PLACENTIA BAY ATLANTIC SALMON AQUACULTURE PROJECT ENVIRONMENTAL EFFECTS MONITORING PLAN (EEMP): GROUNDWATER QUANTITY AND QUALITY AT THE HATCHERY

GRIEG NL

June 2020

Placentia Bay Atlantic Salmon Aquaculture Project
Environmental Effects Monitoring Plan:

Groundwater Quantity and Quality at the Hatchery

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1.0 Introduction

As part of the environmental assessment (EA) process for the proposed Placentia Bay Atlantic Salmon Aquaculture Project, Grieg NL was required to prepare and submit Environmental Effects Monitoring Plans (EEMP) subsequent to the completion of the Environmental Impact Statement (EIS) but prior to initiation of hatchery operations (see Minister's release letter of 5 September 2018). Additionally, the release of the Placentia Bay Atlantic Salmon Aquaculture Project from further environmental assessment by the Minister of the Department of Municipal Affairs and Environment (DMAE) on 5 September 2018 was subject to Grieg NL meeting a series of terms and conditions including eight components requiring an EEMP. The required EEMP for Groundwater Quantity and Quality at the Hatchery is presented in this document. This EEMP is designed to monitor the levels and quality of groundwater used at Grieg NL's Recirculating Aquaculture System (RAS) Hatchery located in Marystown, Newfoundland and Labrador (NL).

Grieg NL is committed to implementation of this EEMP as a component of its Placentia Bay Atlantic Salmon Aquaculture Project. The organization of this document generally follows the requirements outlined in Section 7.4 of the EIS Guidelines (DMAE 2018). The EEMP will be reviewed on an annual basis and updated as needed throughout the Project life.

2.0 Objectives and Scheduling of Monitoring

The EEMP for Groundwater Quantity and Quality at the Hatchery is designed to monitor water quality and water levels of the RAS Hatchery main well. Based upon input from the Water Resources Management Division (WRMD) of DMAE, the groundwater monitoring program will consist of the following primary components:

(1) Monitoring of water levels within the identified recharge area via a monitoring well;
(2) Monitoring of water quality parameters including potential contaminants;
(3) Identification of a wellhead protection area and monitoring; and
(4) Identification of risks to groundwater quality and availability.

The overall objective of this EEMP is to ensure that a robust monitoring program of water levels and water quality of Grieg NL's groundwater source for its RAS Hatchery is in place. The implementation of the EMMP will serve as an early warning system in the event that issues with the groundwater supply arise during the Project. Groundwater levels and quality will be monitored throughout RAS Hatchery Operations. The monitoring program will also serve to address Condition 'i' as stipulated in the Government of Newfoundland and Labrador's Project release letter [1].

3.0 Monitoring Design/Methodology

The RAS Hatchery requires that its water supply has sufficient quantity and that the quality is suitable to support the development of Atlantic salmon at various life stages. A groundwater well has been drilled and

[1] Condition 'i' states "Grieg NL shall identify a back-up water supply and provide anticipated water use numbers, a well-head protection and water-quality monitoring plan (ambient and real-time), and a contingency plan for the hatchery water supply in the event of catastrophic failure either with the well or the pump, to the Department of Municipal Affairs and Environment for approval prior to the commencement of hatchery operations."

tested to provide the water supply. Likewise, a monitoring well is in place for the main well. The monitoring well will also serve as a back-up well in the unlikely event of a catastrophic failure of the main well. The groundwater pumped from the main well will be pumped through a buffer tank and treated before it enters the RAS Hatchery. There will be numerous monitoring steps for water quality and quantity throughout the process. Background information on the wells and the groundwater distribution and treatment system is provided below.

3.1 Background

3.1.1 Overview of the Groundwater Wells

As described in the EIS for the Project (LGL Limited 2018), water required for Grieg NL's aquaculture operations at the RAS Hatchery will be supplied by a nearby well. The well was drilled in June 2015 and is located in the Town of Marystown near the intersection of McGettigan Boulevard and Centennial Road (47.177026°N, 55.151706°W). The eight-inch diameter well was drilled to an approximate depth of 128 m and was completed with 11.8 m of steel casing and bentonite grout. A second well, located adjacent to Centennial Road and approximately 90 m from the main well (47.177759°N, 55.152271°W), has been drilled as a monitoring well and will also serve as a back-up well. The monitoring/back-up well has an eight-inch diameter, a depth of approximately 128 m, and was also completed with 12 m of steel casing and bentonite grout. The locations of both wells relative to the RAS Hatchery are shown in Figure 3.1[2].

Aquifer Testing Reports have been prepared for each well (Appendices 1 and 2) and include descriptions of the surface water flow, groundwater movement, and aquifer recharge zones as required by the WRMD of DMAE. The two wells are considered part of the same aquifer (see Appendix 2). Each well meets the parameters needed to supply the RAS Hatchery (see Section 3.2 below). The WRMD has granted Grieg NL the necessary Water Use Licence (No. WUL-19-10545) to withdraw water and use water from its main groundwater well and the back-up well for the purposes of supplying water to its RAS Hatchery.

3.1.2 Water Distribution, Internal Flow and Pressure Checks, and Water Treatment

Groundwater pumped from the main well will be used to fill the RAS Hatchery tanks and as make-up water to replenish the water that is lost (e.g., through evaporation, spillage) during operations and to supply water to the hatching units. On average, the maximum water pumping rate that will be required is 300 L/min. The tanks in the First-Feeding Facility, Smolt Facility, and Post-Smolt Facility will require 475,000 L, 4,066,000 L, and 8,855,000 L of water to fill, respectively. It will take an estimated 1.1 days, 9.4 days, and 20.5 days to fill the First-Feeding Facility, Smolt Facility, and Post-Smolt Facility, respectively (assuming a 300 L/min rate).

[2] In July 2019, Grieg NL entered into an agreement with the Town of Marystown to acquire the land on which the existing well and the monitoring/back-up well are located, including an easement for the laying, installation and repair (if needed) of waterlines from the wells to the RAS Hatchery.

Figure 3.1. Locations of Grieg NL main well and monitoring/back-up well in Marystown.

After the initial filling of tanks in the RAS Hatchery, well water will be pumped periodically to replenish water levels. All incoming water to the RAS Hatchery from the main well will first pass through a buffer tank in a Water Distribution Facility (WDF); there will be one buffer tank, approximately 18,000 L in volume. The WDF is located on Grieg NL's marine industrial park site on a hill above the hatchery buildings and water will feed down to the hatchery buildings via gravity.

The well water will be pumped from the main well using a water pump designed specifically for a well; the water pump will be enclosed in a pumphouse. The pumphouse can be removed if larger equipment like a drill rig requires access to the wellhead. The well water pump will be suitable for drinking water standards and it will pump the water from the main well through an underground waterline to the WDF at the RAS Hatchery. The waterline will be 160 mm HDPE (high-density polyethylene) pipe and insulated; it will follow the Town's existing waterline routing from the Young Men's Christian Association (YMCA) to the Marine Industrial Park. The waterline leaving the pumphouse will have a bladder type, pre-charged pressure booster expansion tank installed which will be used to activate the well pump. When the pressure reaches a defined high level or low-level threshold the pump will start or stop as needed. As the inlet valve to the water treatment building is opened the pressure will drop thus starting the pump. As the inlet valve is closed, the pressure in the line rises which will shut down the pump. The pump will be set at a rate of 300 L/min and operate as required based on water usage and valve position at the WDF.

Inside the WDF, the water will pass through a filtration system to remove any particles in the water. The first stage of this filtration is a drum filter followed by ultra-violet (UV) treatment to kill any potential pathogens and to disinfect the water prior to the water entering the RAS facility. This water is then held in the buffer tank and will be divided into four "streams" through separate waterlines (see Figure 3.2):

1. The first stream will be fed by gravity to the First-Feeding Facility (i.e., the hatchery).
2. The second stream will be fed by gravity to the vaccination room (located in the Post-Smolt Facility).
3. The third stream is fed by gravity to the Smoltification Denitrification System (DNS) located in the Smoltification Facility. From there, it is stored in a DNS new water storage tank (located in the Smoltification Facility) and pumped into tanks in either the First-Feeding Facility or Smoltification Facility as needed.
4. The fourth stream is fed by gravity to the Post-Smolt DNS located in the Post-Smolt Facility. In the Post-Smolt DNS, the water passes through both ozone and UV to disinfect the water. From there it is stored in a DNS new water storage tank and pumped into tanks in the Post-Smolt Facility (A, B or C buildings) as needed.

For operational purposes, water levels will be carefully monitored and adjusted in the buffer tank located in the WDF and water flow will be monitored as it enters into the First-Feeding, Smoltification, and Post-Smolt facilities.

A water level sensor will be placed in the buffer tank that will detect both high, low and actual water level. If the water level in the buffer tank is too high, the valve feeding the tank will close and the pump will slow down and stop accordingly. If the water level in the tank is too low, the valve feeding the tank will open and the pump will speed up accordingly. The water float in the tank detects the actual level in the tank, but the high/low alarms will provide a redundant feedback to ensure that the tank is never empty or overfilled. A sight glass will also be placed on the tank for manual reading of the tank level.

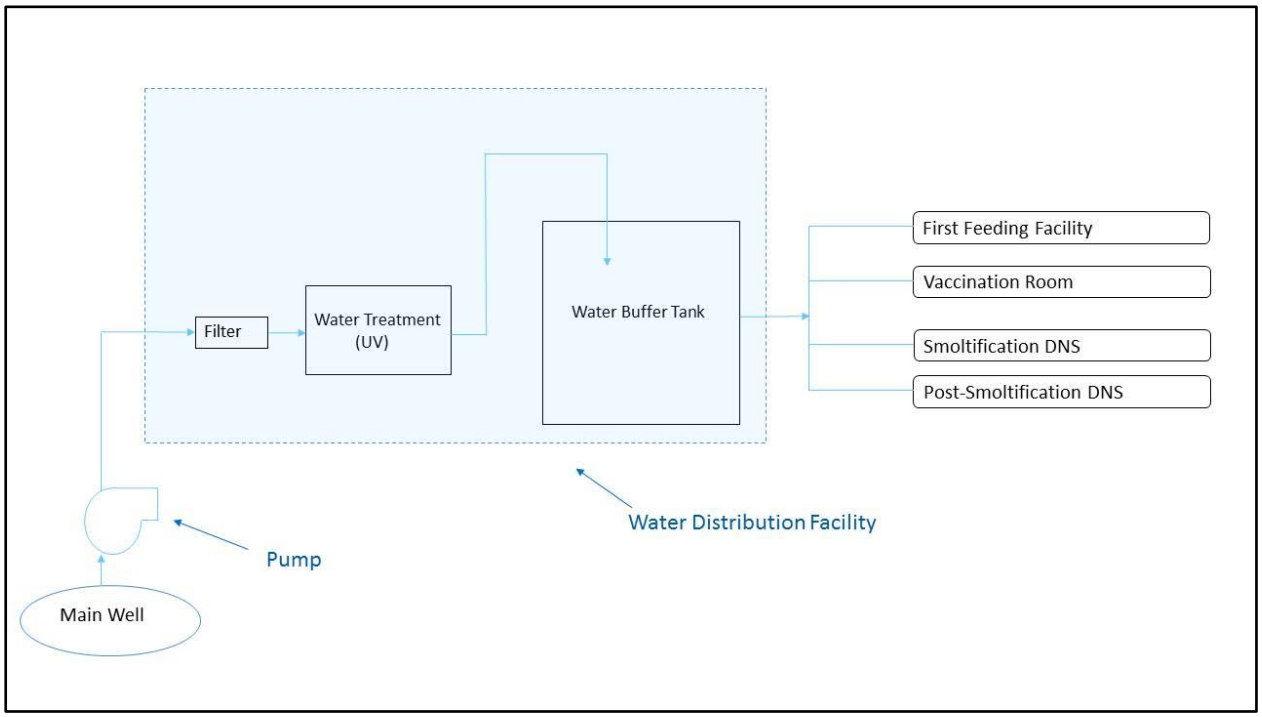

Figure 3.2. Process flow diagram of the inlet ground water distribution and buffer tank.

Flowmeters will be placed on the branches entering the First-Feeding, Smoltification, and Post-Smolt facilities that will detect and help control the water flow entering the buildings. The information will be transmitted to a controller which will have a set point for a desired water flow. If the water flow is not at the set point, the controller will open/close the valve to control the flow entering the buildings until it reaches the set point.

3.2 Baseline Conditions

Each well has been tested as per DMAE permit requirements. The findings, which represent baseline (or ambient) conditions prior to Grieg NL use of the water supply for aquaculture operations are summarized below.

3.2.1 Water Quality

The water at both well sites has been tested for water quality and compared to Health Canada's Guidelines for the Government of Canada Drinking Water Quality (CDWQ) and to the Canadian Council of Ministers of Environment Water Quality (CCMEWQ) Guidelines for the protection of freshwater and marine aquatic life[3]. It should be noted that the water is not intended for use as potable water but for approval by the

[3] http://st-ts.ccme.ca/en/index.html. These guidelines are calculated such that they protect the most sensitive life stage of the most sensitive aquatic life species over the long term. Hence, concentrations of a parameter that are less than the applicable guideline are not expected to cause any adverse effect on aquatic life. Concentrations that exceed the guidelines, however, do not necessarily imply that aquatic biota will be adversely affected, or that the water body is impaired; the concentration at which such effects occur may differ depending on site-specific conditions.

DMAE the water will need to be considered potable and therefore compared against CDWQ standards. All well information along with water quality results and comparison tables are presented in Appendices 1, 2, and 3.

For the main well, the results show that the water satisfies both guidelines except that:

- The water has a phosphorous concentration of 150 µg/L which exceeds the CCMEWQ trigger value of 100µg/L for hyper eutrophic levels.
- The turbidity values of 5.9 Nephelometric Turbidity Units (NTU) and 0.6 NTU collected during the beginning and end of the pumping test, respectively, exceeded the CDWQ maximum turbidity guideline of 0.1 NTU.
- The water has a fluoride concentration of 0.305 mg/L (Appendix 3), which exceeds the CCME guideline for freshwater of 0.12 mg/L[4]. Fluoride concentrations typically leach from igneous and sedimentary strata, such as found in Marystown, and may bioaccumulate in fish (CCME 2002).

The elevated phosphorous is not considered a concern as the RAS Hatchery system is a closed loop system and the phosphorous is expected to precipitate out of solution in the presence of magnesium, calcium and sodium present in the water. Furthermore, the guideline of >100 µg/L is an indicator of trophic status for aquatic life, not a toxicity level. As stated in the CCME Guidelines for Aquatic Life, nutrients such as phosphorus are non-toxic to aquatic organisms at levels and forms present in the environment (CCME 2007). The elevated turbidity is expected to reduce as the well is in use; however, as noted above, a filtration system will be installed to ensure that all water falls below the 0.1 NTU maximum turbidity limit outlined in the CDWQ. Camargo (2003) indicates that the optimum concentrations of inorganic fluorides for freshwater fishes are significantly "erratic" within fish classes, families and genera. He concluded that in soft waters with low ionic content, a fluoride concentration ≥ 0.5 mg/L can adversely affect invertebrates and fishes, and thereby recommended fluoride concentrations below this level to protect freshwater animals from fluoride. As noted above, the water sample collected from the main well had dissolved fluoride levels of 0.305 mg/L, less than the 0.5 mg/L level discussed by Camargo (2003).

For the monitoring well, the results show that the water satisfies both guidelines except that:

- Fluoride concentrations exceeded the CCME guideline for freshwater of 0.12 mg/L at both the beginning (0.36 mg/L) and at the end (0.30 mg/L) of the constant rate test.
- The turbidity values of 0.6 NTU and 0.19 NTU collected at the beginning and end of the pumping test, respectively, exceed the CDWQ maximum turbidity guideline of 0.1 NTU.

As with the main well, elevated turbidity levels are not anticipated to pose any issues in the monitoring well. As noted above, water samples collected from the monitoring well had dissolved fluoride levels ranging from 0.30 to 0.36 mg/L, less than the 0.5 mg/L level discussed by Camargo (2003).

[4] The CCME interim freshwater quality guideline for total inorganic fluoride toxicity to freshwater biota is 0.12 mg/L. Note that this guideline is derived from laboratory exposures of the caddisfly *Hydropsyche bronta*, an invertebrate (Camargo et al. 1992 and Camargo 1996 *in* CCME 2002) and not from laboratory exposures of freshwater fishes. Singh and Tripathi (2015) conclude that the scientific literature regarding the effects of inorganic fluorides on aquaculture species is relatively limited, and that more study of fluoride toxicity in fishes and aquaculture is needed.

Should the health and welfare of the salmon at the hatchery be deemed at risk by health officials because of water quality concerns, Grieg NL will have a developed plan in place to ensure the water quality (including fluoride levels) is adequate to support the growth of the Atlantic salmon in the RAS Hatchery.[5]

3.2.2 Water Levels

On average, the maximum water pumping rate that will be required is 300 L/min. The main well is rated as being able to pump at 1,208 L/min (Appendix 1). The monitoring well is rated as being able to pump at 455 L/min (Appendix 2). Both wells are considered more than adequate to suit the water requirements of the RAS Hatchery.

3.3 Monitoring Water Quality and Water Levels

As described below, water quality and water levels will be monitored in the monitoring well and main well.

Grieg NL as a condition of release from the EA process (i.e., 'Condition j') is participating in the province's real-time water quality and quantity monitoring network. The WRMD of DMAE will be provided with water level and water quality data on a continuous basis (in real time) from Grieg NL's monitoring well. All costs will be borne by Grieg NL as stipulated in the Memorandum of Agreement (MOA) with the DMAE. All water quality and water level sensors will be calibrated and monitored. Sensor calibration will depend on the type of sensor used and will be conducted according to the manufacturer's recommendations. Effective calibration will guarantee that the water quality and quantity data collected are accurate.

3.3.1 Location of the Monitoring Well

The location of the monitoring well was selected in consultation with the drilling contractor (DSD Drilling Services) and the Project engineering firm (Innovative Engineering). Its proximity to the main well and the RAS Hatchery were key factors in determining its location. Additionally, the portion of Centennial Road where it is located is a relatively under-utilized area of Marystown. The area surrounding the main well is utilized by a local YMCA, sports field, roadways and housing. The monitoring well will be utilized as a back-up well should the need arise. The monitoring well can be readily converted to a main pumping well should a catastrophic event occur that incapacitates the main well. Monitoring equipment can be removed, and a pump can be installed in short order to provide the RAS Hatchery with a back-up supply of well water (see Section 3.5).

3.3.2 Monitoring Water Quality

Various water quality parameters will be monitored at the monitoring well (Table 3.1)[6]. Water temperature, pH, salinity, specific conductivity, and oxidation-reduction potential (ORP) data will be collected in the monitoring well hourly throughout the Operations Phase. These data will be collected as part of the

[5] These measures will be included in an updated Environmental Protection Plan (EPP) for RAS Hatchery Operations. The EPP will also be updated to include measures to treat transfer water for potential pathogens prior to fish being transferred to the well boat for delivery to the sea cages.

[6] Water quality parameters will also be measured in the WDF before the water is distributed to the RAS facility and in fish tanks as standard operational procedure but these data are not considered relevant to the EEMP.

DMAE's Real-time Water Quality/Quantity Monitoring Program. Grieg NL, in partnership with DMAE, will cover the cost of the real time water quality monitoring equipment, which will be installed and maintained by DMAE staff. The water quality monitoring equipment has been selected in consultation with the WRMD. The water quality data will be displayed in real-time on a publicly available website maintained by the DMAE. The WRMD of the DMAE will manage the data for archival and public dissemination purposes. Note that ORP measurements will be used as an indication of the ability of the water supply to break down waste and other contaminants that may be present. Likewise, salinity data will serve as an early warning indicator for the presence of potential contaminants in the groundwater supply.

There will be periodic monitoring of a subset of metals, non-metals, and metalloids (see Table 3.1), which were measured as part of the well permitting procedure, in both the monitoring and main wells. Water quality parameters will be compared to CDWQ and CCMEWQ Guidelines and to baseline conditions as summarized in Section 3.2.1 and detailed in Appendices 1, 2, and 3. Monitoring for various metals, non-metals, and metalloids will be conducted quarterly during the first two years of RAS Hatchery Operations. After this time, the frequency of periodic sampling will be determined in consultation with the WRMD. Grieg NL will install a sampling port in each of the monitoring and main wells.

Table 3.1. Water quality parameters that will be monitored continuously at the monitoring well and periodically at the monitoring well and main well.

Water Quality Parameter	Monitoring Well	Main Well
Continous Sampling		
Temperature	x	
pH	x	
Specific Conductivity	x	
Salinity	x	
Oxidation-reduction potential (ORP)	x	
Periodic Sampling*		
Alkalinity, Aluminum, Ammonia, Antimony, Arsenic, Barium, Boron, Bromide, Cadmium, Calcium, Chloride, Chromium, Colour (true), Conductivity, Copper, Dissolved Organic Carbon, Fluoride, Hardness, Iron, Kjeldahl Nitrogen, Lead, Magnesium, Manganese, Mercury, Nickel, Nitrate/Nitrite, pH, Potassium, Selenium, Sodium, Sulphate, Total Dissolved Solids, Total Phosphorus, Turbidity, Uranium and Zinc	x	x

*Periodic sampling will be via a sampling port at the monitoring well and main well as recommended by the WRMD and will occur quarterly for the first two years. Subsequent sampling frequency will be based on consultations with the WRMD.

3.3.3 Monitoring Water Levels

Groundwater levels will be measured in both the main and monitoring wells. Although not directly relevant to the EEMP, checks will be in place to ensure that adequate water supply is being distributed to the WDF and the fish tanks in the RAS Hatchery (see Section 3.1).

3.3.3.1 Monitoring Well Levels

The water level in the main well will be measured continuously (minimum hourly) by Grieg NL using a well water level sensor (with an accompanying data logger) placed directly in the main well. Water level data will be collected in the main well throughout RAS Hatchery Operations. These data will support validation of the wellhead protection area modelling predictions.

3.3.3.2 Provincial Real-time Water Level Monitoring Program

As part of the DMAE's real-time water quality and quantity monitoring program, water level data will be collected on a near continuous basis (i.e., hourly) in the monitoring well. These data will allow Grieg NL to monitor if the water level in the aquifer supplying the RAS Hatchery is increasing or decreasing for any reason and to adjust water use accordingly. The WRMD of the DMAE will manage the data for archival and public dissemination purposes. Grieg NL, in partnership with DMAE, will cover the cost of the real time water quantity monitoring equipment, which will be installed and maintained by DMAE staff. The water level monitoring equipment has been selected in consultation with the WRMD. These data will be uploaded to the DMAE website and also recorded via a data logger that can be accessible when needed.

3.4 Wellhead Protection Area and Monitoring

Grieg NL will undertake the necessary modelling exercise to identify a wellhead protection area such that the groundwater resources will be protected for long-term sustainable use of the bedrock aquifer. A conceptual model and numerical model will be developed within appropriate boundaries (e.g., using topographic data to delineate the watershed encompassing the site) using available groundwater and stream flow data. The model will be calibrated using wells within the WRMD well database, as well as the pumping test results from the main well and monitoring well owned by Grieg NL. Appropriate time of travel scenarios and other modelling parameters will be developed in consultation with the WRMD. Modelling will include consideration of the locations of a nearby quarry and former dump site, which are located ~450 m and 850 m from the wells, respectively. Particle tracking will be used to determine the time of travel at the planned water pumping rate. This will determine the radius of influence of the main and back-up wells including consideration of long-term pumping scenarios (see also Section 6). The results will be provided in a report to the WRMD. Additional information is provided in the Wellhead Protection Plan (see Appendix 4) as per Condition 'i'.

The location of the main well/pump station is considered suitable from a security perspective because it is situated next to the YMCA where nearby human activity should deter vandalism and/or theft. In addition, the main well/pump station is not located next to any heavy industry (e.g., agriculture, manufacturing, etc.) or gas stations that may pose an immediate risk to well contamination. Likewise, the back-up well (i.e., monitoring well) is considered at low risk due to contamination given its location. Given the planned intermittent pumping schedule and water use estimates, it is not anticipated that the radius of influence of the well(s) will reach either the quarry or the former dump site and potential contaminants at these sites. As discussed above, modelling will be undertaken to quantify the radius of influence.

3.5 Risks to Groundwater Quality and Availability

Grieg NL has identified potential risks to the quality and availability of its groundwater supply for the RAS Hatchery and has identified steps in the unlikely event that water quality (see Section 3.5.2) and availability (see Section 3.5.3) are compromised. In addition, Grieg NL will have site security measures in place which are designed to minimize the risks associated with unwanted encroachment (by people and/or wildlife) near the wellheads (see Section 3.5.1).

3.5.1 Site Security

To enhance security of the main well/pumphouse, a security fence will be installed around the perimeter of the area. Closed-circuit television (CCTV) cameras will be installed outside and inside the pumphouse providing real-time video surveillance of the immediate area. Motion detectors integrated into the cameras will automatically record video to a Digital Video Recorder (DVR) (or similar device) so it will be available to appropriate personnel when required. To accommodate night-time surveillance/recording the security cameras will have integrated night vision capabilities.

In addition to cameras, additional security measures will be taken to secure the area during night via the installation of high lumen output Light Emitting Diode (LED) floodlights that will complement the general lighting installed on the building.

A wireless communication network (internet) will be available on the site to allow remote monitoring of the security cameras at all times. Security cameras with network capabilities will be sourced to accommodate this feature. Security measures will also be in place at the monitoring/back-up well.

3.5.2 Groundwater Quality

As discussed with the WRMD, there are some concerns that the quality of Grieg NL's groundwater supply may be negatively affected by contaminants (e.g., salt used to treat roads, oil spill on the adjacent road) given the location of the main well in a relatively developed area of Marystown. Additionally, the locations of the wells relative to a nearby quarry and former dump site may increase the risk of contamination. As noted in Section 3.3.2, salinity levels will be continuously monitored in the monitoring well. Additionally, an ORP sensor will be used to measure the ability of the water supply to break down waste and other contaminants that may be present. Of note, the real-time monitoring parameters are not designed exclusively to monitor contaminants but overall water quality. These parameters may be indicators of contaminants, which would require follow-up water quality sampling. As described in Section 3.4, modelling will be undertaken to determine the radius of influence of the main and back-up wells including consideration of long-term pumping scenarios. Should contaminants be detected, Grieg NL will shut down the water intake from the main well. The water supply in the buffer tank and the capability of operating on recirculated water for an extended period of time will allow sufficient time to address potential water quality issues.

3.5.3 Groundwater Availability

As described in Section 2.4.3.2 of the EIS, the RAS that will be used at Grieg NL's Hatchery is considered state-of-the-art and operates by filtering water from the fish tanks so it can be reused. The system uses

(periodically) 300 L/min versus the 500,000 L/min, which is typical in a flow-through system that is not reusing any water to accomplish an equivalent production (i.e., seven million smolt). In addition, the RAS Hatchery will have a large reserve of water stored in the Denitrification Systems (DNS).

3.5.3.1 Emergency Situation

When groundwater to the facility is unavailable in an emergency situation (or in the extreme instance of a catastrophic well failure—see Section 3.5.3.2), the facility will enter emergency water conservation mode and the following actions will be taken[7] to minimize the need for water in the facility:

- The fish feed will be evaluated and reduced, if necessary, to lower the load on the treatment systems;
- Only operations which are necessary to maintain the fish health will be undertaken and anything not necessary to maintain the fish health will be postponed; and
- The blowers and fan use in the buildings will be minimized to reduce evaporation in the tanks.

The RAS system can run for a period of two weeks without the addition of new water (Y. Dagan, AquaMaof Group, pers. comm., July 2019). This ensures that Grieg NL has adequate time to make necessary repairs including waterline, electrical, and pump failures.

Waterline Failure

If there is an issue with the waterline, Grieg NL has received permission from the Town of Marystown to have full access to the pipeline to initiate repairs immediately.

Electrical Failure

Primary electrical power for the well/pump station will be provided via the local electrical grid which is currently operated and maintained by Newfoundland Power. Under normal conditions, all well/pump station equipment and monitoring systems will utilize this electrical feed for everyday operations.

In the case of an emergency (i.e., power failure), backup power will be supplied to the system to ensure operations continue when power from the main electrical grid is not available. For well/pump station operations, auxiliary or emergency power will be supplied via generators. Emergency or back-up generators will be portable and stored off-site. This is to ensure that no fuel or other associated contaminants are stored on-site which may compromise the quality of water should a spill occur. Mobile generators suitable to handle the backup power requirements of the well/pump station will typically be flatbed mounted and brought to site via truck during emergency power situations. An access road will be available and maintained throughout the year to ensure access during an emergency. Generators will be connected to the well/pump station via electrical inlet isolated from the electrical grid (utility) with a transfer switch.

[7] This is also a benefit during periods of maintenance on the main well. There is no need for shut-down or switching to the back-up well during these periods. During routine maintenance, the facility can transition to complete recirculation mode until maintenance is completed.

Pump Failure

If the pump in the main well fails, a spare pump will be available (at Grieg NL location) and installed in the well. In addition, the monitoring well can be utilized as a backup. The monitoring well will be equipped with a pump and water line connections directly to the RAS Hatchery. With a turn of a valve, the monitoring well can be utilized. The monitoring well pump will be connected to the existing waterline and electrical connections and pumping to the RAS Hatchery will resume.

In the unlikely event of a catastrophic failure with the main well, Grieg NL will implement the measures in its contingency plan for the RAS Hatchery water supply, which are outlined below.

3.5.3.2 Catastrophic Failure

If for any reason the main well is no longer suitable (e.g., major collapse of the well), then the monitoring well will be used as a back-up to supply water to the RAS Hatchery. The primary purpose of this well is for monitoring of the main well, but it will be designed to be used as a back-up in a catastrophic emergency situation. The waterline and infrastructure will be in place to allow for a fast and easy transition to use this well as the main water source and an access road will be available and maintained (snow clearing for example) throughout the year to ensure year-round access. In case of a catastrophic emergency involving the ground water supply, Grieg NL will:

1. Implement emergency water conservation mode (see above);
2. Shut off the main well pump and equipment;
3. Remove all monitoring equipment from the monitoring well;
4. Install the back-up pump in the monitoring well;
5. Connect the pump to the existing waterline and electrical connections; and
6. Pump the water from the monitoring well to the RAS Hatchery site using the same below ground waterlines.

In the rare event that there is a well failure, Grieg NL will work to either restore the main well, or to identify and drill a new well to be used. Once the main well or a new well is in service, Grieg NL will reinstall all necessary monitoring equipment in the monitoring well.

In the highly unlikely event that water quantity was depleted from the aquifer supplying the RAS Hatchery, Grieg NL would drill a new well.

4.0 Frequency, Duration and Geographic Extent of Monitoring

The frequency, duration, and geographic extent of groundwater monitoring summarized in Table 4.1 have been determined in consultation with the WRMD.

Table 4.1. Summary of frequency, duration, and geographic extent of groundwater monitoring.

Groundwater Monitoring	Frequency	Duration	Geographic Extent
A. Water Quality			
Monitoring Well			
Temperature	Hourly	Operations Phase	Not applicable
pH	Hourly	Operations Phase	Not applicable
Specific Conductivity	Hourly	Operations Phase	Not applicable
Salinity	Hourly	Operations Phase	Not applicable
ORP	Hourly	Operations Phase	Not applicable
Monitoring and Main Well			
Alkalinity, Aluminum, Ammonia, Antimony, Arsenic, Barium, Boron, Bromide, Cadmium, Calcium, Chloride, Chromium, Colour (true), Conductivity, Copper, Dissolved Organic Carbon, Fluoride, Hardness, Iron, Kjeldahl Nitrogen, Lead, Magnesium, Manganese, Mercury, Nickel, Nitrate/Nitrite, pH, Potassium, Selenium, Sodium, Sulphate, Total Dissolved Solids, Total Phosphorus, Turbidity, Uranium and Zinc	Quarterly during first two years Thereafter, TBD in consultation with WRMD	Operations Phase	Not applicable
B. Water Levels			
Monitoring Well	Hourly	Operations Phase	Not applicable
Main well	Hourly	Operations Phase	Not applicable

5.0 Reporting and Response Mechanisms

During the first two years of groundwater use at the RAS Hatchery, Grieg NL will provide quarterly reports of groundwater monitoring results to the WRMD. After this time Grieg NL will consult with the WRMD to determine reporting frequency. These reports will include water quality results, water level data, and water use numbers. As appropriate, the collected water level data will be used to update the model that is produced for the wellhead protection area study. Updated modelling will be presented in the annual EEMP report—see below.

Grieg NL will present the findings of this EEMP in its annual EEMP report. It is possible, albeit unlikely, that groundwater levels in the aquifer will be reduced to levels that could adversely affect the regional aquifer system. Given the highly productive wells drilled for the RAS Hatchery and the relatively limited amount of groundwater required to operate the hatchery, it is not considered likely that water levels will decrease as a result of activities by Grieg NL. Using the groundwater model that will be created to identify the wellhead protection area, a threshold for water level (i.e., proportion of available draw down) will be determined that will serve as a trigger for Grieg NL to implement a response mechanism. This threshold will be determined in consultation with WRMD. The response will involve reducing pumping rates and/or ceasing pumping from the main well until the water level returns to an acceptable level.

6.0 Approach to Monitor Cumulative Effects

There are currently no other users that draw from the groundwater aquifer, which will supply the RAS Hatchery. As such, the approach to monitor for cumulative effects focuses on the potential for Grieg NL water use at the RAS Hatchery to deplete water levels in the aquifer. As described in Section 3.1.2 of the EEMP, after the tanks in the RAS Hatchery are initially filled, there will be periodic water use from the main well. Groundwater will be required to replenish water that is lost (e.g., through evaporation, spillage) during operations and to supply water to the hatching units. As established with the DMAE, pumping rates will not exceed 300 L/min. Safe yield calculations completed using the results of the aquifer testing indicate that the main well can sustain long term pumping at rates that are double the planned pumping rate of 300 L/min. Grieg NL is in the process of designating wellhead protection areas using numerical modelling to assess the radius of influence of the well and the interference between the main well and the back-up well. Though cumulative effects from use of the main well are not anticipated, Grieg NL will have a better understanding of any potential current and future groundwater use effects upon completion of the modelling study. The modelling study will be provided to WRMD with information on potential cumulative effects on water quantity detailed in the results of the report. Studies of water quality changes in moderate yield bedrock aquifers (e.g. Praamsma 2016), do not indicate that substantial water quality changes are anticipated over time in the volcanic bedrock aquifer that Grieg NL will use for groundwater abstraction. Grieg NL, however, has committed to conducting groundwater sampling of various quality parameters to allow monitoring of cumulative effects of long-term water use.

7.0 Procedures to Assess Effectiveness of Monitoring and Follow-up Programs, Mitigation Measures, and Recovery Programs

If groundwater level monitoring indicates that levels have decreased below an acceptable value (as determined through modelling to identify the wellhead protection area), Grieg NL will implement the response mechanism as outlined in Section 5. To assess the effectiveness of this approach, data on water levels will continue to be collected, perhaps with a more frequent sampling rate, and analyzed to determine the rate of recovery to acceptable levels. If necessary, additional measures will be put in place to monitor and mitigate groundwater use. These measures will be discussed with the WRMD of the DMAE.

8.0 Communication Plan to Describe the Results

As per ‘Condition c’ in the Government of Newfoundland and Labrador’s Project release letter, Grieg NL will include the results of the groundwater monitoring program within its annual report on EEMPs. This report will be publicly available on the Grieg NL website.

9.0 Literature Cited

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DMAE. 2018. Environmental Impact Statement Guidelines for the Placentia Bay Atlantic Salmon Aquaculture Project. Prepared by the Newfoundland and Labrador Department of Municipal Affairs and Environment, 8 March 2018. 38 p. Available at https://www.mae.gov.nl.ca/env_assessment/projects/Y2016/1834/index.html

LGL Limited. 2018. Environmental Impact Statement of the Placentia Bay Atlantic Salmon Aquaculture Project. LGL Rep. FA0144. Rep. by LGL Limited, St. John's, NL, for Grieg NL, Marystown, NL. 528 p. + appendices.

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List of Appendices

Appendix 1: Grieg NL Main Well Pumping Test Report (Aquifer Testing Report)

Appendix 2: Grieg NL Observation Well Pumping Test Report

Appendix 3: Grieg NL Main Well Water Quality Test Results

Appendix 4: Wellhead Protection Plan

Appendix 1

Greig NL Main Well Pumping Test Report
(Aquifer Testing Report)

Appendix 1

FINAL

Aquifer Testing Report
Grieg Seafarm NL Ltd.
Marystown
Newfoundland and Labrador

Submitted to:

DS Drilling Services Limited

Alexandria Building
4 Hops Street
Conception Bay South, NL
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Submitted by:

Amec Foster Wheeler Environment & Infrastructure,
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3 August 2015
Amec Foster Wheeler Project #: TF1563106

IMPORTANT NOTICE

This report was prepared exclusively for DS Drilling Services Limited by Amec Foster Wheeler Environment & Infrastructure, a Division of Amec Foster Wheeler Americas Limited (Amec Foster Wheeler). The quality of information, conclusions and estimates contained herein is consistent with the level of effort involved in Amec Foster Wheeler's services and based on: i) information available at the time of preparation, ii) data supplied by outside sources and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used by DS Drilling Services Limited only, subject to the terms and conditions of its contract with Amec Foster Wheeler. Any other use of, or reliance on, this report by any third party is at that party's sole risk.

