.2 | EcoSSL | 0.8 | EcoSSL |
| Zinc | 190 | EcoSSL | 290 | EcoSSL |

Notes:
COPC - contaminant of potential concern
LOAEL - Lowest Observed Adverse Effect Level
NOAEL - No Observed Adverse Effect Level
LMW - Low Molecular Weight
HMW - High Molecular Weight
NA - Not Available

Sources:
CCME, 2008: Canadian Council of Ministers of the Environment (CCME). 2008. Canada-Wide Standard for Petroleum Hydrocarbons (PHC) in Soil: Scientific Rationale. Supporting Technical Document. PN 1399.
[a] - NOAEL not available; the NOAEL is set to the LOAEL/10, consistent with the approach in Sample et al., 1996
EcoSSL: United States Environmental Protection Agency Guidance for Developing Ecological Soil Screening Levels Ecological Soil Screening Levels (EcoSSLs), OSWER Directive 9285.7-55.
Geometric mean of NOAELs and LOAELs for survival, growth, and reproduction identified in the chemical-specific Eco-SSL source documents were applied
[a] - Trust et al. (1994) as cited in Eco-SSL source document for PAHs
Sample et al., 1996: Sample, B. E., Opresko, D. M., & Suter II, G. W. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Risk Assessment Program, Health Sciences Research Division. Tennessee: Oak Ridge.
[a] - LOAEL not available; the LOAEL is set to the NOAEL x 10, consistent with the approach in Sample et al., 1996.

**Table F-6**
**Detailed Ecological Hazard Quotients for the River Otter Exposed to Constituents of Concern**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | ADD - Sediment Ingestion (mg/kg-day) | ADD - Water Ingestion (mg/kg-day) | ADD - Marine Plant Ingestion (mg/kg-day) | ADD - Marine Benthic Invertebrate Ingestion (mg/kg-day) | ADD - Marine Fish Ingestion (mg/kg-day) | $ADD_{Total}$ (mg/kg-day) | TRV (mg/kg-day) | EHQ (unitless) |
|---|---|---|---|---|---|---|---|---|
| **Inorganics** | | | | | | | | |
| Arsenic | 0.024 | 0 | 0 | 0.076 | 0.30 | 0.40 | 5.7 | 0.071 |
| Cadmium | 0.00034 | 0 | 0 | 0.1972 | 0.7889 | 0.99 | 7.1 | 0.13894 |
| Copper | 0.10 | 0.0009 | 0 | 0.24 | 0.94 | 1.28 | 74 | 0.017 |
| Lead | 0.22 | 0 | 0 | 0.016 | 0.06 | 0.30 | 170 | 0.0017 |
| Mercury (Total) (1) | | 0 | | | | 0.00 | | 0.03 |
| Mercury (Inorganic) | 0.00010 | 0 | 0 | 0.00057 | 0.0008 | 0.00 | 10 | 0.00014 |
| Mercury (Methyl) | 0 | 0 | 0 | 0.00057 | 0.004 | 0.00 | 0.16 | 0.03 |
| Selenium | 0.00097 | 0.0002 | 0 | 0.0115 | 0.046 | 0.06 | 0.80 | 0.073 |
| Zinc | 1.0 | 0 | 0 | 1.3 | 5.3 | 7.61 | 290 | 0.026 |
| **Polycyclic Aromatic Hydrocarbons** | | | | | | | | |
| LMW PAHs | 0.0036 | 0 | 0 | 0.0023 | 0 | 0.006 | 367 | 0.000016 |
| HMW PAHs | 0.0045 | 0 | 0 | 0.0007 | 0 | 0.005 | 32 | 0.00016 |
| **Polychlorinated Biphenyls** | | | | | | | | |
| Total PCBs | 0.00019 | 0 | 0 | 0.0115 | 0.046 | 0.058 | 0.68 | 0.085 |
| | | | | | | | | |

**Bold Font** identifies EHQ > 1
TRV, toxicity reference value
ADD, average daily dose
LMW PAHs, low molecular weight PAHs
HMW PAH, high molecular weight PAHs
(1) The HQ for total mercury is the sum of the HQs for inorganic mercury and methylmercury.

