FINAL

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

Submitted to:

DS Drilling Services Limited

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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,
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11.0 REFERENCES

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Taylor, S.W. 1978. Geology of the Marystown Map Sheet (E/2), Burin Peninsula, Southeastern Newfoundland, Memorial University of Newfoundland, Master's Thesis.

APPENDIX A: FIGURES

Source:

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

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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
CLIENT: DS DRILLING SERVICES LTD	CHKD BY: T. PRAAMSMA	PROJECT TITLE: SITE LOCATION MAP	PROJ No. TF1563106
	SCALE: AS SHOWN		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

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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)

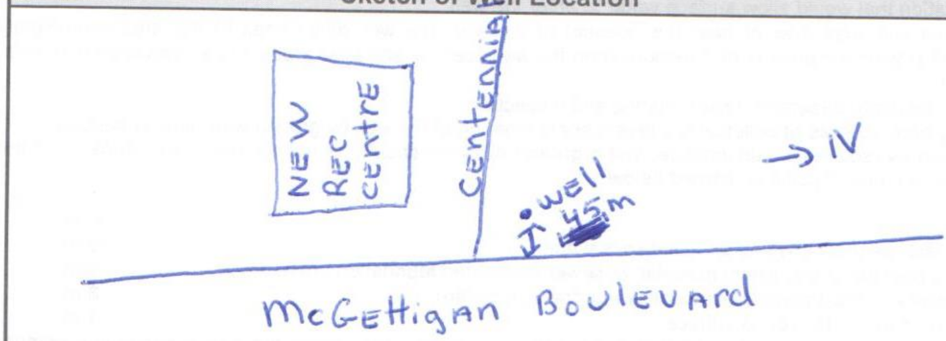
First Name	Last Name	Street Address		
Grieg Seafarms (NL) Ltd		5 Popular Place, P.O. Box 98		
Town/City	LGID For Office Use Only	LGID Name For Office Use Only	Postal Code	Telephone
St. Alban's			A0H 2E0	538-7413

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
48m-91m	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	~~[illegible]~~ 200 m	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	Pump Intake at: Duration:	Recommended Pump Depth:
☐ Other ____	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: [signature] (Sign) — Dave Sullivan (Print)
Driller Assistant: [signature] (Sign) — Matthew White (Print)

This is a Legal Document — *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

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
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	0.0000	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	0.0000	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	0.0000	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	0.0000	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	0.0000	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	0.0000	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	0.0000	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	0.0000	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	0.0000	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	0.0000	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	0.0000	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	0.0000	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	0.0000	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	0.0001	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	0.0005	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	0.0005	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	0.0005	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	0.0005	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 Assurance / 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

Sample Date	Alkalinity	Color	Conductivit	Hardness	pH	TDS	TSS	Turbidity	Boron	Bromide	Calcium	Chloride	Fluoride	Potassium	Sodium	Sulphate
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

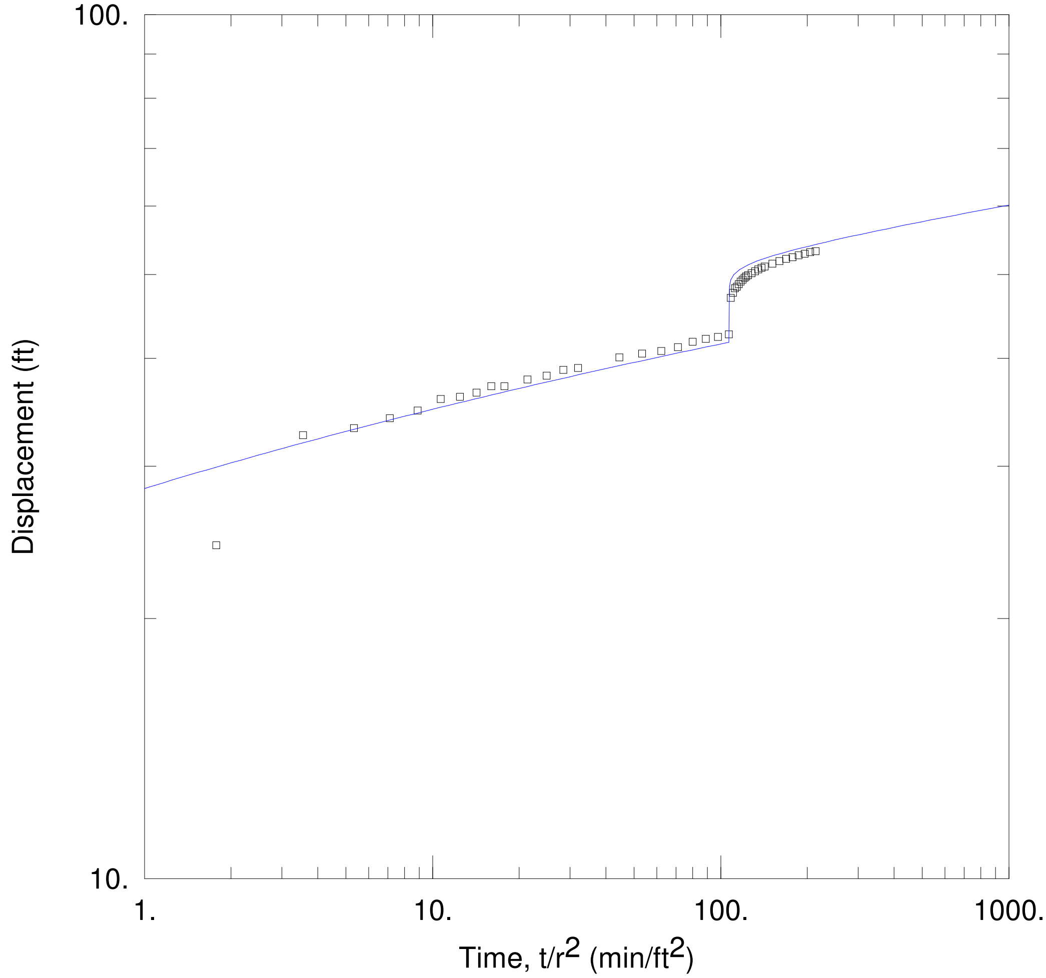
Pump Set@ 217' + 17.2"

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

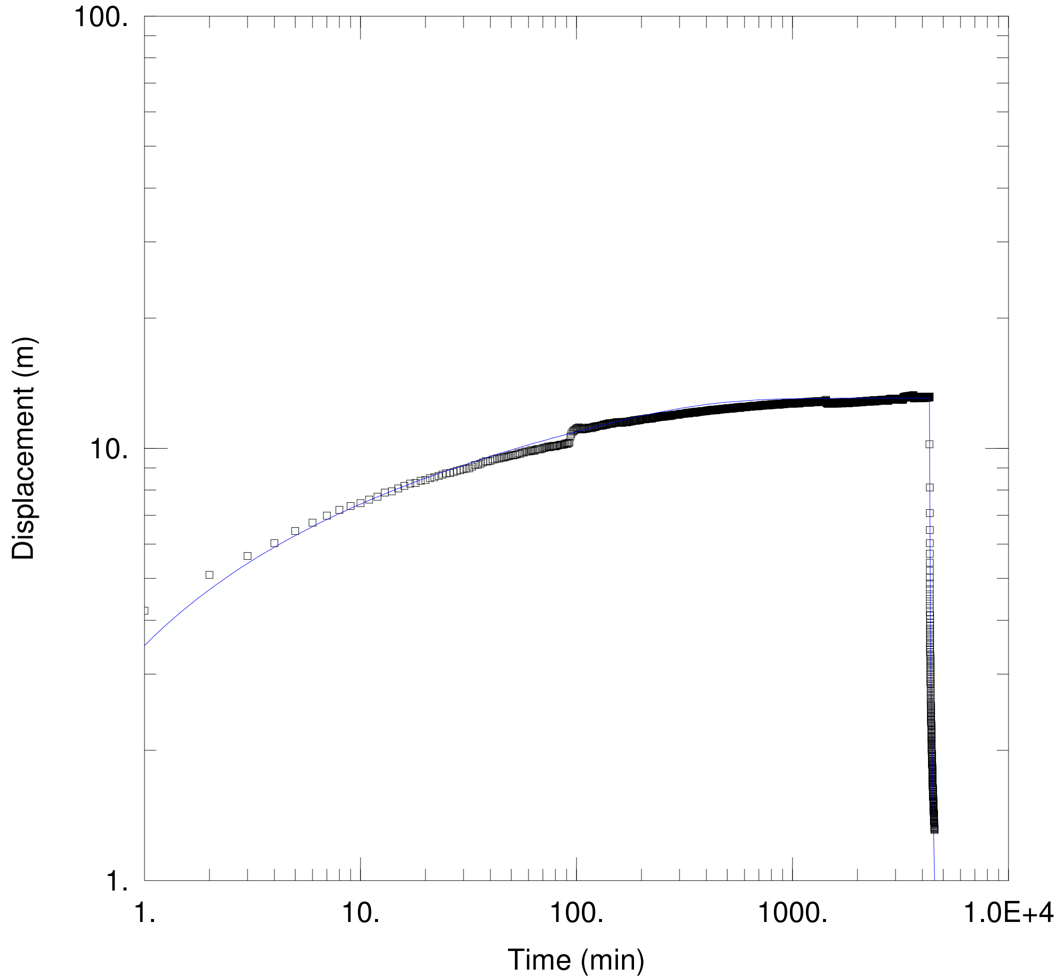
Solution Method: Theis (Step Test)

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
Anisotropy Ratio (Kz/Kr): 0.001
Aquitard Thickness (b'): 1. m
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
S = 0.1612
r/B' = 0.1
ß' = 0.1
r/B" = 0.
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 millilitre
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] = 5 µg/L if pH < 6.5; = 100 µg/L if pH ≥ 6.5

[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 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)
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)

Success Through Science®

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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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
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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.

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

Maxxam Job #: B5C8754
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)

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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
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CERTIFICATE OF ANALYSIS

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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
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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

Maxxam Analytics International Corporation o/a Maxxam Analytics 49-55 Elizabeth Ave, Suite 101A, St.John's, NL, Canada A1A 1W9 Tel: 709-754-0203 Toll Free: 888-492-7227 Fax: 709-754-8612 www.maxxamanalytics.com

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.

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

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	

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

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
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).

VALIDATION SIGNATURE PAGE

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

Mike Mac Gillivray

Mike MacGillivray, Scientific Specialist (Inorganics)

RUN DATE: 06/07/15
RUN TIME: 1005
RUN USER: LABBKGJOB

LABORATORY NPR - EH **LIVE**
PUBLIC HEALTH LABORATORY REPORT - WATER SAMPLES

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.