EXECUTIVE SUMMARY

Amec Foster Wheeler Environment & Infrastructure (Amec Foster Wheeler) was retained by DS Drilling Services Limited (DSD) to evaluate the results of aquifer pumping tests conducted for a new drilled water supply well for Grieg Seafarms NL Ltd. (Grieg) in Marystown, Newfoundland and Labrador (NL), herein referred to as "the Site". It is understood that the bedrock groundwater well will be mainly used to service an aquaculture project in Marystown and is not intended for potable water. Amec Foster Wheeler was not on-Site during drilling of the well or the aquifer pumping tests and therefore this report is based solely on information and data collected and provided by DSD.

The results of the document review, pumping test analyses, and water quality data indicate:

- The average transmissivity of the well calculated from the 72 hour pumping test is 2.3×10^{-4} m^2/s.
- Quantitative evaluation of the pumping test indicates that the well is capable of producing approximately 1208 L/min (265 IGPM).
- The turbidity value of 5.9 NTU and 0.60 NTU detected in the 1 and 72 hour water samples, respectively, exceeded the GCDWQ of 0.1 NTU for treated water. Turbidity typically decreases with time as a new well goes into production. It is also noted that the GCDWQ is for treated water and not for untreated raw water pumped during the pumping test.
- A phosphorus concentration of 150 μg/L exceeded a CCME trigger value for the hyper eutrophic range.

The following recommendations are proposed should the well be used as a water supply well or for aquaculture water source:

- **Well Yield:** The well can sustain a safe pumping rate of 1208 L/min (265 IGPM).
- **Water Level:** Water level within the well should be monitored to ensure sustainable use, and the pumping rate may need to be adjusted to avoid over use.
- **Turbidity**: Filtration is recommended to address the elevated turbidity levels or further water samples should be collected to show that turbidity levels decrease below guidelines.
- **Regulations**: It is recommended that applicable guideline and regulations be followed for design, construction and operation of the water system.

All conclusions and recommendations are based on the results of the document review, aquifer tests, and water quality results.

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1.0 INTRODUCTION

Amec Foster Wheeler Environment & Infrastructure (Amec Foster Wheeler) was retained by DS Drilling Services Limited (DSD) to evaluate the results of aquifer pumping tests conducted for a new drilled water supply well for Grieg Seafarms NL Ltd. (Grieg) in Marystown, Newfoundland and Labrador (NL), herein referred to as "the Site". It is understood that the bedrock groundwater well will be mainly used to service an aquaculture project in Marystown and is not intended for potable water. Amec Foster Wheeler was not on-Site during drilling of the well or the aquifer pumping tests and therefore this report is based solely on information and data collected and provided by DSD.

1.1 Site Description and Use

Marystown is located on the east side of the Burin Peninsula, approximately 300 km southwest of the City of St. John's, NL (refer to Figure 1, Appendix A). The Site is located near the intersection of McGettigan Boulevard and Centennial Road and approximately 45 m north of McGettigan Boulevard. The following is a description of the adjacent land use in the vicinity of the well (refer to Figure 2, Appendix A).

- North: Wooded undeveloped area and a stream
- South: McGettigan Boulevard.
- East: Recreation Centre, Interpretation Centre, Softball Park and stream.
- West: Walmart.

2.0 SCOPE OF WORK

The aquifer testing was conducted to meet the Aquifer Testing Guidelines from the Water Resources Management Division (WRMD) of the Department of Environment and Conservation (DOEC), Government of Newfoundland and Labrador (GNL). As described in Section 22 of the guidelines, wells constructed in fractured bedrock and intended for public use at a rate exceeding 45 litres per minute (L/min) must be tested (pumped) for a minimum of 72 hours (DOEC WRMD, 2013).

As per the Amec Foster Wheeler proposal, dated June 11, 2015, the scope of work included the following:

1. Analyse data from a step drawdown test to determine an optimum pumping rate that may be sustained by the well for an extended period of time.

2. Analyse data from a 72 hour pumping test at the rate determined from the step drawdown test to determine hydraulic properties of the aquifer and potentially a long-term safe yield of the well.

3. Summarize bacteria, general chemistry and metals analytical data for water samples collected at 1 hour and 72 hours during the pumping test to assess water quality.

4. Analyze recovery water level measurements collected immediately following the 72 hour pumping test to support the aquifer pumping test analyses.

A separate observation well is recommended for a 72 hour pumping test since the additional data may provide more useful information to use in the pumping test interpretations described herein. However, an observation was not available for the current pumping test.

3.0 WELL DETAILS AND REQUIRED YIELD

The 0.02 m (8 inch) diameter well was drilled to an approximate depth of 128 m (420 ft) and completed with 11.8 m (38.7 ft) of steel casing and bentonite grout. The water well record indicates that the bedrock in the well consists of alternating layers of reddish green and green volcanic/sedimentary rock. Water bearing zones were identified at 15 m, 39.6 m, 49 m and 128 m. The stick up casing in the well was installed approximately 0.88 m above ground surface (mags). A copy of the water well record is presented in Appendix B.

4.0 METHODOLOGY

4.1 Document Review

Available documentation (i.e., climate information, bedrock and surficial geology maps and hydrogeological information/reports) was reviewed, which included the following:

- Geology of the Marystown Map Sheet (E/2), Burin Peninsula, Southeastern Newfoundland, Memorial University of Newfoundland, Master's Thesis (Taylor, 1978).
- St. Lawrence, Burin district, Newfoundland. Map 77-021. Scale: 1:50 000. In Geology of the Marystown (1M/3) and St Lawrence (1L/14) Map Areas, Newfoundland. Government of Newfoundland and Labrador, Department of Mines and Energy, Mineral Development Division, Report 77-08, 89 pages, enclosures (2 maps). GS# NFLD/1492b (Strong et al., 1997).
- Surficial Geology of the Marystown map sheet (NTS 1M/03). Geological Survey, Department of Natural Resources, Government of Newfoundland and Labrador, Map 2007-18, Open File 001M/03/0586 (Batterson and Taylor, 2007).
- Hydrogeology of Agricultural Development Areas, Newfoundland and Labrador (Jacques Whitford Environmental Limited (JWEL), 2008).
- Hydrogeology of Eastern Newfoundland (AMEC, 2013).
- Eco-regions of Newfoundland: Maritime Barrens Eco-region (DOEC, 2015a), accessed July, 2015: http://www.nr.gov.nl.ca/nr/forestry/maps/mbarrens_eco.html.
- Online Historical Climate Data (Environment Canada, 2015), accessed July, 2015: http://climate.weather.gc.ca/.
- Water Resources Portal (DOEC, 2015b), accessed July 2015: http://maps.gov.nl.ca/water/.

4.2 Aquifer Testing and Safe Yield Calculations

A step drawdown test was conducted on June 28, 2015. The test was completed in two 60 minute duration steps at pumping rates of 454.6 and 568.3 L/min, based on the estimated yield of the airlift test (464 to 680 L/minute). Only two steps were conducted because the maximum pumping rate for the pump was reached at approximately 568 L/min. Using the results of the step draw down test, a 72 hour pumping test was conducted between June 29 and July 2, 2015 at a constant pumping rate of approximately 568.3 L/min. Immediately following the 72 hour pumping test, the submersible pump was turned off and recovery measurements were collected until the well reached at least 80% recovery. Representatives of DSD were on-Site for the duration of the step drawdown test, 72 hour pumping test and recovery period.

The 1.5 horsepower Goulds (model 10SB) submersible pump used during the step drawdown test and 72 hour pumping test was installed and operated by DSD at a depth of 66 m (217 ft). The discharge rate was measured on the dial gauge of a factory calibrated 1 inch diameter Neptune flow meter. The discharge pipe was extended approximately 150 m from the well to direct discharge away from the pumping well. Various isolation valves were installed on the discharge pipe to control pumping and collect water samples.

Water level measurements were collected manually and recorded as metres below top of stick up casing (mbtoc), using an electronic water level meter generally following the intervals:

Step Drawdown Test

- Every 1 minute until 10 minutes
- Every 2 minutes from 10 - 20 minutes
- Every 5 minutes from 20 - 60 minutes

For two steps.

72 hour Pumping Test

- Every 1 minute for the first 15 minutes
- Every 5 minutes from 15 - 60 minutes (1 hour)
- Every 30 minutes from 60 - 300 minutes (1 - 5 hours)
- Every 60 (1 hour) minutes from 300 - 1440 minutes (5 - 24 hours)
- Every 360 minutes (6 hours) from 1440 - 4320 minutes (24 - 72 hours)

Recovery Test

- Every 1 minute for the first 15 minutes
- Every 5 minutes from 15 minutes - 60 minutes (1 hour)
- Every 30 minutes from 60 - 210 minutes (1 - 3.5 hours)

Water levels were also measured during aquifer testing using a pressure transducer set at one minute intervals. The transducer measurements were not corrected for barometric pressure.

The transmissivity of the well was calculated using the Hantush groundwater flow solution. The long term safe yield of the well was calculated using the calculated/modelled transmissivity values using the following equation:

$$Q = 0.7 \times T \times \Delta s / 0.183 \times \log t$$

Where *Q* is the safe pumping rate, *T* is the transmissivity, Δs is the total drawdown during the test, and t is the time that the pumping rate will be used.

4.3 Water Quality Analyses

Water samples were collected by DSD during the first (1 hour) and last hour (72 hours) of the pumping test. Water samples were submitted to Maxxam Analytics Laboratory (Maxxam) in St. John's, NL for general chemistry and metals analyses at their Bedford, Nova Scotia Laboratory. The first water sample was submitted for Maxxam's RCAP-30 limited analysis package, whereas, the 72 hour sample was submitted for Maxxam's comprehensive RCAP-MS package. The water samples were also submitted to the NL Public Health Laboratory in St. John's, NL (Miller Center) for Bacteria (*Escherichia Coli (E. Coli*) and total coliforms) analysis.

5.0 DOCUMENT REVIEW

5.1 Eco-Region and Climate

The Site is part of the ocean climate influenced Southeastern Barrens Subregion of the Maritime Barrens Eco-region, which is marked by cool summers, mild winters and high frequencies of fog and strong southerly winds. Slope bogs, basin bogs and fens are scattered throughout the barrens, reflecting poor drainage and wet climate (DOEC, 2015a).

The most recent data (2000) provided by Environment Canada's monitoring station in St. Lawrence, NL indicated a monthly mean temperature high of 14.7°C in August and a low of -5.0°C in February. Annual monthly precipitation ranged from 106 millimeters (mm) in August to 157.4 mm in September and October (Environment Canada, 2015).

5.2 Topography and Drainage

The topography of the Site is generally flat with a slight to moderate downward gradient to the south toward McGettigan Boulevard. The topography of the overall area is rugged and has an overall moderate upward slope to the northwest and an overall downward slope to the southeast toward Mortier Bay. Based on local topography and surface water elevations, groundwater flow direction is anticipated to be southeast toward Mortier Bay.

5.3 Chemistry of Nearby Potable Water Supplies

Water quality analytical data reports for the surface water body (Fox Hill Reservoir/Clam Pond; WS-S-0448) currently servicing Marystown were downloaded from the DOEC Water Resources portal (DOEC, 2015b) (Appendix C). The reports include nutrient, metal, physical parameter and major ion concentrations in water collected from WS-S-0488 between 1985 and 2014. No groundwater water supply wells were identified in the area near the Site from the DOEC Water Resources Portal mapping. Water chemistry data is presented in Appendix C. Concentrations were compared to Health Canada's Guidelines for Canadian Drinking Water Quality (GCDWQ) (Health Canada, 2015), summarized as follows:

Nutrients and Metals

Concentrations of nutrients (ammonia, dissolved organic carbon, nitrate, kjeldahl nitrogen and phosphorus) and metals detected in the water samples collected from WS-S-0448 were below the GCDWQ between 1985 and 2012.

Physical Parameters and Major Ions

Concentrations of physical parameters (alkalinity, conductivity, hardness, total dissolved solids and total suspended solids) and major ions (boron, bromide, calcium, chloride, fluoride, potassium, sodium and sulphate) detected in the water samples collected from WS-S-0448 were below the GCDWQ between 1985 and 2012. Colour detected in the water samples collected from WS-S-0448 exceeded the GCDWQ aesthetic objective (AO) in 1991 and between 1995 and 2012. pH detected in the water samples collected from WS-S-0448 exceeded the GCDWQ AO in 1999 and 2001. Turbidity detected in water collected from WS-S-0448 exceeded the GCDWQ in 1991, 1998, 2001, 2002, 2006 and 2012.

5.4 Surficial Geology

The surficial geology underlying the Site consists of vegetation concealed thin veneer (<1.5 m) of glacial till and angular frost-heaved bedrock (Batterson and Taylor, 2007).

5.5 Bedrock Geology

Marystown lies within the Avalon tectonostratigraphic zone and is underlain by mafic to acidic volcanic rocks and minor sedimentary rocks of the Mortier Group. Rocks in the area have undergone regional-scale folding related to Devonian Acadian orogenesis and form the core of a broad regional northeast – southwest trending anticline, referred to as the Burin Anticline. A series of joint sets and fracture zones occur within rocks underlying Marystown and are related to deformation (JWEL, 2008).

The Creston Formation of the Mortier Group underlies the Site and is dominated by approximately 500 m of basaltic flows with subordinate acidic pyroclastic and sedimentary rocks with an estimated thickness of 550 m. The basalts are highly amygdaloidal and dark green to purple. The pyroclastic and

sedimentary rocks of the Mortier Group are acidic; although locally they have high concentrations of mafic debris giving the rocks a greenish colour and intermediate composition (Strong et al., 1977).

Rocks of the Cashel Lookout Formation underlie the area north of the site and include undivided acidic pyroclastics, flow banded rhyolite (and/or ignimbrite) and volcaniclastic sediments (Strong et al., 1977).

5.6 Hydrogeology

A study entitled 'The Hydrogeology of Agricultural Development Areas (ADA), Newfoundland and Labrador', was conducted for Winterland which borders Marystown to the west (JWEL, 2008). The groundwater potential of the various geological units underlying the Winterland ADA was assessed using available records for water wells completed within each unit obtained from the DEOC WRMD Drilled Water Well Database for wells drilled between 1950 and March, 2008.

No well records were available for wells drilled in the Mortier Group, however, a total of 23 well records from the community of Winterland were used to characterize the groundwater potential of the geologically similar Marystown Group in the ADA. Based on well data, the Marystown Group strata are considered capable of providing wells with low to moderate yields with water yields ranging from 4 to 90 L/min at well depths of 15 to 132 m, and an average yield of 39 L/min at 71 m depth. However, median yield and depth estimates of 34 L/min at 76 m depth are more likely representative of the typical groundwater potential of this unit.

A study entitled 'Hydrogeology of Eastern Newfoundland' was completed in 2013. A total of 1819 well records were available for a geological unit called Volcanic Strata of eastern Newfoundland. Well yields ranged from 0.3 to 455 L/min with a median value of 9 L/min and averaged 25 L/min. Well depth ranged from 8 to 228 m and averaged 67 m. The available data indicate that wells in Volcanic Strata in Eastern Newfoundland generally have a low to moderate potential yield (AMEC, 2013).

6.0 DISCUSSION OF RESULTS

The depth to water measurements for the step drawdown test, the 72 hour pumping test and recovery test are presented in Appendix D. The following is a summary of the various tests conducted between June 28 and July 2, 2015.

6.1 Air Lift Test

An airlift test was conducted by DSD upon completion of the well, which indicated a potential yield of approximately 454 to 680 L/min.

6.2 Step Drawdown Test

A step drawdown test was conducted in two 60 minute duration steps at pumping rates of 454.6 and 568.3 L/min, based on the estimated yield of the airlift test. Drawdowns of approximately 42.7 and 53.2 m were measured for each of the two steps/respective pumping rates identified above. Results of the

step draw down test analysis, which used the Theis unconfined aquifer model solution, suggested that transmissivity of the well was 0.000571 m2/sec and could sustain a pumping rate of approximately 568 L/min. A graph of the step drawdown test (Figure E-1) is provided in Appendix E.

6.3 72 Hour Pumping Test

The 72 hour pumping test was conducted between July 29 and August 2, 2015 at a constant rate of approximately 568 L/min (determined from the step drawdown test). At the beginning of the pumping test the static water level was 5.33 mbtoc.

During the first hour, the water level decreased approximately 10 m. The water level decreased steadily from the beginning of the pumping test until approximately 200 minutes. Drawdown levelled to 12 m at 600 minutes (10 hours) and decreased less than 2 m during the remainder of the pumping test. A total drawdown of 13 m was measured over the 72 hour duration of the pumping test.

Based on the shape of the drawdown curve, the Hantush leaky aquifer solution was used to interpret the test. A leaky aquifer is interpreted to be over or underlain by a semi-impermeable confining layer (aquitard) which leaks to some extent. Therefore water is pumped from not only the aquifer but also the aquitard. In a leaky aquifer during early pumping times the water level drops relatively quickly as water is pumped from the aquifer. During medium pumping times, more and more water from the aquitard is assumed to be reaching the aquifer. At late pumping times, a significant or dominant portion of water is from leakage through the aquitard, as flow towards the well reaches a steady state (Kruseman and de Ridder, 1991). Though the fractured bedrock conditions on Site may not physically represent leaky conditions, as water is mainly flowing through fractures in the rock, the high estimated yield values indicate that limited primary porosity exists within the rock allowing limited storage that could mimic leaky conditions.

A time – drawdown graph of the 72 pumping test (Figure E-2) is provided in Appendix E.

6.4 Recovery Test

Immediately following the 72 hour pumping test, the submersible pump was turned off and recovery measurements were collected. The water level increased approximately 7 m during the first hour of recovery. Recovery reached over 90% of the original static water level in approximately 3.5 hours. A time – drawdown graph of the recovery test (Figure E-2) is provided in Appendix E.

6.5 Aquifer Test Analyses

- The 72 hour pumping test and recovery data were analyzed using the Hantush leaky aquifer solution. The transmissivity value from the data analyzed was 2.3×10^{-4} m^2/s for the 72 hour pumping test and recovery data. Pumping test results are summarized in Table 1.

Table 1. Pumping Test Results

Data Type	Method	Transmissivity (m^2/s)	Comments
Pumping Test	Hantush with aquitard storage	2.3×10^{-4}	72 hour and recovery data

6.6 Safe Well Yield

Safe yield values were calculated using the transmissivity value calculated from the long term pumping test and an available drawdown of 128 m (Table 2). Calculated values range from approximately 3887 L/min (855 Imperial gallons per minute (IGPM)) for one hour of pumping to 984 L/min (216 IGPM) for 20 years of continuous pumping. For one year of continuous pumping, 1208 L/min (265 IGPM) is considered reasonable. A pumping rate of 265 IGPM is therefore recommended for the Grieg Seafarm well in Marystown.

Table 2. Safe Yield Values for the Well.

Time	Time (min)	Q (m^3/s)	Q (L/min)	Q (Igpm)
1 hour	60	6.48E-02	3887	855
8 hours	480	4.30E-02	2578	567
1 day	1440	3.65E-02	2188	481
30 days	43200	2.49E-02	1491	328
100 days	4320000	1.74E-02	1041	229
1 year	525600	2.01E-02	1208	265
20 years	10512000	1.64E-02	984	216

7.0 WATER QUALITY RESULTS

Water quality results were compared to both potable water and aquatic life guidelines due to the intended water usage.

7.1 Compared to Potable Water Guidelines

The following section provides a summary of the water quality results compared to the Health Canada GCDWQ (Health Canada, 2015). Analytical tables are presented in Appendix F and the certificates of analyses are presented in Appendix G. Results of the water quality results are summarized below:

- *E. coli* and total coliforms were not detected in the 72 hour water samples and therefore did not exceed the GCDWQ value of 0 detected per 100 ml (refer to Table 1, Appendix G). Water samples were collected within the first hour of the test; however, it was a holiday (July 1st) and the lab was not open and holding times were therefore unintentionally exceeded for the first sample.

- The turbidity value of 5.9 NTU and 0.60 NTU detected in the 1 and 72 hour water samples, respectively, exceeded the GCDWQ of 0.1 NTU for treated water.
- Concentrations of other metal and general chemistry parameters were below the GCDWQ.

It is also noted that the GCDWQ is for treated water and not for untreated raw water pumped during the pumping test. Filtration systems should be designed and operated to reduce turbidity levels as low as reasonably achievable and strive to achieve a treated water turbidity target from individual filters of less than 0.1 NTU. Particles can harbour microorganisms, protecting them from disinfection, and can entrap heavy metals and biocides; elevated or fluctuating turbidity in filtered water can indicate a problem with the water treatment process and a potential increased risk of pathogens in treated water (Health Canada, 2014). The turbidity value decreased with time between the 1 hour and 72 hour samples and is anticipated to continue to decrease over time as the well goes into production.

7.2 Compared to Aquatic Life Guidelines

Grieg requested that the water quality data be compared to applicable guidelines for the protection of freshwater and marine aquatic life since the water will be used for aquaculture. It is understood, however, that for approval the DOEC WRMD will assume that the well will be used for potable water.

The following section provides a summary of the water quality results compared to the Canadian Council of Ministers of Environment (CCME) Water Quality Guidelines for the protection of freshwater and marine aquatic life (CCME, 2015). Analytical tables are presented in Appendix F and the certificates of analyses are presented in Appendix G. Results of the water quality results are summarized below:

- A phosphorus concentration of 150 μg/L exceeded the CCME trigger value for the hyper eutrophic range.
- Concentrations of other metal and general chemistry parameters were below the CCME guidelines for the protection of freshwater and marine aquatic life.

Phosphorus is an essential nutrient for all living organisms; living matter contains about 0.3 percent dry weight phosphorus. Water bodies containing low phosphorus concentrations (i.e., unimpacted sites) typically support relatively diverse and abundant aquatic life that are self-sustaining and support various water uses. However, elevated phosphorus concentrations can adversely affect aquatic ecosystems if ionic phosphorus encounters oxygen to form phosphate. The elevated phosphorus is not considered a concern at this site, as it will be operated as a contained system and the phosphorus is expected to precipitate out of the solution as a salt in the presence of magnesium, calcium and sodium.

It should also be noted that the rocks of the Creston Group underlying the Site contains up to 0.44 weight percent (%) P_2O_5 (4400 mg/kg) and 1.15 % apatite. Apatite is a phosphate mineral with chemical formula $Ca_5(PO_4)_3(F,Cl,OH)$. Thus, the source of the phosphorus in the water may be the bedrock (Taylor, 1978).

8.0 CONCLUSIONS

The results of the document review, pumping test analyses, and water quality data indicate:

- The average transmissivity of the well calculated from the 72 hour pumping test is 2.3×10^{-4} m^2/s.
- Quantitative evaluation of the pumping test indicates that the well is capable of producing approximately 1208 L/min (265 IGPM).
- The turbidity value of 5.9 NTU and 0.60 NTU detected in the 1 and 72 hour water samples, respectively, exceeded the GCDWQ of 0.1 NTU for treated water. Turbidity typically decreases with time as a new well goes into production. It is also noted that the GCDWQ is for treated water and not for untreated raw water pumped during the pumping test.
- A phosphorus concentration of 150 ug/L exceeded a CCME trigger value for the hyper eutrophic range.

All conclusions are based on the results of the document review, aquifer tests, and water quality results.

9.0 RECOMMENDATIONS

The following recommendations are proposed should the well be used as a water supply well or for aquaculture water source:

- **Well Yield:** The well can sustain a safe pumping rate of 1208 L/min (265 IGPM).
- **Water Level:** Water level within the well should be monitored to ensure sustainable use, and the pumping rate may need to be adjusted to avoid over use.
- **Turbidity**: Filtration is recommended to address the elevated turbidity levels or further water samples should be collected to show that turbidity levels decrease below guidelines.
- **Regulations**: It is recommended that applicable guideline and regulations be followed for design, construction and operation of the water system.

All recommendations are based on the results of the document review, aquifer tests, and water quality results.

10.0 CLOSURE

This report has been prepared for the exclusive use of DS Drilling Services Limited. The hydrogeological assessment was conducted using standard practices and in accordance with written requests from the client. No further warranty, expressed or implied, is made. The conclusions presented herein are based solely upon the scope of services and time and budgetary limitations described in our contract. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Amec Foster Wheeler Environment & Infrastructure accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. The limitations of this report are attached in Appendix H.

Yours sincerely,

Amec Foster Wheeler Environment & Infrastructure,
a Division of Amec Foster Wheeler Americas Limited

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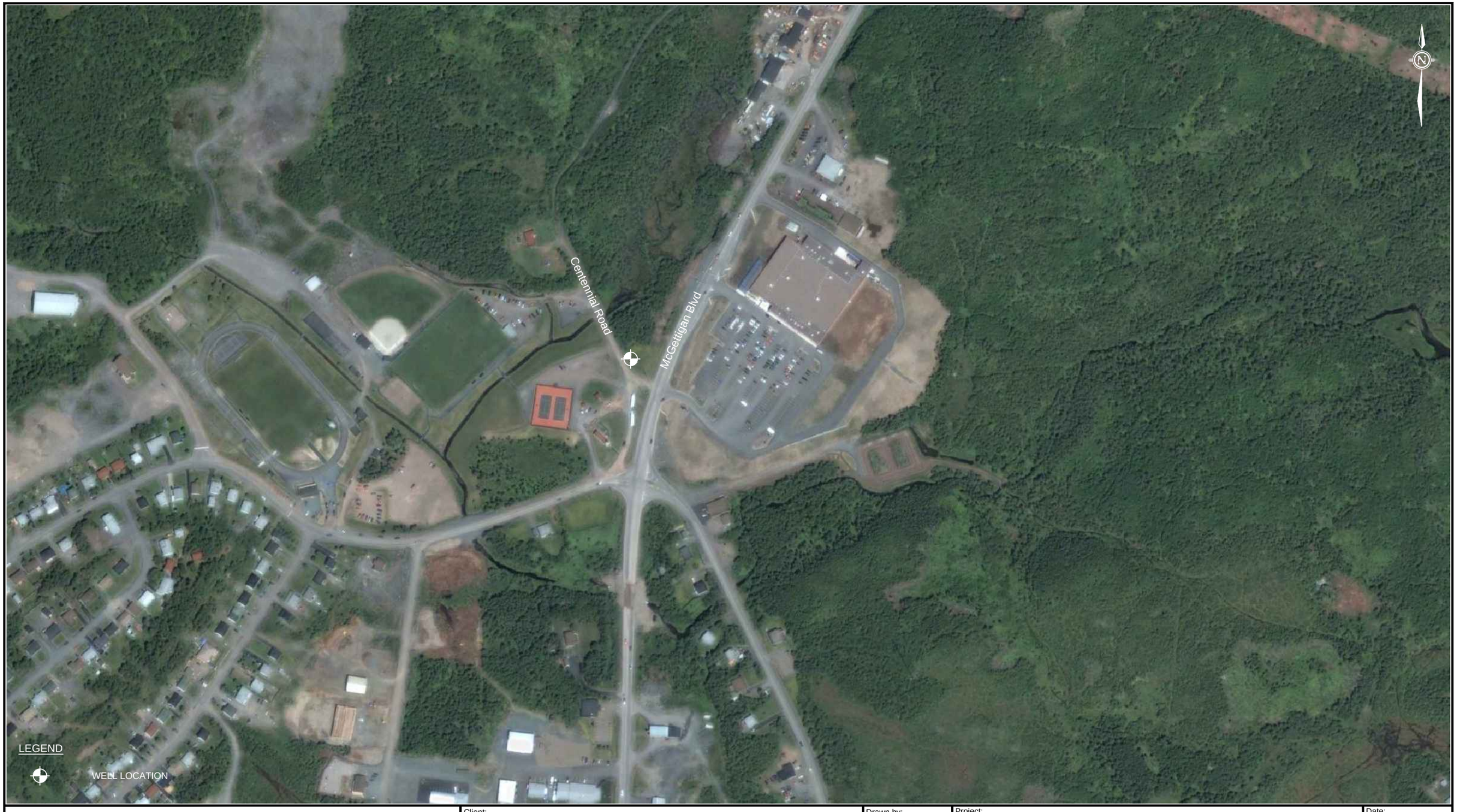
APPENDIX A: FIGURES

Source:

This figure based on 1:50,000 Topographic Map 1M03

Amec Foster Wheeler 133 Crosbie Road St. John's, NL, A1B 4A5 (709) 722-7023	DWN BY: J. ABBOTT	PROJECT NAME: AQUIFER TEST, GREIG'S SEA FARM, MARYSTOWN, NL	DATE: JULY 2015
	CHKD BY: T. PRAAMSMA		PROJ No. TF1563106
CLIENT: DS DRILLING SERVICES LTD	SCALE: AS SHOWN	PROJECT TITLE: SITE LOCATION MAP	DRAWING No. 1



NOTES:
1. DO NOT SCALE FROM DRAWING.
2. ALL LOCATIONS, DIMENSIONS, AND ORIENTATIONS ARE APPROXIMATE.
3. THIS DRAWING IS INTENDED TO SHOW RELATIVE LOCATIONS AND CONFIGURATION IN SUPPORT OF THIS REPORT.

Client: DAVE SULLIVAN'S DRILLING

AMEC Foster Wheeler
Environment & Infrastructure
133 Crosbie Road
St. John's, NL A1B 4A5
709-722-7023

amec foster wheeler

Drawn by: J. Abbott

Approved by: T. Praamsma

Scale: NTS

Project: AQUIFER TEST,
GRIEG'S SEA FARM, MARYSTOWN, NL

Title: SITE PLAN

Date: July 2015

Project No. TF1563106

Rev. No. 0

Figure No. 2

APPENDIX B: WELL RECORD

Newfoundland Labrador

Well Identification Number (WIN)

Department of Environment and Conservation
Water Resources Management Division
Well Construction Record

Measurements: ☒ Metric ☐ US

Well Owner Information (must be the final owner of well or borehole)

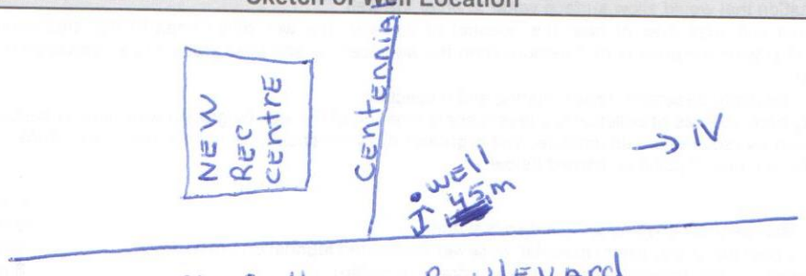
First Name	Last Name	Street Address	
Grieg Seafarms (NL) Ltd		5 Popular Place, P.O. Box 98	
Town/City	**LGID** (For Office Use Only)	**LGID Name** (For Office Use Only)	**Postal Code** / **Telephone**
St. Alban's			A0H 2E0 / 538-7413

Well/Borehole Location

Town/City	Street Address/Lot Number	Land Owner (Developer, Private, etc.)
Marystown	McGettigan Blvd	Town of Marystown

GPS Coordinates — Latitude N 47 ° 10 ' 37.0 " — Longitude W 055 ° 09 ' 06.1 "

Sketch of Well Location



Show distances from at least two landmarks and indicate North
Include street / road name / and house / lot number if available

Water Bearing Zones

Depth	Rate	Type
15 m	8 LPM	
39.6 m	90 LPM	
49 m	180 LPM	
128 m	454 -	680 LPM

Type of Water Encountered

☒ Fresh ☐ Odourous ☐ Salt
☐ Cloudy ☐ Clear ☐ Coloured
☐ Other (Specify) _____

Borehole Lithology

Depth	Colour	Lithology
0-3m	Brown	Sand + Gravel
3-48m	Redish Green	Volcanic/Sedimentary
48-m91m	Green	Volcanic/Sedimentary
91-128	Redish Green	" "

Depth to Bedrock: 3 **Depth of borehole containing casing:** 12.8 **Total depth of borehole:** 128 m

Casing Information - recommended Sch 40, .280 Wall

Casing should be finished 0.60 metres (2 feet) above grade

Depth From	Depth To	Inside Diameter	Type	Thickness
0	12.8	~~m~~ 200	Sch40	6.25

Height of the casing finished above grade: _____

Annular Space and Sealant

The annulus of the well should be sealed with an impermeable sealant from the bottom of the casing/drive shoe to the surface.

Depth From	Depth To	Type of Sealant Used
12.8	1 m	Bentonite Grout

Reason why annulus was not sealed: _____

Screen Information

Was a screen installed? ☐ Yes ☒ No

From	To	Slot	Diameter	Material

Drilling Method

☒ Rotary (Air) ☐ Hammer ☐ Reverse Rotary
☐ Other _____
Drive Shoe installed? ☐ Yes ☐ No

Final Status of Well/Borehole

☐ Domestic ☐ Municipal ☐ Exploration ☐ Sealed Well
☐ Dewatering ☐ Geothermal ☐ Observation ☒ Other Industrial

Pumping Test Results

Flowing Well: ☐ Yes ☐ No
If flowing, rate:

Static Water Level: 12

Recommended Pumping Rate:

Method:
☒ Air Lift ☐ Pump
☐ Other _____

Pump Intake at: Duration:

Recommended Pump Depth:

Pumping Rate during Test:

Estimated Safe Yield: 680 LPM

Licenced Water Well Construction Contractor Information

Comments:

Well Construction Company	Licence Number	Well Completed on: (Day – Month – Year)
DS Drilling Services	020	7/6/2015

Driller		Driller Assistant	
Sign	Print: Dave Sullivan	Sign	Print: Matthew White

This is a Legal Document *Placentia Bay Atlantic Salmon Aquaculture Project EIS-Appendix L* ***Safeguard with Home Owner's Documents***

If you have any questions regarding this document, please call Water Resources Management at 709-729-2563

White Copy – Department of Environment and Conservation **Yellow Copy – Drilling Company** **Pink Copy – Well Owner**

APPENDIX C: NEARBY WATER QUALITY DATA

Source Water Quality for Public Water Supplies
Nutrients and Metals

Sample Date	Ammonia	DOC	Nitrate(ite)	Kjeldahl Nitrogen	Total Phosphorus	Aluminum	Antimony	Arsenic	Barium	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Selenium	Uranium	Zinc
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Guidelines for Canadian Drinking Water Quality			10				0.006	0.01	1.0	0.005	0.05	1.0	0.3	0.01		0.05	0.001		0.01	0.02	5.0
Aesthetic(A) Parameter or Contaminant (C)			C				C	C	C	C	C	A	A	C		A	C		C	C	A
Community Name: **Marystown**																					
Service Area: **Marystown**																					
Source Name: **Fox Hill Reservoir / Clam Pond**																					
Sep 20, 2012	0.000	10.0	0.000	0.120	0.000	0.120	0.00000	0.000	0.000	0.00000	0.00000	0.000	0.180	0.000	0.000	0.130	).0000	0.000	0.000	0.0000	0.000
Nov 17, 2009	0.000	8.0	0.000	0.200	0.000	0.140	0.00000	0.000	0.000	0.00000	0.00000	0.000	0.180	0.000	0.600	0.032	).0000	0.000	0.000	0.0000	0.000
Jun 03, 2009	0.000	5.4	0.000	0.200	0.000	0.080	0.00000	0.000	0.000	0.00000	0.00000	0.000	0.050	0.000	0.700	0.013	).0000	0.000	0.000	0.0000	0.006
Aug 28, 2007	0.060	6.3	0.000	0.300	0.000	0.100	0.00000	0.000	0.005	0.00000	0.00000	0.000	0.090	0.000	0.700	0.028	).0000	0.000	0.000	0.0000	0.000
Feb 14, 2007	0.060	10.1	0.000	0.810	0.020	0.090	0.00000	0.000	0.000	0.00000	0.00000	0.006	0.120	0.000	0.000	0.030	).0000	0.000	0.000	0.0000	0.040
Aug 29, 2006	0.000	8.3	0.000	0.190	0.000	0.120	0.00000	0.000	0.000	0.00000	0.00000	0.000	0.180	0.000	0.000	0.080	).0000	0.000	0.000	0.0000	0.000
Sep 13, 2005	0.000	6.1	0.000	0.230	0.000	0.080	0.00000	0.000	0.000	0.00000	0.00000	0.000	0.080	0.000	0.000	0.040	).0000	0.000	0.000	0.0000	0.000

Sample Date	Ammonia	DOC	Nitrate(ite)	Kjeldahl Nitrogen	Total Phosphorus	Aluminum	Antimony	Arsenic	Barium	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Selenium	Uranium	Zinc
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Guidelines for Canadian Drinking Water Quality			10				0.006	0.01	1.0	0.005	0.05	1.0	0.3	0.01		0.05	0.001		0.01	0.02	5.0
Aesthetic(A) Parameter or Contaminant (C)			C				C	C	C	C	C	A	A	C		A	C		C	C	A
Nov 16, 2004	0.050	7.6	0.000	0.220	0.000	0.120	0.00000	0.000	0.000	0.00000	0.00000	0.000	0.130	0.000	0.000	0.030	).0000	0.000	0.000	0.0000	0.000
Jun 08, 2004	0.060	5.9	0.000	0.350	0.000	0.110	0.00000	0.000	0.000	0.00000	0.00000	0.000	0.100	0.000	0.000	0.020	).0000	0.000	0.000	0.0000	0.000
Nov 12, 2003	0.050	5.9	0.050	0.220	0.010	0.120	0.00050	0.001	0.005	0.00005	0.00050	0.001	0.130	0.001	0.500	0.040	).0000	0.003	0.001		0.005
May 27, 2003	0.010	4.2	0.050	0.210	0.010	0.160	0.00050	0.001	0.010	0.00020	0.00050	0.001	0.110	0.001	1.000	0.036	).0000	0.003	0.001		0.003
Jan 29, 2002	0.010	4.7	0.150	0.240	0.005	0.120	0.00050	0.001	0.005	0.00005	0.00050	0.001	0.130	0.001	1.000	0.020	).0000	0.005	0.001	0.0005	0.005
Nov 20, 2001	0.100	7.6	0.050	0.290	0.005	0.150		0.001	0.005	0.00005	0.00050	0.001	0.170	0.001	0.500	0.050	).0000	0.001	0.001		0.005
Sep 12, 2001	0.010	4.7	0.050	0.270	0.005	0.290		0.001	0.010	0.00005	0.00050	0.001	0.090	0.001	0.500	0.060	).0001	0.005	0.001		0.005
Jun 19, 2001		6.2	0.003	0.300	0.005	0.025		0.005	0.025	0.00100	0.00500	0.005	0.050	0.001	1.170	0.030	).0005	0.005	0.005		0.010
Mar 06, 2001		5.6	0.003	0.350	0.005	0.080				0.00100	0.00500	0.005	0.050	0.001	1.310	0.010	).0005	0.005			0.005
Nov 22, 2000		8.4	0.003	0.200	0.005	0.120				0.00100	0.00500	0.005	0.120	0.001	0.760	0.030	).0005	0.005			0.005
Sep 06, 2000		6.1	0.003	0.220	0.005	0.060				0.00100	0.00500	0.005	0.160	0.001	1.720	0.060	).0005	0.005			0.005

Sample Date	Ammonia	DOC	Nitrate(ite)	Kjeldahl Nitrogen	Total Phosphorus	Aluminum	Antimony	Arsenic	Barium	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Selenium	Uranium	Zinc
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Guidelines for Canadian Drinking Water Quality			10				0.006	0.01	1.0	0.005	0.05	1.0	0.3	0.01		0.05	0.001		0.01	0.02	5.0
Aesthetic(A) Parameter or Contaminant (C)			C				C	C	C	C	C	A	A	C		A	C		C	C	A
Jun 06, 2000		5.2	0.003	0.260	0.005	0.025				0.00100	0.00500	0.005	0.005	0.001	0.600	0.005	).0005	0.005			0.005
Feb 23, 2000		5.0	0.003																		
Oct 19, 1999		8.5	0.003	0.360	0.005	0.025						0.005	0.130	0.001		0.070					0.005
Jul 27, 1999		3.2																			
Jun 01, 1999		5.9	0.003	0.200	0.005	0.025						0.005	0.050	0.001		0.020					0.005
Feb 08, 1999		5.8																			
Oct 20, 1998		7.6	0.003	0.250	0.005	0.080						0.005	0.140	0.001		0.040					0.005
May 27, 1998		6.2	0.003	0.110	0.005	0.110						0.020	0.110	0.001		0.010					0.020
Nov 01, 1995	0.005	6.9	0.025	0.100	0.005	0.110				0.00010	0.00025	0.005	0.104	0.001	0.990	0.060					0.005
Jun 13, 1995	0.008	4.9	0.010	0.160	0.002	0.060				0.00020	0.00025	0.004	0.039	0.001	1.000	0.019					0.005
Oct 23, 1991		6.3				0.130		0.000		0.00050	0.00010	0.001	0.110	0.001	1.030	0.120	).0000	0.001			0.005

Sample Date	Ammonia	DOC	Nitrate(ite)	Kjeldahl Nitrogen	Total Phosphorus	Aluminum	Antimony	Arsenic	Barium	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Selenium	Uranium	Zinc
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Guidelines for Canadian Drinking Water Quality			10				0.006	0.01	1.0	0.005	0.05	1.0	0.3	0.01		0.05	0.001		0.01	0.02	5.0
Aesthetic(A) Parameter or Contaminant (C)			C				C	C	C	C	C	A	A	C		A	C		C	C	A
Jun 04, 1991		3.4				0.063				0.00050	0.00010	0.001	0.050	0.001	0.980	0.020	).0000	0.001			0.005
Nov 07, 1985		5.1	0.030			0.070		0.000		0.00050	0.00010	0.001	0.105	0.001	1.000	0.080	).0000	0.001			0.005
Jun 20, 1985		3.8	0.020			0.015		0.000		0.00100	0.00010	0.001	0.004	0.002	1.060	0.005	).0000	0.001			0.005

Sample Date	Ammonia	DOC	Nitrate(ite)	Kjeldahl Nitrogen	Total Phosphorus	Aluminum	Antimony	Arsenic	Barium	Cadmium	Chromium	Copper	Iron	Lead	Magnesium	Manganese	Mercury	Nickel	Selenium	Uranium	Zinc
Units	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Guidelines for Canadian Drinking Water Quality			10				0.006	0.01	1.0	0.005	0.05	1.0	0.3	0.01		0.05	0.001		0.01	0.02	5.0
Aesthetic(A) Parameter or Contaminant (C)			C				C	C	C	C	C	A	A	C		A	C		C	C	A

Source water samples are collected directly from the source such as a groundwater well, lake, pond, or stream prior to disinfection or other treatment. The source water quality is analyzed to determine the quality of water that flows into your water treatment and distribution system. The quality of the water this water is a direct indicator of the health of the ecosystem that makes up the natural drainage basin, well head recharge area or watershed area. Monitoring of source water quality is the most important tool to assess the impact of land use changes on source water quality, the presence of disinfection by-product (DBP) pre-cursors and to ensure the integrity of a public water supply. The values for each parameter are as reported by the lap and verified by the department.