**Table F-7**
**Detailed Ecological Hazard Quotients for the Lesser Scaup Exposed to Constituents of Concern**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | ADD - Sediment Ingestion (mg/kg-day) | ADD - Water Ingestion (mg/kg-day) | ADD - Marine Plant Ingestion (mg/kg-day) | ADD - Marine Benthic Invertebrate Ingestion (mg/kg-day) | ADD - Marine Fish Ingestion (mg/kg-day) | $ADD_{Total}$ (mg/kg-day) | TRV (mg/kg-day) | EHQ (unitless) |
|---|---|---|---|---|---|---|---|---|
| **Inorganics** | | | | | | | | |
| Arsenic | 0.057 | 0 | 0.0045 | 0.81 | 0 | 0.87 | 4.5 | 0.19 |
| Cadmium | 0.00078 | 0 | 0.0019 | 2.120 | 0 | 2.12 | 7.8 | 0.2721 |
| Copper | 0.24 | 0.001 | 0.062 | 2.5 | 0 | 2.84 | 37 | 0.077 |
| Lead | 0.51 | 0 | 0.030 | 0.2 | 0 | 0.71 | 52 | 0.014 |
| Mercury (Total) (1) | | 0 | | | | 0.00 | | 0.104 |
| Mercury (Inorganic) | 0.00022 | 0 | 0.00056 | 0.0062 | 0 | 0.01 | 0.9 | 0.0077 |
| Mercury (Methyl) | 0 | 0 | 0 | 0.0062 | 0 | 0.01 | 0.064 | 0.096 |
| Selenium | 0.0023 | 0.0001 | 0.0035 | 0.123 | 0 | 0.13 | 1.2 | 0.108 |
| Zinc | 2.4 | 0 | 1.2 | 14 | 0 | 17.78 | 190 | 0.09 |
| **Polycyclic Aromatic Hydrocarbons** | | | | | | | | |
| LMW PAHs | 0.0083 | 0 | 0.0025 | 0.025 | 0 | 0.04 | - | - |
| HMW PAHs | 0.010 | 0 | 0.0050 | 0.01 | 0 | 0.02 | 20 | 0.0011 |
| **Polychlorinated Biphenyls** | | | | | | | | |
| Total PCBs | 0.00045 | 0 | 0.000012 | 0.123 | 0 | 0.12 | 1.8 | 0.0687 |
| | | | | | | | | |

**Bold Font** identifies EHQ > 1
TRV, toxicity reference value
ADD, average daily dose
LMW PAHs, low molecular weight PAHs
HMW PAH, high molecular weight PAHs
(1) The HQ for total mercury is the sum of the HQs for inorganic mercury and methylmercury.

**Table F-8**
**Detailed Ecological Hazard Quotients for the Common Loon Exposed to Constituents of Concern**
**Supplemental Phase II ESA and HHERA**
**Marystown Shipyard**
**Marystown, NL**

| | ADD - Sediment Ingestion (mg/kg-day) | ADD - Water Ingestion (mg/kg-day) | ADD - Marine Plant Ingestion (mg/kg-day) | ADD - Marine Benthic Invertebrate Ingestion (mg/kg-day) | ADD - Marine Fish Ingestion (mg/kg-day) | $ADD_{Total}$ (mg/kg-day) | TRV (mg/kg-day) | EHQ (unitless) |
|---|---|---|---|---|---|---|---|---|
| **Inorganics** | | | | | | | | |
| Arsenic | 0.042 | 0 | 0 | 0.063 | 0.56 | 0.67 | 4.5 | 0.149 |
| Cadmium | 0.00058 | 0 | 0 | 0.1634 | 1.4706 | 1.63 | 7.8 | 0.2096 |
| Copper | 0.18 | 0.00033 | 0 | 0.20 | 1.76 | 2.13 | 37 | 0.058 |
| Lead | 0.38 | 0 | 0 | 0.01 | 0.1 | 0.51 | 52 | 0.010 |
| Mercury (Total) (1) | | | | | | | | 0.12 |
| Mercury (Inorganic) | 0.00017 | 0 | 0 | 0.00048 | 0.0015 | 0.00 | 0.9 | 0.0023 |
| Mercury (Methyl) | 0 | 0 | 0 | 0.00048 | 0.007 | 0.01 | 0.064 | 0.12 |
| Selenium | 0.0017 | 0.00006 | 0 | 0.0095 | 0.086 | 0.10 | 1.2 | 0.081 |
| Zinc | 1.8 | 0 | 0 | 1.1 | 10 | 12.70 | 190 | 0.067 |
| **Polycyclic Aromatic Hydrocarbons** | | | | | | | | |
| LMW PAHs | 0.0062 | 0 | 0 | 0.0019 | 0 | 0.01 | - | - |
| HMW PAHs | 0.0078 | 0 | 0 | 0.0006 | 0 | 0.01 | 20 | 0.00042 |
| **Polychlorinated Biphenyls** | | | | | | | | |
| Total PCBs | 0.00033 | 0 | 0 | 0.0095 | 0.086 | 0.10 | 1.8 | 0.053 |
| | | | | | | | | |