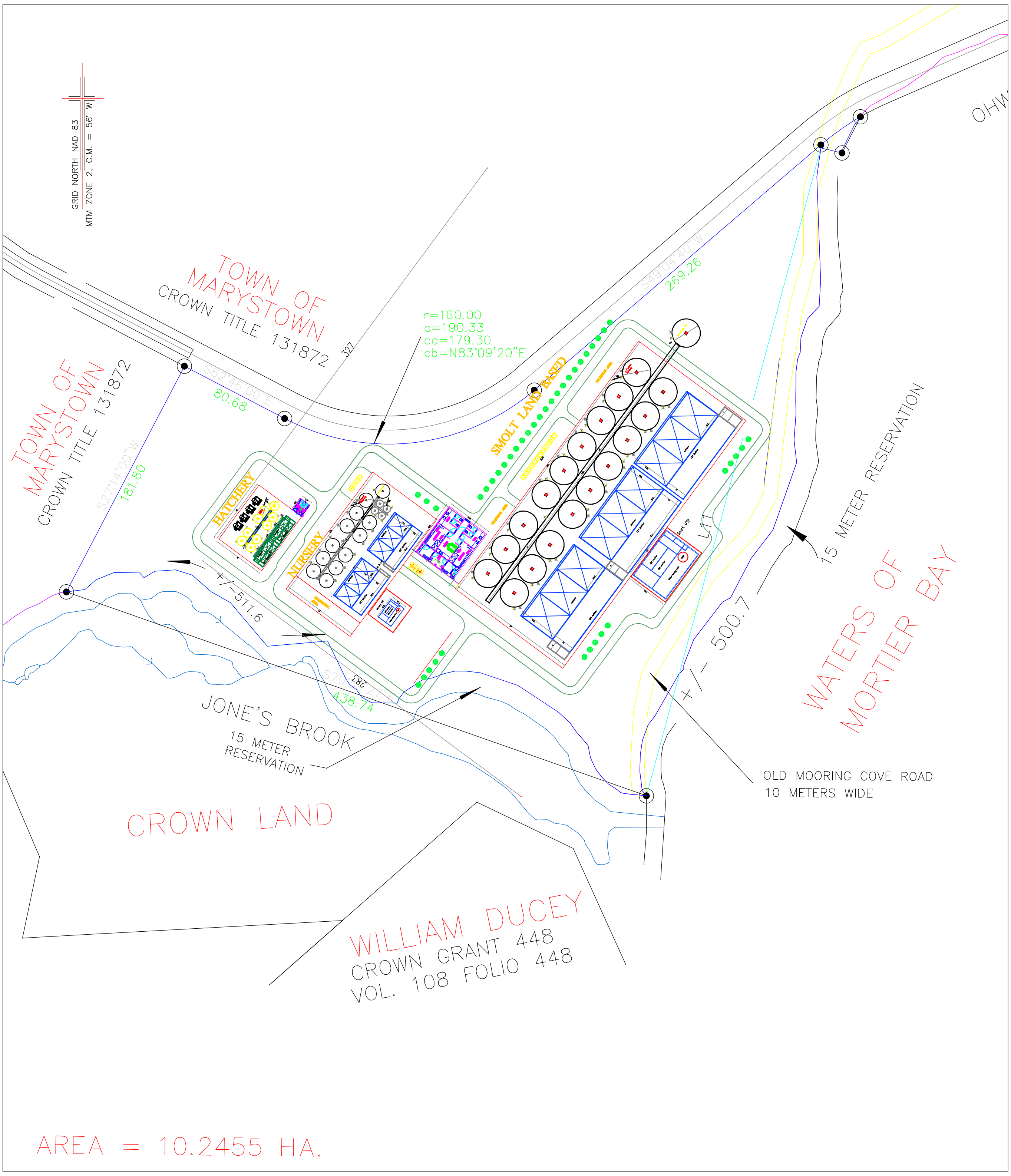
5. The objective of this report was to assess hydrogeological properties at the site, within the context of our contract and existing regulations within the applicable jurisdiction. Evaluating compliance of past or future owners with applicable local, provincial and federal government laws and regulations 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.



NOTES:

ALL DISTANCES ARE METRIC

—x— FENCE

⊙ CAPPED IRON BAR

Fd. EXISTING IRON BAR

○ IRON BAR

COORDINATE TABLE		
NAD 83 CONTROL SURVEY DATABASE		
STATION	NORTHING	EASTING
95G5028	5 214 513.192	367 288.402
95G5029	5 216 968.930	365 460.969
SCALE FACTOR 0.999944		

EDWARDS AND ASSOCIATES LTD.
LAND SURVEYING, ENGINEERING, CONSULTING, INFORMATION MANAGEMENT
BOX 158, MARYSTOWN, NF, AOE 2MO, TEL 709-279-1990, FAX 709-279-2185

PROPERTY SURVEY

TOWN OF MARYSTOWN

BURIN, NEWFOUNDLAND AND LABRADOR

SCALE: 1:4000	LANDGAZETTE # xxxxxx	SURVEY BY: I.E./R.B.
DATE: AUGUST 12, 2015	JOB NO. 6297	

Stage 1 Historic Resources Impact Assessment
of the
Mortier Bay -North Atlantic Marine Service Center,
Powers Cove, NL.

Report prepared for: Town of Marystown, NL
Report prepared by: Aardvark Archaeology Ltd.
Date: October14, 2005

Signed: Stephen Mills

HRIA Archaeological Permit Number 05.53

1. Credit Sheet

The HRIA of the Mortier Bay -North Atlantic Marine Service Center and right-of-way between Route 210 and Powers Cove, NL. was conducted and reported upon by Mr. Stephen Mills and Dr. James A. Tuck. Ms. Jackie McDonald was the project conservator. The authors wish to acknowledge the assistance provided by Barry Gaulton for scanning some of the images; Mr. Ken Reynolds of the Provincial Archaeology Office for provided copies of the relevant archaeological reports and maps; and Mr. Dennis Kelly, Town Manager for Marystown for providing assistance while in the field. Thanks also to Mr. James Kelly and Mrs. Ernistine Kelly for sharing their recollections of Powers Cove.

2. Management Summary

The HRIA of the area proposed for the Mortier Bay -North Atlantic Marine Service Center and right-of-way between Route 210 and Powers Cove was conducted in September 2005. Historical research, informant interviews and archaeological survey failed to uncover significant cultural resources within the impact area. The right-of-way traverses a route that does not lend itself to settlement, or even sporadic habitation. Other than a 150m long expanse of cobble beach, the area within Powers Cove is open to the sea and doesn't appear to provide protection from the north, south and easterly winds. The area to the rear of the barrier beach at the front of the cove is primarily low-lying, marshy and, no doubt, susceptible to inundation from heavy seas. The ground surrounding the north and south approaches to the cove consists of near vertical cliff faces ranging from three to fifteen or more metres in height. The lack of protection from the elements, together with the wet, marshy environment of the cove itself were probably primary factors in the lack of human settlement or even resource exploitation of this part of Mortier Bay.

The HRIA did not uncover any reasons to delay construction of the Mortier Bay - North Atlantic Marine Service Center in Powers Cove and the construction of an access route to the cove from Route 210.

Table of Contents

3. List of Figures

4. Introductory Statement

Powers Cove is located on the west side of Mortier Bay, near the southwest tip of Placentia Bay. It lies within the town boundaries of Marystown (Figures 1 and 2). The Town of Marystown, proponent for the Mortier Bay -North Atlantic Marine Service Center in Powers Cove, contracted Aardvark Archaeology Ltd. to conduct the Stage 1 Historic Resources Impact Assessment of the project. The development would see construction of a 305m long wharf facility at Powers Cove, capable of servicing oil rigs and offshore supply ships, and a 1.2 km long assess road from Route 210 and Powers Cove (Figures 3 to 4). The width of the right-of-way for the access road is approximately 50m wide. The impact area at the north end of the cove, adjacent to the proposed wharf is approximately 45m square.

The objectives and general scope of the HRIA were to research the cultural history of Powers Cove through archival and archaeological survey to determine whether the North Atlantic Marine Service Center would negatively impact cultural resources in the area.

Dr. James Tuck and Mr. Stephen Mills conducted the HRIA. Dr. Tuck holds a PhD in archaeology, has over 40 years experience in the profession and has directed major archaeological projects within Newfoundland and Labrador, in mainland Canada and the United States. Dr. Tuck was the Head of the Archaeology Unit at Memorial University from 1968 to 2005 and is currently Professor Emeritus at Memorial. Mr. Mills holds a M.A. in archaeology and has 28 years experience in the archaeological profession. He has directed archaeological projects in Newfoundland and Labrador, Quebec and Ontario.

The preliminary background research was carried out between September 22nd and 23rd, field reconnaissance was conducted on September 24th and the historical review, informant interviews and report writing carried out between September 26th and 27th, 2005.

The organization follows the guidelines set out by the Provincial Archaeology Office.

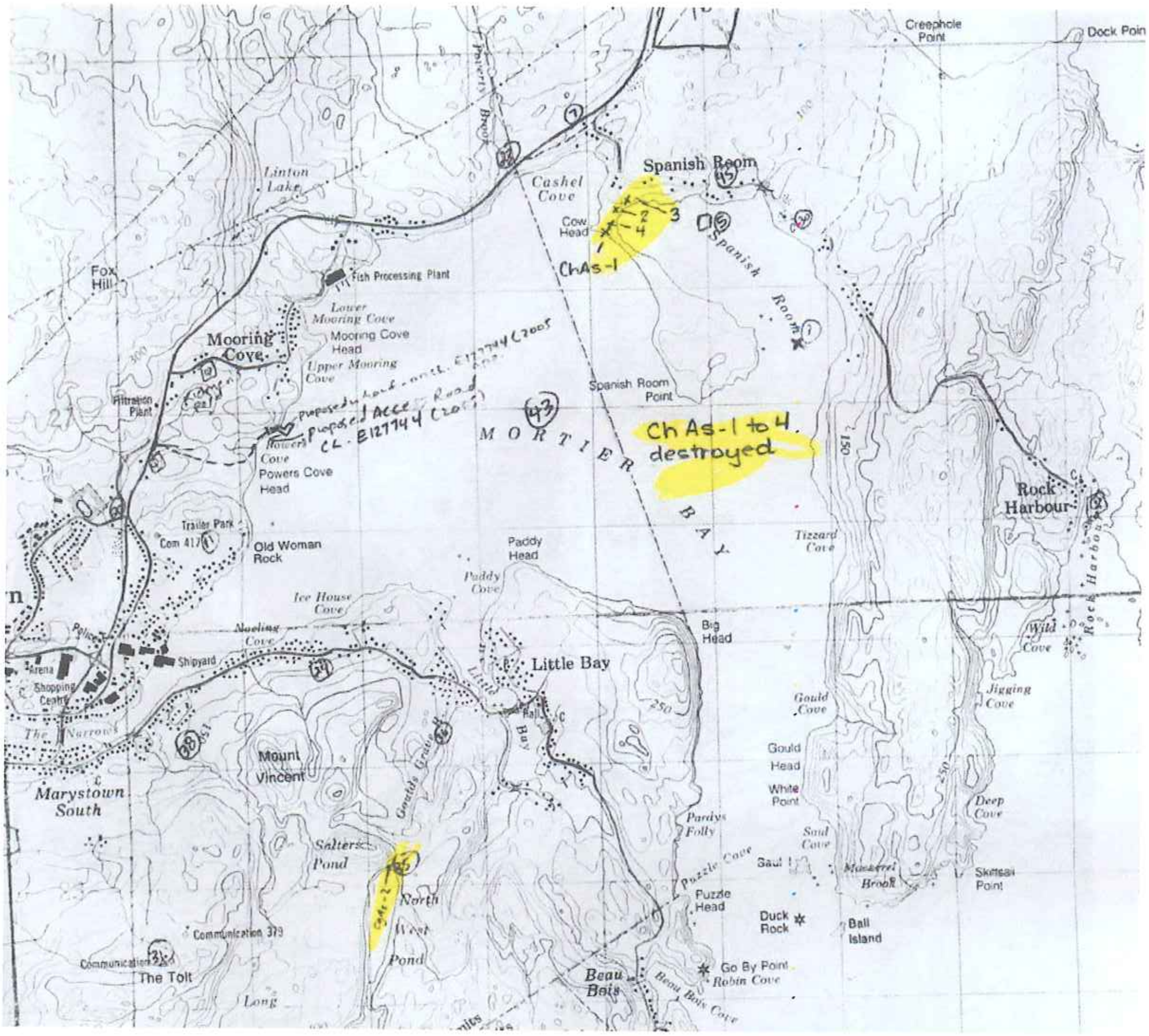


Figure 1 *Map of Mortier Bay showing Powers Cover (at left) with broken line showing the right-of-way between Route 210 and Powers Cove. Map courtesy of Ken Reynolds, Provincial Archaeology Office.*