Quality Assurace / Quality Control (QA/QC) - The department is striving to improve the quality of the data using standard QA/QC protocols. This is an evolving process which many result in minor changes to the reported data.

LTD - Less Than Detection Limit - The detection limit is the lowest concentration of a substance that can be determined using a particular test method and instrument. Detection limits vary from parameter to parameter and change from time to time due to improvements in analytical procedures and equipment.

The exceedence report for source water provides a brief discussion and interpretation of health related water quality parameters, if any, that exceed the acceptable limits as set out in the Guidelines for Canadian Drinking Water Quality, Sixth Edition (GCDWQ). This comparison is only for screening purposes since at present there are no guidelines for untreated source water. The GCDWQ applies to water at the consumers tap. However in the absence of water treatment these guidelines could be applicable to source water quality.

Aesthetic (A) Parameters - Aesthetic parameters reflect substances or characteristics of drinking water that can affect its acceptance by consumers but which usually do not pose any health effects.

Contaminants (C) - Contaminants are substances that are known or suspected to cause adverse effects on the health of some people when present in concentrations greater than the established Maximum Acceptable Concentrations (MACs) or the Interim Maximum Acceptable Concentrations (IMACs) of the GCDWQ. Each MAC has been derived to safeguard health assuming lifelong consumption of drinking water containing the substance at that concentration. IMACs are reviewed periodically as new information becomes available. Please consult your Medical Officer of Health for additional information on the health aspects of contaminants.

Contaminants

Nitrate(ite) - The maximum acceptable concentration for nitrate(ite) in drinking water is 10 mg/L expressed as nitrate-nitrogen. Nitrate and nitrite are naturally occurring ions that are widespread in the environment. High levels of this contaminant can cause adverse health effects for some people.

Arsenic - The interim maximum acceptable concentration for arsenic in drinking water is 0.01 mg/L. Arsenic is introduced into water through the dissolution of minerals and ores, from industrial effluents and via atmospheric deposition. High levels of this contaminant can cause adverse health effects for some people.

Barium - The maximum acceptable concentration for barium in drinking water is 1.0 mg/L. Barium is not found free in nature but occurs as in a number of compounds. High levels of this contaminant can cause adverse health effects for some people.

Cadmium - The maximum acceptable concentration for cadmium in drinking water is 0.005 mg/L. Cadmium that is present as an impurity in galvanized pipes, a constituent of solders used in fitting water heaters or incorporated into stabilizers in black polyethylene pipes may contaminate water supplies during their distribution. High levels of this contaminant can cause adverse health effects for some people.

Chromium - The maximum acceptable concentration for chromium in drinking water is 0.05 mg/L. High levels of this contaminant can cause adverse health effects for some people.

Lead - The maximum acceptable concentration for lead in drinking water is 0.010 mg/l. Lead is present in tap water as a result of dissolution from natural sources or from the distribution systems and plumbing containing lead in pipes, solder or service connections. High levels of this contaminant can cause adverse health effects for some people.

Mercury - The maximum acceptable concentration for mercury in drinking water is 0.001 mg/L. High levels of this contaminant can cause adverse health effects for some people.

Selenium - The maximum acceptable concentration for selenium in drinking water is 0.01 mg/L. High levels of this contaminant can cause adverse health effects for some people.

Uranium - The interim maximum acceptable concentration for uranium in drinking water is 0.02 mg/L. Uranium may enter drinking water from naturally occurring deposits or as a result of human activity, such as mill tailings and phosphate fertilizers. High levels of this contaminant can cause adverse health effects for some people.

Antimony - The interim maximum acceptable concentration (IMAC) for antimony in drinking water is 0.006 mg/L. It is a naturally occurring metal that is introduced into water through the natural weathering of rocks, runoff from soils, effluents from mining and manufacturing operations, industrial and municipal leachate discharges and from household piping and possibly non-leaded solders. High levels of this contaminant can cause adverse health effects for some people.

Aesthetic Parameters

Copper - The aesthetic objective for copper in drinking water is 1.0 mg/L. Copper is widely distributed in nature and is found frequently in surface water and in some groundwater. Usually, copper in tap water is the result of dissolution of copper piping within the distribution system. The aesthetic objective was set to ensure palatability and to minimize staining of laundry and plumbing fixtures. Copper is an essential element in human metabolism and copper deficiency results in a variety of clinical disorders. At extremely high doses copper intake can result in adverse health effects. High levels of copper in tap water may result in blue-green staining on some fixtures.

Iron - The aesthetic objective for iron in drinking water is 0.3 mg/L. Usually, iron in tap water is the result of high iron content in the raw water and dissolution of iron piping within the distribution system. Iron is an essential element in nutrition. High levels of iron in tap water can cause staining of laundry and plumbing fixtures, unpleasant taste, colour and promote biological growths in the distribution system.

Manganese - The aesthetic objective for manganese in drinking water is 0.05 mg/L. Usually, manganese in drinking water is the result of high amounts of manganese in the source water supply's bedrock. Manganese is an essential element in humans and is regarded as one of the least toxic elements. High levels of manganese may cause staining of plumbing and laundry and undesirable tastes in beverages.

Zinc - The aesthetic objective for zinc in drinking water is 5.0 mg/L. Zinc in water can be naturally occurring or due to zinc in plumbing materials. Zinc is an essential element for human nutrition. Long term ingestion of zinc has not resulted in adverse effects. Water with zinc concentrations higher than the aesthetic objective has an astringent taste and may be opalescent and develop a greasy film on boiling.

mg/L = milligrams per litre or parts per million µS/cm = micro Siemens per centimeter NTU = nephelometric turbidity units TDS = total dissolved solids TSS = total suspended solids TCU = true colour units
DOC = dissolved organic carbon Nitrate(ite) = Nitrate + Nitrite WS # = water supply number SA# = serviced area number GCDWQ = Guidelines for Canadian Drinking Water Quality
Notes : Guidelines for Canadian Drinking Water Quality have not been developed for all the parameters listed in this report.
pH has no units

Source Water Quality for Public Water Supplies
Physical Parameters and Major Ions

	Sample Date	Alkalinity	Color	Conductivit	Hardness	pH	TDS	TSS	Turbidity	Boron	Bromide	Calcium	Chloride	Fluoride	Potassium	Sodium	Sulphate
	Units	mg/L	TCU	µS/cm	mg/L		mg/L	mg/L	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
	Guidelines for Canadian Drinking Water Quality		15			6.5 - 8.5	500		1.0	5.0			250	1.5		200	500
	Aesthetic(A) Parameter or Contaminant (C)		A			A	A		C	C			A	C		A	A
Community Name:	**Marystown**																
Service Area:	**Marystown**																
Source Name:	**Fox Hill Reservoir / Clam Pond**																
	Sep 20, 2012	0.00	66	43.0	7.00	6.5	28		1.10	0.00	0.00	3.00	7	0.000	0.000	4	0
	Nov 17, 2009	5.00	64	42.0	9.00	6.4	21		0.70	0.00	0.00	2.30	7	0.000	0.200	5	0
	Jun 03, 2009	6.00	35	46.0	9.00	6.3	21		0.00	0.01	0.00	2.40	7	0.000	0.300	6	0
	Aug 28, 2007	5.00	28	45.0	11.00	6.8	21		0.60	0.01	0.00	3.20	6	0.000	0.300	5	0
	Feb 14, 2007	7.00	55	64.0	5.00	6.4	42		0.90	0.00	0.00	2.00	12	0.000	0.000	6	4
	Aug 29, 2006	7.00	54	49.0	7.00	6.5	32		1.20	0.00	0.00	3.00	8	0.000	0.000	4	3
	Sep 13, 2005	13.00	30	49.0	10.00	7.2	32		0.80	0.00	0.00	4.00	8	0.000	0.000	5	3
	Nov 16, 2004	12.00	57	62.0	10.00	7.1	40		1.00	0.00	0.00	4.00	10	0.000	0.000	5	4
	Jun 08, 2004	8.00	41	60.0	5.00	6.4	39		0.60	0.00	0.00	2.00	9	0.000	0.000	7	3

Sample Date	Alkalinity	Color	Conductivit	Hardness	pH	TDS	TSS	Turbidity	Boron	Bromide	Calcium	Chloride	Fluoride	Potassium	Sodium	Sulphate
Units	mg/L	TCU	µS/cm	mg/L		mg/L	mg/L	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Guidelines for Canadian Drinking Water Quality		15			6.5 - 8.5	500		1.0	5.0			250	1.5		200	500
Aesthetic(A) Parameter or Contaminant (C)		A			A	A		C	C			A	C		A	A
Nov 12, 2003	17.00	42	66.0	7.00	6.4	43		0.70	0.01	0.03	3.00	12	0.050	0.500	7	4
May 27, 2003	18.00	26	67.0	22.00	6.8	44		0.90	0.03	0.03	7.00	13	0.050	0.500	7	4
Jan 29, 2002	10.00	41	63.0	14.00	6.5	41		1.10	0.03	0.03	4.00	11	0.050	0.500	6	4
Nov 20, 2001	10.00	58	54.0	10.00	6.8	36		0.80	0.03	0.03	4.00	9	0.050	0.500	7	4
Sep 12, 2001	11.00	50	61.0	10.00	6.5	36		1.50	0.01	0.03	4.00	9	0.050	0.500	5	4
Jun 19, 2001	7.50	48	60.5	14.00	6.9	46		0.15	0.03	0.03	3.74	15	0.005	0.240	8	2
Mar 06, 2001	9.50	43	72.5		6.4	47	1	0.11		0.03	3.49	11	0.005	0.270	9	2
Nov 22, 2000	8.00	69	50.5		6.6	38	1	0.31		0.03	3.18	7	0.005	0.280	6	2
Sep 06, 2000	8.60	50	58.0		7.1	43	1	0.21		0.03	5.09	8	0.005	0.200	8	2
Jun 06, 2000	7.60	47	59.0		7.2	38	1	0.54		0.03	2.83	8	0.005	0.240	6	2
Feb 23, 2000		38	63.4		6.5			0.32		0.03		10				2
Oct 19, 1999	4.20	75	65.6		6.3	46	1	0.47		0.03	2.91	11	0.025	0.480	6	2

Sample Date	Alkalinity	Color	Conductivit	Hardness	pH	TDS	TSS	Turbidity	Boron	Bromide	Calcium	Chloride	Fluoride	Potassium	Sodium	Sulphate
Units	mg/L	TCU	µS/cm	mg/L		mg/L	mg/L	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Guidelines for Canadian Drinking Water Quality		15			6.5 - 8.5	500		1.0	5.0			250	1.5		200	500
Aesthetic(A) Parameter or Contaminant (C)		A			A	A		C	C			A	C		A	A
Jul 27, 1999		32	63.7		7.1			0.12		0.03						
Jun 01, 1999	5.40	52	55.5		6.8	37	1	0.40		0.03	2.76	8	0.025	0.150	5	2
Feb 08, 1999		27	66.5		6.3			0.30								
Oct 20, 1998	6.70	70	50.1		6.8	34	1	1.10			3.29	7		0.210	5	2
May 27, 1998	4.50	60	43.7		6.6	32	2	0.50			2.33	7		0.150	4	2
Nov 01, 1995	8.59	50	59.0		7.0	40		0.80			3.85	9	0.050	0.260	6	2
Jun 13, 1995	8.81	5	65.7		7.0	50		0.55			4.20	12	0.083	0.300	7	3
Oct 23, 1991		33	67.0		7.0			1.05			4.15	13	0.030	0.410	7	3
Jun 04, 1991		20	69.0		7.0			0.40			4.00	13	0.030	0.380	8	3
Nov 07, 1985	8.80	13	68.0		6.9			1.00			4.10	12	0.030	0.340	7	3
Jun 20, 1985	7.95	5	75.0		7.0			0.35			3.90	14	0.030	0.320	7	4

Sample Date	Alkalinity	Color	Conductivit	Hardness	pH	TDS	TSS	Turbidity	Boron	Bromide	Calcium	Chloride	Fluoride	Potassium	Sodium	Sulphate
Units	mg/L	TCU	µS/cm	mg/L		mg/L	mg/L	NTU	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Guidelines for Canadian Drinking Water Quality		15			6.5 - 8.5	500		1.0	5.0			250	1.5		200	500
Aesthetic(A) Parameter or Contaminant (C)		A			A	A		C	C			A	C		A	A

Source water samples are collected directly from the source such as a groundwater well, lake, pond, or stream prior to disinfection or other treatment. The source water quality is analyzed to determine the quality of water that flows into your water treatment and distribution system. The quality of the water this water is a direct indicator of the health of the ecosystem that makes up the natural drainage basin, well head recharge area or watershed area. Monitoring of source water quality is the most important tool to assess the impact of land use changes on source water quality, the presence of disinfection by-product (DBP) pre-cursors and to ensure the integrity of a public water supply. The values for each parameter are as reported by the lap and verified by the department.

Quality Assurace / Quality Control (QA/QC) - The department is striving to improve the quality of the data using standard QA/QC protocols. This is an evolving process which many result in minor changes to the reported data.
LTD - Less Than Detection Limit - The detection limit is the lowest concentration of a substance that can be determined using a particular test method and instrument. Detection limits vary from parameter to parameter and change from time to time due to improvements in analytical procedures and equipment.

The exceedence report for source water provides a brief discussion and interpretation of health related water quality parameters, if any, that exceed the acceptable limits as set out in the Guidelines for Canadian Drinking Water Quality, Sixth Edition (GCDWQ). This comparison is only for screening purposes since at present there are no guidelines for untreated source water. The GCDWQ applies to water at the consumers tap. However in the absence of water treatment these guidelines could be applicable to source water quality.

Aesthetic (A) Parameters - Aesthetic parameters reflect substances or characteristics of drinking water that can affect its acceptance by consumers but which usually do not pose any health effects.

Contaminants (C) - Contaminants are substances that are known or suspected to cause adverse effects on the health of some people when present in concentrations greater than the established Maximum Acceptable Concentrations (MACs) or the Interim Maximum Acceptable Concentrations (IMACs) of the GCDWQ. Each MAC has been derived to safeguard health assuming lifelong consumption of drinking water containing the substance at that concentration. IMACs are reviewed periodically as new information becomes available. Please consult your Medical Officer of Health for additional information on the

Contaminants:

Turbidity - The maximum acceptable concentration for turbidity is 1 NTU. Turbidity refers to the water's ability to transmit light or the cloudiness of the water. Turbidity in tap water can be the result of turbid raw water and influences within the distribution system. Turbidity is usually the result of fine organic and inorganic particles which do not settle out. Increased turbidity of drinking water results in it being less aesthetically pleasing, and may interfere with the disinfection process.

Boron - The interim maximum acceptable concentration for boron in drinking water is 5.0 mg/L. Boron is widespread in the environment, occurring naturally in over 80 minerals and in the earth's crust. Levels in well water have been reported to be more variable and often higher than those in surface waters, most likely due to erosion from natural resources. High levels of this contaminant can cause adverse health effects for some peopleTurbidity - The maximum acceptable concentration for turbidity is 1 NTU. Turbidity refers to the water's ability to transmit light or the cloudiness of the water. Turbidity in tap water can be the result of turbid raw water and influences within the distribution system. Turbidity is usually the result of fine organic and inorganic particles which do not settle out. Increased turbidity of drinking water results in it being less aesthetically pleasing, and may interfere with the disinfection process.

Fluoride - The maximum acceptable concentration for fluoride in drinking water is 1.5mg/L.The fluoride concentration in natural water varies widely as it depends on such factors as the source of the water and the geological formations present. Trace amounts of fluoride may be essential for human nutrition and the presence of small quantities leads to a reduction of dental caries. High levels of this contaminant can cause adverse health effects for some people.

mg/L = milligrams per litre or parts per million µS/cm = micro Siemens per centimeter NTU = nephelometric turbidity units TDS = total dissolved solids TSS = total suspended solids
TCU = true colour units
DOC = dissolved organic carbon Nitrate(ite) = Nitrate + Nitrite WS # = water supply number SA# = serviced area number GCDWQ = Guidelines for Canadian Drinking Water Quality
Notes : Guidelines for Canadian Drinking Water Quality have not been developed for all the parameters listed in this report.
pH has no units

Asthetic Parameters

Colour - An aesthetic objective of 15 true colour units (TCU) has been established for colour in drinking water. Colour in drinking water may be due to the presence of coloured organic substances or metals such as iron, manganese and copper. Highly coloured industrial wastes also contribute to colour. The presence of colour is not directly linked to health but it can be aesthetically displeasing.

pH -The acceptable range for drinking water pH is 6.5 - 8.5. The control of pH is primarily based on minimizing corrosion and encrustration in the distribution system. Tap water with low pH may accelerate the corrosion process in the distribution system, and contribute to increased levels of copper, lead and possibly other metals. Incrustation and scaling problems may become more frequent above pH 8.5

TDS - The aesthetic objective for TDS in drinking water is 500 mg/L. The term "total dissolved solids"(TDS) refers mainly to the inorganic substances that are dissolved in water. At low levels TDS contributes to the palatability of water. At high levels it may cause excessive hardness, taste, mineral deposition and corrosion.

Chloride - The aesthetic objective for chloride in drinking water is 250 mg/L. Chloride can be in water from a variety of sources, including the dissolution of salt deposits and salting of roads for ice control. No evidence has been found suggesting that ingestion of chloride is harmful to humans. However, high levels of chloride in water can impart undesirable tastes to water and beverages prepared from water.

Sodium - The aesthetic objective for sodium in drinking water is 200 mg/L. Since the body has very effective means to control levels of sodium, sodium is not an acutely toxic element in the normal range of environmental or dietary concentrations. At extremely high dosages it has adverse health effects. Sodium levels may be of interest to authorities who wish to prescribe sodium restricted diets for their patients..

Sulphate - The aesthetic objective for sulphate in drinking water is 500 mg/L. Sulphates, which occur naturally in numerous minerals, are used in the mining and pulping industries and in wood preservation. Large quantities of sulphate can result in catharsis and gastrointestinal irritation. The presence of sulphate above

APPENDIX D: DRAWDOWN MEASUREMENTS

Pumping Well – Step Test Recovery

Location: Marystown **Project: Greig SeaFarms**

Total depth of Well: 420' Cased To: 42' **Screened/Open Hole to: 8"**

Inside Diameter: 8" **Static Water Level: 17.5'**

Measuring Point Above Ground level: 2'9" **Date: June 29, 2015**

GPS Coordinates:47 10' 37" N 55 09' 06" W

Start Time: 8:45 a.m. June 29, 2015 **Pump Test Phase: 72 Hour Pumping Test**

Pump Set@ 217' + 17.2"

Step	Elapsed Time (min)	Water Level	Flow
	1	45.8	
	2	41.15	
	3	38.8	
	4	37.25	
	5	36.15	
	6	35.1	
	7	34.4	
	8	33.75	
	9	33.2	
	10	32.7	
	11	32.25	
	12	31.9	
	13	31.55	
	14	31.2	
	15	30.9	
	20	29.7	
	25	28.8	
	30	28.1	
	35	27.5	
	40	27	
	45	26.55	
	50	26.15	
	55	25.8	
	60	25.5	
	90	24.1	
	120	23.2	
	150	22.4	
	180	22	
	210	21.8	
	240		
	270		
	300		

Pumped Well Record

Location: Marystown **Project:** Greig SeaFarms

Total depth of Well: 420' **Cased To:** 42' **Screened/Open Hole to:** 8"

Inside Diameter: 8" **Static Water Level:** 17.5'

Measuring Point Above Ground level: 2'9" **Date:** June 29, 2015

GPS Coordinates: 47 10' 37" N 55 09' 06" W

Start Time: 8:45 a.m. June 29, 2015 **Pump Test Phase:** 72 Hour Pumping Test

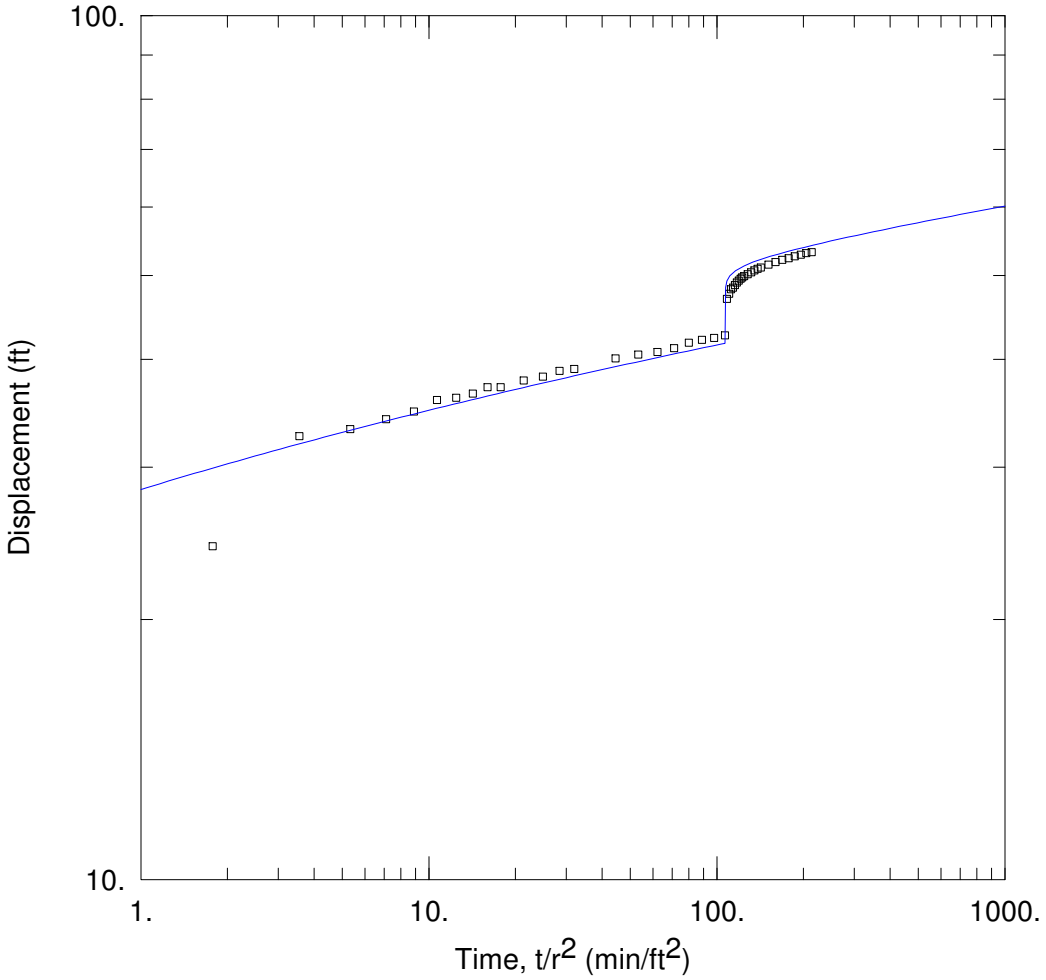
Pump Set@ 217' + 17.2"

Elapsed Time (Min)	Water Level (ft)	Pump Rate (GPM)
0	17.4	125
1	29.9	
2	33	
3	35	
4	36.5	
5	37.9	
6	38.9	
7	39.3	
8	40.4	
9	41	
10	41.5	
11	41.8	
12	42.3	
13	42.72	
14	43.23	
15	43.6	
20	44.75	
25	45.65	
30	46.3	
35	47.15	
40	47.75	
45	48.25	
50	48.6	
55	48.94	
60	49.25	
90	50.8	
120 (2hrs)	53.7	
150	54.55	
180	54.85	
210	55.3	
240 (4 hrs)	55.71	
270	56.1	
300	56.3	
360 (6hrs)	56.75	

420	**57.05**	
480 (8hrs)	**57.3**	
540	**57.47**	
600 (10 hrs)	**57.6**	
660	**57.75**	
720 (12 hrs)	**57.9**	
780	**58.0**	
840 (14 hrs)	**58.15**	
900	**58.2**	
960	**NA**	
1020	**NA**	
1080	**58.45**	
1140	**NA**	
1200	**NA**	
1260	**58.73**	
1320	**58.71**	
1380	**58.75**	
1440 (24 hrs)	**58.7**	
1800 (30 hrs)	**58.43**	
2160 (36 hrs)	**58.7**	
2520 (42 hrs)	**59**	
2880 (48 hrs)	**59.3**	
3240 (54 hrs)	**59.25**	
3600 (60 hrs)	**60.05**	
3960 (66 hrs)	**59.75**	
4320 (72 hrs)	**59.85**	

APPENDIX E: AQUIFER PUMPING TEST ANALYSES

Figure E-1



WELL TEST ANALYSIS

Data Set: P:\...\Griegsseafarm.aqt
Date: 08/03/15 Time: 09:44:42

PROJECT INFORMATION

Company: DS Drilling
Test Well: Grieg Sea Farm
Test Date: June 28, 2015

AQUIFER DATA

Saturated Thickness: 378. ft Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (ft)	Y (ft)
PW	0	0

Observation Wells

Well Name	X (ft)	Y (ft)
▫ PW	0	0

SOLUTION

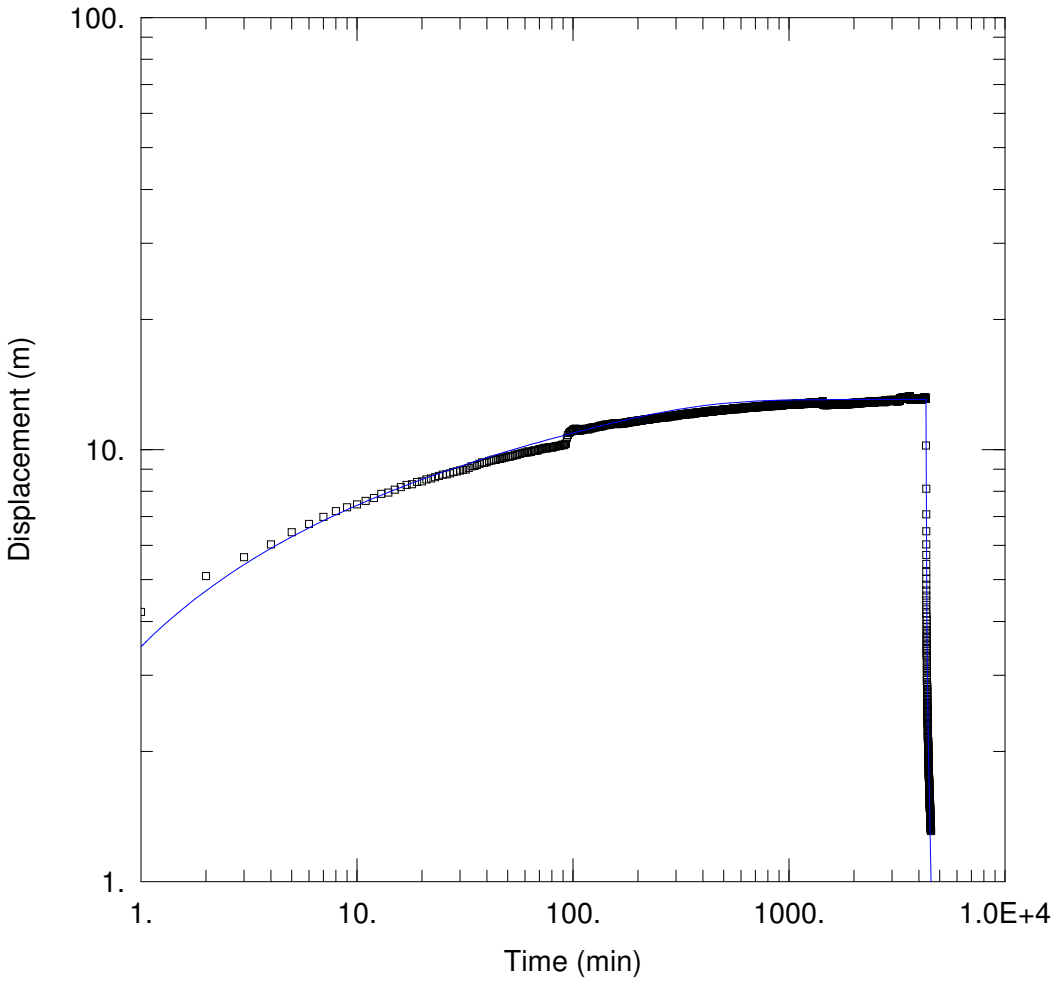
Aquifer Model: Confined
Solution Method: Theis (Step Test)

T = 0.0005711 m^2/sec
S = 4.579E-5
Sw = 0.
C = 0. min^2/ft^5
P = 2.

Step Test Model: Jacob-Rorabaugh
Time (t) = 1. min Rate (Q) in cu. ft/min

$s(t) = 2.239Q + 0.Q^{2.}$
W.E. = 100.% (Q from last step)

Figure E-2



72 HOUR PUMPING TEST

Data Set: P:\...\72 Hour Pumping Test.aqt
Date: 08/03/15 Time: 09:42:43

PROJECT INFORMATION

Company: AMEC Foster Wheeler
Client: Dave Sullivan Drilling
Project: TF1563106
Location: Marystown
Test Well: Well #1
Test Date: June 29 to July 2, 2015

AQUIFER DATA

Saturated Thickness: 122.6 m
Aquitard Thickness (b'): 1. m
Anisotropy Ratio (Kz/Kr): 0.001
Aquitard Thickness (b"): 1. m

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
Well #1	0	0

Observation Wells

Well Name	X (m)	Y (m)
▫ Well #1	0	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush

T = 0.0002335 m^2/sec
r/B' = 0.1
r/B" = 0.

S = 0.1612
ß' = 0.1
ß" = 0.

APPENDIX F: ANALYTICAL DATA TABLES

TABLE F-1: TOTAL COLIFORM AND *E. Coli* in GROUNDWATER

Parameter	Unit	GCDWQ	GS2
		Sample Date (D/M/Y)	02/07/2015
Escherichia Coli (E. Coli)	CFU/100mL	0 per 100 ml	Not Detected
Total Coliforms	CFU/100mL	0 per 100 ml	Not Detected

Notes:
CFU/mL: Colony Forming Unit per mililitre
ND: Not Detected
GCDWQ: Health Canada Guidelines for Canadian Drinking Water Quality (Health Canada, August 2012)
Concentration exceeds GCDWQ

TABLE F-2: GENERAL CHEMISTRY IN GROUNDWATER

Parameter	Units	GCDWQ	CCME		SAMPLE 1	GS2
	Sample Date (D/M/Y)		Freshwater	Marine	29/06/2015	02/07/2015
Calculated Parameters						
Anion Sum	me/L	NG	-	-	5.62	5.73
Bicarbonate Alkalinity (calc. as $CaCO_3$)	mg/L	NG	-	-	120	130
Calculated TDS	mg/L	500 [A]	-	-	310	310
Carbonate Alkalinity (calc. as $CaCO_3$)	mg/L	NG	-	-	1.1	1.1
Cation Sum	me/L	NG	-	-	5.57	5.56
Hardness (as $CaCO_3$)	mg/L	500 [B]	-	-	180	200
Ion Balance (% Difference)	%	NG	-	-	0.450	1.51
Langelier Index (20°C)	N/A	NG	-	-	0.350	0.368
Langelier Index (4°C)	N/A	NG	-	-	0.101	0.119
Nitrate (N)	mg/L	10	13	200	-	0.52
Saturation pH (20°C)	N/A	NG	-	-	7.65	7.60
Saturation pH (4°C)	N/A	NG	-	-	7.90	7.85
Inorganics						
Total Alkalinity (Total as $CaCO_3$)	mg/L	NG	-	-	120	130
Dissolved Chloride (Cl)	mg/L	250 [A]	120	-	110	110
Colour	TCU	15 [A]	narritive [D]	narritive [D]	<5.0	<5.0
Nitrate+Nitrite	mg/L	NG	-	-	0.38	0.52
Nitrite (N)	mg/L	1	0.197 [E]	-	-	<0.010
Nitrogen (Ammonia Nitrogen)	mg/L	NG	0.588 [F]	0.588 [F]	0.056	<0.050
Total Organic Carbon (C)	mg/L	NG	-	-	<0.50	<0.50
Orthophosphate (P)	mg/L	NG	-	-	<0.010	<0.010
pH	units	6.5 - 8.5 [A]	6.5 - 9.5	7.0 - 8.7	8.00	7.96
Reactive Silica (SiO_2)	mg/L	NG	-	-	7.6	7.5
Dissolved Sulfate ($S0_4$)	mg/L	500 [A]	-	-	7.0	6.7
Turbidity	NTU	0.1 [C]	narritive [G]	narritive [G]	**5.9**	**0.60**
Conductivity	µS/cm	NG	-	-	570	590
Dissolved Fluoride (F-)	mg/L	1.5	0.120	-	-	-
Dissolved Organic Carbon (C)	mg/L	NG	-	-	-	-
Salinity	N/A	NG	-	narritive [H]	-	-
Total Kjeldahl Nitrogen	mg/L	NG	-	-	-	-
Bromide (Br-)	mg/L	NG	-	-	-	-

Notes:

me/L: milliequivalent per litre
mg/L: miligram per litre
TCU: True Colour Units
NTU: Nephelometric Turbidity Unit
µS/cm: microsiemens per centimetre
N/A: Not Applicable
NG: No guideline available
GCDWQ: Health Canada Guidelines for Canadian Drinking Water Quality (Health Canada, August 2012)
CCME: Canadian Council of Ministers of Environment Water Quality Guidelines for the Protection of Aquatic Life

Concentration exceeds GCDWQ

Concentration exceeds the CCME Guideline for Freshwater or Marine Aquatic Life

[A] Guideline is an Aesthetic Objective (AO) and is not a health-based guideline.