**Bold Font** identifies EHQ > 1
TRV, toxicity reference value
ADD, average daily dose
LMW PAHs, low molecular weight PAHs
HMW PAH, high molecular weight PAHs
(1) The HQ for total mercury is the sum of the HQs for inorganic mercury and methylmercury.

# Appendix G
# Potential Species at Risk Supporting Information

| | |
|---|---|
| **From:** | Durocher, Adam |
| **To:** | Leslie Williams |
| **Cc:** | DataNL |
| **Subject:** | RE: ACCDC Search Request - Marystown Shipyard, Marystown, NL ~MSC-11178792-02~ |
| **Date:** | Tuesday, November 13, 2018 11:55:42 AM |
| **Attachments:** | Map.jpg<br>RareFauna.xls<br>RareFlora.xls<br>RQ0702.pdf<br>Caveats.doc<br>DATA DICTIONARY.doc<br>herbaria.xls<br>RANKING.rtf |

---

Hi Leslie,
Attached are the data request results for the Marystown Shipyard Property in Marystown, Newfoundland and Labrador.

Summary: Within your study area, there were 2 rare animal records and 1 rare plant record found. These 2 rare animal records were 2 Harlequin Duck observations, a species which is *Vulnerable* under our provincial Endangered Species Act (ESA) and *Special Concern* under COSEWIC. As for the rare plant record, this record is for Seaside Goldenrod (*Solidago sempervirens subsp. sempervirens*), a plant which is not provincially or nationally listed, but is considered rare on the Island of Newfoundland.

Secondly, a new addition to our standard data requests is the use of Expert Opinion Maps. These maps are the result of our work with species-specific experts to gather suggestions about locations where species at risk - either provincially or COSEWIC listed - may be found. While we don't have observations in our database for these species within your study area, our Expert Opinion Maps suggest that Banded Killifish, Short-eared Owls and Boreal Felt Lichen are *possible*. Your area is also said to be within the Barrow's Goldeneye's *range*.

For more information, including a map of the area showing the locations of the rare fauna, rare flora and the area of interest, please refer to the following attached documents:
Map.jpg - shows the locations of the rare fauna, rare flora and the 5 km buffer around the area of interest.
RareFauna.xls – a list of rare animal records, including their SRANK, NRANK, GRANK and habitats.
RareFlora.xls – a list of rare plant records, including their SRANK, NRANK, GRANK and habitats.
Data Dictionary.doc - explains the various columns in RareFauna.xls and RareFlora.xls.
Ranking.rtf - explains the S, N and GRANKS.
Herbaria.xls - A list of herbariums in case you would like to follow up on the specimens included in this request.
Caveats.doc - The fine print - please read.  This is also included at the end of this email.
RQ0702.pdf – Invoice for the data request.

Please do not hesitate to contact me if you have any questions.

***Adam Durocher***
Data Manager
Atlantic Canada Conservation Data Centre
Corner Brook, NL
709-637-2494

DATA SOURCES:
All data housed at Atlantic Canada Conservation Data Centre (ACCDC).  Refer to the 'CITATION' field for data sources.