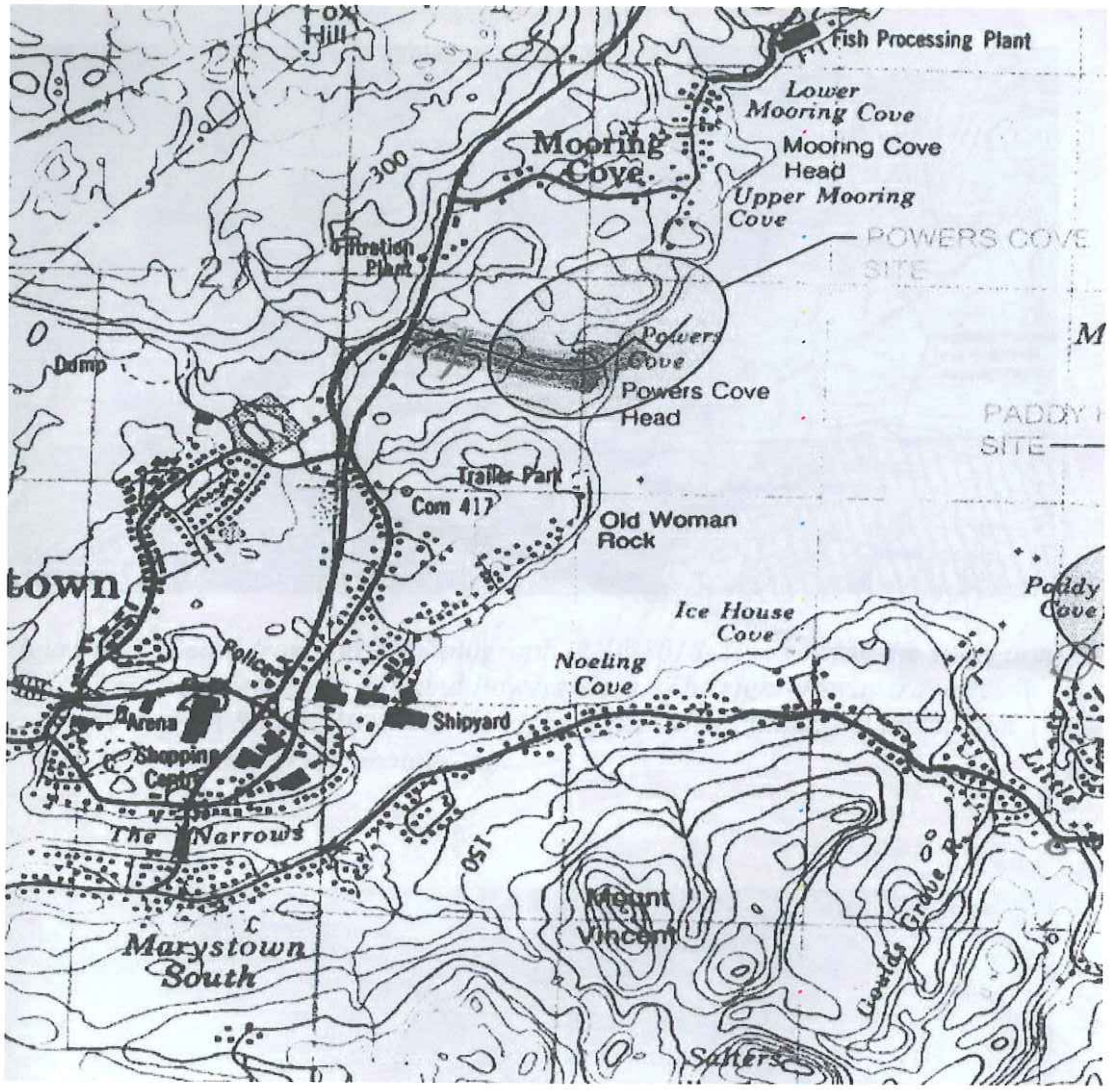


Figure 2 *Detail of the west side of Mortier Bay showing the Powers Cove Site (inside circle) with the study area shaded. Map courtesy of the Town of Marystown.*

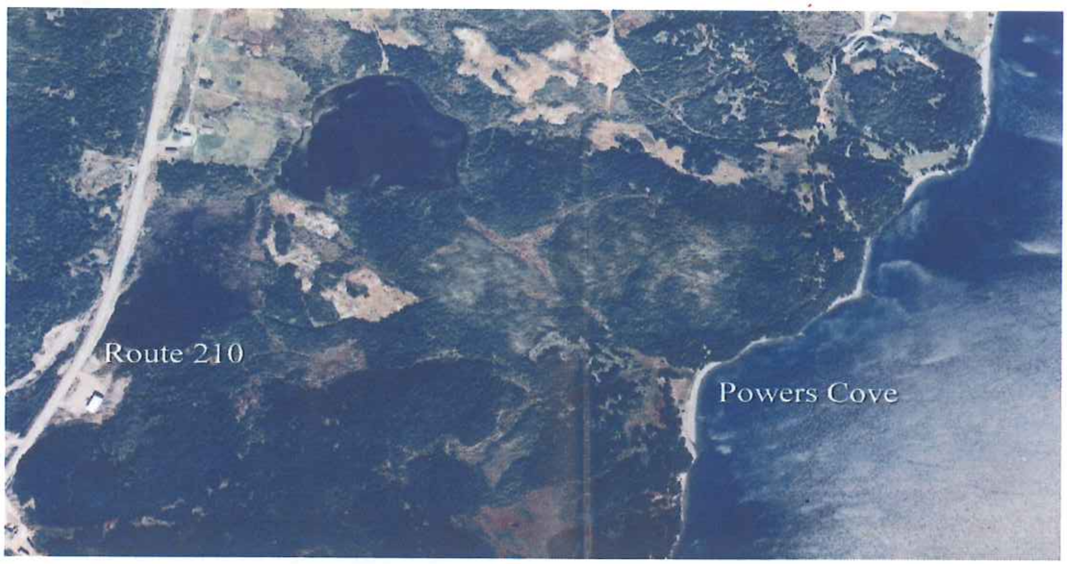


Figure 3 *Detail from Aerial photograph (#NF 8018-21) showing the study area between Route 210 and Powers Cove. The right-of-way traverses in from Route 210 just to the right of the white building at the bottom left side of the photograph.*

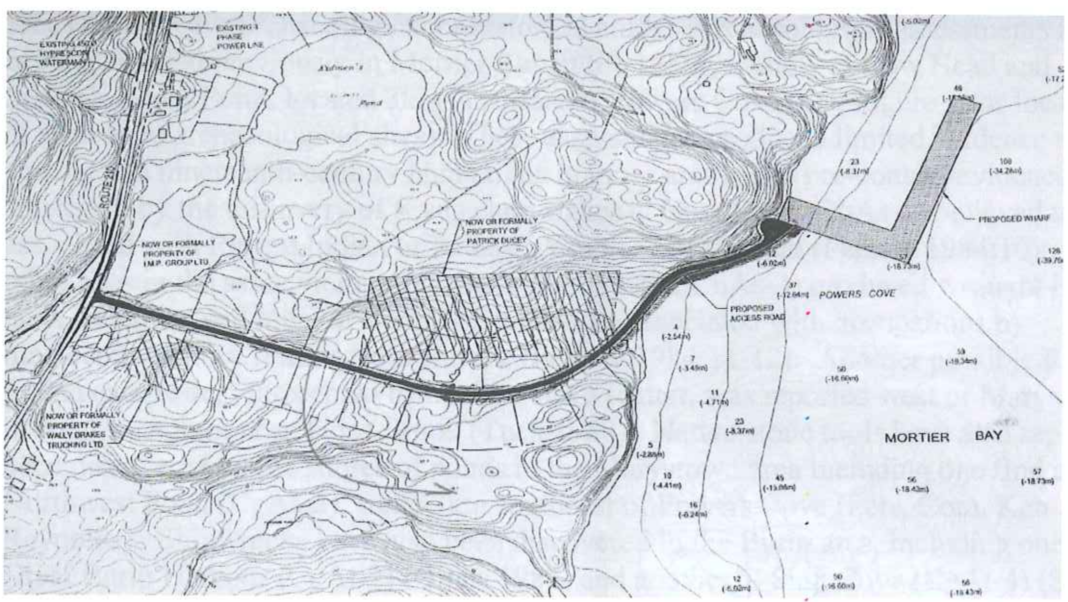


Figure 4 *Topographic map of Powers Cove showing the study area in heavy black line. Map courtesy of the Town of Marystown.*

5. Proposed Development Project

The proposed Mortier Bay -North Atlantic Marine Service Center in Powers Cove is designed to service ships and other offshore oil-related vessels through the construction of a wharf facility accessed by a new road between Route 210 and Powers Cove.

6. Study Area

The study area included the 1.2 km by 50m right-of-way between Route 210 and Powers Cove and the area within Powers Cove from the high water mark back approximately 45m back from the beach (Figures 3 and 4). Figures 5-9 show various views of the right-of-way and Powers Cove taken during the assessment.

7. Methodology

Prior to conducting the field survey, a review of maps, aerial photographs, historical references and archaeological reports was undertaken. Following the literature and cartographic review, the entire study area was traversed on foot. Tree falls were inspected for signs of cultural activity and test pits were judgementally dug along the right-of-way and within Powers Cove.

8. Results

8.1 Archival Search

The literature and cartographic review indicated that Powers Cove has never been the focus of intensive archaeological or historical study. Archaeological assessments have been conducted previously in Mortier Bay in the 1980s, namely at Cow Head and Spanish Room Point, located 3km northeast of Powers Cove (See Figure 1 for locations of registered archaeological sites). These assessments produced limited evidence of pre-contact and nineteenth-century habitations in those areas. The pre-contact evidence was suggested by the discovery of seven chert flakes at Cow Head (ChAs-1) believed to be associated with Recent Indian or Paleo-Eskimo use of the area (Penney 1984:10). Three other sites in the same vicinity (ChAs-2, ChAs-3 and ChAs-4) produced wrought iron nails, ceramics and other artifacts believed to be associated with occupations by nineteenth-century settlers from Europe (Penney 1984:11-12). Another possible Recent Indian camp site, represented by a minor flake scatter, was reported west of Marystown in southwest Arm near Tides Brook (Tuck 1988). Native stone tools have also reportedly been discovered on the shores of ponds in the Marystown area including one find at Northwest Pond (CgAs-2), some 3km southeast of Powers Cove (Pers. Com. Ken Reynolds). Shipwrecks have also been discovered in the Burin area, including one at Great Burin Harbour (CgAt-2) (Ginns 1983) and another at Ship Cove (CgAt-4) (Skanes 1999).

In 1985, Gerald Penney prepared an evaluation of historical resources for this part of Placentia Bay. Penney reported that, although fishers visited the area from southern Europe since the sixteenth century, it was not until the nineteenth century that Irish families settled in Mortier Bay (Penney 1985). Using various census documents and other sources, from 1836 onwards, Penney was able to trace a gradual settlement of the area to the late-twentieth century. Importantly, for this study, Penney did not uncover any documents relating to settlement in Powers Cove.

8.2 Informant Interviews

The current HRIA included interviews with two residents of nearby Mooring Cove: Mr. James Kelly (age 83) and his wife, Mrs. Ernistine Kelly (age 73). Mrs. Kelly was familiar with the study area, but referred to her husband as the one who knew more about the cove than most people. Mr. James Kelly has known Powers Cove since he was a child growing up in Mooring Cove in the 1920s. He walked through Powers Cove to attend school in Marystown for years beginning in 1929. When asked whether anyone lived there, Mr. Kelly recalled that there were no houses in the cove, but some families, including the Flahertys, kept cattle in meadows located some distance behind the cove, towards Route 210. Regarding any activities in the area, the Kellys both recalled that people only went to the area to pick berries and cut wood. Mr. Kelly added that wood-cutting ceased in the area "about 20 years ago". When asked why the cove was not used in his lifetime, he responded that it was never suitable for either fishing or habitation owing to its deep water and the lack of protection from winds. He also noted that when storms hit the area, the sea would wash over the low barrier beach where the "road" passed through the cove. Today, this "road" is a footpath not more than a few metres wide.

8.3 Archaeological Survey

The survey and test pitting within the study area failed to uncover evidence of any cultural activity in the study area older than recent times. Two fire pits, containing melted beer cans and other modern refuse were noted in Powers Cove. Five upright posts were located within a few metres of one of these fire pits. It appears that these posts were associated with a modern structure, perhaps some sort of tilt or other impermanent building. Test pits around these posts did not produce artifacts. The only artifact noted in over 40 test pits dug in Powers Cove was a 410-caliber shotgun shell from the sod layer. It was not retrieved.

Figure 5 *Typical section through the right-of-way, looking west. The water in the foreground is just behind the barrier beach in Powers Cove.*

Figure 6 *The beach at Powers Cove looking north.*

Figure 7 The beach at Powers Cove looking south.

Figure 8 Test pitting on a terrace at the north end of Powers Cove

Figure 9 Test pitting along the right-of-way, Powers Cove in the background.

9. Evaluation and Discussion

Previous archaeological assessments and minor discoveries in the Mortier Bay area indicated minor evidence of pre-contact occupation of the bay; however, rising sea levels in this part of the province may have inundated sites from ancient occupations along the shores. Historical documentation fails to mention any specific references to Powers Cove. It appears that people choosing to settle the bay preferred coves with better anchorage and more protection from the winds than Powers Cove could offer. Mooring Cove and Marystown are less than a kilometre from Powers Cove and both these places were chosen for settlement.

The absence of settlement in the Powers Cove study area, as suggested from the informant's interviews, is corroborated by a lack of historic or pre-contact cultural resources from the archaeological survey. It is speculated that the reasons for this relate to the wet, low-lying nature of the ground in the cove and most importantly, the lack of protection from the elements. Although the aerial photographs of the area, taken in the early 1980s, show what appears to be a grassy area behind the barrier beach, upon investigation, this area turned out to be wet and swampy and therefore uninhabitable. The 1-1.5m high barrier beach surrounding the lowest part of the cove appeared to be no match for heavy seas. This observation was confirmed by one of the informant's recollections of the seas frequently washing over the barrier during big storms. Similarly, the study area bounded by the right-of-way between Route 210 and Powers Cove is a combination of rocky, hilly and wet terrain that is also not conducive to settlement.