[B] Public acceptance of hardness varies considerably. Hardness levels in excess of 500 mg/L are normally considered unacceptable. Hardness levels between 80 and 100 mg/L (as CaCO3) provide acceptable balance between corrosion and incrustation.

[C] Turbidity levels should be less than 0.1 NTU; however, chemically assisted filtration </= 0.3 NTU; slow sand or diatomaceous filtration </= 1.0 NTU and membrane filtration </= 0.1 NTU.

[D] **True Colour**

The mean absorbance of filtered water samples at 456 nm shall not be significantly higher than the seasonally adjusted expected value for the system under consideration.

Apparent Colour

The mean percent transmission of white light per metre shall not be significantly less than the seasonally adjusted expected value for the system under consideration.

[E] Guideline is 60 NO_2-N which can be expressed as µg nitrite-nitrogen/L. This value is equivalent to 197 µg nitrite/L.

[F] Ammonia guideline: Expressed as µg un-ionized ammonia/L. This would be equivalent to 16 µg ammonia-N /L (=19*14.0067 / 17.35052, rounded to two significant figures). Guideline for total ammonia is temperature and pH dependent, please consult factsheet for more information.

[G] **Clear Flow**

Maximum increase of 8 NTUs from background levels for a short-term exposure (e.g., 24-h period). Maximum average increase of 2 NTUs from background levels for a longer term exposure (e.g., 30-d period).

High Flow or Turbid Waters

Maximum increase of 8 NTUs from background levels at any one time when background levels are between 8 and 80 NTUs. Should not increase more than 10% of background levels when background is > 80 NTUs.

[H] Human activities should not cause the salinity (expressed as parts per thousand [‰]) of marine and estuarine waters to fluctuate by more than 10% of the natural level expected at that time and depth. Note Interim guideline.

TABLE F-3: METAL CONCENTRATIONS IN GROUNDWATER

Parameter	Unit	GCDWQ	CCME		Sample 1	GS2
		Sample Date	Freshwater	Marine	29/06/2015	02/07/2015
Aluminum (Al)	ug/L	100 [B]	5 or 100 [D]	-	-	6.8
Antimony (Sb)	ug/L	6	-	-	-	<1.0
Arsenic (As)	ug/L	10	5	12.5	-	3.9
Barium (Ba)	ug/L	1000	-	-	-	290
Beryllium (Be)	ug/L	NG	-	-	-	<1.0
Bismuth (Bi)	ug/L	NG	-	-	-	<2.0
Boron (B)	ug/L	5000	1500	-	-	<50
Cadmium (Cd)	ug/L	5	0.26 [E]	0.12	-	<0.010
Calcium (Ca)	ug/L	NG	-	-	49000	53000
Chromium (Cr)	ug/L	50	1/8.9 [F]	1.5/56 [F]	-	<1.0
Cobalt (Co)	ug/L	NG	-	-	-	<0.40
Copper (Cu)	ug/L	1000 [C]	3.91 [G]	4 [G]	<2.0	<2.0
Iron (Fe)	ug/L	300 [C]	300	-	170	<50
Lead (Pb)	ug/L	10	6.72 [H]	-	-	<0.5
Magnesium (Mg)	ug/L	NG	-	-	14000	16000
Manganese (Mn)	ug/L	50 [C]	-	-	45	42
Molybdenum (Mo)	ug/L	NG	73	-	-	<2.0
Nickel (Ni)	ug/L	NG	149.4 [I]	-	-	<2.0
Phosphorus (P)	ug/L	NG	>100 = hyper-eutrophic	-	-	**150**
Potassium (K)	ug/L	NG	-	-	720	660
Selenium (Se)	ug/L	50	1	-	-	<1.0
Silver (Ag)	ug/L	NG	0.1	-	-	<0.10
Sodium (Na)	ug/L	200,000 [C]	-	-	44,000	36000
Strontium (Sr)	ug/L	NG	-	-	-	1100
Thallium (Tl)	ug/L	NG	0.8	-	-	<0.10
Tin (Sn)	ug/L	NG	-	-	-	<2.0
Titanium (Ti)	ug/L	NG	-	-	-	<2.0
Uranium (U)	ug/L	20	15	-	-	1.2
Vanadium (V)	ug/L	NG	-	-	-	<2.0
Zinc (Zn)	ug/L	5000 [C]	30	-	16	<5.0

Notes:

µg/L: micrograms per litre

NG: No guideline available

GCDWQ: Health Canada Guidelines for Canadian Drinking Water Quality (Health Canada, August 2012)

CCME: Canadian Council of Ministers of Environment Water Quality Guidelines for the Protection of Aquatic Life

Concentration exceeds GCDWQ

Concentration exceeds the CCME Guideline for Freshwater or Marine Aquatic Life

[A] Sample was analyzed for Total Metals

[B] Guidelines for aluminum apply only to drinking water treatment plants using aluminum-based coagulants and are therefore not applicable to groundwater samples collected from the on-site well.

[C] Guideline is an Aesthetic Objective (AO) and is not a health-based guideline.

[D] = 65 µg/L if pH < 6.5; = 100 µg/L if pH

[E] The CWQG for cadmium (i.e. long-term guideline) of 0.09 µg·L-1 is for waters of 50 mg $CaCO_3$·L-1 hardness.
The CWQG for cadmium is related to water hardness (as CaCO3):
When the water hardness is > 0 to < 17 mg/L, the CWQG is 0.04 µg/L
At hardness 17 to 280 mg/L, the CWQG is calculated using this equation (see calculator below)
CWQG (µg/L) = $10^{\{0.83[\log(\text{hardness})] - 2.46\}}$
At hardness > 280 mg/L, the CWQG is 0.37 µg/L

[F] Guidelines are for hexavalent (Cr(VI)) and trivalent chromium (Cr(III)), respectively.

[G] The CWQG for copper is related to water hardness (as $CaCO_3$):
When the water hardness 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 (see calculator below)
CWQG (µg/L) = $0.2 * e^{\{0.8545[\ln(\text{hardness})] - 1.465\}}$
At hardness >180 mg/L, the CWQG is 4 µg/L
If the hardness is unknown, the CWQG is 2 µg/L

[H] The CWQG for lead is related to water hardness (as $CaCO_3$):
When the hardness 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 (see calculator below)
CWQG (µg/L)= $e^{\{1.273[\ln(\text{hardness})] - 4.705\}}$
At hardness >180 mg/L, the CWQG is 7 µg/L
If the hardness is unknown, the CWQG is 1 µg/L

[I] The CWQG for nickel is related to water hardness (as $CaCO_3$):
When the hardness 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 (see calculator below)
CWQG (µg/L) = $e^{\{0.76[\ln(\text{hardness})] + 1.06\}}$
At hardness >180 mg/L, the CWQG is 150 µg/L
If the hardness is unknown, the CWQG is 25 µg/L

[J] Canadian Guidance Framework for Phosphorus is for developing phosphorus guidelines (does not provide guidance on other freshwater nutrients). It provides Trigger Ranges for Total Phosphorus (µg/L) (see Guidance Framework for Phosphorus factsheet):
ultra-oligotrophic <4
oligotrophic 4-10
mesotrophic 10-20
meso-eutrophic 20-35
eutrophic 35-100
hyper-eutrophic >100

APPENDIX G: LABORATORY CERTIFICATES OF ANALYSES (COAS)

Site Location: GREIG SEAFOODS MARYSTOWN
Your C.O.C. #: B 153519

Attention:Elaine Sullivan

Geothermal Solutions
54 Vineyard Dr
Paradise, NL
CANADA A1L 3W5

Report Date: 2015/07/10
Report #: R3569413
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B5C8754
Received: 2015/07/03, 09:43

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Carbonate, Bicarbonate and Hydroxide (1)	1	N/A	2015/07/10	N/A	SM 22 4500-CO2 D
Alkalinity (1)	1	N/A	2015/07/07	ATL SOP 00013	EPA 310.2 R1974 m
Chloride (1)	1	N/A	2015/07/09	ATL SOP 00014	SM 22 4500-Cl- E m
Colour (1)	1	N/A	2015/07/08	ATL SOP 00020	SM 22 2120C m
Conductance - water (1)	1	N/A	2015/07/09	ATL SOP 00004	SM 22 2510B m
Hardness (calculated as CaCO3) (1)	1	N/A	2015/07/09	ATL SOP 00048	SM 22 2340 B
Metals Water Total MS (1)	1	2015/07/07	2015/07/09	ATL SOP 00058	EPA 6020A R1 m
Ion Balance (% Difference) (1)	1	N/A	2015/07/10		Auto Calc.
Anion and Cation Sum (1)	1	N/A	2015/07/10		Auto Calc.
Nitrogen Ammonia - water (1)	1	N/A	2015/07/08	ATL SOP 00015	EPA 350.1 R2 m
Nitrogen - Nitrate + Nitrite (1)	1	N/A	2015/07/09	ATL SOP 00016	USGS SOPINCF0452.2 m
pH (1, 2)	1	N/A	2015/07/09	ATL SOP 00003	SM 22 4500-H+ B m
Phosphorus - ortho (1)	1	N/A	2015/07/08	ATL SOP 00021	EPA 365.2 m
Sat. pH and Langelier Index (@ 20C) (1)	1	N/A	2015/07/10	ATL SOP 00049	Auto Calc.
Sat. pH and Langelier Index (@ 4C) (1)	1	N/A	2015/07/10	ATL SOP 00049	Auto Calc.
Reactive Silica (1)	1	N/A	2015/07/08	ATL SOP 00022	EPA 366.0 m
Sulphate (1)	1	N/A	2015/07/09	ATL SOP 00023	EPA 375.4 R1978 m
Total Dissolved Solids (TDS calc) (1)	1	N/A	2015/07/09		Auto Calc.
Organic carbon - Total (TOC) (1, 3)	1	N/A	2015/07/08	ATL SOP 00037	SM 22 5310C m
Turbidity (1)	1	N/A	2015/07/10	ATL SOP 00011	EPA 180.1 R2 m

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) This test was performed by Maxxam Bedford
(2) The APHA Standard Method require pH to be analyzed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the APHA Standard Method holding time.
(3) TOC / DOC present in the sample should be considered as non-purgeable TOC / DOC.

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Site Location: GREIG SEAFOODS MARYSTOWN
Your C.O.C. #: B 153519

Attention:Elaine Sullivan

Geothermal Solutions
54 Vineyard Dr
Paradise, NL
CANADA A1L 3W5

Report Date: 2015/07/10
Report #: R3569413
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B5C8754
Received: 2015/07/03, 09:43

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Keri Mackay, Project Manager - Bedford
Email: kmackay@maxxam.ca
Phone# (902)420-0203 Ext:294
==========

This report has been generated and distributed using a secure automated process.
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

Maxxam Job #: B5C8754
Report Date: 2015/07/10

Geothermal Solutions
Site Location: GREIG SEAFOODS MARYSTOWN

ATLANTIC RCAP TOTAL METALS IN WATER (WATER)

Maxxam ID		AOB999		
Sampling Date		2015/06/29		
COC Number		B 153519		
	Units	**SAMPLE 1**	**RDL**	**QC Batch**
Calculated Parameters				
Anion Sum	me/L	5.62	N/A	4092060
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	120	1.0	4092057
Calculated TDS	mg/L	310	1.0	4092063
Carb. Alkalinity (calc. as CaCO3)	mg/L	1.1	1.0	4092057
Cation Sum	me/L	5.57	N/A	4092060
Hardness (CaCO3)	mg/L	180	1.0	4092058
Ion Balance (% Difference)	%	0.450	N/A	4092059
Langelier Index (@ 20C)	N/A	0.350		4092061
Langelier Index (@ 4C)	N/A	0.101		4092062
Saturation pH (@ 20C)	N/A	7.65		4092061
Saturation pH (@ 4C)	N/A	7.90		4092062
Inorganics				
Total Alkalinity (Total as CaCO3)	mg/L	120	25	4094585
Dissolved Chloride (Cl)	mg/L	110	1.0	4094590
Colour	TCU	ND	5.0	4094593
Nitrate + Nitrite	mg/L	0.38	0.050	4094596
Nitrogen (Ammonia Nitrogen)	mg/L	0.056	0.050	4094520
Total Organic Carbon (C)	mg/L	ND	0.50	4096103
Orthophosphate (P)	mg/L	ND	0.010	4094594
pH	pH	8.00	N/A	4098117
Reactive Silica (SiO2)	mg/L	7.6	0.50	4094592
Dissolved Sulphate (SO4)	mg/L	7.0	2.0	4094591
Turbidity	NTU	5.9	0.10	4100238
Conductivity	uS/cm	570	1.0	4098121
Metals				
Total Calcium (Ca)	ug/L	49000	100	4092997
Total Copper (Cu)	ug/L	ND	2.0	4092997
Total Iron (Fe)	ug/L	170	50	4092997
Total Magnesium (Mg)	ug/L	14000	100	4092997
Total Manganese (Mn)	ug/L	45	2.0	4092997
Total Potassium (K)	ug/L	720	100	4092997
Total Sodium (Na)	ug/L	44000	100	4092997
Total Zinc (Zn)	ug/L	16	5.0	4092997

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable
ND = Not detected

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Maxxam Job #: B5C8754
Report Date: 2015/07/10

Geothermal Solutions
Site Location: GREIG SEAFOODS MARYSTOWN

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	6.7°C

Results relate only to the items tested.

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Maxxam Job #: B5C8754
Report Date: 2015/07/10

Geothermal Solutions
Site Location: GREIG SEAFOODS MARYSTOWN

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	Units	QC Limits
4092997	BAN	Matrix Spike	Total Calcium (Ca)	2015/07/09		96	%	80 - 120
			Total Copper (Cu)	2015/07/09		99	%	80 - 120
			Total Iron (Fe)	2015/07/09		105	%	80 - 120
			Total Magnesium (Mg)	2015/07/09		104	%	80 - 120
			Total Manganese (Mn)	2015/07/09		101	%	80 - 120
			Total Potassium (K)	2015/07/09		103	%	80 - 120
			Total Sodium (Na)	2015/07/09		105	%	80 - 120
			Total Zinc (Zn)	2015/07/09		100	%	80 - 120
4092997	BAN	Spiked Blank	Total Calcium (Ca)	2015/07/09		97	%	80 - 120
			Total Copper (Cu)	2015/07/09		101	%	80 - 120
			Total Iron (Fe)	2015/07/09		106	%	80 - 120
			Total Magnesium (Mg)	2015/07/09		105	%	80 - 120
			Total Manganese (Mn)	2015/07/09		104	%	80 - 120
			Total Potassium (K)	2015/07/09		104	%	80 - 120
			Total Sodium (Na)	2015/07/09		108	%	80 - 120
			Total Zinc (Zn)	2015/07/09		101	%	80 - 120
4092997	BAN	Method Blank	Total Calcium (Ca)	2015/07/09	ND, RDL=100		ug/L	
			Total Copper (Cu)	2015/07/09	ND, RDL=2.0		ug/L	
			Total Iron (Fe)	2015/07/09	ND, RDL=50		ug/L	
			Total Magnesium (Mg)	2015/07/09	ND, RDL=100		ug/L	
			Total Manganese (Mn)	2015/07/09	ND, RDL=2.0		ug/L	
			Total Potassium (K)	2015/07/09	ND, RDL=100		ug/L	
			Total Sodium (Na)	2015/07/09	ND, RDL=100		ug/L	
			Total Zinc (Zn)	2015/07/09	ND, RDL=5.0		ug/L	
4094520	ARS	Matrix Spike	Nitrogen (Ammonia Nitrogen)	2015/07/08		NC	%	80 - 120
4094520	ARS	Spiked Blank	Nitrogen (Ammonia Nitrogen)	2015/07/08		105	%	80 - 120
4094520	ARS	Method Blank	Nitrogen (Ammonia Nitrogen)	2015/07/08	ND, RDL=0.050		mg/L	
4094520	ARS	RPD	Nitrogen (Ammonia Nitrogen)	2015/07/08	4.3		%	25
4094585	MCN	Matrix Spike	Total Alkalinity (Total as CaCO3)	2015/07/07		97	%	80 - 120
4094585	MCN	Spiked Blank	Total Alkalinity (Total as CaCO3)	2015/07/07		102	%	80 - 120
4094585	MCN	Method Blank	Total Alkalinity (Total as CaCO3)	2015/07/07	ND, RDL=5.0		mg/L	
4094585	MCN	RPD	Total Alkalinity (Total as CaCO3)	2015/07/07	NC		%	25
4094590	MCN	Matrix Spike	Dissolved Chloride (Cl)	2015/07/09		105	%	80 - 120
4094590	MCN	QC Standard	Dissolved Chloride (Cl)	2015/07/09		106	%	80 - 120
4094590	MCN	Spiked Blank	Dissolved Chloride (Cl)	2015/07/09		110	%	80 - 120
4094590	MCN	Method Blank	Dissolved Chloride (Cl)	2015/07/09	ND, RDL=1.0		mg/L	
4094590	MCN	RPD	Dissolved Chloride (Cl)	2015/07/09	4.6		%	25
4094591	ARS	Matrix Spike	Dissolved Sulphate (SO4)	2015/07/09		111	%	80 - 120
4094591	ARS	Spiked Blank	Dissolved Sulphate (SO4)	2015/07/09		98	%	80 - 120
4094591	ARS	Method Blank	Dissolved Sulphate (SO4)	2015/07/09	ND, RDL=2.0		mg/L	
4094591	ARS	RPD	Dissolved Sulphate (SO4)	2015/07/09	NC		%	25

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Report Date: 2015/07/10

Geothermal Solutions
Site Location: GREIG SEAFOODS MARYSTOWN

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	Units	QC Limits
4094592	ARS	Matrix Spike	Reactive Silica (SiO2)	2015/07/08		98	%	80 - 120
4094592	ARS	Spiked Blank	Reactive Silica (SiO2)	2015/07/08		100	%	80 - 120
4094592	ARS	Method Blank	Reactive Silica (SiO2)	2015/07/08	ND, RDL=0.50		mg/L	
4094592	ARS	RPD	Reactive Silica (SiO2)	2015/07/08	NC		%	25
4094593	NRG	Spiked Blank	Colour	2015/07/08		100	%	80 - 120
4094593	NRG	Method Blank	Colour	2015/07/08	ND, RDL=5.0		TCU	
4094593	NRG	RPD	Colour	2015/07/08	NC		%	20
4094594	NRG	Matrix Spike	Orthophosphate (P)	2015/07/08		97	%	80 - 120
4094594	NRG	Spiked Blank	Orthophosphate (P)	2015/07/08		99	%	80 - 120
4094594	NRG	Method Blank	Orthophosphate (P)	2015/07/08	ND, RDL=0.010		mg/L	
4094594	NRG	RPD	Orthophosphate (P)	2015/07/08	NC		%	25
4094596	ARS	Matrix Spike	Nitrate + Nitrite	2015/07/09		100	%	80 - 120
4094596	ARS	Spiked Blank	Nitrate + Nitrite	2015/07/09		96	%	80 - 120
4094596	ARS	Method Blank	Nitrate + Nitrite	2015/07/09	ND, RDL=0.050		mg/L	
4094596	ARS	RPD	Nitrate + Nitrite	2015/07/09	NC		%	25
4096103	MCY	Matrix Spike	Total Organic Carbon (C)	2015/07/08		100	%	80 - 120
4096103	MCY	Spiked Blank	Total Organic Carbon (C)	2015/07/08		100	%	80 - 120
4096103	MCY	Method Blank	Total Organic Carbon (C)	2015/07/08	ND, RDL=0.50		mg/L	
4096103	MCY	RPD	Total Organic Carbon (C)	2015/07/08	5.7		%	20
4098117	KSR	QC Standard	pH	2015/07/09		101	%	97 - 103
4098117	KSR	RPD	pH	2015/07/09	0.13		%	N/A
4098121	KSR	Spiked Blank	Conductivity	2015/07/09		103	%	80 - 120
4098121	KSR	Method Blank	Conductivity	2015/07/09	1.1, RDL=1.0		uS/cm	
4098121	KSR	RPD	Conductivity	2015/07/09	0.28		%	25
4100238	KSR	QC Standard	Turbidity	2015/07/10		96	%	80 - 120
4100238	KSR	Method Blank	Turbidity	2015/07/10	ND, RDL=0.10		NTU	
4100238	KSR	RPD	Turbidity	2015/07/10	0.92		%	25

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

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Maxxam Job #: B5C8754
Report Date: 2015/07/10

Geothermal Solutions
Site Location: GREIG SEAFOODS MARYSTOWN

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Mike MacGillivray, Scientific Specialist (Inorganics)

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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Site Location: GREIG SEAFARMS-MARYSTOWN
Your C.O.C. #: B 111807

Attention:Elaine Sullivan

Geothermal Solutions
54 Vineyard Dr
Paradise, NL
CANADA A1L 3W5

Report Date: 2015/07/10
Report #: R3569418
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B5C9180
Received: 2015/07/03, 09:42

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Carbonate, Bicarbonate and Hydroxide (1)	1	N/A	2015/07/10	N/A	SM 22 4500-CO2 D
Alkalinity (1)	1	N/A	2015/07/08	ATL SOP 00013	EPA 310.2 R1974 m
Chloride (1)	1	N/A	2015/07/09	ATL SOP 00014	SM 22 4500-Cl- E m
Colour (1)	1	N/A	2015/07/08	ATL SOP 00020	SM 22 2120C m
Conductance - water (1)	1	N/A	2015/07/09	ATL SOP 00004	SM 22 2510B m
Hardness (calculated as CaCO3) (1)	1	N/A	2015/07/09	ATL SOP 00048	SM 22 2340 B
Metals Water Total MS (1)	1	2015/07/07	2015/07/08	ATL SOP 00058	EPA 6020A R1 m
Ion Balance (% Difference) (1)	1	N/A	2015/07/10		Auto Calc.
Anion and Cation Sum (1)	1	N/A	2015/07/10		Auto Calc.
Nitrogen Ammonia - water (1)	1	N/A	2015/07/08	ATL SOP 00015	EPA 350.1 R2 m
Nitrogen - Nitrate + Nitrite (1)	1	N/A	2015/07/09	ATL SOP 00016	USGS SOPINCF0452.2 m
Nitrogen - Nitrite (1)	1	N/A	2015/07/08	ATL SOP 00017	SM 22 4500-NO2- B m
Nitrogen - Nitrate (as N) (1)	1	N/A	2015/07/09	ATL SOP 00018	ASTM D3867
pH (1, 2)	1	N/A	2015/07/09	ATL SOP 00003	SM 22 4500-H+ B m
Phosphorus - ortho (1)	1	N/A	2015/07/08	ATL SOP 00021	EPA 365.2 m
Sat. pH and Langelier Index (@ 20C) (1)	1	N/A	2015/07/10	ATL SOP 00049	Auto Calc.
Sat. pH and Langelier Index (@ 4C) (1)	1	N/A	2015/07/10	ATL SOP 00049	Auto Calc.
Reactive Silica (1)	1	N/A	2015/07/08	ATL SOP 00022	EPA 366.0 m
Sulphate (1)	1	N/A	2015/07/09	ATL SOP 00023	EPA 375.4 R1978 m
Total Dissolved Solids (TDS calc) (1)	1	N/A	2015/07/09		Auto Calc.
Organic carbon - Total (TOC) (1, 3)	1	N/A	2015/07/06	ATL SOP 00037	SM 22 5310C m
Turbidity (1)	1	N/A	2015/07/10	ATL SOP 00011	EPA 180.1 R2 m

Reference Method suffix “m” indicates test methods incorporate validated modifications from specific reference methods to improve performance.

* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.

(1) This test was performed by Maxxam Bedford
(2) The APHA Standard Method require pH to be analyzed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the APHA Standard Method holding time.
(3) TOC / DOC present in the sample should be considered as non-purgeable TOC / DOC.

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Site Location: GREIG SEAFARMS-MARYSTOWN
Your C.O.C. #: B 111807

Attention:Elaine Sullivan

Geothermal Solutions
54 Vineyard Dr
Paradise, NL
CANADA A1L 3W5

Report Date: 2015/07/10
Report #: R3569418
Version: 1 - Final

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: B5C9180
Received: 2015/07/03, 09:42

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Keri Mackay, Project Manager - Bedford
Email: kmackay@maxxam.ca
Phone# (902)420-0203 Ext:294
==========

This report has been generated and distributed using a secure automated process.
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Maxxam Job #: B5C9180
Report Date: 2015/07/10

Geothermal Solutions
Site Location: GREIG SEAFARMS-MARYSTOWN

ATLANTIC RCAP-MS TOTAL METALS IN WATER (WATER)

Maxxam ID		AOE091		
Sampling Date		2015/07/02 06:15		
COC Number		B 111807		
	Units	GS2	RDL	QC Batch
Calculated Parameters				
Anion Sum	me/L	5.73	N/A	4092060
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	130	1.0	4092057
Calculated TDS	mg/L	310	1.0	4092063
Carb. Alkalinity (calc. as CaCO3)	mg/L	1.1	1.0	4092057
Cation Sum	me/L	5.56	N/A	4092060
Hardness (CaCO3)	mg/L	200	1.0	4092058
Ion Balance (% Difference)	%	1.51	N/A	4092059
Langelier Index (@ 20C)	N/A	0.368		4092061
Langelier Index (@ 4C)	N/A	0.119		4092062
Nitrate (N)	mg/L	0.52	0.050	4092065
Saturation pH (@ 20C)	N/A	7.60		4092061
Saturation pH (@ 4C)	N/A	7.85		4092062
Inorganics				
Total Alkalinity (Total as CaCO3)	mg/L	130	25	4094598
Dissolved Chloride (Cl)	mg/L	110	1.0	4094600
Colour	TCU	ND	5.0	4094604
Nitrate + Nitrite	mg/L	0.52	0.050	4094606
Nitrite (N)	mg/L	ND	0.010	4094607
Nitrogen (Ammonia Nitrogen)	mg/L	ND	0.050	4094528
Total Organic Carbon (C)	mg/L	ND	0.50	4093199
Orthophosphate (P)	mg/L	ND	0.010	4094605
pH	pH	7.96	N/A	4098124
Reactive Silica (SiO2)	mg/L	7.5	0.50	4094603
Dissolved Sulphate (SO4)	mg/L	6.7	2.0	4094601
Turbidity	NTU	0.60	0.10	4100286
Conductivity	uS/cm	590	1.0	4098125
Metals				
Total Aluminum (Al)	ug/L	6.8	5.0	4094129
Total Antimony (Sb)	ug/L	ND	1.0	4094129
Total Arsenic (As)	ug/L	3.9	1.0	4094129
Total Barium (Ba)	ug/L	290	1.0	4094129
Total Beryllium (Be)	ug/L	ND	1.0	4094129
Total Bismuth (Bi)	ug/L	ND	2.0	4094129

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable
ND = Not detected

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Maxxam Job #: B5C9180
Report Date: 2015/07/10

Geothermal Solutions
Site Location: GREIG SEAFARMS-MARYSTOWN

ATLANTIC RCAP-MS TOTAL METALS IN WATER (WATER)

Maxxam ID		AOE091		
Sampling Date		2015/07/02 06:15		
COC Number		B 111807		
	Units	GS2	RDL	QC Batch
Total Boron (B)	ug/L	ND	50	4094129
Total Cadmium (Cd)	ug/L	ND	0.010	4094129
Total Calcium (Ca)	ug/L	53000	100	4094129
Total Chromium (Cr)	ug/L	ND	1.0	4094129
Total Cobalt (Co)	ug/L	ND	0.40	4094129
Total Copper (Cu)	ug/L	ND	2.0	4094129
Total Iron (Fe)	ug/L	ND	50	4094129
Total Lead (Pb)	ug/L	ND	0.50	4094129
Total Magnesium (Mg)	ug/L	16000	100	4094129
Total Manganese (Mn)	ug/L	42	2.0	4094129
Total Molybdenum (Mo)	ug/L	ND	2.0	4094129
Total Nickel (Ni)	ug/L	ND	2.0	4094129
Total Phosphorus (P)	ug/L	150	100	4094129
Total Potassium (K)	ug/L	660	100	4094129
Total Selenium (Se)	ug/L	ND	1.0	4094129
Total Silver (Ag)	ug/L	ND	0.10	4094129
Total Sodium (Na)	ug/L	36000	100	4094129
Total Strontium (Sr)	ug/L	1100	2.0	4094129
Total Thallium (Tl)	ug/L	ND	0.10	4094129
Total Tin (Sn)	ug/L	ND	2.0	4094129
Total Titanium (Ti)	ug/L	ND	2.0	4094129
Total Uranium (U)	ug/L	1.2	0.10	4094129
Total Vanadium (V)	ug/L	ND	2.0	4094129
Total Zinc (Zn)	ug/L	ND	5.0	4094129

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
ND = Not detected

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Maxxam Job #: B5C9180
Report Date: 2015/07/10

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GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	13.1°C

Results relate only to the items tested.

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Maxxam Job #: B5C9180
Report Date: 2015/07/10

Geothermal Solutions
Site Location: GREIG SEAFARMS-MARYSTOWN

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	Units	QC Limits
4093199	MCY	Matrix Spike	Total Organic Carbon (C)	2015/07/06		105	%	80 - 120
4093199	MCY	Spiked Blank	Total Organic Carbon (C)	2015/07/06		99	%	80 - 120
4093199	MCY	Method Blank	Total Organic Carbon (C)	2015/07/06	ND, RDL=0.50		mg/L	
4093199	MCY	RPD	Total Organic Carbon (C)	2015/07/06	NC		%	20
4094129	MLB	Matrix Spike	Total Aluminum (Al)	2015/07/08		103	%	80 - 120
			Total Antimony (Sb)	2015/07/08		112	%	80 - 120
			Total Arsenic (As)	2015/07/08		100	%	80 - 120
			Total Barium (Ba)	2015/07/08		103	%	80 - 120
			Total Beryllium (Be)	2015/07/08		102	%	80 - 120
			Total Bismuth (Bi)	2015/07/08		105	%	80 - 120
			Total Boron (B)	2015/07/08		112	%	80 - 120
			Total Cadmium (Cd)	2015/07/08		104	%	80 - 120
			Total Calcium (Ca)	2015/07/08		97	%	80 - 120
			Total Chromium (Cr)	2015/07/08		96	%	80 - 120
			Total Cobalt (Co)	2015/07/08		97	%	80 - 120
			Total Copper (Cu)	2015/07/08		95	%	80 - 120
			Total Iron (Fe)	2015/07/08		102	%	80 - 120
			Total Lead (Pb)	2015/07/08		102	%	80 - 120
			Total Magnesium (Mg)	2015/07/08		103	%	80 - 120
			Total Manganese (Mn)	2015/07/08		101	%	80 - 120
			Total Molybdenum (Mo)	2015/07/08		107	%	80 - 120
			Total Nickel (Ni)	2015/07/08		96	%	80 - 120
			Total Phosphorus (P)	2015/07/08		107	%	80 - 120
			Total Potassium (K)	2015/07/08		106	%	80 - 120
			Total Selenium (Se)	2015/07/08		100	%	80 - 120
			Total Silver (Ag)	2015/07/08		106	%	80 - 120
			Total Sodium (Na)	2015/07/08		NC	%	80 - 120
			Total Strontium (Sr)	2015/07/08		104	%	80 - 120
			Total Thallium (Tl)	2015/07/08		104	%	80 - 120
			Total Tin (Sn)	2015/07/08		109	%	80 - 120
			Total Titanium (Ti)	2015/07/08		102	%	80 - 120
			Total Uranium (U)	2015/07/08		109	%	80 - 120
			Total Vanadium (V)	2015/07/08		97	%	80 - 120
			Total Zinc (Zn)	2015/07/08		96	%	80 - 120
4094129	MLB	Spiked Blank	Total Aluminum (Al)	2015/07/08		108	%	80 - 120
			Total Antimony (Sb)	2015/07/08		110	%	80 - 120
			Total Arsenic (As)	2015/07/08		101	%	80 - 120
			Total Barium (Ba)	2015/07/08		103	%	80 - 120
			Total Beryllium (Be)	2015/07/08		103	%	80 - 120
			Total Bismuth (Bi)	2015/07/08		104	%	80 - 120
			Total Boron (B)	2015/07/08		114	%	80 - 120
			Total Cadmium (Cd)	2015/07/08		104	%	80 - 120
			Total Calcium (Ca)	2015/07/08		98	%	80 - 120
			Total Chromium (Cr)	2015/07/08		99	%	80 - 120
			Total Cobalt (Co)	2015/07/08		100	%	80 - 120
			Total Copper (Cu)	2015/07/08		99	%	80 - 120
			Total Iron (Fe)	2015/07/08		104	%	80 - 120
			Total Lead (Pb)	2015/07/08		103	%	80 - 120
			Total Magnesium (Mg)	2015/07/08		106	%	80 - 120
			Total Manganese (Mn)	2015/07/08		104	%	80 - 120
			Total Molybdenum (Mo)	2015/07/08		105	%	80 - 120
			Total Nickel (Ni)	2015/07/08		99	%	80 - 120
			Total Phosphorus (P)	2015/07/08		108	%	80 - 120

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Maxxam Job #: B5C9180
Report Date: 2015/07/10

Geothermal Solutions
Site Location: GREIG SEAFARMS-MARYSTOWN

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	Units	QC Limits
			Total Potassium (K)	2015/07/08		105	%	80 - 120
			Total Selenium (Se)	2015/07/08		101	%	80 - 120
			Total Silver (Ag)	2015/07/08		109	%	80 - 120
			Total Sodium (Na)	2015/07/08		101	%	80 - 120
			Total Strontium (Sr)	2015/07/08		104	%	80 - 120
			Total Thallium (Tl)	2015/07/08		103	%	80 - 120
			Total Tin (Sn)	2015/07/08		107	%	80 - 120
			Total Titanium (Ti)	2015/07/08		104	%	80 - 120
			Total Uranium (U)	2015/07/08		110	%	80 - 120
			Total Vanadium (V)	2015/07/08		100	%	80 - 120
			Total Zinc (Zn)	2015/07/08		98	%	80 - 120
4094129	MLB	Method Blank	Total Aluminum (Al)	2015/07/08	ND, RDL=5.0		ug/L	
			Total Antimony (Sb)	2015/07/08	ND, RDL=1.0		ug/L	
			Total Arsenic (As)	2015/07/08	ND, RDL=1.0		ug/L	
			Total Barium (Ba)	2015/07/08	ND, RDL=1.0		ug/L	
			Total Beryllium (Be)	2015/07/08	ND, RDL=1.0		ug/L	
			Total Bismuth (Bi)	2015/07/08	ND, RDL=2.0		ug/L	
			Total Boron (B)	2015/07/08	ND, RDL=50		ug/L	
			Total Cadmium (Cd)	2015/07/08	ND, RDL=0.010		ug/L	
			Total Calcium (Ca)	2015/07/08	ND, RDL=100		ug/L	
			Total Chromium (Cr)	2015/07/08	ND, RDL=1.0		ug/L	
			Total Cobalt (Co)	2015/07/08	ND, RDL=0.40		ug/L	
			Total Copper (Cu)	2015/07/08	ND, RDL=2.0		ug/L	
			Total Iron (Fe)	2015/07/08	ND, RDL=50		ug/L	
			Total Lead (Pb)	2015/07/08	ND, RDL=0.50		ug/L	
			Total Magnesium (Mg)	2015/07/08	ND, RDL=100		ug/L	
			Total Manganese (Mn)	2015/07/08	ND, RDL=2.0		ug/L	
			Total Molybdenum (Mo)	2015/07/08	ND, RDL=2.0		ug/L	
			Total Nickel (Ni)	2015/07/08	ND, RDL=2.0		ug/L	
			Total Phosphorus (P)	2015/07/08	150, RDL=100		ug/L	
			Total Potassium (K)	2015/07/08	ND, RDL=100		ug/L	

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Maxxam Job #: B5C9180
Report Date: 2015/07/10

Geothermal Solutions
Site Location: GREIG SEAFARMS-MARYSTOWN

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	Units	QC Limits
			Total Selenium (Se)	2015/07/08	ND, RDL=1.0		ug/L	
			Total Silver (Ag)	2015/07/08	ND, RDL=0.10		ug/L	
			Total Sodium (Na)	2015/07/08	ND, RDL=100		ug/L	
			Total Strontium (Sr)	2015/07/08	ND, RDL=2.0		ug/L	
			Total Thallium (Tl)	2015/07/08	ND, RDL=0.10		ug/L	
			Total Tin (Sn)	2015/07/08	ND, RDL=2.0		ug/L	
			Total Titanium (Ti)	2015/07/08	ND, RDL=2.0		ug/L	
			Total Uranium (U)	2015/07/08	ND, RDL=0.10		ug/L	
			Total Vanadium (V)	2015/07/08	ND, RDL=2.0		ug/L	
			Total Zinc (Zn)	2015/07/08	ND, RDL=5.0		ug/L	
4094129	MLB	RPD	Total Aluminum (Al)	2015/07/08	1.8		%	20
4094528	ARS	Matrix Spike	Nitrogen (Ammonia Nitrogen)	2015/07/08		90	%	80 - 120
4094528	ARS	Spiked Blank	Nitrogen (Ammonia Nitrogen)	2015/07/08		104	%	80 - 120
4094528	ARS	Method Blank	Nitrogen (Ammonia Nitrogen)	2015/07/08	ND, RDL=0.050		mg/L	
4094528	ARS	RPD	Nitrogen (Ammonia Nitrogen)	2015/07/08	NC		%	25
4094598	MCN	Matrix Spike	Total Alkalinity (Total as CaCO3)	2015/07/08		NC	%	80 - 120
4094598	MCN	Spiked Blank	Total Alkalinity (Total as CaCO3)	2015/07/07		100	%	80 - 120
4094598	MCN	Method Blank	Total Alkalinity (Total as CaCO3)	2015/07/07	ND, RDL=5.0		mg/L	
4094598	MCN	RPD	Total Alkalinity (Total as CaCO3)	2015/07/08	0.74		%	25
4094600	MCN	Matrix Spike	Dissolved Chloride (Cl)	2015/07/09		NC	%	80 - 120
4094600	MCN	QC Standard	Dissolved Chloride (Cl)	2015/07/09		105	%	80 - 120
4094600	MCN	Spiked Blank	Dissolved Chloride (Cl)	2015/07/09		106	%	80 - 120
4094600	MCN	Method Blank	Dissolved Chloride (Cl)	2015/07/09	ND, RDL=1.0		mg/L	
4094600	MCN	RPD	Dissolved Chloride (Cl)	2015/07/09	0.017		%	25
4094601	ARS	Matrix Spike	Dissolved Sulphate (SO4)	2015/07/09		NC	%	80 - 120
4094601	ARS	Spiked Blank	Dissolved Sulphate (SO4)	2015/07/09		100	%	80 - 120
4094601	ARS	Method Blank	Dissolved Sulphate (SO4)	2015/07/09	ND, RDL=2.0		mg/L	
4094601	ARS	RPD	Dissolved Sulphate (SO4)	2015/07/09	1.5		%	25
4094603	ARS	Matrix Spike	Reactive Silica (SiO2)	2015/07/08		97	%	80 - 120
4094603	ARS	Spiked Blank	Reactive Silica (SiO2)	2015/07/08		99	%	80 - 120
4094603	ARS	Method Blank	Reactive Silica (SiO2)	2015/07/08	ND, RDL=0.50		mg/L	
4094603	ARS	RPD	Reactive Silica (SiO2)	2015/07/08	NC		%	25
4094604	NRG	Spiked Blank	Colour	2015/07/08		104	%	80 - 120
4094604	NRG	Method Blank	Colour	2015/07/08	ND, RDL=5.0		TCU	
4094604	NRG	RPD	Colour	2015/07/08	NC		%	20
4094605	NRG	Matrix Spike	Orthophosphate (P)	2015/07/08		96	%	80 - 120

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Geothermal Solutions
Site Location: GREIG SEAFARMS-MARYSTOWN

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	Units	QC Limits
4094605	NRG	Spiked Blank	Orthophosphate (P)	2015/07/08		99	%	80 - 120
4094605	NRG	Method Blank	Orthophosphate (P)	2015/07/08	ND, RDL=0.010		mg/L	
4094605	NRG	RPD	Orthophosphate (P)	2015/07/08	NC		%	25
4094606	ARS	Matrix Spike	Nitrate + Nitrite	2015/07/09		97	%	80 - 120
4094606	ARS	Spiked Blank	Nitrate + Nitrite	2015/07/09		99	%	80 - 120
4094606	ARS	Method Blank	Nitrate + Nitrite	2015/07/09	ND, RDL=0.050		mg/L	
4094606	ARS	RPD	Nitrate + Nitrite	2015/07/09	NC		%	25
4094607	NRG	Matrix Spike	Nitrite (N)	2015/07/08		97	%	80 - 120
4094607	NRG	Spiked Blank	Nitrite (N)	2015/07/08		104	%	80 - 120
4094607	NRG	Method Blank	Nitrite (N)	2015/07/08	ND, RDL=0.010		mg/L	
4094607	NRG	RPD	Nitrite (N)	2015/07/08	NC		%	25
4098124	KSR	QC Standard	pH	2015/07/09		101	%	97 - 103
4098124	KSR	RPD	pH	2015/07/09	0.65		%	N/A
4098125	KSR	Spiked Blank	Conductivity	2015/07/09		106	%	80 - 120
4098125	KSR	Method Blank	Conductivity	2015/07/09	1.2, RDL=1.0		uS/cm	
4098125	KSR	RPD	Conductivity	2015/07/09	0.80		%	25
4100286	KSR	QC Standard	Turbidity	2015/07/10		94	%	80 - 120
4100286	KSR	Method Blank	Turbidity	2015/07/10	ND, RDL=0.10		NTU	
4100286	KSR	RPD	Turbidity	2015/07/10	0.34		%	25

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spiked amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than 2x that of the native sample concentration).