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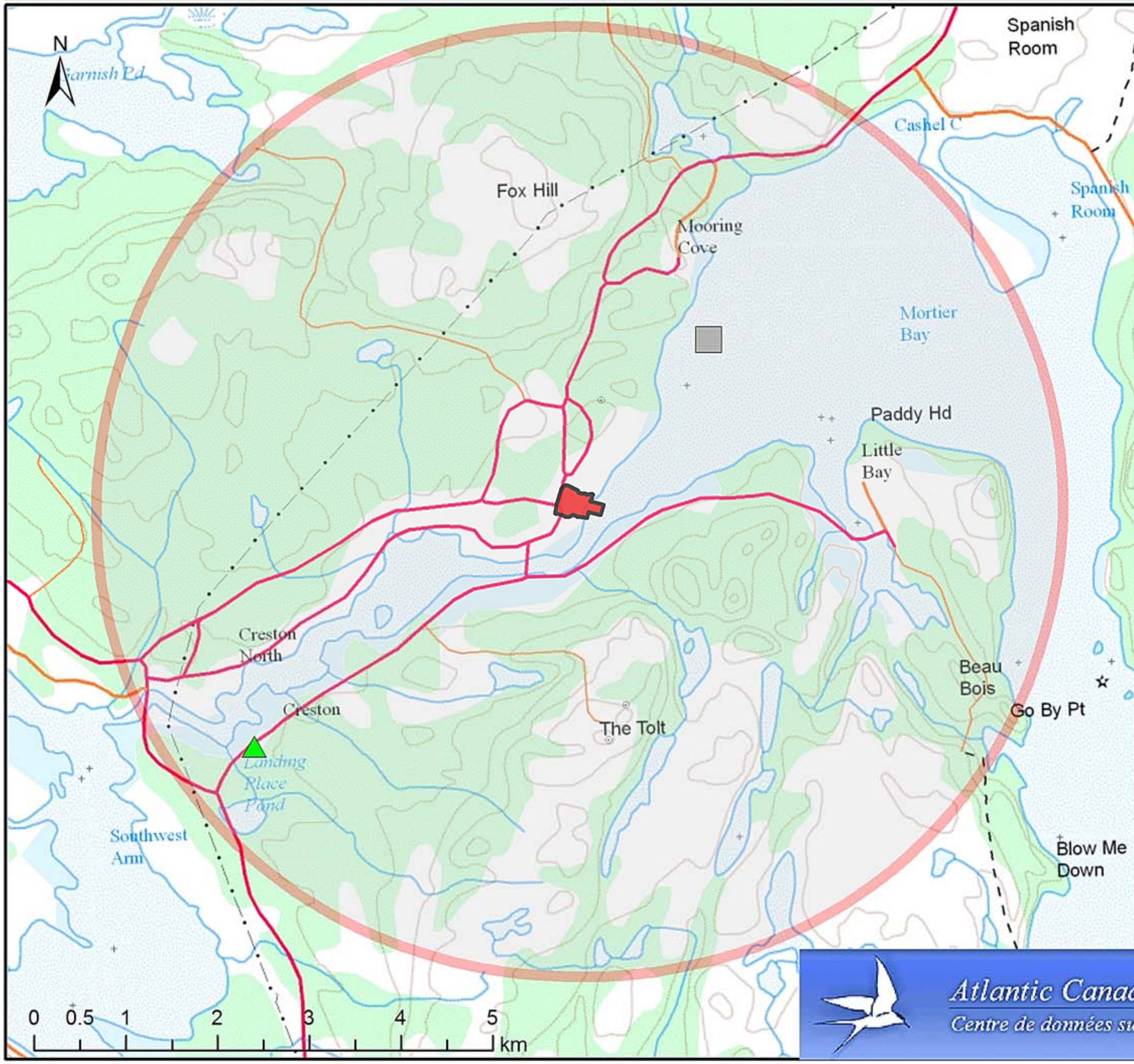
CAVEATS:
ACCDC rare taxa occurrence records are offered as a guide recognizing that the ability to find plants and animals will

# GIS Scan of Rare and Provincially/Federally Listed Species for Marystown Shipyard Property in Marystown, Newfoundland and Labrador




## Legend

Shipyard Property

5 km Buffer Around AOI

**Rare Flora**

1000m Accuracy

**Rare Fauna**

Unknown Accuracy

Atlantic Canada Conservation Data Centre
November 9, 2018
For: GHD Ltd.
Data Request: RQ0702

Datum: Transverse Mercator NAD83
Note: Interpretations of this map should always be conducted in relation with data provided in spreadsheets and any other communications.