10. Recommendations

It is recommended that the development of the Mortier Bay -North Atlantic Marine Service Center in Powers Cove proceed. It should be noted that, as the archaeological survey did not involve a total excavation of the study area, there is always a possibility that evidence of past cultural activity could be uncovered. Should the construction activity uncover artifacts or archaeological features, the Provincial Archaeological Office should be notified immediately.

11. References Cited

Ginns, J. 1983 Newfoundland and Labrador Archaeological Site Record Form for CgAt-2, Great Burin Harbour. On file at the Provincial Archaeology Office, Department of Tourism Recreation and Culture, St. John's, NL.

Penney, G. 1984 Cow Head/Spanish room Oil Rig Repair Facility Historic Resources Impact Assessment. On file at the Provincial Archaeology Office, Department of Tourism Recreation and Culture, St. John's, NL.

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Skanes, R. 1999 Newfoundland and Labrador Archaeological Site Record Form for CgAt-4, Ship Cove Wreck. On file at the Provincial Archaeology Office, Department of Tourism Recreation and Culture, St. John's, NL.

Tuck, J. 1988 Newfoundland and Labrador Archaeological Site Record Form for CgAt-1, South East Arm. On file at the Provincial Archaeology Office, Department of Tourism Recreation and Culture, St. John's, NL.

Proposal for Establishing an Atlantic Salmon Smolt Production Facility for Grieg Nurseries NL Ltd.

Aqua Maof Group / June 2015

Table of Contents

Project Description

Introduction

AquaMaof Aquaculture Technologies is pleased to submit this proposal for the development of a salmon hatchery, smoltification, and Atlantic salmon smolt growing facility. The proposal is based upon general discussions on requirements for Grieg Nurseries NL project development. AquaMaof is providing a full facility design that will enable production of 7 million smolt per year on a production schedule that results in 300 gram smolt and large size smolt at 1.4 to 1.8 kg (Table 1). The 300 gram smolt will be produced on a schedule to enable harvest of market fish from the cage systems every month of the year. The large 1.4 kg smolt will enable harvest of market salmon after one summer of growth in the sea cages, significantly reducing the production risk of winter months at sea. The 1 million 1.4 kg smolt in November are smolt held in the land based growing system primarily to enable continuous operation of the RAS.

Table 1. Facility annual smolt production schedule in 1000's.

Smolt size	April	May	June	July	October	November
300 grams	1,000	1,000	1,000	1,000		
1.0 kgs					1,000	
1.5 kgs	500					1,000
1.8 kgs		500				

The project is divided into three stages of production: the hatchery from egg through first feeding, the smoltification from approximately 2.5 grams to 50 gram smolt, and nursery growing from 50 grams to 300 grams or 1.5 kg. The total facility is designed for low water use and optimum use of electrical energy resulting in a low total cost of production.

Hatchery

Description and General Specifications

The hatchery capacity is designed to hold 2 monthly batches of salmon eggs. The batches resulting in 300 gram smolt in April, May and June are each 1 million and the smolt batch for July is 3 million.

Therefore the hatchery capacity required is 4 million. Each batch of 1 million eggs requires 3 units of Alvestad CompHatch 8-level systems (Table 2). The hatchery includes 4-1 million egg hatching systems for a total of 12 CompHatch units. Each of the 1 million egg systems has an AquaMaof water treatment system for two first-feeding tanks. The first-feeding tanks have a separate AquaMaof water treatment system described below.

Table 2. Alvestad CompHatch specifications.

CompHatch	
Capacity	360,000 roe / unit
Liters of water / minute	0.8 liter / liter roe
Water exchanges / hour	7 to 12
Outer measurements	Height 1750 mm, length 1650 mm, depth 800 mm
Material	Aluminum and plastic
Option	Light proof cover

Water circulated through the CompHatch trays will flow into Alvestad Kube Hatch treatment systems and recirculated through the trays. The hatchery will use 2 Kube hatch units to supply water treatment for 12 CompHatch units (see Figure 1). Water temperature is maintained at the proper set points from 8 C to 12 C with a heat exchanger. Specifications for the Kube hatch systems are listed in Table 3.

Table 3. Alvestad Kube hatch specifications.

Kube Hatch 8000	
Capacity	7 CompHatch units
Bioreactor	800 liters / min
Foam fractionator	800 liters / min
Hydrotech HT801	30 micron mesh
UV	40 mJ/cm2
Heating and cooling	8-12 C
Degassing	vacuum

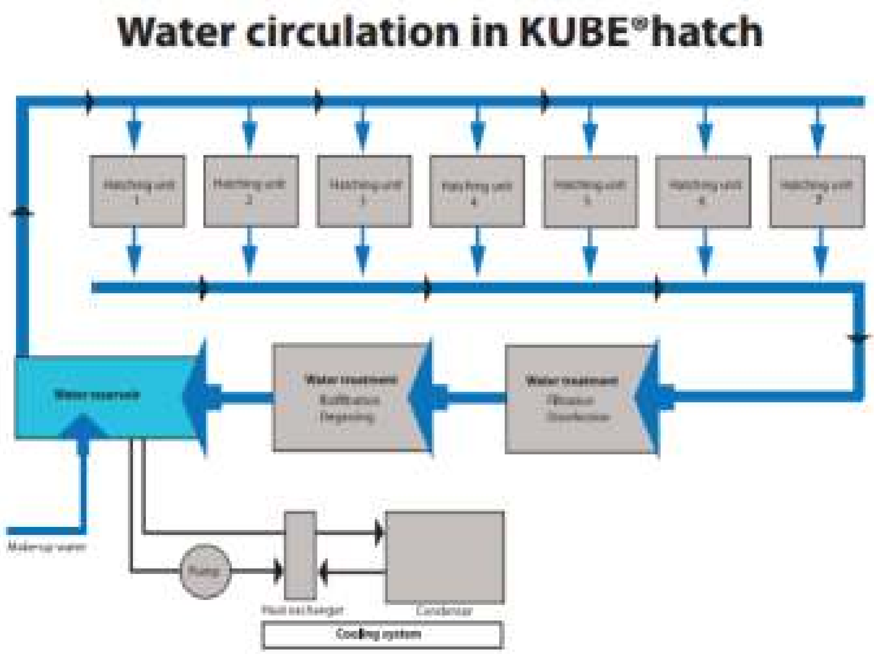

Figure 1. Diagram of water-flow through the hatching water treatment system (source Alvestad)

The first-feeding tanks are an AquaMaof 8 tank module with separate water treatment systems for each 2 tanks. The AquaMaof tank module is comprised of the fish tank, solids separation settler, biofilter, pumping sump, and ODS (oxygen dissolving system) (Table 4). There are also openings in each tank into the harvest channel. This channel is used to move fry by swimming from the fish tanks to the area adjacent to the fish transfer tank. Fry are then transferred by net from the harvest channel into the fish transfer tank. The fish transfer tank is filled with nursery system water and when a batch of fry are moved into the nursery the water and fish are then transferred by gravity flow from the hatchery transfer tank into the nursery. The fish transfer tank will be in a separate room from the hatchery production system to aid in maintaining biosecurity between the hatchery and nursery systems.

Table 4. Specifications of the tank system for each 1 million hatching unit.

Component	Size	Number
Water circulation pumps	75 m3/hour	2
Tank water exchange	26.5 minutes	
AquaMaof solids settler	10 m x 3.8 m	1
Biofilter	10 m x 3.4 m x 3 m	1
Daily feed capacity	70 kg	
Tanks	6.4m x 1.0m	2
AquaMaof ODS	75 m3/hr x 5m depth	2
Harvest channel	1m x 10m	1
Water temperature control	8 to 12 C	central heat pump

Process Concept Review

The hatchery system is designed for water recirculation rather than flow through, therefore requires high quality water treatment. The hatching trays are standard Alvestad CompHatch systems integrated with the Alvestad Kube hatch treatment system used in the salmon industry. The water circulation rate is as suggested for this hatching system.

The first-feeding tank system is designed with 2 tanks for each egg hatching unit. This system is temperature controlled ranging from 8 to 12 C and has the capability to feed 70 kg/day to the 1 million batch of fry at an average weight of 2.5 grams. This system includes the solids settlers (Brentwood ACCU-PAC IFR 6036-36 inches of depth), trickling biofilter (also for degassing), oxygen dissolving systems, and pumps. The trickling biofilter (Brentwood ACCU-PAC CF 1200 crossflow media) has been selected to provide the highest level of degassing without vacuum and this combined with the water circulation rate will result in carbon dioxide concentrations less than 10 mg/liter in the fish tanks. There is also a harvest channel for moving fish by swimming from each tank to the fish transfer tank. Fry are netted from the harvest channel into the transfer tank to avoid moving hatchery water into the nursery. The transfer tank is filled with water from the nursery and then water and fish are gravity flowed from the hatchery into the nursery.

The hatchery building will be placed at an elevation on the property to allow for gravity movement of fish and water from the hatchery to the nursery. The building will be a steel framed insulated building (Table 5).

Table 5. Specifications for the hatchery building

Component	Size	Number
Dimensions	36 m x 43 m	
Building height	6 m	
Office space	10 m2	1
Biosecure entrance / restroom	20 m2	1
Conference / break room	15 m2	1
HVAC	14 C production	

Nursery

The nursery is designed to grow each of the 5 batches of smolt to 50 grams completing smoltification and vaccination. The total growth time will be 4 months, therefore four batches of smolt at various stages can be grown in the facility at one time.

Description and General Specifications

The nursery has 2 production modules with 11 large tanks and 4 small tanks (Table 7). Batches of 1 million fry will be stocked from the hatchery into the nursery in November, December, and January of each year followed by a 3 million batch in February. Then the last batch of 1 million fry will be stocked in July. This last batch will be sent to the land-based smolt growing facility in October. These smolt will then be 1.3 kg in April and 1.8 kg in May for stocking into sea cages. These smolt will then reach harvest size with only one summer and fall in the sea cages.

Each nursery tank will have tent type covers and lighted individually to control smoltification. The lighting system will be installed at multiple water depths around the circumference of the tank walls to provide uniform light throughout each tank preventing shadows. These lights have the capability to simulate natural daylight including dusk and dawn gradual reductions and increases in light intensity.

Table 7. Specifications for the smolt nursery facility.

Component	Size	Number
Water circulation pumps	1053 m3/hour	4
Pump for fish transfer tank	175 m3/hour	2
Tank water exchange	24 minutes	
AquaMaof solids settler	12 m x 33 m	2
Biofilter and gas stripping	1620 m3 x 6 m depth	2
Carbon dioxide maximum	15 mg/liter free CO2	
Daily feed capacity	3032 kg	
Maximum fish density	100 kg/m3	
Tanks, large	10 m dia. x 1.8 m depth	11
Tanks, small	5 m dia. x 1.8 m depth	4
AquaMaof ODS	350 m3/hr x 15 m depth	12
AquaMaof ODS	88 m3/hr x 15 m depth	4
Harvest channel	1 m wide x 66 m long	1
Fish transfer tank	10 m dia. x 1.8 m depth	1
Denitrification / water reuse	20 m3/hour	1
Sludge discharge, 20% solids	0.25 m3/day	
Water discharge, fish tank water	25 liters/min annual average	
Water temperature control	8 to 12 C	central

The process flow diagram is shown in Figure 2. This shows the water recirculation for 4210 m3/hour and 20 m3/hour through the water reuse and denitrification treatment process. This represents 99.5% recirculation with 0.5% sent through the waste treatment process and returned to the fish production system. The alkalinity adjustment buffer system will be used primarily during startup phases. Once the total treatment system stabilizes most alkalinity will be returned to the system through the bacterial processes in the solids settler and the denitrification system.