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (one or both samples < 5x RDL).

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Geothermal Solutions
Site Location: GREIG SEAFARMS-MARYSTOWN

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).

Mike MacGillivray, Scientific Specialist (Inorganics)

Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. For Service Group specific validation please refer to the Validation Signature Page.

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LOCATION

LABORATORY MEDICINE REPORT
EASTERN HEALTH REGIONAL AUTHORITY
PUBLIC HEALTH LABORATORY

Name: CW,DS DRILLING SERVICES **U#:** S00000014811 **hcn:**
Acct#: LL000956/15 **Unit#:** S00000014811 **Status:** REG REF **Location:** PL-MISC
Reg: 02/07/15 **Disch:** **Age/Sex:** 1Y 00M/U **Attend Dr:** NL PUBLIC HEALTH LABORA

Pt Address: 4 HOPS STREET,CONCEPTION BAY SOUTH,NL A1W 0E8 709-781-6038
BIRTHDATE: **MAIDEN / OTHER NAME:**

Order Site: NEWFOUNDLAND PUBLIC HEALTH LAB

Specimen: 15:E0001763R **Collected:** 02/07/15-0620 **Status:** COMP **Req#:** 16569625
Received: 02/07/15-1437 **Source:** WATER PRIV **Sp Desc:** DRILLED WE
Subm Dr: NL PUBLIC HEALTH LABORATORY
Collected by: U

Ordered: PRIVATE WATER
Comments: SOURCE:MCGETTINGAN BLVD MARYSTOWN
LAB SITE: NFPHL
NL PUBLIC HEALTH LABORATORY

Procedure	Result	Site
> ENVIRONMENTAL PHL PRIVATE WAT	Final	PHL
Total Coliforms	Not Detected	
E.coli	Not Detected	

@PHL - NEWFOUNDLAND PUBLIC HEALTH LAB
100 Forest Road, St John's, NL, A1A 4E5

APPENDIX H: LIMITATIONS

LIMITATIONS

1. The work performed in this report was carried out in accordance with the Standard Terms of Conditions made part of our contract. The conclusions presented herein are based solely upon the scope of services and time and budgetary limitations described in our contract.

2. The report was prepared in accordance with generally accepted hydrogeological study and/or engineering practices for the exclusive use of DS Drilling Services Limited. No other warranties, either expressed or implied, are made as to the professional services provided under the terms of our contract and included in this report.

3. Third party information reviewed and used to develop the opinions and conclusions contained in this report is assumed to be complete and correct. This information was used in good faith and Amec Foster Wheeler Environment & Infrastructure does not accept any responsibility for deficiencies, misinterpretation or incompleteness of the information contained in documents prepared by third parties.

4. The services performed and outlined in this report were based, in part, upon visual observations of the site and attendant structures. Our opinion cannot be extended to portions of the site which were unavailable for direct observation, reasonably beyond our control.

5. The objective of this report was to assess hydrogeological properties at the site, within the context of our contract and existing regulations within the applicable jurisdiction. Evaluating compliance of past or future owners with applicable local, provincial and federal government laws and regulations was not included in our contract for services.

6. Our observations relating to the condition of environmental media at the site are described in this report. It should be noted that compounds or materials other than those described could be present in the site environment.

7. The findings and conclusions presented in this report are based exclusively on the field parameters measured and the chemical parameters tested at specific locations. It should be recognized that subsurface conditions between and beyond the sample locations may vary. Amec Foster Wheeler Environment & Infrastructure cannot expressly guarantee that subsurface conditions between and beyond the sample locations do not vary from the results determined at the sample locations. Notwithstanding these limitations, this report is believed to provide a reasonable representation of site conditions at the date of issue.

8. The contents of this report are based on the information collected during the monitoring and investigation activities, our understanding of the actual site conditions, and our professional opinion according to the information available at the time of preparation of this report. This report gives a professional opinion and, by consequence, no guarantee is attached to the conclusions or expert advice depicted in this report. This report does not provide a legal opinion in regards to Regulations and applicable Laws.

9. Any use of this report by a third party and any decision made based on the information contained in this report by the third party is the sole responsibility of the third party. Amec Foster Wheeler Environment & Infrastructure will not accept any responsibility for damages resulting from a decision or an action made by a third party based on the information contained in this report.

Appendix 2

Greig NL Observation Well Pumping Test Report

Appendix 2

FINAL

Grieg NL Observation Well
Pumping Test Report

Submitted to:
DSD Services Ltd.
Alexandria Building
4 Hops Street
Conception Bay South, NL
A1W 0E8

Submitted by:
Wood Environment & Infrastructure Solutions,
a Division of Wood Canada Limited
36 Pippy Place
PO Box 13216
St. John's, NL A1B 4A5

11 October 2019
Wood Project #: TF1963111
Document No. TF1963111-0000-RPT-0001, REV. B

IMPORTANT NOTICE

This report was prepared exclusively for DSD Services Ltd. by Wood Environment & Infrastructure Solutions, a Division of Wood Canada Limited (Wood). The quality of information, conclusions and estimates contained herein is consistent with the level of effort involved in Wood's services and based on: i) information available at the time of preparation, ii) data supplied by outside sources and iii) the assumptions, conditions and qualifications set forth in this report. This report is intended to be used by DSD Services Ltd. only, subject to the terms and conditions of its contract with Wood. Any other use of, or reliance on, this report by any third party is at that party's sole risk.

GRIEG NL OBSERVATION WELL
PUMPING TEST REPORT

FOR

DS Drilling Services

REV.	DATE	REVISION(S)	PREPARED BY	CHECK	APP	CLIENT
C	11 Oct. 2019	Reissued for Final	TP	GV	TP	
B	04 Oct. 2019	Issued for Final	TP	GV	TP	
A	03 Oct. 2019	Issued for Review	TP	GV	TP	

wood.

GRIEG NL OBSERVATION WELL
PUMPING TEST REPORT

Wood
Environment & Infrastructure Solutions
Job No. TF1963111

REPORT NO.
TF1963111-0000-RPT-0001

REV.
C

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1.0 INTRODUCTION

Wood Environment & Infrastructure Solutions, a division of Wood Canada Limited (Wood) was retained by DS Drilling Services Limited (DSD) to evaluate the results of an aquifer test conducted for an observation well for the Grieg NL facilities, in Marystown, Newfoundland and Labrador (NL). It is understood that the well will be used as an observation well for the primary pumping well that provides water to the nurseries. A pumping test on the new observation well was required as part of the environmental assessment process for Grieg NL. Wood was not onsite during drilling of the well or the aquifer pumping test, and therefore, this report is based solely on information and data collected and provided by DSD.

2.0 SCOPE OF WORK

The aquifer testing was conducted to meet the Aquifer Testing Guidelines from the Water Resources Management Division (WRMD) of the Department of Municipal Affairs and Environment (MAE), Government of Newfoundland and Labrador (GNL).

As per our proposal, dated August 27, 2019, the scope of work included the following activities for one water supply well:

1. Analyze data from a step drawdown test to determine the optimum pumping rate that may be sustained by the wells for an extended period of time.
2. Analyze data from the 72-hour pumping test at the rate determined from the step drawdown test to determine hydraulic properties of the aquifer and potentially a long-term safe yield of the wells.
3. Summarize bacteria, general chemistry and metals analytical data for water samples collected within the first hour and the last hour (71 hours) of the pumping test to assess water quality.
4. Analyze recovery water level measurements collected immediately following the 72-hour pumping test to support the aquifer pumping test analyses.

3.0 BACKGROUND AND SITE DESCRIPTION

Marystown is located on the east side of the Burin Peninsula, approximately 300 km southwest of the City of St. John's, NL (refer to Drawing 1, Appendix A). The Site is located near the intersection of McGettigan Boulevard and Centennial Road and approximately 70 m north of McGettigan Boulevard.

3.1 Eco-Region and Climate

The Site is part of the ocean climate influenced Southeastern Barrens Subregion of the Maritime Barrens Eco-region, which is marked by cool summers, mild winters and high frequencies of fog and strong winds. Slope bogs, basin bogs and fens are scattered throughout the barrens, reflecting poor drainage and wet climate (FLR, 2019).

The 30 year climate normals (1981-2010) from Environment Canada's monitoring station in Garnish, NL indicate a mean daily temperature high of 16.3°C in August and a low of -7.8°C in February. Annual average precipitation is 1421.5 mm, ranging from 93.9 mm in August to 148.5 mm in September (Environment Canada, 2019).

3.2 Topography and Drainage

The topography of the Site is generally flat with a slight downward gradient to the south toward McGettigan Boulevard. The topography of the overall area is rugged and has an overall moderate upward slope to the northwest and an overall downward slope to the southeast toward Mortier Bay. Based on local topography and surface water elevations, groundwater flow direction is anticipated to be southeast toward Mortier Bay.

3.3 Surficial Geology

The surficial geology underlying the Site consists of vegetation concealed thin veneer (<1.5 m) of glacial till and angular frost-heaved bedrock (Batterson and Taylor, 2007).

3.4 Bedrock Geology

Marystown lies within the Avalon tectonostratigraphic zone and is underlain by mafic to acidic volcanic rocks and minor sedimentary rocks of the Mortier Group. Rocks in the area have undergone regional-scale folding related to Devonian Acadian orogenesis and form the core of a broad regional northeast – southwest trending anticline, referred to as the Burin Anticline. A series of joint sets and fracture zones occur within rocks underlying Marystown and are related to deformation (JWEL, 2008).

The Creston Formation of the Mortier Group underlies the Site and is dominated by approximately 500 m of basaltic flows with subordinate acidic pyroclastic and sedimentary rocks with an estimated thickness of 550 m. The basalts are highly amygdaloidal and dark green to purple. The pyroclastic and sedimentary rocks of the Mortier Group are acidic; although locally they have high concentrations of mafic debris giving the rocks a greenish colour and intermediate composition (Strong et al., 1977).

Rocks of the Cashel Lookout Formation underlie the area north of the site and include undivided acidic pyroclastics, flow banded rhyolite (and/or ignimbrite) and volcaniclastic sediments (Strong et al., 1977).

3.5 Hydrogeology

A study entitled 'Hydrogeology of Eastern Newfoundland' was completed by AMEC in 2013. A total of 1819 well records were available for a geological unit called volcanic strata of eastern Newfoundland. Well yields ranged from 0.3 to 455 L/min with a median value of 9 L/min and average value of 25 L/min. Well depths ranged from 8 to 228 m with an average depth of 67 m. The available data indicate that wells in volcanic strata in Eastern Newfoundland generally have a low to moderate potential yield (AMEC, 2013).

Aquifer testing on Grieg's pumping well (Amec Foster Wheeler, 205) indicates that the hydrostratigraphy in the vicinity of Grieg's Marystown facilities is capable of elevated safe yield values in comparison to the local bedrock. The calculated transmissivity of the pumping well is 2.3×10^{-4} m^2/s.

4.0 WELL DETAILS

DSD drilled an observation well on August 2, 2019 on Centennial Road in Marystown, NL. The well location is shown on Drawing 2, Appendix A.

The well is 0.20 m (8 inch) diameter and was drilled to an approximate depth of 128 m (420 ft). It was completed with 12 m (40 ft) of steel casing and bentonite grout. Approximately 1.5 m (5 ft) of gravel overlying 126.5 m (415 ft) of red and green volcanic/sedimentary rock were encountered during drilling.

Airlift tests were conducted by DSD during well drilling, which indicated yields of 91 L/min (20 IGPM) at 27.5 m below ground surface (bgs) (90 ftbgs), 136 L/min (30 IGPM) at 36.5 mbgs (120 ftbgs) and 364-454 L/min (80-100 IGPM) at 97.5 mbgs (320 ftbgs)

The observation well is located approximately 90 m from the pumping well that was drilled in 2015.

A copy of the water well record is included in Appendix B.

5.0 METHODOLOGY

The methods of the aquifer testing and water quality analyses are described in the following sections.

5.1 Aquifer Testing

A step drawdown test was conducted based on the estimated yield of the airlift test. Five 60 minute duration steps were conducted at pumping rates of 227, 341, 455, 568, and 636 litres per minute (L/min) (50, 75, 100, 125 and 140 imperial gallons per minute (IGPM)) on August 9, 2019. Using the results of the step drawdown test, the 72 hour pumping test was conducted from August 12-15, 2019 at a constant pumping rate of approximately 455 L/min (100 IGPM). Immediately following the 72 hour pumping test, the submersible pump was turned off and recovery measurements were collected until the well reached at least 80% recovery. Representatives of DSD were onsite for the duration of the step drawdown test,72 hour pumping test and recovery period.

The 1.5 horsepower Goulds (model 10SB) submersible pump used during the step drawdown test and 72 hour pumping test was installed and operated by DSD at a depth of 61 m (200 ft). The discharge rate was measured on the dial gauge of a factory calibrated 1 inch diameter Neptune flow meter. The discharge pipe was extended approximately 150 m from the pumping well to direct discharge away from the pumping well. Various isolation valves were installed on the discharge pipe to control pumping and collect water samples.

Water level measurements were collected manually and recorded as metres below top of stick up casing (mbtoc), using an electronic water level meter generally following the intervals:

Step Drawdown Test

For four steps:

- Every 1 minute until 10 minutes
- Every 2 minutes from 10 - 20 minutes
- Every 5 minutes from 20 - 60 minutes

72 hour Pumping Test

- Every 1 minute for the first 15 minutes
- Every 5 minutes from 15 - 60 minutes (1 hour)
- Every 30 minutes from 60 - 300 minutes (1 - 5 hours)
- Every 60 (1 hour) minutes from 300 - 4320 minutes (5 - 72 hours)

Recovery Test

- Every 1 minute for the first 15 minutes
- Every 5 minutes from 15 minutes - 60 minutes (1 hour)

Water levels were also measured during aquifer testing using a pressure transducer set at one second intervals. It is noted that the transducer measurements were not corrected for barometric pressure.

Water level data was also collected at Grieg's primary pumping well, located approximately 90 m from the observation well, during the constant rate pumping test. No pumping was conducted through the duration of the pumping test.

5.2 Water Quality Analyses

Water samples were collected by DSD during the first (1 hour) and last hour (71 hours) of the 72 hour pumping test. Water samples were submitted to Maxxam Analytics Laboratory (Maxxam) in St. John's, NL for general chemistry and metals analyses at their Bedford, Nova Scotia Laboratory. The samples were submitted for Maxxam's comprehensive RCAP-MS package as well as mercury, dissolved fluoride, total kjeldahl nitrogen (TKN), dissolved organic carbon, and salinity to meet the criteria stipulated in the MAE (2013) Aquifer Testing Guidelines. No water samples were submitted for *E. coli* and Total Coliform testing, as DSD was unable to meet the laboratory timeline required for bacteriological analyses.

6.0 AQUIFER TESTING RESULTS

Graphs and analyses for the step drawdown test, the 72 hour pumping test and recovery test are presented in Appendix C. The following is a discussion of the step test, pumping test and recovery test.

6.1 Air Lift Test

Airlift tests were conducted by DSD upon completion of the well, which indicated yields of 91 L/min (20 IGPM) at 27.5 m below ground surface (bgs) (90 ftbgs), 136 L/min (30 IGPM) at 36.5 mbgs (120 ftbgs) and 364-454 L/min (80-100 IGPM) at 97.5 mbgs (320 ftbgs).

6.2 Step Drawdown Test

Based on the results of the air lift testing, four 60 minute duration steps were conducted at pumping rates of 227, 341, 455, 568, and 636 litres per minute (L/min) (50, 75, 100, 125 and 140 imperial gallons per minute (IGPM)) on August 9, 2019.Total drawdowns of approximately 2.1, 3.4, 4.7, 6.7, and 7.6 m were measured for the five steps/respective pumping rates identified above. Specific capacity of each step ranged from 120 - 159 m^3/day/m (Table 6-1), with the lowest specific capacity at the highest pumping rate. Analysis of the step draw down test analysis using the Theis unconfined aquifer solution provided a calculated a transmissivity value 9.5 x 10^{-4} m^2/s. Using the specific capacity results, the results of the calculations and the available drawdown in the well, it was determined that the well could sustain a pumping rate of approximately 455 L/min (100 IGPM) for the 72 hour pumping test. A graph of the step drawdown test is provided in Appendix C.

Table 6-1: Specific Capacity during the Step Drawdown Tests

Step	Pumping Rate (L/min)	Pumping Rate (m^3/day)	Drawdown (m)	Specific Capacity (m^3/day/m)
1	50	327.3	2.1	159.1
2	75	491.0	3.4	145.8
3	100	654.6	4.7	139.5
4	125	818.3	6.7	122.9
5	140	916.5	7.6	120.0

6.3 72-Hour Pumping Test

The 72-hour pumping test was conducted from August 12-15, 2019 at a constant pumping rate of approximately 455 L/min (100 IGPM). At the beginning of the test, the static water level was 3.6 metres below the top of casing. Available drawdown in the well was 57.4 m (61 – 3.6m). The total drawdown during the test was 6.05 m. Observation well data were collected during the test from the pumping well that is also located on Centennial Drive (Drawing 2; Appendix A).

The 72-hour pumping test data were analyzed using the Hantush-Jacob solution for unconfined aquifers. The transmissivity value from the data analyzed was 1.3 × 10^{-3} m^2/s for the 72-hour pumping test. Transmissivity results of all the aquifer tests are summarized in Table 6-2.

A time – drawdown graph of the 72-hour pumping test is provided in Appendix C.

6.4 Observation Well Data

Throughout the duration of the constant rate pumping test, water level measurements were collected at Grieg's primary pumping well (Figure 1). The Grieg NL pumping well was not used during the test and was thus considered an observation well for this test. The water level in the observation well decreased 2.8 m (9.2 ft) during the course of the test. As with the pumping test, most of the drawdown occurred within the first four hours of the test and then remained close to equilibrium for the duration of the test. The observation well also recovered to 50 % of the static water level within 75 minutes of completing the test.

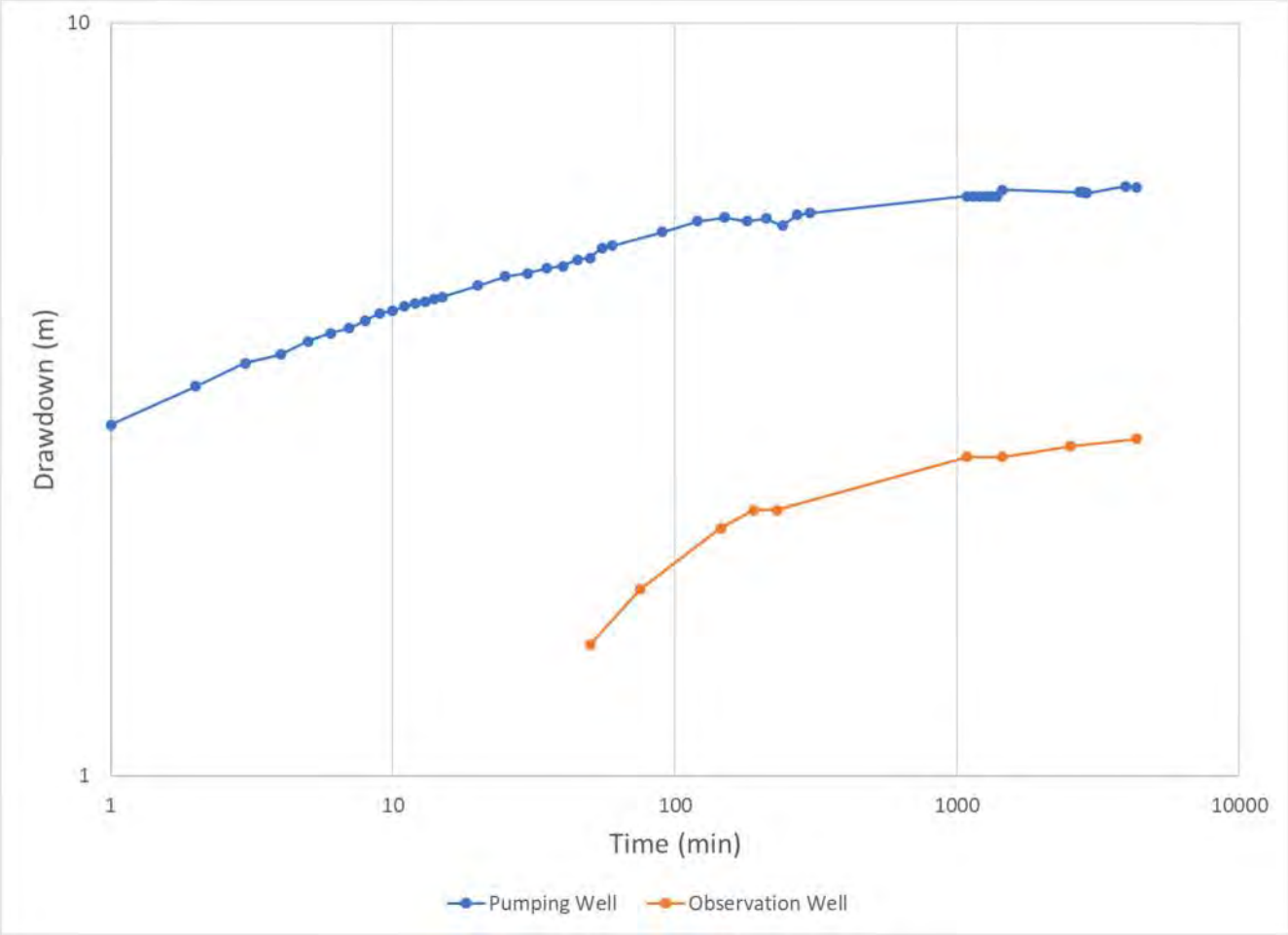


Figure 6-1: Pumping and observation well data during the 72-hour pumping test.

6.5 Recovery Test

Immediately following the 72-hour pumping test, the submersible pump was turned off and recovery measurements were collected. Recovery reached 72% of the original static water level in approximately 1.5 hours.

The recovery data were analyzed using the Hantush-Jacob solution for unconfined aquifers. The transmissivity value from the data analyzed was 1.3×10^{-3} m^2/s for the recovery data. Transmissivity results of all the aquifer tests are summarized in Table 6-2.

A time – drawdown graph of the recovery test is provided in Appendix C.

6.6 Pumping Test Interpretation

The Hantush-Jacob solution for leaky-confined aquifers was used to interpret the test as the shape of the drawdown curve exhibited a reasonable fit with the solution, with the curve flattened in the later time of the test. The analysed data were collected using a handheld water level tape and a pressure transducer with data logging capabilities. There was good agreement between the two datasets. All results are summarized in Table 6-2.

Table 6-2: Pumping Test Results

Method	Transmissivity (m^2/s)	Comments
Hantush-Jacob	1.3×10^{-3}	72-hour Test
Hantush-Jacob	1.3×10^{-3}	Recovery data

6.7 Safe Well Yield

Safe yield values were estimated using the actual 72-hour pumping test data and taking consideration of the available drawdown of 57.4 m Considering the intended water usage of the site, that mainly consists of acting as an observation well, a safe well yield of 455 L/min (100 IGPM) is considered reasonable should any pumping requirements arise for this well as this rate was clearly exhibited to be sustainable during the long term pumping test. The recommended safe yield value is within the high range (maximum) of the well yields reported by AMEC (2013), ranging from 0.3 to 455 L/min.

7.0 WATER QUALITY RESULTS

The following section provides a summary of the water quality results from the new observation well compared to the Health Canada GCDWQ (Health Canada, 2018) and the Canadian Council of Ministers of Environment (CCME) Water Quality Guidelines for the protection of freshwater and marine aquatic life (CCME, 2019). Analytical tables are presented in Appendix D and the laboratory certificates of analyses are presented in Appendix E. Results of the water quality are summarized below:

- All metals analyzed were within the acceptable range outlined in the GCDWQ.
- Turbidity was above the GCDWQ criteria of 0.1 NTU at the beginning (0.6 NTU) and at the end (0.19 NTU) of the 72-hour pumping test. The turbidity criteria is related to the operation of water treatment plants and should not present an issue as an observation well.
- All other water chemistry parameters analyzed were within the acceptable range outlined by the GCDWQ.
- Total coliforms and *Escherichia Coli* (*E. Coli*) were not analyzed due to time constraints with respect to the bacteriological hold times and the proximity of a testing laboratory to the site. Bacteriological sampling and analyses are recommended if the water in the observation well is intended for human consumption.
- Fluoride concentrations exceeded the CCME guideline for freshwater of 0.12 mg/L at both the beginning (0.36 mg/L) and at the end (0.30 mg/L) of the constant rate test. Fluoride concentrations typically leach from igneous and sedimentary strata, such as found in Marystown, and may bioaccumulate in fish (CCME, 2002)

8.0 DISCUSSION AND CONCLUSIONS

Wood analyzed a step test, 72-hour pumping test, and water quality samples for a well drilled on August 2, 2019 by DSD. The tests were conducted by DSD. The well is 0.20 m (8 inch) diameter and was drilled to an approximate depth of 128 m (420 ft). It was completed with 12 m (40 ft) of steel casing and bentonite grout. Approximately 1.5 m (5 ft) of gravel overlying 99 m (415 ft) of red and green volcanic/sedimentary rock were encountered during drilling. The well is located approximately 90 m from the pumping well that was drilled in 2015 and is planned to be a long-term observation well for the pumping well.

The results of the pumping test analyses include:

- The calculated transmissivity of the observation well for the 72-hour pumping test is 1.3×10^{-3} m^2/s. The calculated transmissivity is an order of magnitude higher than Greig's main pumping well (2.3×10^{-4} m^2/s).
- The 72-hour pumping test was conducted at a constant discharge of 455 L/min (100 IGPM) with a drawdown of 6.05 m, from an available drawdown of 57.4 m. Considering the intended water usage of the site, that mainly consists of acting as an observation well, a safe well yield of 455 L/min (100 IGPM) is considered reasonable should any pumping requirements arise for this well as this rate was clearly exhibited to be sustainable during the long-term pumping test. The recommended safe yield value is within the high range (maximum) of the well yields reported by AMEC (2013), ranging from 0.3 to 455 L/min.
- The water level in the observation well decreased 2.8 m (9.2 ft) during the 72-hour pumping test, with, most of the drawdown occurred within the first four hours of the test and then remained close to equilibrium for the duration of the test. Water level results in the observation well indicate that the pumping well and observation well are hydraulically connected.

The water quality results indicate that the water quality onsite is good with the exception of the following results:

- Turbidity was above the GCDWQ criteria of 0.1 NTU at the beginning (0.6 NTU) and at the end (0.19 NTU) of the 72-hour pumping test. The turbidity criteria are related to the operation of water treatment plants and should not present an issue as an observation well.
- All other water chemistry parameters analyzed were within the acceptable range outlined by the GCDWQ.
- Total coliforms and Escherichia Coli (E. Coli) were not analyzed due to time constraints with respect to the bacteriological hold times and the proximity of a testing laboratory to the site. Bacteriological sampling and analyses are recommended if the water in the observation well is intended for human consumption.
- Fluoride concentrations exceeded the CCME guideline for freshwater of 0.12 mg/L at both the beginning (0.36 mg/L) and at the end (0.30 mg/L) of the constant rate test. Fluoride concentrations typically leach from igneous and sedimentary strata, such as found in Marystown, and may bioaccumulate in fish (CCME, 2002)

All conclusions are based on the results of the document review, aquifer tests, and water quality results.

9.0 RECOMMENDATIONS

Based on the findings presented in this report, the following recommendations are proposed should the well be used as a water supply well:

Well Yield: A safe well yield of 455 L/min (100 IGPM) is considered reasonable should any pumping requirements arise for this well as this rate was clearly exhibited to be sustainable during the long term pumping test. The recommended safe yield value is within the high range (maximum) of the well yields reported by AMEC (2013), ranging from 0.3 to 455 L/min.

Water Quality: The water quality in the new well is considered good, with the exception of fluoride with respect to the CCME freshwater aquatic life guidelines. Long term water quality monitoring for bacteria and general water quality parameters is recommended.

Land Use Planning: A groundwater model should be used to delineate a wellhead protection area around the Grieg pumping well. As the well is connected hydraulically to the observation well, the protected water supply area will be instrumental in maintaining the long term sustainability of the source water quality.

10.0 CLOSURE

This report has been prepared for the exclusive use of DS Drilling Services Limited. The hydrogeological assessment was conducted using standard practices and in accordance with written requests from the client. No further warranty, expressed or implied, is made. The conclusions presented herein are based solely upon the scope of services and time and budgetary limitations described in our contract. Any use which a third party makes of this report, or any reliance on or decisions to be made based on it, are the responsibility of such third parties. Wood accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions based on this report. The limitations of this report are attached in Appendix F.

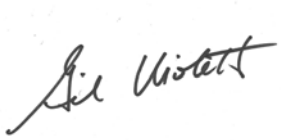
Yours sincerely,

Wood Environment & Infrastructure Solutions,
a Division of Wood Canada Limited

Prepared by:

Titia Praamsma, PhD, P.Geo.
Senior Hydrogeologist

Reviewed by:



Gil Violette, M.Sc.E, P.Eng
Senior Associate Hydrogeologist

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APPENDIX A: MAPS


N
Clam Pond
Linton Lake
SITE
Mortier Bay
Marystown
Creston Inlet
Freshwater Pond
Source:

wood.			

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APPENDIX B: WELL RECORD

Newfoundland Labrador

Well Identification Number (WIN)

Department of Municipal Affairs and Environment
Water Resources Management Division
Well Construction Record

Measurements: ☐ Metric ☐ US ☒ Imperial

Well Owner Information (must be the final owner of well or borehole)

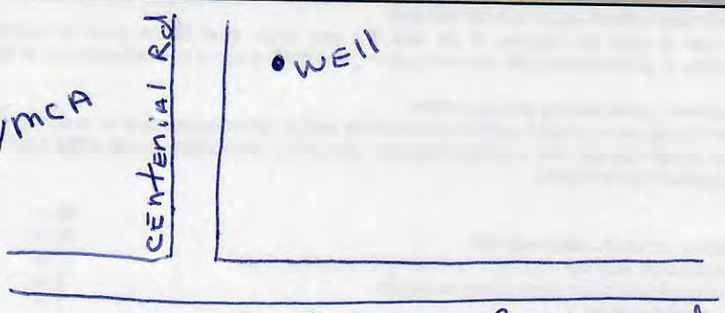
First Name	Last Name	Street Address			
Grieg NL		205 McGettingan Blvd			
Town/City	**LGID** For Office Use Only	**LGID Name** For Office Use Only	**Postal Code**	**Telephone**	
Marystown			A0E 2M0	(709) 279-3440	

Well/Borehole Location

Town/City	Street Address/Lot Number	Land Owner (Developer, Private, etc.)
Marystown	~~McGettingan Blvd~~ Centennial Road	GRIEGNL

GPS Coordinates — **Latitude** N 47 ° 10 ' 38.5 " — **Longitude** W 055 ° 09 ' 08.1 "

Sketch of Well Location



Show distances from at least two landmarks and indicate North
Include street / road name / and house / lot number if available

Water Bearing Zones

Depth	Rate	Type
90'	20 GPM	
120'	30 GPM	
320'	80-100 GPM	

Type of Water Encountered

☒ Fresh ☐ Odourous ☐ Salt
☐ Cloudy ☐ Clear ☐ Coloured
☐ Other (Specify) _____

Borehole Lithology

Depth	Colour	Lithology
0-5'	Brown	Gravel
5'-100'	Redish	Volcanic/Sedimentary
100-300	Green	Volcaic / Sedimentary
300'-420'	Redish	[redacted] Volcanic/Sedimentary

Depth to Bedrock: 5' **Depth of borehole containing casing:** 40' **Total depth of borehole:** 420

Casing Information - recommended Sch 40, .280 Wall

Casing should be finished 0.60 metres (2 feet) above grade

Depth From	Depth To	Inside Diameter	Type	Thickness
0	42'	8"	Sch 40	3/8

Height of the casing finished above grade: 2'

Annular Space and Sealant

The annulus of the well should be sealed with an impermeable sealant from the bottom of the casing/drive shoe to the surface.