Atlantic Canada Conservation Data Centre
Centre de données sur la conservation du Canada Atlantique

# Appendix H
# Divers Report

2018

# Marystown Sampling December 2018

DETAILS

SITE LOCATION - MARYSTOWN

Report Writer: Brandon Sparkes

Date: Dec 11-14 2018

Brandon Sparkes
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Mobile: (709) 660 0787
Brandon@sparkessubsea.ca

## CONTENTS

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## SCOPE OF WORK

The scope of work included the completion of a dive survey and collection of marine sediment and biological tissue samples. The dive survey included the documentation of bottom substrate conditions and aquatic habitat, and obtaining photographic evidence and video footage of the benthic communities at each sampling location.

## PRELIMINARY INFORMATION

### WATER CONDITIONS

Wave Height(M) - 0
Depth – Max depth 35
Temperature – 2 Celsius
Visibility – 5-10 Meters
Tide – 0-3 Knots

### DIVE CREW

Supervisor – Brandon Sparkes
Crew – Nick Wadded
Crew – Riley Allen
Crew – Cole Saldat

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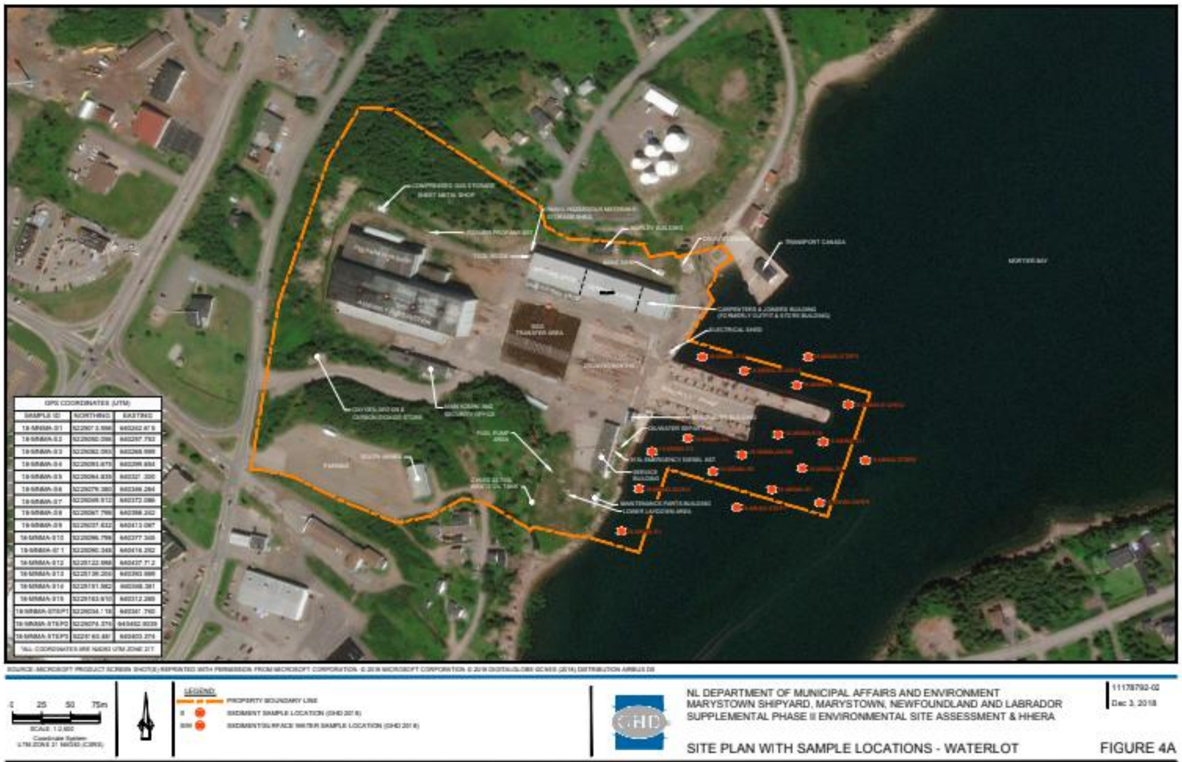
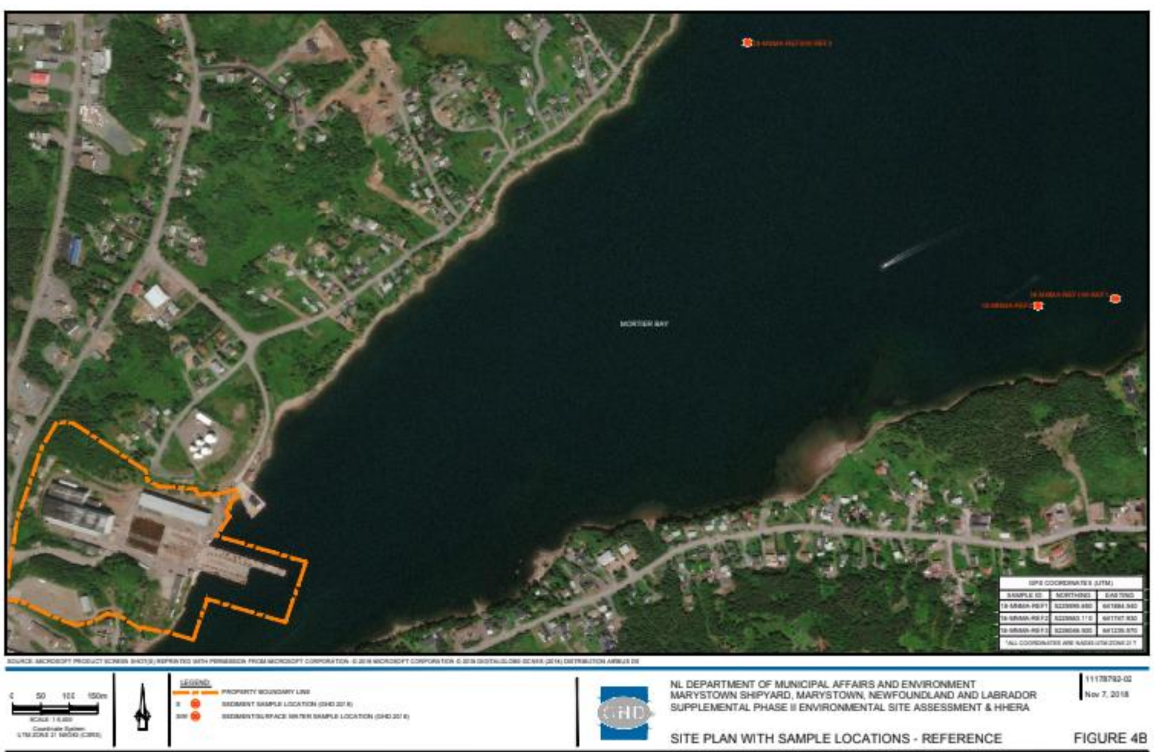
## SAMPLE LOCATIONS PLANS