The AquaMaof aquaculture recirculation system includes several design concepts that are duplicate systems and some used only for emergencies. A summary the characteristics of the AquaMaof design includes:

1. The total system is divided into independent production modules, should there be a catastrophic factor that disables a single module then all other modules will remain in full operation.
    a. Multiple and independent fish production modules
    b. Fish transfer channel to quickly move fish between modules
2. The water circulation system is installed in duplicate. Many designs have multiple pumps, however piping can fail and few have duplicate water circulation systems.

    a. Duplicate water pumps
    b. Duplicate circulation piping systems
    c. Duplicate valves
3. The oxygenation system has several points of duplication.
    a. The main oxygenation is through the ODS with backup oxygen diffusers in each fish production tank
    b. The oxygen pipe delivery system is duplicated, the main oxygen supply and the emergency supply. Either pipe system can be used for regular or emergency oxygen supply changing with control valves.
    c. The main oxygen supply is from an oxygen generator with liquid oxygen tank backup for when the oxygen generator is offline for maintenance or there is a disruption in the electrical supply. There are duplicate liquid oxygen tanks as backup for each other in the event of disrupted plumbing failure on one.
4. Electricity supply.
    a. The main electric supply has a diesel or natural gas stand-by electric generation system that automatically starts with any disruption to the public electric supply.
    b. The electric transformers are duplicated such that the duplicated water pumps are on separate electric transformers.
5. Should total electric supply disruption occur (both the main public supply and internal backup supply) all electrically supplied water circulation will then be disrupted. The following tertiary non-mechanical systems will engage. This mode of operation can be maintained as long as sufficient liquid oxygen can be supplied. Two LOX tanks with 25 tons of oxygen is sufficient for 5 hours of operation. In this emergency mode all feeding is stopped.
    a. Emergency oxygen diffusers will automatically operate in each fish production tank.
    b. The AquaMaof ODS units will automatically go into reverse flow mode and using the main oxygen supply as an air lift to circulate water and strip CO_2 within each fish production tank.
6. There are 3 solid waste settlers for each fish production module. Any one of these settlers can be removed from operation <u>and</u> the module will continue to function normally.
7. There is 1 large CIFT biofilter for each module, overcapacity in the CIFT biofilter is such that it can operate in sections and continue to function normally with any selected portion out of service.
8. Should there be a disruption to all three settlers of a module or a full disruption of the CIFT biofilter there is a water by-pass that enables the recirculation system and oxygenation system to continue operation. This can also be used should fish treatments be necessary that could damage the biological community of the biofilter and water by-pass is necessary.
9. Overcapacity is built into the modules such that should it be necessary to remove one complete module from operation, water can then be by-passed to the two remaining modules and the overall system will continue to function normally during all months except February, March, April, and May. During these months of high fish biomass feed quantities will need to be reduced to enable safe operation.

The nursery building will be constructed downgrade from the hatchery building and will be an insulated steel-frame building (Table 8). Smolt will be transferred from the nursery to the land based smolt growing facility by gravity flow from the nursery fish transfer tank. The nursery fish transfer tank is located in a separate room of the nursery facility and smolt are transferred into the transfer through a dewatering grate that returns nursery water back to the nursery. The fish transfer tank is filled with land based facility water.

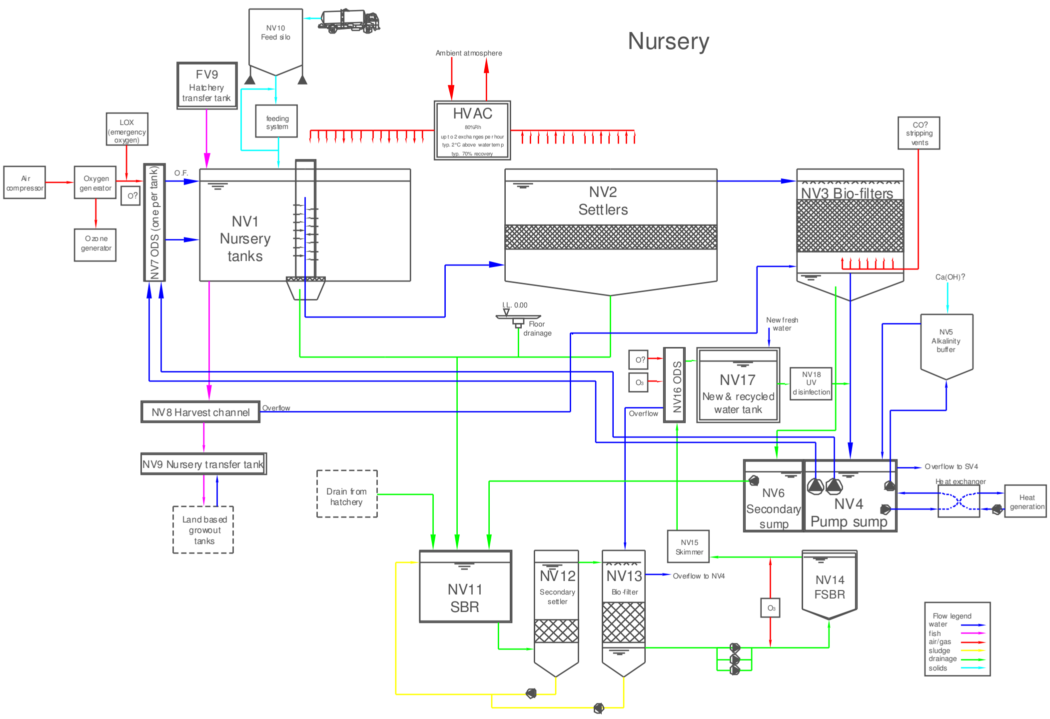

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Figure 2. Process flow for Nursery & Smolt.

Table 8. Specifications for the nursery building.

Dimensions	56 m x 80 m	1
Building height	6 m	
Office space	10 m2	2
Biosecure entrance / restroom	20 m2	1
Conference / break room	15 m2	1
HVAC	14 C production	

Process Concept Review

The proposed system design is AquaMaof's standard design adapted for salmon smolt production which includes the recirculation pump, ODS, fish production tank, solids settler, controlled intermittent flow trickling (CIFT) biofilter (which includes CO_2 gas stripping), and harvest channel. Smolt growth will require 4 months from 2.5 grams to 50 grams. After 2 months of growth the fish will be redistributed in the tanks to maintain less than 81 kg/m3 fish biomass for this first 2 months of smolt growth.

The water circulation system is designed for a single pumping step to complete the recirculation. These pumps are submerged vertical turbine type pumps. These pumps provide high efficiency pumping (80% or greater) at 9.4 meters of head. The recirculated water flows from the pump into the ODS (oxygen dissolving system).

The ODS is designed to provide high dissolved oxygen concentration with a small amount of pumped head pressure (about 0.3 m head pressure). Improved dissolving of oxygen can be attained with the following methods: 1) increase of water pressure where oxygen bubbles are dispersed; 2) increase of residence time of oxygen bubbles in the water; 3) oxygen gas bubble size, smaller bubbles result in more gas to water surface area; and 4) water temperature, colder water results in higher oxygen concentrations at 100% saturation and warmer water results in faster dissolving rate. The ODS obtains the increased pressure with the column of water and injection of the oxygen gas near the bottom of the column, thereby attaining higher water pressure without costly pumping. The residence time for allowing the oxygen bubbles to dissolve is attained in the ODS by creating a flow of water counter to the flow of oxygen bubbles. The AquaMaof ODS allows for low head requirement for dissolving oxygen and attaining oxygen concentrations sufficient to eliminate oxygen concentration as a limiting factor in design of water flow volume. This ODS design has capability to attain oxygen concentrations up to 40 mg/liter, which is an over design safety factor to assure oxygen will never be a limiting factor for the fish and capability to maintain above 90% saturation at all times.

Oxygenated water flows from the ODS directly into the fish production tank with the water added tangentially at the outer edge of the tank at a slight downward angle which creates circular water flow in the tank and distributes water from near the surface to the tank floor. Circulated water flow leaves the tank from the drain stand-pipe at the center of the tank. The stand-pipe is perforated starting 30 cm from the tank bottom to the normal operating water level. This reduces the potential for any full blockage or plugging of the exit screen.

The fish tank is the first step in solids removal. The tank acts as a clarifier and has a drain trap around and below the central drain pipe. This sediment trap collects settled solids that are moved towards the center of the tank bottom by the circular water flow in the tank. This sediment trap is not a continuous flow but is drained 1-2 times per day significantly reducing the amount of water sent out with the settled solids. The settled solids and water in the trap are sent directly to the water re-use treatment and is not part of the recirculation water flow. The main recirculation water flows into the tank main drain pipe and directly into the solid waste settler distribution channel via gravity with minimal turbulence or bends in the pipe.

The second step in the solids removal process is the solids settler with a design concept adapted from the potable water industry used for removal of fine particulates. The settling basin is rectangular with the floor sloped to a center drain. Water is evenly distributed across the basin approximately 0.5 m above the floor from the distribution channel with pipes. A large portion of the solids settle on the floor of the basin and water flows upward through the tube settler media (Brentwood ACCU-PAC IFR 6036) and into water collection launderers and by gravity is distributed through the spray nozzles of the CIFT biofilter. Solid waste accumulated in the settler basin and on the settler media is periodically drained and washed from the media and basin into the discharge waste treatment. The exact schedule depends upon solid waste loading and can range from once every 4 days to once every 10 days.

There are several advantages of this solids removal process compared to other methods. First there are no continuously moving parts that need maintenance or replacement. Second, this method has capability to remove very fine particles compared to mechanical screen methods which tend to increase the amount of fine particles. Third, this process will result in denitrification when managed on a proper draining schedule. The schedule for cleaning is adjusted after several months of operation to allow for stabilizing the denitrification process. The schedule will have longer intervals between cleaning in the early phase of operation then a regular schedule will be established which is in the range of 1 time per week.

The CIFT biofilter is the next step in the water recycle process. This is a trickling filter adapted for stripping carbon dioxide from the water and using a controlled and intermittent water flow over the media. The depth of media (Brentwood ACCU-PAC CF 1200) is 6 meters to provide maximum nitrification (removal of ammonia) with a single pass of water flow. This depth also allows for movement of carbon dioxide bound in the alkalinity buffer to free CO_2 as the carbon dioxide concentration is reduced in the water with counter flowing air. With this method we can strip more mg/liter CO_2 from the water than exists as free CO_2 in the fish tanks. The hydraulic loading across the entire biofilter for CO2 stripping is 7.8 m3/hour/m2, an order of magnitude less than hydraulic loadings typically used in CO2 stripping by other companies.

The hydraulic loading on the trickling filter is designed for the optimum wetting of all surfaces of the biofilter media (14.6 m3/hour/m2). This loading is intermittent to obtain additional treatment advantages. The use of air circulation through the biofilter from bottom to top of the media provides all required oxygen for the bacterial processes and leaves the biofilter at near 100% oxygen saturation. This ebm-papst axial flow fan provides air flow of 10 times more air volume than water flow volume. The air flow is counter current to the water with air entering the base of the CIFT biofilter and water entering through the spray nozzles at the top. The CIFT biofilter can also be used for water temperature control when outside air temperature and humidity are appropriate during many months of the year. If the culture water needs to be increased and outside air temperature is higher than the water temperature then outside air is used to supply the air fan. Also when outside humidity is low the trickling filter acts as a cooling tower. Because the facility has low water exchange rate the normal requirement for temperature control in the system water is cooling. This use for the CIFT biofilter reduces the electrical energy required for cooling fish water. Advantages for the CIFT biofilter are:

1. Water temperature increase or decrease depending upon a controlled source of air flow, inside building air or outside air. The CIFT biofilter can effectively be used as a cooling tower.
2. Can be scaled to match any nitrification quantity required by changing depth, width, and length dimensions with no change in the type of equipment used.
3. Use of solid cone spray pattern provides uniform optimal wetting of the media surfaces, much better than drip pans or the use of perforated pipes.
4. Intermittent flow provides for more effective nitrification by allowing water to more fully drain from the media surface before another water surge. This biological growth phenomenon can be observed in natural water settings of wave action (intermittent wetting or high energy areas) promoting increased biological growth.
5. Intermittent flow allows for more residence time on the media and time with thinner water film improving CO2 stripping. Average daily hydraulic loading rate is an order of magnitude less than normal CO2 strippers used in aquaculture applications.
6. Controlled intermittent water flow (control both the amount of time a nozzle is flowing and the interval between flow cycles) enables development of a biofilter of any required nitrification rate, maintain a specified media depth, and most importantly maintain optimum hydraulic loading. Many traditional trickling filter designs cannot attain optimum hydraulic loading with continuous flow regimes; the recirculation system water flow rate is not sufficient to enable proper hydraulic loading because the square meter footprint area is too large resulting in much less than optimum hydraulic loading. The water flow volume rate is not sufficient to properly wet the bacterial surface area of the media.

Requirements of the CIFT biofilter include:

1. Requires a larger footprint for construction, however this biofilter also provides for CO2 stripping, temperature control capabilities, and water storage pumping basin.
2. Requires water pumping energy to allow water to gravity flow through the media with the counter current flow of air. Submerged biofilter design concepts require less energy for pumping but increased energy for oxygenation, gas stripping, and mixing. The total energy required for the complete recirculation cycle must be considered, and this is where the combination of AquaMaof system components results in lower total energy required for operation.

The water basin below the CIFT biofilter is used as a surge tank for holding a supply of water for the total system, one third of the fish production tank volume. This allows for capacity to drain a fish tank for harvest and retain all water in the operating system.