Depth From	Depth To	Type of Sealant Used
6'	42'	Bentonite Grout

Reason why annulus was not sealed: _____

Screen Information

Was a screen installed? ☐ Yes ☒ No

From	To	Slot	Diameter	Material

Drilling Method

☒ Rotary (Air) ☐ Hammer ☐ Reverse Rotary
☐ Other _____
Drive Shoe installed? ☒ Yes ☐ No

Final Status of Well/Borehole

☐ Domestic ☐ Municipal ☐ Exploration ☐ Sealed Well
☐ Dewatering ☐ Geothermal ☐ Observation ☒ Other Industrial

Pumping Test Results

Flowing Well: ☐ Yes ☒ No
If flowing, rate:

Static Water Level: 11'

Recommended Pumping Rate:

Method:
☐ Air Lift ☐ Pump
☐ Other _____

Pump Intake at: Duration:

Recommended Pump Depth:

Pumping Rate during Test:

Estimated Safe Yield: 140 GPM

Licenced Water Well Construction Contractor Information

Comments:

Well Construction Company	Licence Number	Well Completed on: (Day – Month – Year)
DS Drilling	020	2/8/2019

Driller — Sign _____ Print DAVE Sullivan

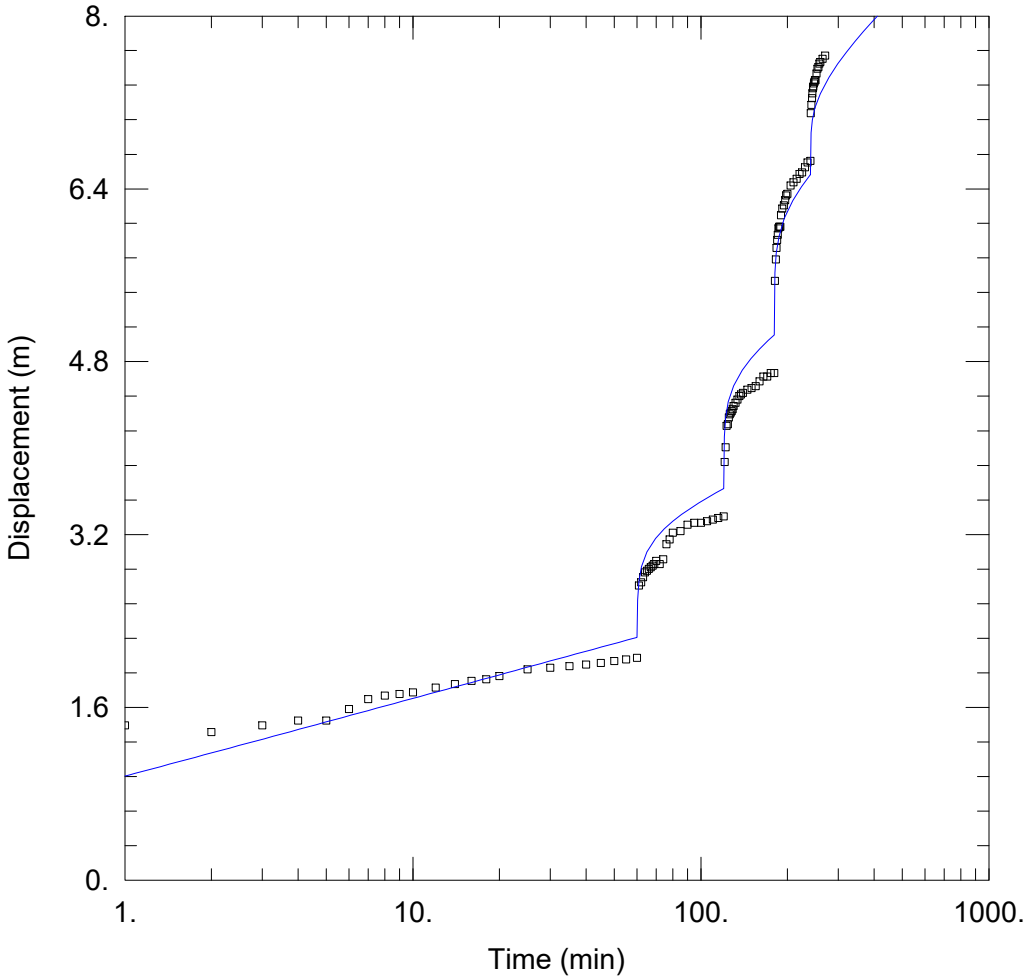
Driller Assistant — Sign _____ Print Boghrat N

This is a Legal Document ***Safeguard with Home Owner's Documents***

If you have any questions regarding this document, please call the Groundwater Section, Water Resources Management at 709-729-2539
White Copy – Department of Municipal Affairs and Environment **Yellow Copy – Drilling Company** **Pink Copy – Well Owner**

158725

APPENDIX C: AQUIFER TEST ANALYSES



WELL TEST ANALYSIS

Data Set: M:\My Documents\working files\grieg\grieg step test.aqt
Date: 10/03/19 Time: 10:52:29

PROJECT INFORMATION

Company: Wood E&IS
Client: DSD
Project: TF1963111
Location: Marystown
Test Date: August 6, 2019

AQUIFER DATA

Saturated Thickness: 124. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
OW-1	0	0

Observation Wells

Well Name	X (m)	Y (m)
OW-1	0	0

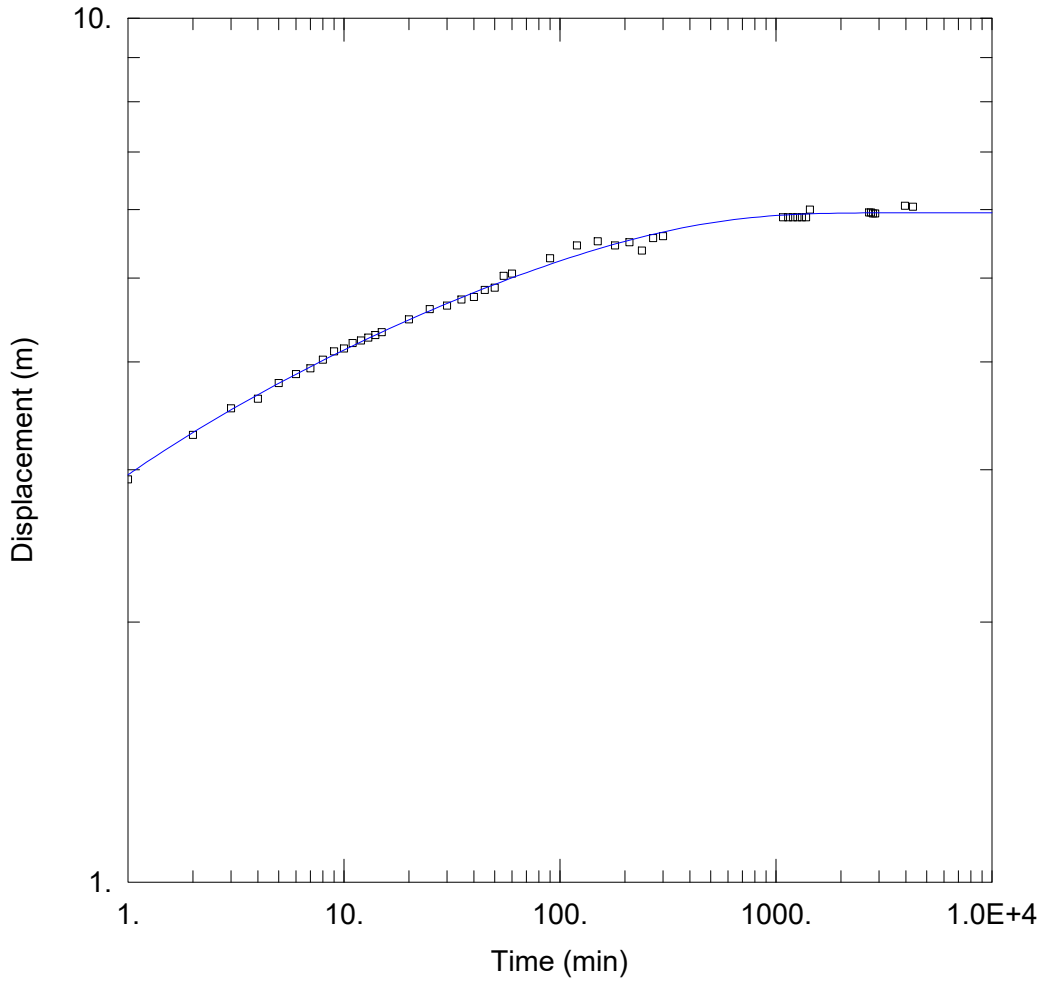
SOLUTION

Aquifer Model: Confined
Solution Method: Theis (Step Test)

T = 0.000954 m^2/sec
S = 0.6969
Sw = 0.
C = 1. min^2/m^5
P = 2.315

Step Test Model: Jacob-Rorabaugh
Time (t) = 1. min Rate (Q) in cu. m/min

$s(t) = 4.094Q + 1.Q^{2.315}$
W.E. = 88.12% (Q from last step)



WELL TEST ANALYSIS

Data Set: M:\My Documents\working files\grieg\grieg pumping test.aqt
Date: 10/03/19 Time: 10:50:02

PROJECT INFORMATION

Company: Wood E&IS
Client: DSD
Project: TF1963111
Location: Marystown
Test Well: OW-1
Test Date: August 15, 2019

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
OW-1	0	0

Observation Wells

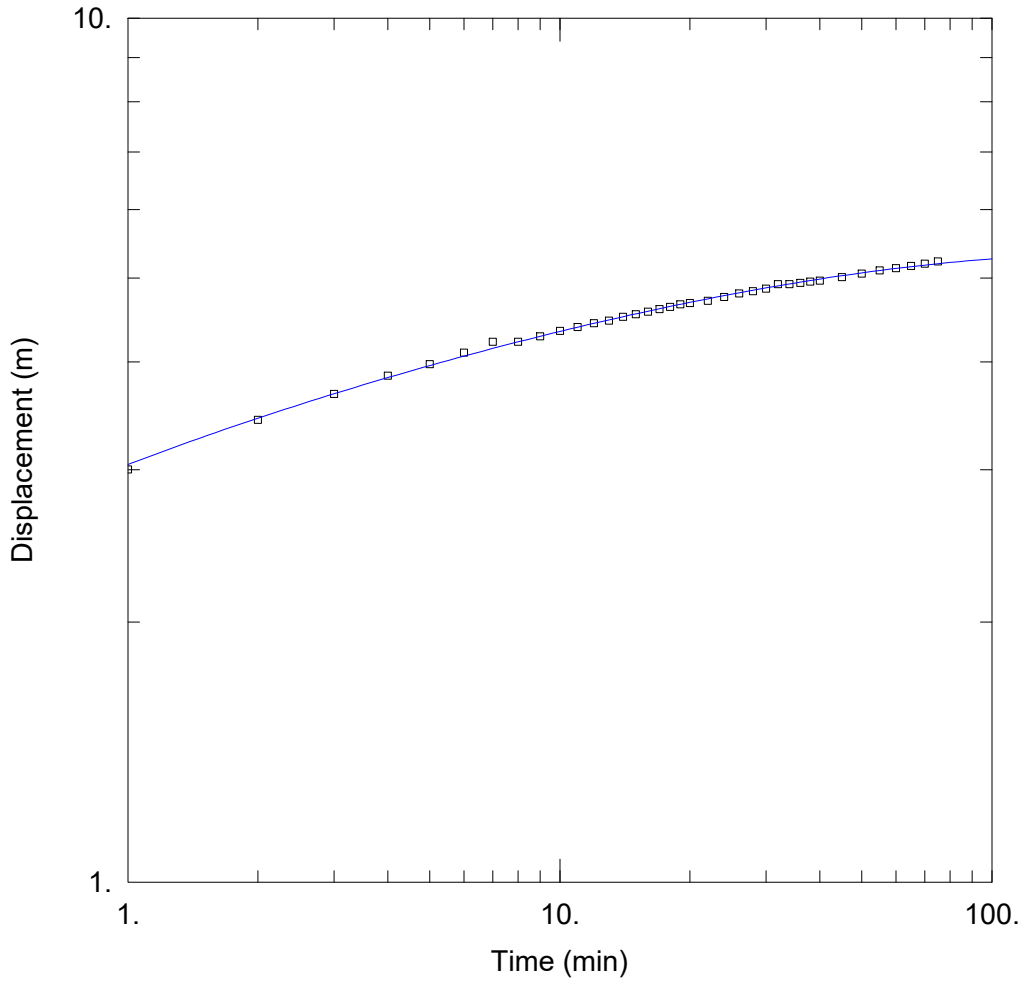
Well Name	X (m)	Y (m)
▫ OW-1	0	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush-Jacob

T = 0.00118 m^2/sec
r/B = 0.003315
b = 124. m

S = 0.04839
Kz/Kr = 1.538E+7



WELL TEST ANALYSIS

Data Set: M:\My Documents\working files\grieg\grieg pumping test recovery.aqt
Date: 10/03/19 Time: 10:51:16

PROJECT INFORMATION

Company: Wood E&IS
Client: DSD
Project: TF1963111
Location: Marystown
Test Date: August 15, 2019

WELL DATA

Pumping Wells

Well Name	X (m)	Y (m)
OW-1	0	0

Observation Wells

Well Name	X (m)	Y (m)
▫ OW-1	0	0

SOLUTION

Aquifer Model: Leaky
Solution Method: Hantush-Jacob

T = 0.001029 m^2/sec
r/B = 0.01136
b = 124. m

S = 0.07653
Kz/Kr = 1.538E+7

APPENDIX D: ANALYTICAL DATA TABLES

TABLE D-1: GENERAL CHEMISTRY IN GROUNDWATER

Parameter	Units	GCDWQ	CCME		GNL01	GNL02
	Sample Date (D/M/Y)		Freshwater	Marine	8/12/2019	8/15/2019
Calculated Parameters						
Anion Sum	me/L	NG	-	-	4.26	4.61
Bicarbonate Alkalinity (calc. as $CaCO_3$)	mg/L	NG	-	-	120	120
Calculated TDS	mg/L	500 [A]	-	-	230	240
Carbonate Alkalinity (calc. as $CaCO_3$)	mg/L	NG	-	-	1.3	<1.0
Cation Sum	me/L	NG	-	-	4.19	4.09
Hardness (as $CaCO_3$)	mg/L	500[B]	-	-	130	140
Ion Balance (% Difference)	%	NG	-	-	0.83	5.98
Langelier Index (20°C)	N/A	NG	-	-	0.246	0.129
Langelier Index (4°C)	N/A	NG	-	-	-0.004	-0.12
Nitrate (N)	mg/L	10	13	200	0.15	0.2
Saturation pH (20°C)	N/A	NG	-	-	7.81	7.77
Saturation pH (4°C)	N/A	NG	-	-	8.06	8.02
Inorganics						
Total Alkalinity (Total as $CaCO_3$)	mg/L	NG	-	-	120	130
Dissolved Chloride (Cl)	mg/L	250 [A]	120	-	63	68
Colour	TCU	15 [A]	narrative[D]	narrative[D]	<5.0	<5.0
Nitrate+Nitrite	mg/L	NG	-	-	0.15	0.2
Nitrite (N)	mg/L	1	0.197[E]	-	<0.01	<0.01
Nitrogen (Ammonia Nitrogen)	mg/L	NG	0.588[F]	0.588[F]	<0.05	<0.05
Total Organic Carbon (C)	mg/L	NG	-	-	<0.50	<0.50
Orthophosphate (P)	mg/L	NG	-	-	<0.01	<0.01
pH	units	6.5 - 8.5 [A]	6.5 - 9.5	7.0 - 8.7	8.05	7.9
Reactive Silica (SiO_2)	mg/L	NG	-	-	6.9	6.8
Dissolved Sulfate ($S0_4$)	mg/L	500 [A]	-	-	3.7	7.1
Turbidity	NTU	0.1[C]	narrative[G]	narrative[G]	**0.6**	**0.19**
Conductivity	µS/cm	NG	-	-	450	450
Dissolved Fluoride (F-)	mg/L	1.5	0.120	-	**0.36**	**0.3**
Dissolved Organic Carbon (C)	mg/L	NG	-	-	-	-
Salinity	N/A	NG	-	narrative[H]	<2.0	<2.1
Total Kjeldahl Nitrogen	mg/L	NG	-	-	<0.1	<0.2
Bromide (Br-)	mg/L	NG	-	-	-	-

Notes:

me/L: milliequivalent per litre
mg/L: miligram per litre
TCU: True Colour Units
NTU: Nephelometric Turbidity Unit
µS/cm: microsiemens per centimetre
N/A: Not Applicable
NG: No guideline available
GCDWQ: Health Canada Guidelines for Canadian Drinking Water Quality (Health Canada, August 2012)
CCME: Canadian Council of Ministers of Environment Water Quality Guidelines for the Protection of Aquatic Life

Concentration exceeds GCDWQ

Concentration exceeds the CCME Guideline for Freshwater or Marine Aquatic Life

[A] Guideline is an Aesthetic Objective (AO) and is not a health-based guideline.

[B] Public acceptance of hardness varies considerably. Hardness levels in excess of 500 mg/L are normally considered unacceptable. Hardness levels between 80 and 100 mg/L (as CaCO3) provide acceptable balance between corrosion and incrustation.

[C] Turbidity levels should be less than 0.1 NTU; however, chemically assisted filtration </= 0.3 NTU; slow sand or diatomaceous filtration </= 1.0 NTU and membrane filtration </= 0.1 NTU.

[D] **True Colour**

The mean absorbance of filtered water samples at 456 nm shall not be significantly higher than the seasonally adjusted expected value for the system under consideration.

Apparent Colour

The mean percent transmission of white light per metre shall not be significantly less than the seasonally adjusted expected value for the system under consideration.

[E] Guideline is 60 NO_2-N which can be expressed as µg nitrite-nitrogen/L. This value is equivalent to 197 µg nitrite/L.

[F] Ammonia guideline: Expressed as µg un-ionized ammonia/L. This would be equivalent to 16 µg ammonia-N /L (=19*14.0067 / 17.35052, rounded to two significant figures). Guideline for total ammonia is temperature and pH dependent, please consult factsheet for more information.

[G] **Clear Flow**

Maximum increase of 8 NTUs from background levels for a short-term exposure (e.g., 24-h period). Maximum average increase of 2 NTUs from background levels for a longer term exposure (e.g., 30-d period).

High Flow or Turbid Waters

Maximum increase of 8 NTUs from background levels at any one time when background levels are between 8 and 80 NTUs. Should not increase more than 10% of background levels when background is > 80 NTUs.

[H] Human activities should not cause the salinity (expressed as parts per thousand [‰]) of marine and estuarine waters to fluctuate by more than 10% of the natural level expected at that time and depth. Note Interim guideline.

TABLE D-2: METAL CONCENTRATIONS IN GROUNDWATER

Parameter[A]	Unit	GCDWQ	CCME		GNL01	GNL02
		Sample Date	Freshwater	Marine	8/12/2019	8/15/2019
Aluminum (Al)	ug/L	100[B]	5 or 100[D]	-	25	5.1
Antimony (Sb)	ug/L	6	-	-	<1.0	<1.0
Arsenic (As)	ug/L	10	5	12.5	<1.0	<1.0
Barium (Ba)	ug/L	1000	-	-	100	100
Beryllium (Be)	ug/L	NG	-	-	<1.0	<1.0
Bismuth (Bi)	ug/L	NG	-	-	<2.0	<2.0
Boron (B)	ug/L	5000	1500	-	<50	<50
Cadmium (Cd)	ug/L	5	0.09	0.12	<0.01	<0.01
Calcium (Ca)	ug/L	NG	-	-	33000	34000
Chromium (Cr)	ug/L	50	8.9	56	<1.0	<1.0
Cobalt (Co)	ug/L	NG	-	-	<0.4	<0.4
Copper (Cu)	ug/L	1000[C]	3.91[E]	4[G]	<0.5	<0.5
Iron (Fe)	ug/L	300[C]	300	-	<50	<50
Lead (Pb)	ug/L	10	6.72[F]	-	<0.5	<0.5
Magnesium (Mg)	ug/L	NG	-	-	12000	12000
Manganese (Mn)	ug/L	50[C]	-	-	<2.0	<2.0
Molybdenum (Mo)	ug/L	NG	73	-	<2.0	<2.0
Nickel (Ni)	ug/L	NG	149.4[G]	-	<2.0	<2.0
Phosphorus (P)	ug/L	NG	>100 = hyper-eutrophic[H]	-	<100	<100
Potassium (K)	ug/L	NG	-	-	430	410
Selenium (Se)	ug/L	50	1	-	<0.5	<0.5
Silver (Ag)	ug/L	NG	0.25	7.5	<0.1	<0.1
Sodium (Na)	ug/L	200,000[C]	-	-	36000	32000
Strontium (Sr)	ug/L	NG	-	-	570	580
Thallium (Tl)	ug/L	NG	0.8	-	<0.1	<0.1
Tin (Sn)	ug/L	NG	-	-	<2.0	<2.0
Titanium (Ti)	ug/L	NG	-	-	<2.0	<2.0
Uranium (U)	ug/L	20	15	-	0.31	0.28
Vanadium (V)	ug/L	NG	-	-	<2.0	<2.0
Zinc (Zn)	ug/L	5000[C]	37[I]	-	12	<5.0
Mercury (Hg)	ug/L	1	0.026	0.016	<0.013	<0.013

Notes:

µg/L: micrograms per litre

NG: No guideline available

GCDWQ: Health Canada Guidelines for Canadian Drinking Water Quality (Health Canada, August 2012)

CCME: Canadian Council of Ministers of Environment Water Quality Guidelines for the Protection of Aquatic Life

Concentration exceeds GCDWQ

Concentration exceeds the CCME Guideline for Freshwater or Marine Aquatic Life

[A] Sample was analyzed for Total Metals

[B] Guidelines for aluminum apply only to drinking water treatment plants using aluminum-based coagulants and are therefore not applicable to groundwater samples collected from the on-site well.

[C] Guideline is an Aesthetic Objective (AO) and is not a health-based guideline.

[D] = 5 µg/L if pH < 6.5; = 100 µg/L if pH ≥ 6.5

[E] The CCME for copper is related to water hardness (as $CaCO_3$):
When the water hardness 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 (see calculator below)
CCME (µg/L) = $0.2 * e^{\{0.8545[\ln(\text{hardness})]-1.465\}}$
At hardness >180 mg/L, the CCME is 4 µg/L
If the hardness is unknown, the CCME is 2 µg/L

[F] The CCME for lead is related to water hardness (as $CaCO_3$):
When the hardness 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 (see calculator below)
CCME (µg/L)= $e^{\{1.273[\ln(\text{hardness})]-4.705\}}$
At hardness >180 mg/L, the CWQG is 7 µg/L
If the hardness is unknown, the CWQG is 1 µg/L

[G] The CCME for nickel is related to water hardness (as $CaCO_3$):
When the water hardness 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 (see calculator below)
CCME (µg/L) = $e^{\{0.76[\ln(\text{hardness})]+1.06\}}$
At hardness >180 mg/L, the CCME is 150 µg/L
If the hardness is unknown, the CCME is 25 µg/L

[H] Canadian Guidance Framework for Phosphorus is for developing phosphorus guidelines (does not provide guidance on other freshwater nutrients). It provides Trigger Ranges for Total Phosphorus (µg/L) (see Guidance Framework for Phosphorus factsheet):
ultra-oligotrophic <4
oligotrophic 4-10
mesotrophic 10-20
meso-eutrophic 20-35
eutrophic 35-100
hyper-eutrophic >100

[I] CCME guideline for Zinc is related to hardness and DOC using the following equation: CCME = exp(0.947[ln(hardness mg·L-1)] - 0.815[pH] + 0.398[ln(DOC mg·L-1)] + 4.625).

APPENDIX E: LABORATORY CERTIFICATE OF ANALYSES

Your Project #: GNL01
Site#: 1
Site Location: GRIEG NL
Your C.O.C. #: 727560-01-01

Attention: Elaine Sullivan

Dave Sullivan Drilling
54 Vineyard Dr
Paradise, NL
CANADA A1L 3W5

Report Date: 2019/08/28
Report #: R5857527
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: B9M9299
Received: 2019/08/19, 08:15

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Carbonate, Bicarbonate and Hydroxide (1)	1	N/A	2019/08/22	N/A	SM 23 4500-CO2 D
Alkalinity (1)	1	N/A	2019/08/26	ATL SOP 00013	EPA 310.2 R1974 m
Chloride (1)	1	N/A	2019/08/26	ATL SOP 00014	SM 23 4500-Cl- E m
Colour (1)	1	N/A	2019/08/26	ATL SOP 00020	SM 23 2120C m
Conductance - water (1)	1	N/A	2019/08/22	ATL SOP 00004	SM 23 2510B m
Fluoride (1)	1	N/A	2019/08/22	ATL SOP 00043	SM 23 4500-F- C m
Hardness (calculated as CaCO3) (1)	1	N/A	2019/08/22	ATL SOP 00048	Auto Calc
Mercury - Total (CVAA,LL) (1)	1	2019/08/21	2019/08/22	ATL SOP 00026	EPA 245.1 R3 m
Metals Water Total MS (1)	1	2019/08/21	2019/08/23	ATL SOP 00058	EPA 6020B R2 m
Ion Balance (% Difference) (1)	1	N/A	2019/08/27	N/A	Auto Calc.
Anion and Cation Sum (1)	1	N/A	2019/08/27	N/A	Auto Calc.
Nitrogen Ammonia - water (1)	1	N/A	2019/08/26	ATL SOP 00015	EPA 350.1 R2 m
Nitrogen - Nitrate + Nitrite (1)	1	N/A	2019/08/26	ATL SOP 00016	USGS I-2547-11m
Nitrogen - Nitrite (1)	1	N/A	2019/08/26	ATL SOP 00017	SM 23 4500-NO2- B m
Nitrogen - Nitrate (as N) (1)	1	N/A	2019/08/27	ATL SOP 00018	ASTM D3867-16
pH (1, 3)	1	N/A	2019/08/22	ATL SOP 00003	SM 23 4500-H+ B m
Phosphorus - ortho (1)	1	N/A	2019/08/26	ATL SOP 00021	SM 23 4500-P E m
Salinity (1, 4)	1	N/A	2019/08/26		SM 22 2520B
Sat. pH and Langelier Index (@ 20C) (1)	1	N/A	2019/08/27	ATL SOP 00049	Auto Calc.
Sat. pH and Langelier Index (@ 4C) (1)	1	N/A	2019/08/27	ATL SOP 00049	Auto Calc.
Reactive Silica (1)	1	N/A	2019/08/26	ATL SOP 00022	EPA 366.0 m
Sulphate (1)	1	N/A	2019/08/26	ATL SOP 00023	ASTM D516-16 m
Total Dissolved Solids (TDS calc) (1)	1	N/A	2019/08/27	N/A	Auto Calc.
Total Kjeldahl Nitrogen in Water (2)	1	2019/08/23	2019/08/23	CAM SOP-00938	OMOE E3516 m
Organic carbon - Total (TOC) (1, 5)	1	N/A	2019/08/27	ATL SOP 00203	SM 23 5310B m
Turbidity (1)	1	N/A	2019/08/21	ATL SOP 00011	EPA 180.1 R2 m

Remarks:

Bureau Veritas Laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by BV Labs are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

All work recorded herein has been done in accordance with procedures and practices ordinarily exercised by professionals in BV Labs profession using

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Your Project #: GNL01
Site#: 1
Site Location: GRIEG NL
Your C.O.C. #: 727560-01-01

Attention: Elaine Sullivan

Dave Sullivan Drilling
54 Vineyard Dr
Paradise, NL
CANADA A1L 3W5

Report Date: 2019/08/28
Report #: R5857527
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: B9M9299
Received: 2019/08/19, 08:15

accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and BV Labs in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

BV Labs liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. BV Labs has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by BV Labs, unless otherwise agreed in writing. BV Labs is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by BV Labs, results relate to the supplied samples tested.
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Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) This test was performed by BV Labs Bedford
(2) This test was performed by Bureau Veritas Laboratories Mississauga
(3) The APHA Standard Method require pH to be analyzed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the APHA Standard Method holding time.
(4) Non-accredited test method
(5) TOC / DOC present in the sample should be considered as non-purgeable TOC / DOC.

Encryption Key

AUTHORIZED REPORT
RAPPORT AUTORISÉ

Bureau Veritas Laboratories
28 Aug 2019 11:20:38

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Kavya Nair, Project Manager
Email: Kavya.Nair@bvlabs.com
Phone# (902)420-0203 Ext:252

==========

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BV Labs Job #: B9M9299
Report Date: 2019/08/28

Dave Sullivan Drilling
Client Project #: GNL01
Site Location: GRIEG NL
Sampler Initials: DSD

ATLANTIC RCAP-MS TOTAL METALS IN WATER (WATER)

BV Labs ID		KNZ616		
Sampling Date		2019/08/12 14:06		
COC Number		727560-01-01		
	UNITS	GNL01	RDL	QC Batch
Calculated Parameters				
Anion Sum	me/L	4.26	N/A	6287272
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	120	1.0	6287265
Calculated TDS	mg/L	230	1.0	6287280
Carb. Alkalinity (calc. as CaCO3)	mg/L	1.3	1.0	6287265
Cation Sum	me/L	4.19	N/A	6287272
Hardness (CaCO3)	mg/L	130	1.0	6287268
Ion Balance (% Difference)	%	0.830	N/A	6287270
Langelier Index (@ 20C)	N/A	0.246		6287276
Langelier Index (@ 4C)	N/A	-0.00400		6287278
Nitrate (N)	mg/L	0.15	0.050	6287274
Saturation pH (@ 20C)	N/A	7.81		6287276
Saturation pH (@ 4C)	N/A	8.06		6287278
Inorganics				
Total Alkalinity (Total as CaCO3)	mg/L	120	25	6296726
Dissolved Chloride (Cl-)	mg/L	63	1.0	6296736
Colour	TCU	ND	5.0	6296743
Nitrate + Nitrite (N)	mg/L	0.15	0.050	6296745
Nitrite (N)	mg/L	ND	0.010	6296746
Nitrogen (Ammonia Nitrogen)	mg/L	ND	0.050	6295936
Total Organic Carbon (C)	mg/L	ND	0.50	6301238
Orthophosphate (P)	mg/L	ND	0.010	6296744
pH	pH	8.05	N/A	6293293
Reactive Silica (SiO2)	mg/L	6.9	0.50	6296738
Dissolved Sulphate (SO4)	mg/L	3.7	2.0	6296737
Turbidity	NTU	0.60	0.10	6291012
Conductivity	uS/cm	450	1.0	6293306
Metals				
Total Aluminum (Al)	ug/L	25	5.0	6290840
Total Antimony (Sb)	ug/L	ND	1.0	6290840
Total Arsenic (As)	ug/L	ND	1.0	6290840
Total Barium (Ba)	ug/L	100	1.0	6290840
Total Beryllium (Be)	ug/L	ND	1.0	6290840

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable
ND = Not detected

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BV Labs Job #: B9M9299
Report Date: 2019/08/28

Dave Sullivan Drilling
Client Project #: GNL01
Site Location: GRIEG NL
Sampler Initials: DSD

ATLANTIC RCAP-MS TOTAL METALS IN WATER (WATER)

BV Labs ID		KNZ616		
Sampling Date		2019/08/12 14:06		
COC Number		727560-01-01		
	UNITS	GNL01	RDL	QC Batch
Total Bismuth (Bi)	ug/L	ND	2.0	6290840
Total Boron (B)	ug/L	ND	50	6290840
Total Cadmium (Cd)	ug/L	ND	0.010	6290840
Total Calcium (Ca)	ug/L	33000	100	6290840
Total Chromium (Cr)	ug/L	ND	1.0	6290840
Total Cobalt (Co)	ug/L	ND	0.40	6290840
Total Copper (Cu)	ug/L	ND	0.50	6290840
Total Iron (Fe)	ug/L	ND	50	6290840
Total Lead (Pb)	ug/L	ND	0.50	6290840
Total Magnesium (Mg)	ug/L	12000	100	6290840
Total Manganese (Mn)	ug/L	ND	2.0	6290840
Total Molybdenum (Mo)	ug/L	ND	2.0	6290840
Total Nickel (Ni)	ug/L	ND	2.0	6290840
Total Phosphorus (P)	ug/L	ND	100	6290840
Total Potassium (K)	ug/L	430	100	6290840
Total Selenium (Se)	ug/L	ND	0.50	6290840
Total Silver (Ag)	ug/L	ND	0.10	6290840
Total Sodium (Na)	ug/L	36000	100	6290840
Total Strontium (Sr)	ug/L	570	2.0	6290840
Total Thallium (Tl)	ug/L	ND	0.10	6290840
Total Tin (Sn)	ug/L	ND	2.0	6290840
Total Titanium (Ti)	ug/L	ND	2.0	6290840
Total Uranium (U)	ug/L	0.31	0.10	6290840
Total Vanadium (V)	ug/L	ND	2.0	6290840
Total Zinc (Zn)	ug/L	12	5.0	6290840

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
ND = Not detected

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BV Labs Job #: B9M9299
Report Date: 2019/08/28

Dave Sullivan Drilling
Client Project #: GNL01
Site Location: GRIEG NL
Sampler Initials: DSD

RESULTS OF ANALYSES OF WATER

BV Labs ID		KNZ616		
Sampling Date		2019/08/12 14:06		
COC Number		727560-01-01		
	UNITS	GNL01	RDL	QC Batch
Inorganics				
Dissolved Fluoride (F-)	mg/L	0.36	0.10	6293307
Total Kjeldahl Nitrogen (TKN)	mg/L	ND	0.10	6296377
Salinity	N/A	ND	2.0	6299093

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
ND = Not detected

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BV Labs Job #: B9M9299
Report Date: 2019/08/28

Dave Sullivan Drilling
Client Project #: GNL01
Site Location: GRIEG NL
Sampler Initials: DSD

MERCURY BY COLD VAPOUR AA (WATER)

BV Labs ID		KNZ616		
Sampling Date		2019/08/12 14:06		
COC Number		727560-01-01		
	UNITS	GNL01	RDL	QC Batch
Metals				
Total Mercury (Hg)	ug/L	ND	0.013	6291014

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
ND = Not detected

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BV Labs Job #: B9M9299
Report Date: 2019/08/28

Dave Sullivan Drilling
Client Project #: GNL01
Site Location: GRIEG NL
Sampler Initials: DSD

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	21.0°C

Average temperature upon receipt >10°C

Results relate only to the items tested.