| Station ID | GPS Coordinates (Northing / Easting)[1,2] | Water Depth (m) | Harbour Bottom/ Substrate[3] | Macro faunal Life Observed | Macro floral Life Observed | Fish/Shellfish Specimens Collected (# and type) |
|---|---|---|---|---|---|---|
| 18-MNMA-S1 | LAT 47° 9' 49.22" LONG 55° 8' 58.71" | 14 | Black Mud | Periwinkles, Rock Crab, Scallops | Eel Grass, Tubed weed, Kelp | 3 Scallop<br>2 Crab |
| 18-MNMA-S2 | LAT 47° 9' 50.39" LONG 55° 8' 57.95" | 14 | Black Mud | Periwinkles, Rock Crab, Scallops | Eel Grass, Tubed weed, Kelp | 3 Scallop<br>2 Crab |
| 18-MNMA-S3 | LAT 47° 9' 51.42" LONG 55° 8' 57.38" | 25 | Black Mud | Periwinkles, Scallops | Eel Grass, Tubed weed, Kelp | 5 Scallop<br>2 Periwinkles |
| 18-MNMA-S4 | LAT 47° 9' 51.77" LONG 55° 8' 55.9" | 31 | Black Mud | Periwinkles, Rock Crab, Scallops | Eel Grass, Tubed weed, Kelp | 2 Crab<br>2 Scallop |
| 18-MNMA-S5 | LAT 47° 9' 50.82" LONG 55° 8' 54.92" | 23 | Black Mud | Periwinkles, Rock Crab, Scallops | Eel Grass, Tubed weed, Kelp | 6 Scallop<br>1 Crab |
| 18-MNMA-S6 | LAT 47° 9' 51.27" LONG 55° 8' 53.71" | 32 | Black Mud | Periwinkles, Rock Crab, Scallops | Eel Grass, Tubed weed, Kelp | 2 Scallop<br>1 Crab |
| 18-MNMA-S7 | LAT 47° 9' 50.29" LONG 55° 8' 52.52" | 30 | Black Mud | Periwinkles, Rock Crab, Scallops | Kelp | 2 Scallop<br>2 Crab |
| 18-MNMA-S8 | LAT 47° 9' 50.86" LONG 55° 8' 51.26" | 30 | Sand/Gravel | Periwinkles, Rock Crab, Mussels | Knotted Wrack, Tubed weed | 2 Crab<br>4 Mussel |
| 18-MNMA-S9 | LAT 47° 9' 49.88" LONG 55° 8' 50.59" | 28 | Sand/Gravel | Periwinkles, Mussels, Rock Crab | Kelp, Knotted Wrack | 1 Mussel<br>1 Crab |
| 18-MNMA-S10 | 47° 9' 51.81" LONG 55° 8' 52.22" | 36 | Black Mud | Scallops, Rock Crab | Kelp, Sea Colander | 9 Scallop<br>1 Crab |
| 18-MNMA-S11 | LAT 47° 9' 51.57" LONG 55° 8' 50.38" | 22 | Black Mud | Mussels, Scallop | Kelp, Sea Colander | 5 Scallop |
| 18-MNMA-S12 | LAT 47° 9' 52.6" LONG 55° 8' 49.32" | 32 | Black Mud | Mussels, Scallop, Rock | Kelp, Sea Colander | 5 Scallop<br>1 Crab |