Waste water is drained from each tank secondary drain (from the sediment trap in the tank center) and from the solid waste settlers directly to the waste treatment / denitrification system (Figure 2). This water treatment system returns the water back to original quality standards. The process includes sequencing batch reactors, decanting and solids settler, trickling biofilter for aeration and gas stripping, followed by fluidized bed reactor, ozone, and UV. One day supply of new water is held in storage for use as continuous addition or in larger quantities in a short time for refilling the system. This one day supply of water will also ensure the facility will remain within the 300 liter per minute regulated water use for the facility in case of any increase in water need.

The sequencing batch reactors are chosen because of the capability to process varying flow rates and allow for control flexibility. The fluidized bed reactor and ozone are selected for final polishing and breakdown of complex organic compounds that can build in aquaculture systems with very low to no water exchange. UV treatment is the final step in the waste treatment and this assures no residual ozone will reach fish production water. Waste water treatment is the only area where ozone is required or used in the salmon production facility.

Land Based Smolt—Growing

The land based smolt growing facility is designed for growing smolt in seawater from 50 grams to large smolt of 300 grams for stocking sea cages. There will be one batch of smolt that will be grown to 1.3 to 1.4 kg for early spring stocking with the plan for attaining market size with one summer and fall of growth time. This significantly reduces the risk related to holding salmon over the winter season in sea cages. Since this land based unit is best operated continuously to maintain the biofilters, the plan is to hold some fish for later stocking dates which will result in some fish being moved to sea cages at 1 kg and 1.8 kg sizes.

Description and General Specifications

The land based smolt growing facility has 3 production modules with 18 tanks (Table 10). The smolt will be grown for 3 months to reach 300 grams and be ready for stocking sea cages. This facility will be lighted but follow normal seasonal light cycles to coincide with the day / night cycles of the sea cages. The lighting system will be installed at multiple water depths around the circumference of the tank walls to provide uniform light throughout each tank preventing shadows. These lights have the capability to simulate natural daylight including dusk and dawn gradual reductions and increases in light intensity.

Batches of smolt from the nursery will be stocked into the land based growing system in February, March, April, May, and October. The last batch of smolt will then be 1.3 kg in April and 1.8 kg in May for stocking into sea cages.

Table 10. Specifications for the land based smolt growing facility.

Component	Size	Number
Water circulation pumps	4417 m3/hour	6
Pump for fish transfer tank	735 m3/hour	2
Tank water exchange	51 minutes	
AquaMaof solids settler	27 m x 63 m	3
Biofilter and gas stripping	5653 m3 x 6 m depth	3
Carbon dioxide maximum	15 mg/liter free CO2	
Daily feed capacity	19,080 kg	
Maximum fish density	91 kg/m3	
Tanks	20 m dia. x 4.3 m depth	18
AquaMaof ODS	491 m3/hr x 15 m depth	55
Harvest channel	1 m wide x 190 m long	1
Fish transfer tank	20 m dia. x 4 m depth	1
Denitrification / water reuse	125 m3/hour	1
Sludge discharge, 20% solids	1 m3/day	
Water discharge, fish tank water	175 liters/min annual average	
Water temperature control	8 to 12 C	central

The process flow diagram is shown in Figure 2, the same process concept as for the nursery. Water recirculation in the land based smolt system is 26,500 m3/hour and 125 m3/hour through the water reuse and denitrification treatment process. This represents 99.5% recirculation with 0.5% sent through the waste treatment process and returned to the fish production system approximately one day later. The alkalinity adjustment buffer system will be used primarily during startup phases. Once the total treatment system stabilizes most alkalinity will be returned to the system through the bacterial processes in the solids settler and the denitrification system.

The AquaMaof aquaculture recirculation system includes several design concepts that are duplicate systems and some used only for emergency. A summary the characteristics of the AquaMaof design includes:

1. The total system is divided into independent production modules, should there be a catastrophic factor that disables a single module then all other modules will remain in full operation.
    a. Multiple and independent fish production modules
    b. Fish transfer channel to quickly move fish between modules
2. The water circulation system is installed in duplicate. Many designs have multiple pumps, however piping can fail and few have duplicate water circulation systems.
    a. Duplicate water pumps
    b. Duplicate circulation piping systems
    c. Duplicate valves
    d. Multiple ODS units for each fish production tank
3. The oxygenation system has several points of duplication.
    a. The main oxygenation is through the ODS with backup oxygen diffusers in each fish production tank
    b. The oxygen pipe delivery system is duplicated, the main oxygen supply and the emergency supply. Either pipe system can be used for regular or emergency oxygen supply changing with control valves.
    c. The main oxygen supply is from an oxygen generator with liquid oxygen tank backup for when the oxygen generator is offline for maintenance or there is a disruption in the electrical supply. There are duplicate liquid oxygen tanks as backup for each other in the event of disrupted plumbing failure on one.
4. Electricity supply.
    a. The main electric supply has a diesel or natural gas stand-by electric generation system that automatically starts with any disruption to the public electric supply.
    b. The electric transformers are duplicated such that the duplicated water pumps are on separate electric transformers.
5. Should total electric supply disruption occur (both the main public supply and internal backup supply) all electrically supplied water circulation will then be disrupted. The following tertiary non-mechanical systems will engage. This mode of operation can be

maintained as long as sufficient liquid oxygen can be supplied. Two LOX tanks with 25 tons of oxygen is sufficient for 5 hours of operation. In this emergency mode all feeding is stopped.
   a. Emergency oxygen diffusers will automatically operate in each fish production tank.
   b. The AquaMaof ODS units will automatically go into reverse flow mode using the main oxygen supply as an air lift to circulate water and strip CO2 within each fish production tank.
6. There are 3 solid waste settlers for each fish production module. Any one of these settlers can be removed from operation and the module will continue to function normally.
7. There is 1 large CIFT biofilter for each module, overcapacity in the CIFT biofilter is such that it can operate in sections and continue to function normally with any selected portion out of service.
8. Should there be a disruption to all three settlers of a module or a full disruption of the CIFT biofilter there is a water by-pass that enables the recirculation system and oxygenation system to continue operation. This can also be used should fish treatments be necessary that could damage the biological community of the biofilter and water by-pass is necessary.
9. Overcapacity is built into the modules such that should it be necessary to remove one complete module from operation, water can then be by-passed to the two remaining modules and the overall system will continue to function normally during all months except October, April, and May. During these months of high fish biomass feed quantities will need to be reduced to enable safe operation.

The land based smolt growing building will be constructed downgrade from the nursery building and will be an insulated steel frame building (Table 11). The fish transfer tank will be outside of the land based growing facility and filled with seawater. Post smolt will be transferred over a dewatering system prior to entering the transfer tank.

Table 11. Specifications for land based smolt growing building.

Component	Size	Number
Dimensions	100 m x 230 m	1
Building height	7 m	
Office space	10 m2	3
Biosecure entrance / restroom	40 m2	1
Conference / break room	40 m2	1
HVAC	14 C production	

AquaMaof aquaculture production modules operate as independent systems in part for increased biosecurity but also water temperature and salinity can be adjusted in each module. The AquaMaof system is also unique in that individual solid waste settlers can be taken off-line and the system continue to operate normally. The complete settler and biofilter can also be by-passed and taken out of the water recirculation if necessary for special fish treatments.

In addition, any single tank can be taken off the recirculation system for special treatment for these fish such as, medical treatments, a temperature adjustment for preparation of moving fish, or salinity adjustments. The isolation and special water treatment for any single tank is accomplished by closing the incoming water valves bringing system water to the tank and closing the tank drain pipe at the beginning of the solids settler (slide gate valves located in the distribution channel). Then water is circulated through the ODS unit in reverse flow direction using the air lift principle to create air lift in the center tube of the ODS and water then flows from the ODS overflow into the tank with the water source being the normal tank inlet pipe. Air is temporarily used to create this air lift water flow as well as strip CO2 from the water. Oxygen can be supplied either from the emergency oxygen diffusers or in the ODS. If oxygen is used for the air lift in the ODS then the air source is temporarily off. New water can be added and drained either to the recirculation system or directly to the waste water treatment system. This concept can also be adapted for depuration of fish if needed prior to marketing of full size fish.

Process Concept Review

The proposed system design is AquaMaof's standard design adapted for salmon smolt production which includes the recirculation pump, ODS, fish production tank, solids settler, controlled intermittent flow trickling (CIFT) biofilter (which includes CO2 gas stripping), and harvest channel. Smolt growth will require 3 months from 50 grams to 300 grams and 7 months to 1.3 kg. After 2, 4, and 6 months of growth the fish will be redistributed in the tanks to maintain less than 100 kg/m3 fish biomass.

The water circulation system is designed for a single pumping step to complete the recirculation. These pumps are submerged vertical turbine type pumps. The pumps provide high efficiency pumping at 9.4 meters of head. The recirculated water flows from the pump into the ODS (oxygen dissolving system).

The ODS is designed to provide high dissolved oxygen concentration with a small amount of pumped head pressure (about 0.3 m head pressure). Improved dissolving of oxygen can be attained with the following methods: 1) increase of water pressure where oxygen bubbles are dispersed; 2) increase of residence time of oxygen bubbles in the water; 3) oxygen gas bubble size, smaller bubbles result in more gas to water surface area; and 4) water temperature, colder water results in higher oxygen concentrations at 100% saturation and warmer water results in faster dissolving rate. The ODS obtains the increased pressure with the column of water and injection of the oxygen gas near the bottom of the column, thereby attaining higher water pressure without costly pumping. The residence time for allowing the oxygen bubbles to dissolve is attained in the ODS by creating a flow of water counter to the flow of oxygen bubbles. The AquaMaof ODS allows for low head requirement for dissolving oxygen and attaining oxygen concentrations sufficient to eliminate oxygen concentration as a limiting factor in design of water flow volume. This ODS design has capability to attain oxygen concentrations up to 40 mg/liter, which is an over design safety factor to assure oxygen will never be a limiting factor for the fish and capability to maintain above 90% saturation at all times.

Oxygenated water flows from the ODS directly into the fish production tank with the water added tangentially at the outer edge of the tank at a slight downward angle which creates circular water flow in the tank and distributes water from near the surface to the tank floor. There will be 3 ODS for each tank and each ODS will discharge water at a different depth in the tank. Circulated water flow leaves the tank from the drain stand-pipe at the center of the tank. The stand-pipe is perforated starting 30 cm from the tank bottom upward to the normal operating water level. This reduces the potential for any full blockage or plugging of the exit screen.

The fish tank is the first step in solids removal. The tank acts as a clarifier and has a drain trap around and below the central drain pipe. This sediment trap collects settled solids that are moved towards the center of the tank bottom by the circular water flow in the tank. This sediment trap is not a continuous flow but is drained 1-2 times per day significantly reducing the amount of water sent out with the settled solids. The settled solids and water in the trap are sent directly to the water re-use treatment and is not part of the recirculation water flow. The main recirculation water flows into the tank main drain pipe and directly into the solid waste settler distribution channel via gravity with minimal turbulence or bends in the pipe.

The second step in the solids removal process is the solids settler, with a design concept adapted from the potable water industry used for removal of fine particulates. The settling basin is rectangular with the floor sloped to a center drain. Water is evenly distributed across the basin approximately 0.5 m above the floor from the distribution channel with pipes. A large portion of the solids settle on the floor of the basin and water flows upward through the tube settler media (Brentwood ACCU-PAC IFR 6036) and into water collection launderers and by gravity is distributed through the spray nozzles of the biofilter. Solid waste accumulated in the settler basin and on the settler media is periodically drained and washed from the media and basin into the discharge waste treatment. The exact schedule depends upon solid waste loading and can range from once every 4 days to once every 10 days.

There are several advantages of this solids removal process compared to other methods. First there are no continuously moving parts that need maintenance or replacement. Second, this method has capability to remove very fine particles compared to mechanical screen methods with increase the amount of fine particles during the process of collecting larger particles. Third, this settling process will result in denitrification when managed on a proper draining schedule. The schedule for cleaning is adjusted after several months of operation to allow for stabilizing the denitrification process. The schedule will have longer intervals between cleaning in the early phase of operation then a regular schedule will be established which is in the range of 1 time per week.

The CIFT biofilter is the next step in the water recycle process. This is a trickling filter adapted for stripping carbon dioxide from the water and using a controlled and intermittent water flow over the media. The depth of media (Brentwood ACCU-PAC CF 1200) is 6 meters to provide maximum nitrification (removal of ammonia) with a single pass of water flow. This depth also allows for movement of carbon dioxide bound in the alkalinity buffer to free CO2 as the carbon dioxide concentration is reduced in the water with counter-current flowing air. With this method we can strip more mg/liter of CO2 from the water than exists as free CO2 in the fish tanks. The hydraulic loading across the entire biofilter for CO2 stripping is 7.8 m3/hour/m2, an order of magnitude less than hydraulic loadings typically used in CO2 stripping by other companies.