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BV Labs Job #: B9M9299
Report Date: 2019/08/28

Dave Sullivan Drilling
Client Project #: GNL01
Site Location: GRIEG NL
Sampler Initials: DSD

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
6290840	BAN	Matrix Spike	Total Aluminum (Al)	2019/08/21		101	%	80 - 120
			Total Antimony (Sb)	2019/08/21		105	%	80 - 120
			Total Arsenic (As)	2019/08/21		96	%	80 - 120
			Total Barium (Ba)	2019/08/21		100	%	80 - 120
			Total Beryllium (Be)	2019/08/21		101	%	80 - 120
			Total Bismuth (Bi)	2019/08/21		91	%	80 - 120
			Total Boron (B)	2019/08/21		NC	%	80 - 120
			Total Cadmium (Cd)	2019/08/21		94	%	80 - 120
			Total Calcium (Ca)	2019/08/21		NC	%	80 - 120
			Total Chromium (Cr)	2019/08/21		94	%	80 - 120
			Total Cobalt (Co)	2019/08/21		94	%	80 - 120
			Total Copper (Cu)	2019/08/21		87	%	80 - 120
			Total Iron (Fe)	2019/08/21		92	%	80 - 120
			Total Lead (Pb)	2019/08/21		93	%	80 - 120
			Total Magnesium (Mg)	2019/08/21		NC	%	80 - 120
			Total Manganese (Mn)	2019/08/21		91	%	80 - 120
			Total Molybdenum (Mo)	2019/08/21		104	%	80 - 120
			Total Nickel (Ni)	2019/08/21		92	%	80 - 120
			Total Phosphorus (P)	2019/08/21		104	%	80 - 120
			Total Potassium (K)	2019/08/21		NC	%	80 - 120
			Total Selenium (Se)	2019/08/21		95	%	80 - 120
			Total Silver (Ag)	2019/08/21		94	%	80 - 120
			Total Sodium (Na)	2019/08/21		NC	%	80 - 120
			Total Strontium (Sr)	2019/08/21		NC	%	80 - 120
			Total Thallium (Tl)	2019/08/21		95	%	80 - 120
			Total Tin (Sn)	2019/08/21		105	%	80 - 120
			Total Titanium (Ti)	2019/08/21		89	%	80 - 120
			Total Uranium (U)	2019/08/21		95	%	80 - 120
			Total Vanadium (V)	2019/08/21		102	%	80 - 120
			Total Zinc (Zn)	2019/08/21		90	%	80 - 120
6290840	BAN	Spiked Blank	Total Aluminum (Al)	2019/08/21		99	%	80 - 120
			Total Antimony (Sb)	2019/08/21		101	%	80 - 120
			Total Arsenic (As)	2019/08/21		95	%	80 - 120
			Total Barium (Ba)	2019/08/21		100	%	80 - 120
			Total Beryllium (Be)	2019/08/21		95	%	80 - 120
			Total Bismuth (Bi)	2019/08/21		99	%	80 - 120
			Total Boron (B)	2019/08/21		97	%	80 - 120
			Total Cadmium (Cd)	2019/08/21		96	%	80 - 120
			Total Calcium (Ca)	2019/08/21		101	%	80 - 120
			Total Chromium (Cr)	2019/08/21		94	%	80 - 120
			Total Cobalt (Co)	2019/08/21		97	%	80 - 120
			Total Copper (Cu)	2019/08/21		95	%	80 - 120
			Total Iron (Fe)	2019/08/21		101	%	80 - 120
			Total Lead (Pb)	2019/08/21		99	%	80 - 120
			Total Magnesium (Mg)	2019/08/21		100	%	80 - 120
			Total Manganese (Mn)	2019/08/21		98	%	80 - 120
			Total Molybdenum (Mo)	2019/08/21		102	%	80 - 120
			Total Nickel (Ni)	2019/08/21		97	%	80 - 120
			Total Phosphorus (P)	2019/08/21		100	%	80 - 120
			Total Potassium (K)	2019/08/21		98	%	80 - 120
			Total Selenium (Se)	2019/08/21		95	%	80 - 120
			Total Silver (Ag)	2019/08/21		96	%	80 - 120
			Total Sodium (Na)	2019/08/21		93	%	80 - 120

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Total Strontium (Sr)	2019/08/21		101	%	80 - 120
			Total Thallium (Tl)	2019/08/21		102	%	80 - 120
			Total Tin (Sn)	2019/08/21		104	%	80 - 120
			Total Titanium (Ti)	2019/08/21		98	%	80 - 120
			Total Uranium (U)	2019/08/21		104	%	80 - 120
			Total Vanadium (V)	2019/08/21		98	%	80 - 120
			Total Zinc (Zn)	2019/08/21		94	%	80 - 120
6290840	BAN	Method Blank	Total Aluminum (Al)	2019/08/21	ND, RDL=5.0		ug/L	
			Total Antimony (Sb)	2019/08/21	ND, RDL=1.0		ug/L	
			Total Arsenic (As)	2019/08/21	ND, RDL=1.0		ug/L	
			Total Barium (Ba)	2019/08/21	ND, RDL=1.0		ug/L	
			Total Beryllium (Be)	2019/08/21	ND, RDL=1.0		ug/L	
			Total Bismuth (Bi)	2019/08/21	ND, RDL=2.0		ug/L	
			Total Boron (B)	2019/08/21	ND, RDL=50		ug/L	
			Total Cadmium (Cd)	2019/08/21	ND, RDL=0.010		ug/L	
			Total Calcium (Ca)	2019/08/21	ND, RDL=100		ug/L	
			Total Chromium (Cr)	2019/08/21	ND, RDL=1.0		ug/L	
			Total Cobalt (Co)	2019/08/21	ND, RDL=0.40		ug/L	
			Total Copper (Cu)	2019/08/21	ND, RDL=0.50		ug/L	
			Total Iron (Fe)	2019/08/21	ND, RDL=50		ug/L	
			Total Lead (Pb)	2019/08/21	ND, RDL=0.50		ug/L	
			Total Magnesium (Mg)	2019/08/21	ND, RDL=100		ug/L	
			Total Manganese (Mn)	2019/08/21	ND, RDL=2.0		ug/L	
			Total Molybdenum (Mo)	2019/08/21	ND, RDL=2.0		ug/L	
			Total Nickel (Ni)	2019/08/21	ND, RDL=2.0		ug/L	
			Total Phosphorus (P)	2019/08/21	ND, RDL=100		ug/L	
			Total Potassium (K)	2019/08/21	ND, RDL=100		ug/L	
			Total Selenium (Se)	2019/08/21	ND, RDL=0.50		ug/L	
			Total Silver (Ag)	2019/08/21	ND, RDL=0.10		ug/L	
			Total Sodium (Na)	2019/08/21	ND, RDL=100		ug/L	

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Total Strontium (Sr)	2019/08/21	ND, RDL=2.0		ug/L	
			Total Thallium (Tl)	2019/08/21	ND, RDL=0.10		ug/L	
			Total Tin (Sn)	2019/08/21	ND, RDL=2.0		ug/L	
			Total Titanium (Ti)	2019/08/21	ND, RDL=2.0		ug/L	
			Total Uranium (U)	2019/08/21	ND, RDL=0.10		ug/L	
			Total Vanadium (V)	2019/08/21	ND, RDL=2.0		ug/L	
			Total Zinc (Zn)	2019/08/21	ND, RDL=5.0		ug/L	
6290840	BAN	RPD	Total Aluminum (Al)	2019/08/21	NC		%	20
			Total Antimony (Sb)	2019/08/21	NC		%	20
			Total Arsenic (As)	2019/08/21	NC		%	20
			Total Barium (Ba)	2019/08/21	6.4		%	20
			Total Beryllium (Be)	2019/08/21	NC		%	20
			Total Bismuth (Bi)	2019/08/21	NC		%	20
			Total Boron (B)	2019/08/21	6.6		%	20
			Total Cadmium (Cd)	2019/08/21	NC		%	20
			Total Calcium (Ca)	2019/08/21	3.5		%	20
			Total Chromium (Cr)	2019/08/21	NC		%	20
			Total Cobalt (Co)	2019/08/21	NC		%	20
			Total Copper (Cu)	2019/08/21	NC		%	20
			Total Iron (Fe)	2019/08/21	NC		%	20
			Total Lead (Pb)	2019/08/21	NC		%	20
			Total Magnesium (Mg)	2019/08/21	5.0		%	20
			Total Manganese (Mn)	2019/08/21	NC		%	20
			Total Molybdenum (Mo)	2019/08/21	NC		%	20
			Total Nickel (Ni)	2019/08/21	NC		%	20
			Total Phosphorus (P)	2019/08/21	NC		%	20
			Total Potassium (K)	2019/08/21	2.8		%	20
			Total Selenium (Se)	2019/08/21	NC		%	20
			Total Silver (Ag)	2019/08/21	NC		%	20
			Total Sodium (Na)	2019/08/21	5.7		%	20
			Total Strontium (Sr)	2019/08/21	4.6		%	20
			Total Thallium (Tl)	2019/08/21	NC		%	20
			Total Tin (Sn)	2019/08/21	NC		%	20
			Total Titanium (Ti)	2019/08/21	NC		%	20
			Total Uranium (U)	2019/08/21	0.54		%	20
			Total Vanadium (V)	2019/08/21	NC		%	20
			Total Zinc (Zn)	2019/08/21	NC		%	20
6291012	JMV	QC Standard	Turbidity	2019/08/21		102	%	80 - 120
6291012	JMV	Spiked Blank	Turbidity	2019/08/21		98	%	80 - 120
6291012	JMV	Method Blank	Turbidity	2019/08/21	ND, RDL=0.10		NTU	
6291012	JMV	RPD	Turbidity	2019/08/21	7.3		%	20
6291014	NHU	Matrix Spike	Total Mercury (Hg)	2019/08/22		105	%	80 - 120
6291014	NHU	Spiked Blank	Total Mercury (Hg)	2019/08/22		106	%	80 - 120
6291014	NHU	Method Blank	Total Mercury (Hg)	2019/08/22	ND, RDL=0.013		ug/L	

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
6291014	NHU	RPD	Total Mercury (Hg)	2019/08/22	NC		%	20
6293293	JMV	QC Standard	pH	2019/08/22		101	%	97 - 103
6293293	JMV	RPD	pH	2019/08/22	1.7		%	N/A
6293306	JMV	Spiked Blank	Conductivity	2019/08/22		103	%	80 - 120
6293306	JMV	Method Blank	Conductivity	2019/08/22	ND, RDL=1.0		uS/cm	
6293306	JMV	RPD	Conductivity	2019/08/22	0.49		%	10
6293307	JMV	Matrix Spike	Dissolved Fluoride (F-)	2019/08/22		99	%	80 - 120
6293307	JMV	Spiked Blank	Dissolved Fluoride (F-)	2019/08/22		105	%	80 - 120
6293307	JMV	Method Blank	Dissolved Fluoride (F-)	2019/08/22	ND, RDL=0.10		mg/L	
6293307	JMV	RPD	Dissolved Fluoride (F-)	2019/08/22	0		%	20
6295936	SRM	Matrix Spike	Nitrogen (Ammonia Nitrogen)	2019/08/27		110	%	80 - 120
6295936	SRM	Spiked Blank	Nitrogen (Ammonia Nitrogen)	2019/08/26		98	%	80 - 120
6295936	SRM	Method Blank	Nitrogen (Ammonia Nitrogen)	2019/08/26	ND, RDL=0.050		mg/L	
6295936	SRM	RPD	Nitrogen (Ammonia Nitrogen)	2019/08/27	NC		%	20
6296377	RTY	Matrix Spike	Total Kjeldahl Nitrogen (TKN)	2019/08/23		NC	%	80 - 120
6296377	RTY	QC Standard	Total Kjeldahl Nitrogen (TKN)	2019/08/23		99	%	80 - 120
6296377	RTY	Spiked Blank	Total Kjeldahl Nitrogen (TKN)	2019/08/23		107	%	80 - 120
6296377	RTY	Method Blank	Total Kjeldahl Nitrogen (TKN)	2019/08/23	ND, RDL=0.10		mg/L	
6296377	RTY	RPD	Total Kjeldahl Nitrogen (TKN)	2019/08/23	0.090		%	20
6296726	SRM	Matrix Spike	Total Alkalinity (Total as CaCO3)	2019/08/26		107	%	80 - 120
6296726	SRM	Spiked Blank	Total Alkalinity (Total as CaCO3)	2019/08/26		114	%	80 - 120
6296726	SRM	Method Blank	Total Alkalinity (Total as CaCO3)	2019/08/26	ND, RDL=5.0		mg/L	
6296726	SRM	RPD	Total Alkalinity (Total as CaCO3)	2019/08/26	5.6		%	25
6296736	SRM	Matrix Spike	Dissolved Chloride (Cl-)	2019/08/26		99	%	80 - 120
6296736	SRM	Spiked Blank	Dissolved Chloride (Cl-)	2019/08/26		99	%	80 - 120
6296736	SRM	Method Blank	Dissolved Chloride (Cl-)	2019/08/26	ND, RDL=1.0		mg/L	
6296736	SRM	RPD	Dissolved Chloride (Cl-)	2019/08/26	1.1		%	25
6296737	SRM	Matrix Spike	Dissolved Sulphate (SO4)	2019/08/26		107	%	80 - 120
6296737	SRM	Spiked Blank	Dissolved Sulphate (SO4)	2019/08/26		105	%	80 - 120
6296737	SRM	Method Blank	Dissolved Sulphate (SO4)	2019/08/26	ND, RDL=2.0		mg/L	
6296737	SRM	RPD	Dissolved Sulphate (SO4)	2019/08/26	9.5		%	25
6296738	SRM	Matrix Spike	Reactive Silica (SiO2)	2019/08/26		101	%	80 - 120
6296738	SRM	Spiked Blank	Reactive Silica (SiO2)	2019/08/26		104	%	80 - 120
6296738	SRM	Method Blank	Reactive Silica (SiO2)	2019/08/26	ND, RDL=0.50		mg/L	
6296738	SRM	RPD	Reactive Silica (SiO2)	2019/08/26	1.3		%	25
6296743	SRM	Spiked Blank	Colour	2019/08/26		98	%	80 - 120
6296743	SRM	Method Blank	Colour	2019/08/26	ND, RDL=5.0		TCU	
6296743	SRM	RPD	Colour	2019/08/26	NC		%	20
6296744	SRM	Matrix Spike	Orthophosphate (P)	2019/08/26		90	%	80 - 120
6296744	SRM	Spiked Blank	Orthophosphate (P)	2019/08/26		98	%	80 - 120
6296744	SRM	Method Blank	Orthophosphate (P)	2019/08/26	ND, RDL=0.010		mg/L	
6296744	SRM	RPD	Orthophosphate (P)	2019/08/26	NC		%	25
6296745	SRM	Matrix Spike	Nitrate + Nitrite (N)	2019/08/26		87	%	80 - 120

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BV Labs Job #: B9M9299
Report Date: 2019/08/28

Dave Sullivan Drilling
Client Project #: GNL01
Site Location: GRIEG NL
Sampler Initials: DSD

QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
6296745	SRM	Spiked Blank	Nitrate + Nitrite (N)	2019/08/26		92	%	80 - 120
6296745	SRM	Method Blank	Nitrate + Nitrite (N)	2019/08/26	ND, RDL=0.050		mg/L	
6296745	SRM	RPD	Nitrate + Nitrite (N)	2019/08/26	15		%	25
6296746	SRM	Matrix Spike	Nitrite (N)	2019/08/26		64 (1)	%	80 - 120
6296746	SRM	Spiked Blank	Nitrite (N)	2019/08/26		100	%	80 - 120
6296746	SRM	Method Blank	Nitrite (N)	2019/08/26	ND, RDL=0.010		mg/L	
6296746	SRM	RPD	Nitrite (N)	2019/08/26	NC		%	20
6299093	BBD	QC Standard	Salinity	2019/08/26		102	%	80 - 120
6299093	BBD	Method Blank	Salinity	2019/08/26	ND, RDL=2.0		N/A	
6299093	BBD	RPD	Salinity	2019/08/26	NC		%	25
6301238	EMT	Matrix Spike	Total Organic Carbon (C)	2019/08/27		99	%	85 - 115
6301238	EMT	Spiked Blank	Total Organic Carbon (C)	2019/08/27		97	%	80 - 120
6301238	EMT	Method Blank	Total Organic Carbon (C)	2019/08/27	ND, RDL=0.50		mg/L	
6301238	EMT	RPD	Total Organic Carbon (C)	2019/08/27	3.8		%	15

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

(1) Poor spike recovery due to sample matrix.

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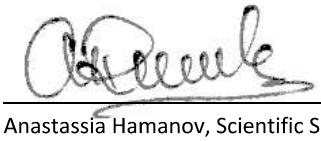
BV Labs Job #: B9M9299
Report Date: 2019/08/28

Dave Sullivan Drilling
Client Project #: GNL01
Site Location: GRIEG NL
Sampler Initials: DSD

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).



Anastassia Hamanov, Scientific Specialist

Eric Dearman, Scientific Specialist

Mike MacGillivray, Scientific Specialist (Inorganics)

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Page of

Chain Of Custody Record

INVOICE TO:		Report Information		Project Information		Laboratory Use Only	
Company Name	#24261 Dave Sullivan Drilling	Company Name		Quotation #	GriegNL	BV Labs Job #	Bottle Order #:
Contact Name	Elaine Sullivan	Contact Name		P.O. #		B9M9299	727560
Address	54 Vineyard Dr Paradise NL A1L 3W5	Address		Project #	GNL01	Chain Of Custody Record	Project Manager
Phone	(709) 781-6038 Fax (709) 781-0668	Phone	Fax:	Project Name	GriegNL 1	C#727560-01-01	Kavya Nair
Email	elaine@geothermalsolutionsinc.ca	Email		Site #			
				Sampled By	DS Drilling		

Regulatory Criteria

Special Instructions

Note: For regulated drinking water samples - please use the Drinking Water Chain of Custody Form

Samples must be kept cool (< 10°C) from time of sampling until delivery to BV Labs

Turnaround Time (TAT) Required

Please provide advance notice for rush projects

Regular (Standard) TAT ☑
(will be applied if Rush TAT is not specified)
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: _____ Time Required: _____
Rush Confirmation Number: _____ *(call lab for #)*

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Regulated Drinking Water ? (Y / N)	Metals Field Filtered ? (Y / N)	Atlantic RCAp-MS Total Metals in Water	Mercury - Total (CVAA,LL)	Fluoride	Organic carbon -Lab filtered	Nitrogen TKN - water (as N)	Salinity	Chloride	# of Bottles	Comments
1	Sample 1	GNL01	12/08/19	14:06				V	V	V		V	V	✓		
2																
3																
4																
5																
6																
7																
8																
9																
10																

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted	Lab Use Only		
				19/08/16	12:45		Time Sensitive ☐	Temperature (°C) on Receipt 21, 21, 21	Custody Seal Intact on Cooler? ☐ Yes ☐ No

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BV LABS' STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVLABS.COM/TERMS-AND-CONDITIONS.
* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

White: BV Labs Yellow: Client

Bureau Veritas Canada (2019) Inc.

Maxxam
A Bureau Veritas Group Company

ADDITIONAL COOLER TEMPERATURE RECORD

CHAIN-OF-CUSTODY RECORD NL Coolers

CHAIN OF CUSTODY #	
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COOLER OBSERVATIONS:	MAXXAM JOB#:

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	2 (1)	3 (2)	4 (3)
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	5 (1)	6 (2)	4 (3)
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1 (1)	7 (2)	2 (3)
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1 (1)	1 (2)	2 (3)
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

RECEIVED BY (SIGN & PRINT)		DATE (YYYY/MM/DD)	TIME (HH:MM)
			2019 AUG 19 13:15

Your Project #: GNL02
Site#: 1
Site Location: GRIEG NL
Your C.O.C. #: 727560-01-01

Attention: Elaine Sullivan

Dave Sullivan Drilling
54 Vineyard Dr
Paradise, NL
CANADA A1L 3W5

Report Date: 2019/08/28
Report #: R5857521
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: B9M9223
Received: 2019/08/19, 08:15

Sample Matrix: Water
Samples Received: 1

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Reference
Carbonate, Bicarbonate and Hydroxide (1)	1	N/A	2019/08/22	N/A	SM 23 4500-CO2 D
Alkalinity (1)	1	N/A	2019/08/26	ATL SOP 00013	EPA 310.2 R1974 m
Chloride (1)	1	N/A	2019/08/26	ATL SOP 00014	SM 23 4500-Cl- E m
Colour (1)	1	N/A	2019/08/26	ATL SOP 00020	SM 23 2120C m
Conductance - water (1)	1	N/A	2019/08/22	ATL SOP 00004	SM 23 2510B m
Fluoride (1)	1	N/A	2019/08/22	ATL SOP 00043	SM 23 4500-F- C m
Hardness (calculated as CaCO3) (1)	1	N/A	2019/08/22	ATL SOP 00048	Auto Calc
Mercury - Total (CVAA,LL) (1)	1	2019/08/21	2019/08/22	ATL SOP 00026	EPA 245.1 R3 m
Metals Water Total MS (1)	1	2019/08/21	2019/08/23	ATL SOP 00058	EPA 6020B R2 m
Ion Balance (% Difference) (1)	1	N/A	2019/08/27	N/A	Auto Calc.
Anion and Cation Sum (1)	1	N/A	2019/08/27	N/A	Auto Calc.
Nitrogen Ammonia - water (1)	1	N/A	2019/08/26	ATL SOP 00015	EPA 350.1 R2 m
Nitrogen - Nitrate + Nitrite (1)	1	N/A	2019/08/26	ATL SOP 00016	USGS I-2547-11m
Nitrogen - Nitrite (1)	1	N/A	2019/08/26	ATL SOP 00017	SM 23 4500-NO2- B m
Nitrogen - Nitrate (as N) (1)	1	N/A	2019/08/27	ATL SOP 00018	ASTM D3867-16
pH (1, 3)	1	N/A	2019/08/22	ATL SOP 00003	SM 23 4500-H+ B m
Phosphorus - ortho (1)	1	N/A	2019/08/26	ATL SOP 00021	SM 23 4500-P E m
Salinity (1, 4)	1	N/A	2019/08/26		SM 22 2520B
Sat. pH and Langelier Index (@ 20C) (1)	1	N/A	2019/08/27	ATL SOP 00049	Auto Calc.
Sat. pH and Langelier Index (@ 4C) (1)	1	N/A	2019/08/27	ATL SOP 00049	Auto Calc.
Reactive Silica (1)	1	N/A	2019/08/26	ATL SOP 00022	EPA 366.0 m
Sulphate (1)	1	N/A	2019/08/26	ATL SOP 00023	ASTM D516-16 m
Total Dissolved Solids (TDS calc) (1)	1	N/A	2019/08/27	N/A	Auto Calc.
Total Kjeldahl Nitrogen in Water (2)	1	2019/08/23	2019/08/23	CAM SOP-00938	OMOE E3516 m
Organic carbon - Total (TOC) (1, 5)	1	N/A	2019/08/27	ATL SOP 00203	SM 23 5310B m
Turbidity (1)	1	N/A	2019/08/22	ATL SOP 00011	EPA 180.1 R2 m

Remarks:

Bureau Veritas Laboratories are accredited to ISO/IEC 17025 for specific parameters on scopes of accreditation. Unless otherwise noted, procedures used by BV Labs are based upon recognized Provincial, Federal or US method compendia such as CCME, MELCC, EPA, APHA.

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Your Project #: GNL02
Site#: 1
Site Location: GRIEG NL
Your C.O.C. #: 727560-01-01

Attention: Elaine Sullivan

Dave Sullivan Drilling
54 Vineyard Dr
Paradise, NL
CANADA A1L 3W5

Report Date: 2019/08/28
Report #: R5857521
Version: 1 - Final

CERTIFICATE OF ANALYSIS

BV LABS JOB #: B9M9223
Received: 2019/08/19, 08:15

accepted testing methodologies, quality assurance and quality control procedures (except where otherwise agreed by the client and BV Labs in writing). All data is in statistical control and has met quality control and method performance criteria unless otherwise noted. All method blanks are reported; unless indicated otherwise, associated sample data are not blank corrected. Where applicable, unless otherwise noted, Measurement Uncertainty has not been accounted for when stating conformity to the referenced standard.

BV Labs liability is limited to the actual cost of the requested analyses, unless otherwise agreed in writing. There is no other warranty expressed or implied. BV Labs has been retained to provide analysis of samples provided by the Client using the testing methodology referenced in this report. Interpretation and use of test results are the sole responsibility of the Client and are not within the scope of services provided by BV Labs, unless otherwise agreed in writing. BV Labs is not responsible for the accuracy or any data impacts, that result from the information provided by the customer or their agent.

Solid sample results, except biota, are based on dry weight unless otherwise indicated. Organic analyses are not recovery corrected except for isotope dilution methods.
Results relate to samples tested. When sampling is not conducted by BV Labs, results relate to the supplied samples tested.
This Certificate shall not be reproduced except in full, without the written approval of the laboratory.
Reference Method suffix "m" indicates test methods incorporate validated modifications from specific reference methods to improve performance.
* RPDs calculated using raw data. The rounding of final results may result in the apparent difference.
(1) This test was performed by BV Labs Bedford
(2) This test was performed by Bureau Veritas Laboratories Mississauga
(3) The APHA Standard Method require pH to be analyzed within 15 minutes of sampling and therefore field analysis is required for compliance. All Laboratory pH analyses in this report are reported past the APHA Standard Method holding time.
(4) Non-accredited test method
(5) TOC / DOC present in the sample should be considered as non-purgeable TOC / DOC.

Encryption Key

AUTHORIZED REPORT
RAPPORT AUTORISÉ

Bureau Veritas Laboratories
28 Aug 2019 11:18:44

Please direct all questions regarding this Certificate of Analysis to your Project Manager.
Kavya Nair, Project Manager
Email: Kavya.Nair@bvlabs.com
Phone# (902)420-0203 Ext:252

==========

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BV Labs Job #: B9M9223
Report Date: 2019/08/28

Dave Sullivan Drilling
Client Project #: GNL02
Site Location: GRIEG NL
Sampler Initials: DSD

ATLANTIC RCAP-MS TOTAL METALS IN WATER (WATER)

BV Labs ID		KNZ164		
Sampling Date		2019/08/15 12:06		
COC Number		727560-01-01		
	UNITS	GNL02	RDL	QC Batch
Calculated Parameters				
Anion Sum	me/L	4.61	N/A	6287272
Bicarb. Alkalinity (calc. as CaCO3)	mg/L	120	1.0	6287265
Calculated TDS	mg/L	240	1.0	6287280
Carb. Alkalinity (calc. as CaCO3)	mg/L	ND	1.0	6287265
Cation Sum	me/L	4.09	N/A	6287272
Hardness (CaCO3)	mg/L	140	1.0	6287268
Ion Balance (% Difference)	%	5.98	N/A	6287270
Langelier Index (@ 20C)	N/A	0.129		6287276
Langelier Index (@ 4C)	N/A	-0.120		6287278
Nitrate (N)	mg/L	0.20	0.050	6287274
Saturation pH (@ 20C)	N/A	7.77		6287276
Saturation pH (@ 4C)	N/A	8.02		6287278
Inorganics				
Total Alkalinity (Total as CaCO3)	mg/L	130	25	6296726
Dissolved Chloride (Cl-)	mg/L	68	1.0	6296736
Colour	TCU	ND	5.0	6296743
Nitrate + Nitrite (N)	mg/L	0.20	0.050	6296745
Nitrite (N)	mg/L	ND	0.010	6296746
Nitrogen (Ammonia Nitrogen)	mg/L	ND	0.050	6295936
Total Organic Carbon (C)	mg/L	ND	0.50	6301238
Orthophosphate (P)	mg/L	ND	0.010	6296744
pH	pH	7.90	N/A	6293293
Reactive Silica (SiO2)	mg/L	6.8	0.50	6296738
Dissolved Sulphate (SO4)	mg/L	7.1	2.0	6296737
Turbidity	NTU	0.19	0.10	6293344
Conductivity	uS/cm	450	1.0	6293306
Metals				
Total Aluminum (Al)	ug/L	5.1	5.0	6290840
Total Antimony (Sb)	ug/L	ND	1.0	6290840
Total Arsenic (As)	ug/L	ND	1.0	6290840
Total Barium (Ba)	ug/L	100	1.0	6290840
Total Beryllium (Be)	ug/L	ND	1.0	6290840

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
N/A = Not Applicable
ND = Not detected

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BV Labs Job #: B9M9223
Report Date: 2019/08/28

Dave Sullivan Drilling
Client Project #: GNL02
Site Location: GRIEG NL
Sampler Initials: DSD

ATLANTIC RCAP-MS TOTAL METALS IN WATER (WATER)

BV Labs ID		KNZ164		
Sampling Date		2019/08/15 12:06		
COC Number		727560-01-01		
	UNITS	GNL02	RDL	QC Batch
Total Bismuth (Bi)	ug/L	ND	2.0	6290840
Total Boron (B)	ug/L	ND	50	6290840
Total Cadmium (Cd)	ug/L	ND	0.010	6290840
Total Calcium (Ca)	ug/L	34000	100	6290840
Total Chromium (Cr)	ug/L	ND	1.0	6290840
Total Cobalt (Co)	ug/L	ND	0.40	6290840
Total Copper (Cu)	ug/L	ND	0.50	6290840
Total Iron (Fe)	ug/L	ND	50	6290840
Total Lead (Pb)	ug/L	ND	0.50	6290840
Total Magnesium (Mg)	ug/L	12000	100	6290840
Total Manganese (Mn)	ug/L	ND	2.0	6290840
Total Molybdenum (Mo)	ug/L	ND	2.0	6290840
Total Nickel (Ni)	ug/L	ND	2.0	6290840
Total Phosphorus (P)	ug/L	ND	100	6290840
Total Potassium (K)	ug/L	410	100	6290840
Total Selenium (Se)	ug/L	ND	0.50	6290840
Total Silver (Ag)	ug/L	ND	0.10	6290840
Total Sodium (Na)	ug/L	32000	100	6290840
Total Strontium (Sr)	ug/L	580	2.0	6290840
Total Thallium (Tl)	ug/L	ND	0.10	6290840
Total Tin (Sn)	ug/L	ND	2.0	6290840
Total Titanium (Ti)	ug/L	ND	2.0	6290840
Total Uranium (U)	ug/L	0.28	0.10	6290840
Total Vanadium (V)	ug/L	ND	2.0	6290840
Total Zinc (Zn)	ug/L	ND	5.0	6290840

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
ND = Not detected

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BV Labs Job #: B9M9223
Report Date: 2019/08/28

Dave Sullivan Drilling
Client Project #: GNL02
Site Location: GRIEG NL
Sampler Initials: DSD

RESULTS OF ANALYSES OF WATER

BV Labs ID		KNZ164		
Sampling Date		2019/08/15 12:06		
COC Number		727560-01-01		
	UNITS	GNL02	RDL	QC Batch
Inorganics				
Dissolved Fluoride (F-)	mg/L	0.30	0.10	6293307
Total Kjeldahl Nitrogen (TKN)	mg/L	ND	0.10	6296374
Salinity	N/A	ND	2.0	6299093

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
ND = Not detected

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BV Labs Job #: B9M9223
Report Date: 2019/08/28

Dave Sullivan Drilling
Client Project #: GNL02
Site Location: GRIEG NL
Sampler Initials: DSD

MERCURY BY COLD VAPOUR AA (WATER)

BV Labs ID		KNZ164		
Sampling Date		2019/08/15 12:06		
COC Number		727560-01-01		
	UNITS	GNL02	RDL	QC Batch
Metals				
Total Mercury (Hg)	ug/L	ND	0.013	6291014

RDL = Reportable Detection Limit
QC Batch = Quality Control Batch
ND = Not detected

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BV Labs Job #: B9M9223
Report Date: 2019/08/28

Dave Sullivan Drilling
Client Project #: GNL02
Site Location: GRIEG NL
Sampler Initials: DSD

GENERAL COMMENTS

Each temperature is the average of up to three cooler temperatures taken at receipt

Package 1	21.0°C

Average temperature upon receipt >10°C

Sample KNZ164 [GNL02] : Poor RCAp Ion Balance due to sample matrix.

Results relate only to the items tested.

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BV Labs Job #: B9M9223
Report Date: 2019/08/28

Dave Sullivan Drilling
Client Project #: GNL02
Site Location: GRIEG NL
Sampler Initials: DSD

QUALITY ASSURANCE REPORT

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
6290840	BAN	Matrix Spike	Total Aluminum (Al)	2019/08/21		101	%	80 - 120
			Total Antimony (Sb)	2019/08/21		105	%	80 - 120
			Total Arsenic (As)	2019/08/21		96	%	80 - 120
			Total Barium (Ba)	2019/08/21		100	%	80 - 120
			Total Beryllium (Be)	2019/08/21		101	%	80 - 120
			Total Bismuth (Bi)	2019/08/21		91	%	80 - 120
			Total Boron (B)	2019/08/21		NC	%	80 - 120
			Total Cadmium (Cd)	2019/08/21		94	%	80 - 120
			Total Calcium (Ca)	2019/08/21		NC	%	80 - 120
			Total Chromium (Cr)	2019/08/21		94	%	80 - 120
			Total Cobalt (Co)	2019/08/21		94	%	80 - 120
			Total Copper (Cu)	2019/08/21		87	%	80 - 120
			Total Iron (Fe)	2019/08/21		92	%	80 - 120
			Total Lead (Pb)	2019/08/21		93	%	80 - 120
			Total Magnesium (Mg)	2019/08/21		NC	%	80 - 120
			Total Manganese (Mn)	2019/08/21		91	%	80 - 120
			Total Molybdenum (Mo)	2019/08/21		104	%	80 - 120
			Total Nickel (Ni)	2019/08/21		92	%	80 - 120
			Total Phosphorus (P)	2019/08/21		104	%	80 - 120
			Total Potassium (K)	2019/08/21		NC	%	80 - 120
			Total Selenium (Se)	2019/08/21		95	%	80 - 120
			Total Silver (Ag)	2019/08/21		94	%	80 - 120
			Total Sodium (Na)	2019/08/21		NC	%	80 - 120
			Total Strontium (Sr)	2019/08/21		NC	%	80 - 120
			Total Thallium (Tl)	2019/08/21		95	%	80 - 120
			Total Tin (Sn)	2019/08/21		105	%	80 - 120
			Total Titanium (Ti)	2019/08/21		89	%	80 - 120
			Total Uranium (U)	2019/08/21		95	%	80 - 120
			Total Vanadium (V)	2019/08/21		102	%	80 - 120
			Total Zinc (Zn)	2019/08/21		90	%	80 - 120
6290840	BAN	Spiked Blank	Total Aluminum (Al)	2019/08/21		99	%	80 - 120
			Total Antimony (Sb)	2019/08/21		101	%	80 - 120
			Total Arsenic (As)	2019/08/21		95	%	80 - 120
			Total Barium (Ba)	2019/08/21		100	%	80 - 120
			Total Beryllium (Be)	2019/08/21		95	%	80 - 120
			Total Bismuth (Bi)	2019/08/21		99	%	80 - 120
			Total Boron (B)	2019/08/21		97	%	80 - 120
			Total Cadmium (Cd)	2019/08/21		96	%	80 - 120
			Total Calcium (Ca)	2019/08/21		101	%	80 - 120
			Total Chromium (Cr)	2019/08/21		94	%	80 - 120
			Total Cobalt (Co)	2019/08/21		97	%	80 - 120
			Total Copper (Cu)	2019/08/21		95	%	80 - 120
			Total Iron (Fe)	2019/08/21		101	%	80 - 120
			Total Lead (Pb)	2019/08/21		99	%	80 - 120
			Total Magnesium (Mg)	2019/08/21		100	%	80 - 120
			Total Manganese (Mn)	2019/08/21		98	%	80 - 120
			Total Molybdenum (Mo)	2019/08/21		102	%	80 - 120
			Total Nickel (Ni)	2019/08/21		97	%	80 - 120
			Total Phosphorus (P)	2019/08/21		100	%	80 - 120
			Total Potassium (K)	2019/08/21		98	%	80 - 120
			Total Selenium (Se)	2019/08/21		95	%	80 - 120
			Total Silver (Ag)	2019/08/21		96	%	80 - 120
			Total Sodium (Na)	2019/08/21		93	%	80 - 120

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Total Strontium (Sr)	2019/08/21		101	%	80 - 120
			Total Thallium (Tl)	2019/08/21		102	%	80 - 120
			Total Tin (Sn)	2019/08/21		104	%	80 - 120
			Total Titanium (Ti)	2019/08/21		98	%	80 - 120
			Total Uranium (U)	2019/08/21		104	%	80 - 120
			Total Vanadium (V)	2019/08/21		98	%	80 - 120
			Total Zinc (Zn)	2019/08/21		94	%	80 - 120
6290840	BAN	Method Blank	Total Aluminum (Al)	2019/08/21	ND, RDL=5.0		ug/L	
			Total Antimony (Sb)	2019/08/21	ND, RDL=1.0		ug/L	
			Total Arsenic (As)	2019/08/21	ND, RDL=1.0		ug/L	
			Total Barium (Ba)	2019/08/21	ND, RDL=1.0		ug/L	
			Total Beryllium (Be)	2019/08/21	ND, RDL=1.0		ug/L	
			Total Bismuth (Bi)	2019/08/21	ND, RDL=2.0		ug/L	
			Total Boron (B)	2019/08/21	ND, RDL=50		ug/L	
			Total Cadmium (Cd)	2019/08/21	ND, RDL=0.010		ug/L	
			Total Calcium (Ca)	2019/08/21	ND, RDL=100		ug/L	
			Total Chromium (Cr)	2019/08/21	ND, RDL=1.0		ug/L	
			Total Cobalt (Co)	2019/08/21	ND, RDL=0.40		ug/L	
			Total Copper (Cu)	2019/08/21	ND, RDL=0.50		ug/L	
			Total Iron (Fe)	2019/08/21	ND, RDL=50		ug/L	
			Total Lead (Pb)	2019/08/21	ND, RDL=0.50		ug/L	
			Total Magnesium (Mg)	2019/08/21	ND, RDL=100		ug/L	
			Total Manganese (Mn)	2019/08/21	ND, RDL=2.0		ug/L	
			Total Molybdenum (Mo)	2019/08/21	ND, RDL=2.0		ug/L	
			Total Nickel (Ni)	2019/08/21	ND, RDL=2.0		ug/L	
			Total Phosphorus (P)	2019/08/21	ND, RDL=100		ug/L	
			Total Potassium (K)	2019/08/21	ND, RDL=100		ug/L	
			Total Selenium (Se)	2019/08/21	ND, RDL=0.50		ug/L	
			Total Silver (Ag)	2019/08/21	ND, RDL=0.10		ug/L	
			Total Sodium (Na)	2019/08/21	ND, RDL=100		ug/L	

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
			Total Strontium (Sr)	2019/08/21	ND, RDL=2.0		ug/L	
			Total Thallium (Tl)	2019/08/21	ND, RDL=0.10		ug/L	
			Total Tin (Sn)	2019/08/21	ND, RDL=2.0		ug/L	
			Total Titanium (Ti)	2019/08/21	ND, RDL=2.0		ug/L	
			Total Uranium (U)	2019/08/21	ND, RDL=0.10		ug/L	
			Total Vanadium (V)	2019/08/21	ND, RDL=2.0		ug/L	
			Total Zinc (Zn)	2019/08/21	ND, RDL=5.0		ug/L	
6290840	BAN	RPD	Total Aluminum (Al)	2019/08/21	NC		%	20
			Total Antimony (Sb)	2019/08/21	NC		%	20
			Total Arsenic (As)	2019/08/21	NC		%	20
			Total Barium (Ba)	2019/08/21	6.4		%	20
			Total Beryllium (Be)	2019/08/21	NC		%	20
			Total Bismuth (Bi)	2019/08/21	NC		%	20
			Total Boron (B)	2019/08/21	6.6		%	20
			Total Cadmium (Cd)	2019/08/21	NC		%	20
			Total Calcium (Ca)	2019/08/21	3.5		%	20
			Total Chromium (Cr)	2019/08/21	NC		%	20
			Total Cobalt (Co)	2019/08/21	NC		%	20
			Total Copper (Cu)	2019/08/21	NC		%	20
			Total Iron (Fe)	2019/08/21	NC		%	20
			Total Lead (Pb)	2019/08/21	NC		%	20
			Total Magnesium (Mg)	2019/08/21	5.0		%	20
			Total Manganese (Mn)	2019/08/21	NC		%	20
			Total Molybdenum (Mo)	2019/08/21	NC		%	20
			Total Nickel (Ni)	2019/08/21	NC		%	20
			Total Phosphorus (P)	2019/08/21	NC		%	20
			Total Potassium (K)	2019/08/21	2.8		%	20
			Total Selenium (Se)	2019/08/21	NC		%	20
			Total Silver (Ag)	2019/08/21	NC		%	20
			Total Sodium (Na)	2019/08/21	5.7		%	20
			Total Strontium (Sr)	2019/08/21	4.6		%	20
			Total Thallium (Tl)	2019/08/21	NC		%	20
			Total Tin (Sn)	2019/08/21	NC		%	20
			Total Titanium (Ti)	2019/08/21	NC		%	20
			Total Uranium (U)	2019/08/21	0.54		%	20
			Total Vanadium (V)	2019/08/21	NC		%	20
			Total Zinc (Zn)	2019/08/21	NC		%	20
6291014	NHU	Matrix Spike	Total Mercury (Hg)	2019/08/22		105	%	80 - 120
6291014	NHU	Spiked Blank	Total Mercury (Hg)	2019/08/22		106	%	80 - 120
6291014	NHU	Method Blank	Total Mercury (Hg)	2019/08/22	ND, RDL=0.013		ug/L	
6291014	NHU	RPD	Total Mercury (Hg)	2019/08/22	NC		%	20
6293293	JMV	QC Standard	pH	2019/08/22		101	%	97 - 103
6293293	JMV	RPD	pH	2019/08/22	1.7		%	N/A
6293306	JMV	Spiked Blank	Conductivity	2019/08/22		103	%	80 - 120