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| | | | | | | |
|---|---|---|---|---|---|---|
| | | | | Crab | | |
| 18-MNMA-S13 | LAT 47° 9' 53.17" LONG 55° 8' 51.4" | 33 | Black Mud | Scallop, Rock Crab | Kelp, Edible Kelp, Tubed Weed | 1 Crab<br>2 Scallop |
| 18-MNMA-S14 | LAT 47° 9' 53.61" LONG 55° 8' 53.53" | 32 | Black Mud | Scallop, Rock Crab, | Rockweed, Kelp | 5 Scallop<br>1 Crab |
| 18-MNMA-S15 | LAT 47° 9' 54.03" LONG 55° 8' 55.23" | 32 | Black Mud | Rock Crab, Periwinkle, Scallop | Eel Grass, Brown Seaweed, Tube Weed | 4 Scallop<br>1 Crab |
| 18-MNMA-REF1 | LAT 47° 10' 06.8" LONG 55° 07' 40.1" | 25 | Grey Sand / Gravel | Periwinkle, Scallops, Common Sea Star, Rock Crab | Brown Seaweed, Eel Grass, Knotted Wrack, Tubed Weed | 3 Scallop<br>1 Crab |
| 18-MNMA-REF2 | LAT 47° 10' 06.5" LONG 55° 07' 46.6" | 10 | Grey Sand/ Gravel | Periwinkles, Scallop | Eel Grass, Kelp, Tubed weed | 2 Scallop |
| 18-MNMA-REF3 | LAT 47° 10' 21.9" LONG 55° 08' 10.4" | 30 | Grey Sand | Scallop, Mussels | Tubed Weed, Kelp | 2 Scallop<br>4 Mussel |
| 18-MNMA-STEP1 | LAT47°49.81"N<br>LONG 55° 8'54.01"W | 25 | Grey Sand/ Gravel | Scallop, mussels, periwinkles | Tubed Weed, Kelp, Rock Weed | None Collected |
| 18-MNMA-STEP2 | LAT 47° 9'51.02"N<br>LONG 55° 8'48.70"W | 25 | Black Mud/ Sand | Mussels, Scallop, Periwinkles, Common Sea Star | Rock Weed, Kelp | None Collected |
| 18-MNMA-STEP3 | LAT 47° 9'53.94"N<br>LONG 55° 8'50.93"W | 35 | Black Mud/ Sand | Scallops, Periwinkles, Mussels, Hermit crab | Rock Weed, Kelp | None Collected |