The hydraulic loading on the trickling filter is designed for the optimum wetting of all surfaces of the CIFT biofilter media (14.6 m3/hour/m2). This loading is intermittent to obtain additional treatment advantages. The use of air circulation through the CIFT biofilter from bottom to top of the media provides all required oxygen for the bacterial processes and leaves the biofilter at near 100% oxygen saturation. This Megafan axial flow fan provides air flow of 10 times more air volume than water flow volume. The air flow is counter current to the water with air entering the base of the trickling filter and water entering through the spray nozzles at the top. The biofilter can also be used for water temperature control when outside air temperature and humidity are appropriate during many months of the year. If the culture water needs to be increased and outside air temperature is higher than the water temperature then outside air is used to supply the air fan. Also when outside humidity is low the trickling filter acts as a cooling tower. Because the facility has low water exchange rate the normal requirement for temperature control in the system water is cooling. The CIFT biofilter reduces the electrical energy required for cooling fish water. Advantages for the CIFT biofilter are:

1. Water temperature increase or decrease depending upon a controlled source of air flow, inside building air or outside air. The CIFT biofilter can effectively be used as a cooling tower.

2. Can be scaled to match any nitrification quantity required by changing depth, width, and length dimensions with no change in the type of equipment used.
3. Use of solid cone spray pattern provides uniform optimal wetting of the media surfaces, much better than drip pans or the use of perforated pipes.
4. Intermittent flow provides for more effective nitrification by allowing water to more fully drain from the media surface before another water surge. This biological growth phenomenon can be observed in natural water settings of wave action (intermittent wetting or high energy areas) promoting increased biological growth.
5. Intermittent flow allows for more residence time on the media and time with thinner water film improving CO2 stripping. Average daily hydraulic loading rate is an order of magnitude less than normal CO2 strippers used in aquaculture applications.
6. Controlled intermittent water flow (control both the amount of time a nozzle is flowing and the interval between flow cycles) enables development of a biofilter of any required nitrification rate, maintain a specified media depth, and most importantly maintain optimum hydraulic loading. Many traditional trickling filter designs cannot attain optimum hydraulic loading with continuous flow regimes; the recirculation system water flow rate is not sufficient to enable proper hydraulic loading because the square meter footprint area is too large resulting in much less than optimum hydraulic loading. The water flow volume rate is not sufficient to properly wet the bacterial surface area of the media.

Requirements of the CIFT biofilter include:

1. Requires a larger footprint for construction, however this biofilter also provides for CO2 stripping, temperature control capabilities, and water storage pumping basin.
2. Requires water pumping energy to allow water to gravity flow through the media with the counter current flow of air. Submerged biofilter design concepts require less energy for pumping but increased energy for oxygenation, gas stripping, and mixing. The total energy required for the complete recirculation cycle must be considered, and this is where the combination of AquaMaof system components results in lower total energy required for operation.

The water basin below the CIFT biofilter is used as a surge tank for holding a supply of water for the total system, a volume equal to the volume of 1 fish tank. This enables the operator to drain a fish tank for harvest and retain all water in the operating system. If necessary the water levels in each production tank can be adjusted up or down to store or make additional water available.

Waste water is drained from each tank secondary drain (from the sediment trap in the tank center) and from the solid waste settlers directly to the waste treatment/ denitrification system (Figure 2). This water treatment system returns the water back to original quality standards. The process includes sequencing batch reactors, decanting and solids settler, trickling biofilter for aeration and gas stripping, followed by fluidized bed reactor, ozone, and UV. One day supply of new water is held in storage for use as continuous addition or in larger quantities in a short time for refilling the system. This one day supply of water will also ensure the facility will remain within the 300 liter per minute regulated water use for the facility in case of any increase in water need.

The sequencing batch reactors are chosen because of the capability to process varying flow rates and allow for control flexibility. The fluidized bed reactor and ozone are selected for final polishing and breakdown of complex organic compounds that can build in aquaculture systems with very low to no water exchange. UV treatment is the final step in the waste treatment and this assures no residual ozone will reach fish production water. Waste water treatment is the only area where ozone is required or used in the salmon production facility.

Control and Monitoring

Hatchery

Table 13. Monitoring and automatic control for the Hatchery.

Factor	Monitored	Controlled
Water temperature egg hatching	X	X
Sump water level egg hatching	X	X
Dissolved oxygen	X	X
ORP and pH	X	X
Pump water flow	X	X
UV lamp operation	X	X
Sump water level first feeding tanks	X	X
Dissolved oxygen first feeding tanks	X	X
Water temp first feeding tanks	X	X
Biofilter valves and tank water level	X	X
Room air temperature	X	X
Room humidity	X	X

Nursery and Land Based Smolt Growing

Table 14. Monitoring and automatic control for the Nursery and Land Based Smolt.

Factor	Monitored	Controlled
Water temperature in each module	X	X
Room air temperature	X	X
Room humidity	X	X
Sump water level	X	X
Dissolved oxygen in each tank	X	X
Pump water flow	X	X
Biofilter valves and tank water level	X	X
ORP (used to regulate ozone) and pH	X	X
Ozone generation in waste treatment		X
UV lamp operation, waste treatment	X	X
Water levels in waste treatment	X	X
Dissolved oxygen waste treatment	X	X
Water temperature waste treatment	X	X
ORP & pH in waste treatment	X	X
Alkalinity	X	
Total suspended solids	X	
Nitrate	X	
Nitrite	X	
Hydrogen sulfide	X	
Aeration blowers waste treatment	X	X
Pumps in waste treatment	X	X

Capital Cost

The project capital costs are separated into two major categories. AquaMaof technology cost and all the civil works (site development, building, concrete, etc. costs). AquaMaof technology cost includes aquaculture design, equipment, installation, and commissioning. The site development cost in this proposal is an estimate and final costs will be determined only after the final design. This category includes site civil engineering, site excavation, fencing, roads, building, and all concrete structures (including fish tanks and water holding basins).

No.	Description	Unit Price USD	Qty	Total USD
1.	**Aquamaof scope (fixed price):**			
	I. – Smolt Hatchery	2,545,000	1	
	II – Salmon Smolt Nursery	8,747,000	1	
	III – Salmon Smolt Land Based	30,380,000	1	
2.	Subtotal			41,672,000
3.	**Buildings, Concrete, earth and all the civil works at Site Preparations (estimated only)**:			
	I. – Smolt Hatchery	892,000	1	
	II – Salmon Smolt Nursery	2,522,000	1	
	III – Salmon Smolt Land Based	10,985,000	1	
4.	Subtotal			14,399,000

5.	**Total Project (estimated)**			56,071,000

Site Layout and Design Concept Drawings

Introduction

The site is located with a down slope from the site entrance to the water front. The site plan is for the fish to move down from the hatchery to the nursery, to the land based smolt growing, and then to well boats for transporting to sea cages.