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
6293306	JMV	Method Blank	Conductivity	2019/08/22	ND, RDL=1.0		uS/cm	
6293306	JMV	RPD	Conductivity	2019/08/22	0.49		%	10
6293307	JMV	Matrix Spike	Dissolved Fluoride (F-)	2019/08/22		99	%	80 - 120
6293307	JMV	Spiked Blank	Dissolved Fluoride (F-)	2019/08/22		105	%	80 - 120
6293307	JMV	Method Blank	Dissolved Fluoride (F-)	2019/08/22	ND, RDL=0.10		mg/L	
6293307	JMV	RPD	Dissolved Fluoride (F-)	2019/08/22	0		%	20
6293344	JMV	QC Standard	Turbidity	2019/08/22		102	%	80 - 120
6293344	JMV	Spiked Blank	Turbidity	2019/08/22		98	%	80 - 120
6293344	JMV	Method Blank	Turbidity	2019/08/22	ND, RDL=0.10		NTU	
6293344	JMV	RPD	Turbidity	2019/08/22	NC		%	20
6295936	SRM	Matrix Spike	Nitrogen (Ammonia Nitrogen)	2019/08/27		110	%	80 - 120
6295936	SRM	Spiked Blank	Nitrogen (Ammonia Nitrogen)	2019/08/26		98	%	80 - 120
6295936	SRM	Method Blank	Nitrogen (Ammonia Nitrogen)	2019/08/26	ND, RDL=0.050		mg/L	
6295936	SRM	RPD	Nitrogen (Ammonia Nitrogen)	2019/08/27	NC		%	20
6296374	RTY	Matrix Spike [KNZ164-07]	Total Kjeldahl Nitrogen (TKN)	2019/08/23		101	%	80 - 120
6296374	RTY	QC Standard	Total Kjeldahl Nitrogen (TKN)	2019/08/23		92	%	80 - 120
6296374	RTY	Spiked Blank	Total Kjeldahl Nitrogen (TKN)	2019/08/23		104	%	80 - 120
6296374	RTY	Method Blank	Total Kjeldahl Nitrogen (TKN)	2019/08/23	ND, RDL=0.10		mg/L	
6296374	RTY	RPD [KNZ164-07]	Total Kjeldahl Nitrogen (TKN)	2019/08/23	NC		%	20
6296726	SRM	Matrix Spike	Total Alkalinity (Total as CaCO3)	2019/08/26		107	%	80 - 120
6296726	SRM	Spiked Blank	Total Alkalinity (Total as CaCO3)	2019/08/26		114	%	80 - 120
6296726	SRM	Method Blank	Total Alkalinity (Total as CaCO3)	2019/08/26	ND, RDL=5.0		mg/L	
6296726	SRM	RPD	Total Alkalinity (Total as CaCO3)	2019/08/26	5.6		%	25
6296736	SRM	Matrix Spike	Dissolved Chloride (Cl-)	2019/08/26		99	%	80 - 120
6296736	SRM	Spiked Blank	Dissolved Chloride (Cl-)	2019/08/26		99	%	80 - 120
6296736	SRM	Method Blank	Dissolved Chloride (Cl-)	2019/08/26	ND, RDL=1.0		mg/L	
6296736	SRM	RPD	Dissolved Chloride (Cl-)	2019/08/26	1.1		%	25
6296737	SRM	Matrix Spike	Dissolved Sulphate (SO4)	2019/08/26		107	%	80 - 120
6296737	SRM	Spiked Blank	Dissolved Sulphate (SO4)	2019/08/26		105	%	80 - 120
6296737	SRM	Method Blank	Dissolved Sulphate (SO4)	2019/08/26	ND, RDL=2.0		mg/L	
6296737	SRM	RPD	Dissolved Sulphate (SO4)	2019/08/26	9.5		%	25
6296738	SRM	Matrix Spike	Reactive Silica (SiO2)	2019/08/26		101	%	80 - 120
6296738	SRM	Spiked Blank	Reactive Silica (SiO2)	2019/08/26		104	%	80 - 120
6296738	SRM	Method Blank	Reactive Silica (SiO2)	2019/08/26	ND, RDL=0.50		mg/L	
6296738	SRM	RPD	Reactive Silica (SiO2)	2019/08/26	1.3		%	25
6296743	SRM	Spiked Blank	Colour	2019/08/26		98	%	80 - 120
6296743	SRM	Method Blank	Colour	2019/08/26	ND, RDL=5.0		TCU	
6296743	SRM	RPD	Colour	2019/08/26	NC		%	20
6296744	SRM	Matrix Spike	Orthophosphate (P)	2019/08/26		90	%	80 - 120
6296744	SRM	Spiked Blank	Orthophosphate (P)	2019/08/26		98	%	80 - 120
6296744	SRM	Method Blank	Orthophosphate (P)	2019/08/26	ND, RDL=0.010		mg/L	
6296744	SRM	RPD	Orthophosphate (P)	2019/08/26	NC		%	25

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QUALITY ASSURANCE REPORT(CONT'D)

QA/QC Batch	Init	QC Type	Parameter	Date Analyzed	Value	Recovery	UNITS	QC Limits
6296745	SRM	Matrix Spike	Nitrate + Nitrite (N)	2019/08/26		87	%	80 - 120
6296745	SRM	Spiked Blank	Nitrate + Nitrite (N)	2019/08/26		92	%	80 - 120
6296745	SRM	Method Blank	Nitrate + Nitrite (N)	2019/08/26	ND, RDL=0.050		mg/L	
6296745	SRM	RPD	Nitrate + Nitrite (N)	2019/08/26	15		%	25
6296746	SRM	Matrix Spike	Nitrite (N)	2019/08/26		64 (1)	%	80 - 120
6296746	SRM	Spiked Blank	Nitrite (N)	2019/08/26		100	%	80 - 120
6296746	SRM	Method Blank	Nitrite (N)	2019/08/26	ND, RDL=0.010		mg/L	
6296746	SRM	RPD	Nitrite (N)	2019/08/26	NC		%	20
6299093	BBD	QC Standard	Salinity	2019/08/26		102	%	80 - 120
6299093	BBD	Method Blank	Salinity	2019/08/26	ND, RDL=2.0		N/A	
6299093	BBD	RPD [KNZ164-06]	Salinity	2019/08/26	NC		%	25
6301238	EMT	Matrix Spike	Total Organic Carbon (C)	2019/08/27		99	%	85 - 115
6301238	EMT	Spiked Blank	Total Organic Carbon (C)	2019/08/27		97	%	80 - 120
6301238	EMT	Method Blank	Total Organic Carbon (C)	2019/08/27	ND, RDL=0.50		mg/L	
6301238	EMT	RPD	Total Organic Carbon (C)	2019/08/27	3.8		%	15

N/A = Not Applicable

Duplicate: Paired analysis of a separate portion of the same sample. Used to evaluate the variance in the measurement.

Matrix Spike: A sample to which a known amount of the analyte of interest has been added. Used to evaluate sample matrix interference.

QC Standard: A sample of known concentration prepared by an external agency under stringent conditions. Used as an independent check of method accuracy.

Spiked Blank: A blank matrix sample to which a known amount of the analyte, usually from a second source, has been added. Used to evaluate method accuracy.

Method Blank: A blank matrix containing all reagents used in the analytical procedure. Used to identify laboratory contamination.

NC (Matrix Spike): The recovery in the matrix spike was not calculated. The relative difference between the concentration in the parent sample and the spike amount was too small to permit a reliable recovery calculation (matrix spike concentration was less than the native sample concentration)

NC (Duplicate RPD): The duplicate RPD was not calculated. The concentration in the sample and/or duplicate was too low to permit a reliable RPD calculation (absolute difference <= 2x RDL).

(1) Poor spike recovery due to sample matrix.

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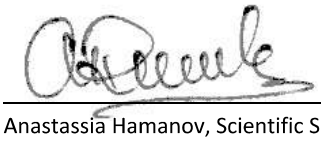
BV Labs Job #: B9M9223
Report Date: 2019/08/28

Dave Sullivan Drilling
Client Project #: GNL02
Site Location: GRIEG NL
Sampler Initials: DSD

VALIDATION SIGNATURE PAGE

The analytical data and all QC contained in this report were reviewed and validated by the following individual(s).



Anastassia Hamanov, Scientific Specialist

Eric Dearman, Scientific Specialist

Mike MacGillivray, Scientific Specialist (Inorganics)

BV Labs has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per ISO/IEC 17025, signing the reports.
For Service Group specific validation please refer to the Validation Signature Page.

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Page of

Chain Of Custody Record

INVOICE TO:		Report Information		Project Information		Laboratory Use Only	
Company Name	#24261 Dave Sullivan Drilling	Company Name		Quotation #	Grieg NL	BV Labs Job #	Bottle Order #:
Contact Name	Elaine Sullivan	Contact Name		P.O. #		B9M9223	727550
Address	54 Vineyard Dr Paradise NL A1L 3W5	Address		Project #	GNL-02	Chain Of Custody Record	Project Manager
Phone	(709) 781-6038 Fax: (709) 781-0668	Phone	Fax:	Project Name	Grieg NL	C#727560-01-01	Kavya Nair
Email	elaine@geothermalsolutionsinc.ca	Email		Site #	1		
				Sampled By	DS Drilling		

Regulatory Criteria

Special Instructions

Note: For regulated drinking water samples - please use the Drinking Water Chain of Custody Form

Samples must be kept cool (< 10°C) from time of sampling until delivery to BV Labs

Analysis Requested

	Sample Barcode Label	Sample (Location) Identification	Date Sampled	Time Sampled	Matrix	Regulated Drinking Water? (Y/N)	Metals Field Filtered? (Y/N)	Atlantic RCAp-MS Total Metals in Water	Mercury - Total (CVAA,LL)	Fluoride	Organic carbon - Lab filtered	Nitrogen TKN - water (as N)	Salinity	Chloride	# of Bottles	Comments
1	Sample2	GNL02	15/08/19	12:06				✓	✓	✓		✓	✓	✓		
2																
3																
4																
5																
6																
7																
8																
9																
10																

Turnaround Time (TAT) Required

Please provide advance notice for rush projects

Regular (Standard) TAT ✓
(will be applied if Rush TAT is not specified)
Standard TAT = 5-7 Working days for most tests.
Please note: Standard TAT for certain tests such as BOD and Dioxins/Furans are > 5 days - contact your Project Manager for details.

Job Specific Rush TAT (if applies to entire submission)
Date Required: _____ Time Required: _____
Rush Confirmation Number: _____ (call lab for #)

* RELINQUISHED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	RECEIVED BY: (Signature/Print)	Date: (YY/MM/DD)	Time	# jars used and not submitted
				14/08/16	12:45	

Lab Use Only: Time Sensitive ☐ | Temperature (°C) on Receipt: 21,21,21 | Custody Seal Intact on Cooler? ☐ Yes ☐ No

* UNLESS OTHERWISE AGREED TO IN WRITING, WORK SUBMITTED ON THIS CHAIN OF CUSTODY IS SUBJECT TO BV LABS' STANDARD TERMS AND CONDITIONS. SIGNING OF THIS CHAIN OF CUSTODY DOCUMENT IS ACKNOWLEDGMENT AND ACCEPTANCE OF OUR TERMS WHICH ARE AVAILABLE FOR VIEWING AT WWW.BVLABS.COM/TERMS-AND-CONDITIONS.

* IT IS THE RESPONSIBILITY OF THE RELINQUISHER TO ENSURE THE ACCURACY OF THE CHAIN OF CUSTODY RECORD. AN INCOMPLETE CHAIN OF CUSTODY MAY RESULT IN ANALYTICAL TAT DELAYS.

White: BV Labs Yellow: Client

Bureau Veritas Canada (2019) Inc.

Attempt to Cool:
Yes _____
No ✓

Maxxam
A Bureau Veritas Group Company

ADDITIONAL COOLER TEMPERATURE RECORD

CHAIN-OF-CUSTODY RECORD NL Coolers

CHAIN OF CUSTODY #	
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COOLER OBSERVATIONS:

MAXXAM JOB#:

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	2 (1)	3 (2)	4 (3)
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	5 (1)	6 (2)	4 (3)
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1 (1)	7 (2)	2 (3)
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1 (1)	1 (2)	2 (3)
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

CUSTODY SEAL	YES	NO	COOLER ID			
PRESENT			TEMP	1	2	3
INTACT						
ICE PRESENT						

RECEIVED BY (SIGN & PRINT)		DATE (YYYY/MM/DD)	TIME (HH:MM)
			2019 AUG 19 8:15

APPENDIX F: LIMITATIONS

LIMITATIONS

1. The work performed in this report was carried out in accordance with the Standard Terms of Conditions made part of our contract. The conclusions presented herein are based solely upon the scope of services and time and budgetary limitations described in our contract.
2. The report was prepared in accordance with generally accepted hydrogeological study and/or engineering practices for the exclusive use of DS Drilling Services Limited. No other warranties, either expressed or implied, are made as to the professional services provided under the terms of our contract and included in this report.
3. Third party information reviewed and used to develop the opinions and conclusions contained in this report is assumed to be complete and correct. This information was used in good faith and Wood does not accept any responsibility for deficiencies, misinterpretation or incompleteness of the information contained in documents prepared by third parties.
4. The services performed and outlined in this report were based, in part, upon visual observations of the site and attendant structures. Our opinion cannot be extended to portions of the site which were unavailable for direct observation, reasonably beyond our control.
5. The objective of this report was to assess hydrogeological properties at the site, within the context of our contract and existing regulations within the applicable jurisdiction. Evaluating compliance of past or future owners with applicable local, provincial and federal government laws and regulations was not included in our contract for services.
6. Our observations relating to the condition of environmental media at the site are described in this report. It should be noted that compounds or materials other than those described could be present in the site environment.
7. The findings and conclusions presented in this report are based exclusively on the field parameters measured and the chemical parameters tested at specific locations. It should be recognized that subsurface conditions between and beyond the sample locations may vary. Wood cannot expressly guarantee that subsurface conditions between and beyond the sample locations do not vary from the results determined at the sample locations. Notwithstanding these limitations, this report is believed to provide a reasonable representation of site conditions at the date of issue.

Appendix 3

Greig NL Main Well Water Quality Test Results

Appendix 3

CERTIFICATE OF ANALYSIS

Customer: Candice Way
Grieg NL Nurseries
205 McGettigan, P.O. Box 457
Marystown, NL
709-538-7220

Sample: Water – 1 Sample(s)
Date Received: 01-Jun-20
Date Reported: 09-Jun-20
Project No.: 11384
Report ID: WQ3884

			Sample Description	**Well Water**		
			Sample ID	**GSF – Main June 01/20, 0845**		
			Lab ID	**W20-0937**		
Analysis	**Units**	**RDL**	**Analysis Date**	**Results**	**Uncertainty Value**	**Water Quality Guidelines for the Protection of Aquatic Life***
INORGANIC ANALYSIS						
Alkalinity (as $CaCO_3$)	mg/L	1.5	05-Jun-20	326.9	± 2.12	-
Ammonia (as N)	mg/L	0.02	03-Jun-20	< 0.02	± 0.23	Variable
Conductivity	µS/cm	0.3	05-Jun-20	228.8	± 5.76	-
Colour (True)	CU	6	02-Jun-20	< 6	± 0.81	Variable
pH	-	-	01-Jun-20	7.50	± 0.81	6.5 to 9.0 (Long Term)
TDS	mg/L	6	02-Jun-20	293	± 0.02	-
DOC (as C)	mg/L	0.6	09-Jun-20	1.6	± 32.89	-
Turbidity	NTU	0.2	02-Jun-20	0.2	± 5.33	Variable
TKN	mg/L	0.6	05-Jun-20	< 0.6		-
ANIONS ANALYSIS						
Fluoride	mg/L	0.007	04-Jun-20	0.305	± 0.04	120 µg/L (Long Term)
Chloride	mg/L	0.1	04-Jun-20	126.2	± 0.05	640 mg/L (Short Term)
Nitrite (as N)	mg/L	0.007	04-Jun-20	< 0.007	± 0.348	60 mg/L (Long Term)
Bromide	mg/L	0.05	04-Jun-20	0.385	± 0.01	-
Nitrate (as N)	mg/L	0.005	04-Jun-20	0.267	± 0.01	550 mg/L (Short Term)
o-Phosphate	mg/L	0.05	04-Jun-20	< 0.05	± 0.368	-
Sulfate	mg/L	0.015	04-Jun-20	6.335	± 0.29	-
Nitrate + Nitrite (as N)	mg/L	-	04-Jun-20	0.267	-	-

CALCULATED PARAMETERS	
Hardness (mg/L as $CaCO_3$)	241.9

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Sample Description	**Well Water**
Sample ID	**GSF – Main June 01/20, 0845**
Lab ID	**W20-0937**

Analysis	Units	RDL	Analysis Date	Results	Uncertainty Values	Water Quality Guidelines for the Protection of Aquatic Life*
METALS ANALYSIS						
Beryllium	µg/L	0.4	02-Jun-20	< 0.4	± 0.014	-
Boron	µg/L	4	02-Jun-20	36.0	± 0.022	29000 µg/L (Short Term)
Sodium	mg/L	0.1	02-Jun-20	46.0	± 1.026	-
Magnesium	mg/L	0.02	02-Jun-20	18.7	± 0.552	-
Aluminum	µg/L	3	02-Jun-20	5.3	± 0.025	100 µg/L (Long Term)
Phosphorus	mg/L	0.02	02-Jun-20	< 0.02	± 0.567	Variable
Potassium	mg/L	0.08	02-Jun-20	0.69	± 0.992	-
Calcium	mg/L	0.4	02-Jun-20	66.1	± 0.780	-
Titanium	µg/L	0.15	02-Jun-20	9.2	± 0.006	-
Vanadium	µg/L	0.2	02-Jun-20	0.82	± 0.012	-
Chromium	µg/L	0.3	02-Jun-20	< 0.3	± 0.015	-
Manganese	µg/L	0.3	02-Jun-20	33.8	± 0.012	Variable
Iron	µg/L	30	02-Jun-20	< 30	± 0.019	300 µg/L (Long Term)
Cobalt	µg/L	0.2	02-Jun-20	< 0.2	± 0.012	-
Nickel	µg/L	0.4	02-Jun-20	< 0.4	± 0.013	150 µg/L (Long Term)
Copper	µg/L	0.5	02-Jun-20	< 0.5	± 0.012	4 µg/L (Long Term)
Zinc	µg/L	10	02-Jun-20	< 10	± 0.013	Variable
Arsenic	µg/L	0.5	02-Jun-20	4.9	± 0.012	5 µg/L (Long Term)
Selenium	µg/L	0.8	02-Jun-20	< 0.8	± 0.013	1 µg/L (Long Term)
Strontium	µg/L	0.5	02-Jun-20	1420	± 0.039	-
Molybdenum	µg/L	2	02-Jun-20	< 2	± 0.012	73 µg/L (Long Term)
Silver	µg/L	0.6	02-Jun-20	< 0.6	± 0.003	0.25 µg/L (Long Term)
Cadmium	µg/L	0.2	02-Jun-20	< 0.2	± 0.016	5.1 µg/L (Short Term)
Tin	µg/L	0.4	02-Jun-20	< 0.4	± 0.083	-
Antimony	µg/L	3	02-Jun-20	< 3	± 0.012	-
Barium	µg/L	6	02-Jun-20	328	± 0.014	-
Mercury	µg/L	0.2	02-Jun-20	< 0.2	± 0.04	0.026 µg/L (Long Term)
Thallium	µg/L	0.2	02-Jun-20	< 0.2	± 0.012	0.8 µg/L (Long Term)
Lead	µg/L	0.3	02-Jun-20	< 0.3	± 0.012	7 µg/L (Long Term)
Bismuth	µg/L	0.1	02-Jun-20	< 0.1	± 0.196	-
Uranium	µg/L	0.1	02-Jun-20	1.1	± 0.006	33 µg/L (Short Term)

Comments: The above analyses were conducted according to protocols indicated. For the list of test methods, please refer to the attached 'Appendix – References for Water Quality Analyses'. The above results, which refer to the sample(s) tested as they were received only, are for your information and will be held in the strictest of confidence by this firm. The report shall not be reproduced except in full without approval of the laboratory, as the laboratory cannot provide assurance that parts of the report are not taken out of context. All analyses have a degree of uncertainty. Each parameter's uncertainty value is calculated based on Avalon Laboratories' method validation study and can be found in the Uncertainty Values column above. Uncertainty values should be taken into consideration when deciding if results fall within your required limits. Avalon Laboratories is not responsible for classifying any result as within acceptable limits. *Canadian Council of Ministers of the Environment, Water Quality Guidelines for the Protection of Aquatic Life, Freshwater (2003).

The arrival temperature was 11.5°C.

Technical Reviewer: Anna Flynn **Senior Reviewer:** Jennifer Mews

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QA/QC REPORT

Analyte	Units	RDL	Method Blank	Reference Material Measured Recovery	Criteria (%)	Lab Fortified Blank Measured Recovery	Criteria (%)	Matrix Spike Measured Recovery	Criteria (%)	Duplicates		RPD	Criteria (%)
										No. 1	No. 2		
METALS ANALYSIS													
Beryllium	µg/L	0.4	< 0.4	93.166 (93.2%)	90-110	93.20	85-115	93.267	70-130	93.29	93.15	0.15	≤ 10
Boron	µg/L	4	< 4	92.303 (92.3%)	90-110	94.18	85-115	92.927	70-130	104.274	105.45	1.12	≤ 10
Sodium	mg/L	0.1	< 0.1	19.211 (96.1%)	90-110	97.29	85-115	94.205	70-130	32.316	32.71	1.20	≤ 10
Magnesium	mg/L	0.02	< 0.02	19.000 (95.0%)	90-110	97.34	85-115	95.4	70-130	22.87	22.88	0.06	≤ 10
Aluminum	µg/L	3	< 3	91.033 (91.0%)	90-110	97.25	85-115	94.404	70-130	97.784	97.35	0.45	≤ 10
Phosphorus	mg/L	0.02	< 0.2	19.293 (96.5%)	90-110	98.95	85-115	103.75	70-130	20.752	20.63	0.58	≤ 10
Potassium	mg/L	0.08	< 0.8	19.587 (97.9%)	90-110	100.30	85-115	101.15	70-130	21.121	21.00	0.56	≤ 10
Calcium	mg/L	0.4	< 0.4	18.932 (94.7%)	90-110	96.83	85-115	85.75	70-130	73.2	72.37	1.14	≤ 10
Titanium	µg/L	0.15	< 0.15	90.522 (90.5%)	90-110	92.96	85-115	85.685	70-130	101.068	103.36	2.25	≤ 10
Vanadium	µg/L	0.2	< 0.2	92.292 (92.3%)	90-110	92.56	85-115	90.401	70-130	90.425	89.46	1.07	≤ 10
Chromium	µg/L	0.3	< 0.3	92.451 (92.5%)	90-110	92.40	85-115	89.638	70-130	89.882	88.93	1.07	≤ 10
Manganese	µg/L	0.3	< 0.3	92.609 (92.6%)	90-110	93.66	85-115	90.564	70-130	135.999	133.99	1.49	≤ 10
Iron	µg/L	30	< 30	93.979 (94.0%)	90-110	95.41	85-115	89.015	70-130	148.193	146.28	1.30	≤ 10
Cobalt	µg/L	0.2	< 0.2	97.006 (97.0%)	90-110	96.79	85-115	89.878	70-130	90.094	89.09	1.12	≤ 10
Nickel	µg/L	0.4	< 0.4	93.852 (93.9%)	90-110	93.82	85-115	89.748	70-130	90.087	89.77	0.36	≤ 10
Copper	µg/L	0.5	< 0.5	93.347 (93.3%)	90-110	93.89	85-115	88.799	70-130	89.02	88.71	0.35	≤ 10
Zinc	µg/L	10	< 10	93.284 (93.3%)	90-110	94.92	85-115	95.479	70-130	97.623	97.16	0.48	≤ 10
Arsenic	µg/L	0.5	< 0.5	94.184 (94.2%)	90-110	95.55	85-115	98.233	70-130	98.64	97.78	0.87	≤ 10
Selenium	µg/L	0.8	< 0.8	473.465 (94.7%)	90-110	96.92	85-115	104.3108	70-130	521.642	523.26	0.31	≤ 10
Strontium	µg/L	0.5	< 0.5	95.702 (95.7%)	90-110	97.27	85-115	93.899	70-130	219.051	218.39	0.30	≤ 10
Molybdenum	µg/L	2	< 2	92.313 (92.3%)	90-110	94.07	85-115	94.833	70-130	98.849	99.05	0.21	≤ 10
Silver	µg/L	0.6	< 0.6	94.812 (94.8%)	90-110	96.02	85-115	84.656	70-130	84.683	84.93	0.29	≤ 10
Cadmium	µg/L	0.2	< 0.2	94.619 (94.6%)	90-110	95.37	85-115	98.465	70-130	98.468	97.59	0.90	≤ 10
Tin	µg/L	0.4	< 0.4	93.876 (93.9%)	90-110	94.56	85-115	95.445	70-130	95.481	95.62	0.14	≤ 10
Antimony	µg/L	3	< 3	93.172 (93.2%)	90-110	95.51	85-115	96.887	70-130	97.017	96.82	0.20	≤ 10
Barium	µg/L	6	< 6	96.602 (96.6%)	90-110	98.75	85-115	98.487	70-130	104.26	104.85	0.57	≤ 10
Mercury	µg/L	0.2	< 0.2	4.699 (94.0%)	90-110	89.56	85-115	106.62	70-130	5.431	5.38	0.91	≤ 10
Thallium	µg/L	0.2	< 0.2	94.365 (94.4%)	90-110	94.96	85-115	91.254	70-130	91.261	92.16	0.98	≤ 10
Lead	µg/L	0.3	< 0.3	95.151 (95.2%)	90-110	95.48	85-115	92.168	70-130	92.235	92.34	0.11	≤ 10
Bismuth	µg/L	0.1	< 0.1	94.337 (94.3%)	90-110	95.48	85-115	90.696	70-130	90.7	91.48	0.85	≤ 10
Uranium	µg/L	0.1	< 0.1	99.372 (99.4%)	90-110	98.84	85-115	96.051	70-130	96.134	96.96	0.86	≤ 10

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QA/QC REPORT

Analyte	Units	RDL	Method Blank	Reference Material Measured Recovery	Criteria (%)	Lab Fortified Blank Measured Recovery	Criteria (%)	Matrix Spike Measured Recovery	Criteria (%)	Duplicates		RPD	Criteria (%)
ANIONS ANALYSIS													
Fluoride	mg/L	0.007	-	90.4	90-110	-	-	-	-	-	-	-	-
Chloride	mg/L	0.1	-	96.2	90-110	-	-	-	-	-	-	-	-
Nitrite (as N)	mg/L	0.023	-	96.2	90-110	-	-	-	-	-	-	-	-
Bromide	mg/L	0.05	-	97.9	90-110	-	-	-	-	-	-	-	-
Nitrate (as N)	mg/L	0.021	-	94.2	90-110	-	-	-	-	-	-	-	-
o-Phosphate	mg/L	0.05	-	100.4	90-110	-	-	-	-	-	-	-	-
Sulfate	mg/L	0.015	-	96.5	90-110	-	-	-	-	-	-	-	-
INORGANIC ANALYSIS													
Alkalinity	mg/L	1.5	< 5	98.0	90-110	101.81	90-110	-	-	59.97	59.00	1.6	≤ 20
Ammonia	mg/L	0.02	< 0.01	102	90-110	112	80-120	117	70-130	< 0.02	< 0.02	NC	-
Conductivity	µS/cm	0.3	-	-	-	100.2	90-110	-	-	196.2	204.2	4.0	≤ 5
Colour	CU	6	-	-	-	97.6	90-110	-	-	< 6	< 6	NC	≤ 20
pH	-	-	-	-	-	-	-	-	-	7.50	7.52	0.3	≤ 1
TDS	mg/L	6	-	-	-	104.8	80-120	-	-	293	317	7.2	≤ 10
DOC	mg/L	1.0	< 0.5	105.3	90-110	-	-	-	-	1.632	1.506	8.03	≤ 10
TKN	mg/L	0.6	< 0.3	95.5	90-110	96.8	90-110	94.4	70-130	< 0.6	< 0.6	NC	-
Turbidity	NTU	0.2	-	106	90-110	102	90-110	-	-	0.2	< 0.2	NC	≤ 20

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APPENDIX
References for Water Quality Analyses

Analyte	Laboratory Method ID	Reference Method ID
Alkalinity	SOP 15050	Modified SM 2320 B
Ammonia (as N)	SOP 15061	Modified EPA 350.1
Anions	SOP 15038	Modified SM 4110 B
Biochemical Oxygen Demand (BOD)	SOP 15053	Modified SM 5210 B
Carbonaceous Biochemical Oxygen Demand (CBOD)	SOP 15053	Modified SM 5210 B
Chlorine (Free)	SOP 15062	Modified SM 4500-Cl G
Chlorine (Total)	SOP 15062	Modified SM 4500-Cl G
Chemical Oxygen Demand (COD)	SOP 15063	Modified SM 5220 D
Colour (Apparent)	SOP 15058	Modified SM 2120 C
Colour (True)	SOP 15058	Modified SM 2120 C
Conductivity	SOP 15057	SM 2510B
Dissolved Oxygen	SOP 16069	Modified SM4500-O G
Dissolved Organic Carbon (DOC)	SOP 15064	Modified SM 5310 B
Haloacetic Acids (HAA)	SOP 19058	Modified EPA 552.3
Hexavalent Chromium	SOP 16067	Modified SM 3500-Cr B
Metals	SOP 15036	Modified EPA 200.8
Polycyclic Aromatic Hydrocarbon (PAH)	SOP 19053	Modified EPA 3510C/Modified EPA 8270E
pH	SOP 15060	Modified SM 4500-H+ B
Reactive Silica	SOP 16068	Modified SM4500-Si02 D
Sulfides	SOP 16066	Modified SM 4500-S2- D
Total Dissolved Solids (TDS)	SOP 15056	Modified SM 2540 C
Trihalomethanes (THM)	SOP 19057	Modified EPA 551.1
Total Inorganic Carbon (TIC)	SOP 15064	Modified SM 5310 B
Total Kjeldahl Nitrogen (TKN)	SOP 16071	Modified EPA 351.2
Total Organic Carbon (TOC)	SOP 15064	Modified SM 5310 B
Total Cyanide	SOP 16078	Modified EPA 335.2
Total Oil & Grease (TOG)	SOP 16077	Modified SM 5520B
Total Phenolics	SOP 16070	Modified EPA 420.1
Total Suspended Solids (TSS)	SOP 15055	Modified SM 2540 D
Turbidity	SOP 15054	Modified EPA 180.1
WAD Cyanide	SOP 16078	Modified EPA 335.4
Volatile Organic Carbon (VOC)/BTEX	SOP 19051	EPA 5030C/EPA 8260D

Legend for Acronyms & Symbols:

<	Less than the lowest detection limit for the test
>	Greater than the highest detection limit for the test
%	Percent
g	Gram
mg	Milligram
ml	Millilitre
µg	Microgram
meq	Milliequivalents
CU	Colour Unit
NTU	Nephelometric Turbidity Unit
AO/OG	Canadian Drinking Water Guidelines Aesthetic Objective/Operational Guideline
RDL	Reporting Detection Limit
NC	Not Calculable

Appendix 4

Wellhead Protection Plan

APPENDIX 4: WELLHEAD PROTECTION PLAN

As part of Condition 'i' of the release of the Placentia Bay Atlantic Salmon Aquaculture Project from further environmental assessment by the Minister of the Department of Municipal Affairs and Environment (DMAE), Grieg NL was required to develop a wellhead protection plan. The wellhead protection plan presented here includes a description of the modelling which will be undertaken to define the wellhead protection area around Grieg NL's main and back-up wells located in Marystown, NL. Based on the model findings, zones will be identified to allow potential mitigation of contaminant risks to the bedrock aquifer such that the groundwater resources will be protected for long-term sustainable use in the RAS Hatchery. Grieg NL will work with the Water Resources Management Division (WRMD) of the DMAE to identify model inputs and parameters and to review modelling results for development of protection zones.

Modelling Study

A conceptual model and numerical model will be developed[1] to define the wellhead protection area. The modelling study will entail pre-modelling and modelling tasks.

Pre-modelling Tasks

Available data (i.e., topographic, groundwater, well records and regional hydraulic conductivity values, and stream flow data) will be compiled and maps will be generated to delineate the watershed encompassing the well sites. A site visit will be conducted to view the wells, the RAS Hatchery site, potential groundwater recharge area, discharge area, geological and topographic boundaries[2]. Using data collected and the site visit, an inventory of land uses in the vicinity of the Grieg NL well sites will be conducted to identify historic or active uses of the area that may impact the groundwater aquifer (e.g., storage of chemicals, landfills), which will be used to supply the RAS Hatchery. Based on available data, the site visit findings, and feedback from WRMD, the parameters of the model and data inputs will be determined.

Modelling Tasks

Groundwater modelling, using the numerical model, MODFLOW, will be the main tool used to delineate the wellhead protection area. Modelling will include consideration of the locations of a nearby quarry and former dump site, which are located ~450 m and 850 m from the wells, respectively. Effective groundwater modelling requires a series of steps that are detailed below.

Develop a Conceptual Groundwater Model.—A comprehensive conceptual groundwater model will be developed using available data, including local geology and available hydrogeological information. The conceptual flow model will be created from available data and based on previous experience. The conceptual groundwater model will be used to develop the numerical groundwater flow model. As much as possible, cross-sections and illustrations of the groundwater flow characteristics will be created to clearly depict how groundwater flow occurs within the aquifer that will be used by Grieg NL. The recharge from precipitation will be estimated.

[1] Modelling will be conducted by Wood Environment & Infrastructure Solutions and led by Senior Hydrogeologist, Dr. T. Praamsma.
[2] The site visit was conducted on 25 February 2020.

Numerical Groundwater Model Development.—Using the data gathered for the conceptual geological model, a comprehensive hydrogeological flow model will be set up. Identified potential recharge areas, boundary conditions, such as surface water features, aquifer properties, and topographical information will be used to set up the model. The extent of the model will be selected to encompass inferred groundwater divides and major recharge/discharge zones, including municipal boundaries. Available site-specific pumping test data will be assigned to the model at the initial stage of its development. Initial estimates of aquifer recharge rates will be based on the available surficial geology maps, corrected for the local site-specific conditions, observed gradients and estimated baseflow contribution to the local creeks.

Model Calibration.—Once the appropriate model domain and numerical groundwater flow model are set up, model calibration will be completed using available groundwater level and stream flow data. Calibration of the model (i.e., matching the model simulated hydraulic heads and flows to the main well and observation well) will be achieved by adjusting the physical and hydraulic parameters that are associated with highest degree of certainty in order to obtain a reasonable match between computed and observed (measured) data.

Sensitivity Analysis.—In addition to the calibrated input parameters, the groundwater flow model will also be run with other sets of input data as part of the predictive sensitivity analysis. The main purpose of this analysis will be to evaluate the influence of uncertainty in the input parameters on the model predictions. The following input parameters are expected to be varied within the framework of sensitivity/uncertainty analysis:

- Hydraulic conductivity of simulated bedrock hydrostratigraphic units; and
- Recharge rates.

Sensitivity analyses will also allow the identification of major data gaps, and therefore provide guidance for future model refinement.

Predictive Simulations.—After successful model calibration and an understanding of the model sensitivity, predictive simulations will be conducted. At this stage, the model will be utilized to create predictive scenarios of different levels of demand and recharge. Predictive model runs will be used to:

- Assess water availability under different pumping scenarios;
- Estimate combined capture zones for the groundwater extraction well;
- Examine the limits of the capture zone and potentially impacting activities within the capture zone (e.g., former dump site and quarry); and
- Examine and assess the overlap of delineated capture zones with the local surface water features, including wetlands in order to determine if any of the currently existing or additional groundwater pumping wells could fall under the direct influence of surface water, and could be flagged as groundwater under the direct influence (GUDI) of surface water well.

Particle Tracking.—Backwards particle tracking methods will be used to delineate the potential capture zones for different times of travel. These will be used to complete the wellhead protection area delineation for two-year (Zone A), five-year (Zone B), and 25-year (Zone C) time of travel zones.

Wellhead Protection Area Delineation.—The results of the particle tracking exercise will be imported to a GIS to delineate the final wellhead protection area. Graphical representation will be produced for Protection Zones A, B, C. In addition, critical and conflicting land uses (i.e., those that could affect the quality of water in the Grieg NL wells), if any, will be shown on the maps.

Protection Zones

Based on the findings of the modelling study, three Protection Zones with two-, five-, and 25-year travel times will be delineated. Appropriate and feasible steps will be developed and implemented to mitigate potential contaminant risks within the wellhead protection area. Grieg NL will work with WRMD to develop these steps.

Reporting

A report presenting the methodology and findings of the modelling study including the identification of protection zones will be prepared and provided to the WRMD.