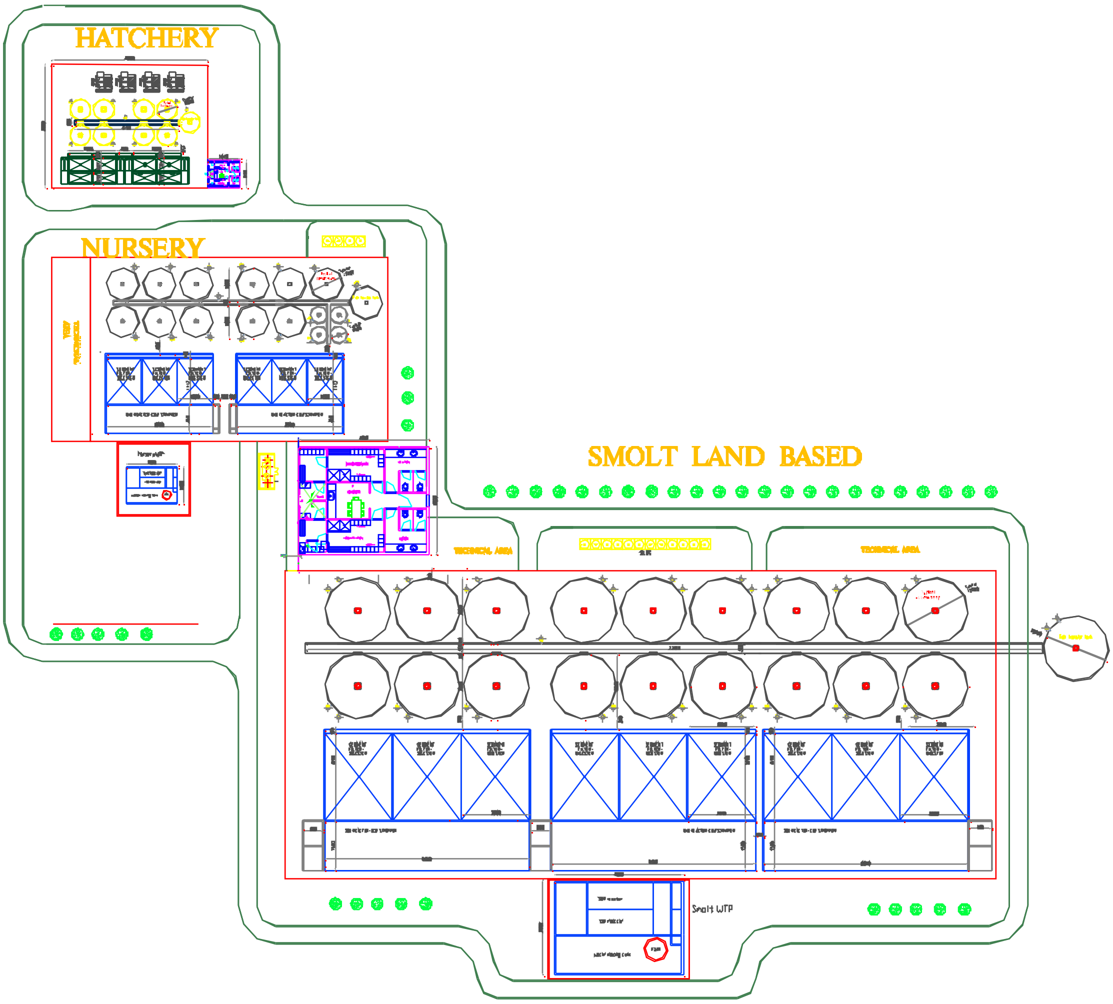


Figure 2 Layout of entire Facility

Hatchery

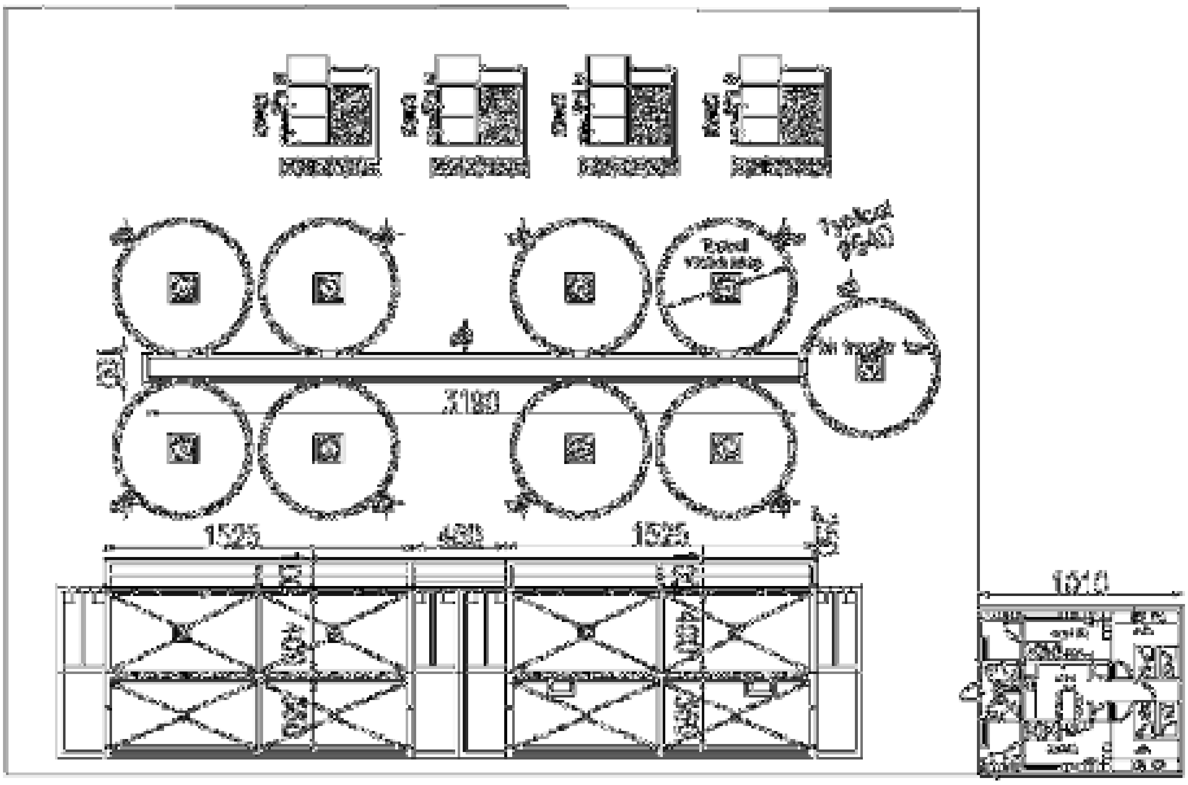


Figure 3 Hatchery layout

Nursery

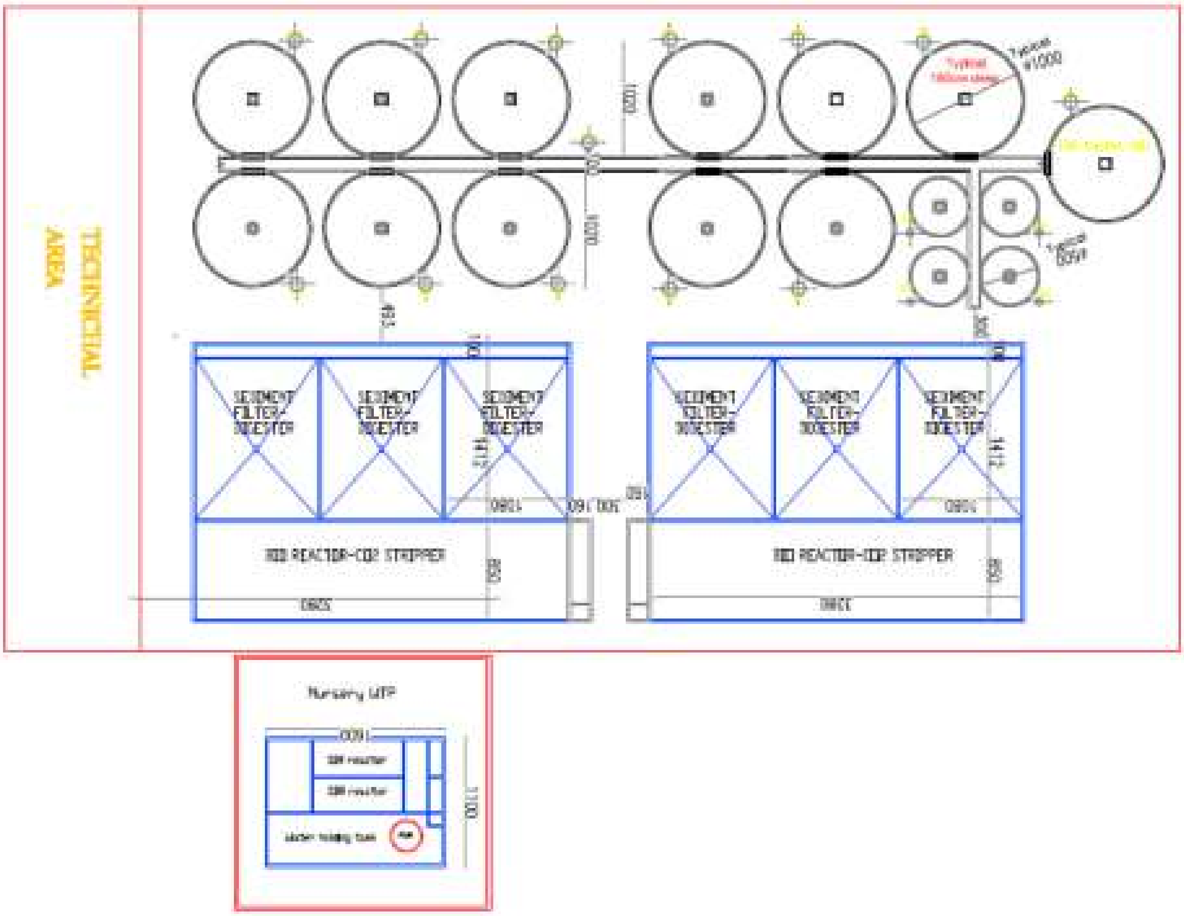


Figure 4 Nursery Layout

Land Based Smolt-Growing

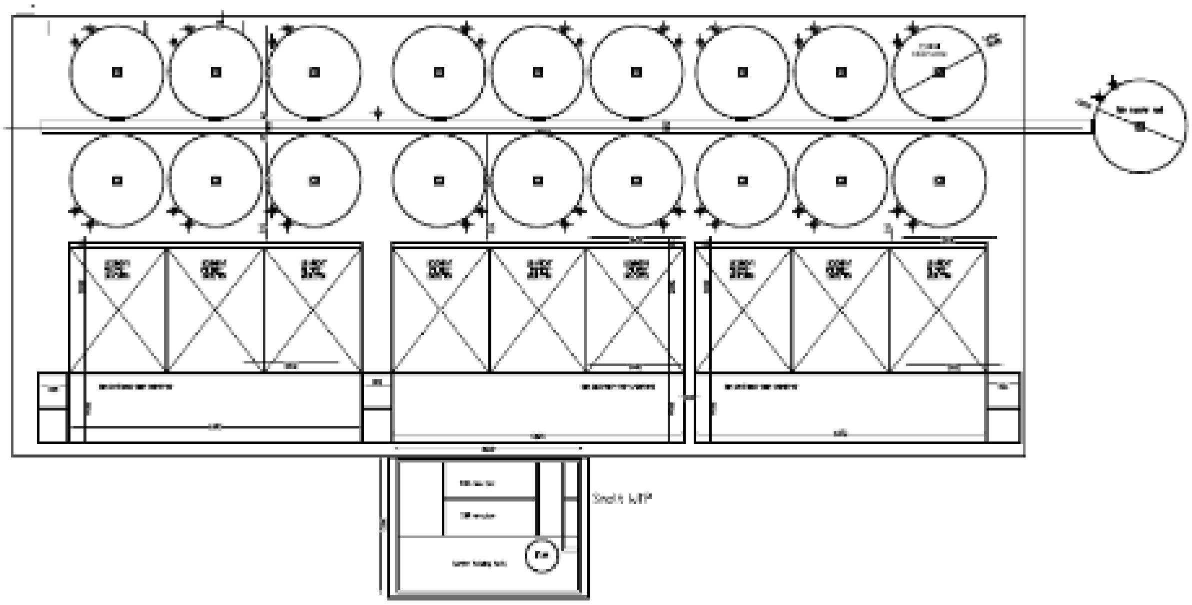
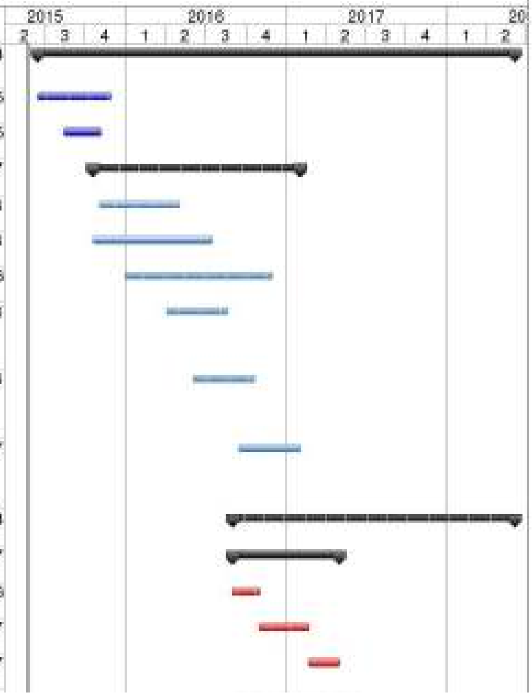


Figure 5 Smolt Layout

Design and Construction Schedule

Design, construction and growing schedule

[illegible]	Task Name	Start	Finish
1	**Smolt project**	**15/06/15**	**05/06/18**
2	Design Project	15/06/15	27/11/15
3	Project permits	14/08/15	05/11/15
4	**Project erection**	**19/10/15**	**01/02/17**
5	Civil works for the Hatchery	03/11/15	02/05/16
6	Civil works for the Nursery	19/10/15	15/07/16
7	Civil works for the land based	01/01/16	30/11/16
8	Installation works and equipments for the Hatchery	04/04/16	19/08/16
9	Installation works and equipments for the Nursery	03/06/16	20/10/16
10	Installation works and equipments for the Land based	15/09/16	01/02/17
11	**Growing**	**01/09/16**	**05/06/18**
12	**first batch**	**01/09/16**	**01/05/17**
13	first batch in the Hatchery	01/09/16	01/11/16
14	first batch in the Nursery	01/11/16	20/02/17
15	first batch in the land based	21/02/17	01/05/17



Appendix A-Equipment Specifications

Hatchery, Nursery, Land Based Smolt-Growing

Appendix A - Newfoundland Equipment predesign

Equipment specifications	building	number	size		Specs	Manufacture	Model
Vertical turbine pump	nursery	4	1,053 m3/hr	292.5 l/s	9.4 m	Flygt (Xylem)	P7035.180; 40KW, column diameter 550 mm
Vertical turbine pump	smolt	6	4,418 m3/hr	1,227 l/s	9.4 m	Flygt (Xylem)	P7065; 160KW, column diameter 800 mm
UV inline treatment	nursery	1	40 m3/hr	11.11 l/s	90 kJ/cm2	must remove ozone	Trojen - 06AS20
UV inline treatment	smolt	1	250 m3/hr	70 l/s	90 kJ/cm2	must remove ozone	Trojen - 18AL40
Oxygen generator	nursery	1	2,000 kg/day		3 bars	Adsorptech USA	E40-43
Oxygen generator	smolt	1	11,000 kg/day		3 bars	Adsorptech USA	E210-43
CO2 air blowers	hatchery	4	750 m3/hr	208.33 l/s	6 mm	ebmpapst	
CO2 air blowers	nursery	4	10,530 m3/hr	2,925 l/s	6 mm	ebmpapst	

CO_2 air blowers	smolt	6	44,180 m3/hr	12,272 l/s	6 mm	Megafan	
Ozone generator	nursery	1	200 g/h		2 bars	Wedeco (Xylem)	OCS-GSO 40 generator only
Ozone generator	smolt	1	1,250 g/h		2 bars	Wedeco (Xylem)	OCS-GSO 40 generator only
Fluidized Bed Reactor	nursery denitrification	1	20 m3/hr			Aquaneering	
Fluidized Bed Reactor	smolt denitrification	1	125 m3/hr			Aquaneering	

Equipment specifications	**building**	**number**	**size**		**head pressure**	**Manufacture**	**Model**
Electrical generator	hatchery	1	40 kW			caterpillar	
Electrical generator	nursery	1	250 kW			caterpillar	
Electrical generator	smolt	1	1500 kW			caterpillar	
Settler media	all	5507	36 inch			Brentwood	
Bio-filter media	all	20,533	CF-1200			Brentwood	
Control System	hatchery	1	Complete			Siemens + Nave	ET200S + Vuiniq

					Cohen	
Control System	nursery	1	Complete		Siemens + Nave Cohen	ET200S + Vuiniq
Control System	smolt	1	Complete		Siemens + Nave Cohen	S7-316 + ET200S + Vuiniq
Electrical technological cabinets	hatchery	1	Complete		Schneider Electric componnets	
Electrical technological cabinets	nursery	1	Complete		Schneider Electric componnets	
Electrical technological cabinets	smolt	1	Complete		Schneider Electric componnets	
ORP + PH	hatchery	4			Hach Lange	
ORP + PH for water re-use	nursery	3			Hach Lange	
ORP + PH for water re-use	smolt	3			Hach Lange	
ORP Sensor	nursery denitrification	5	(+2000 /-2000 mV)		Hach Lange	
ORP Sensor	smolt denitrification	5			Hach Lange	
Equipment	**building**	**number**	**size**	**head**	**Manufacture**	**Model**

specifications					**pressure**		
Oxygen and temperature	hatchery	12				Hach Lange	
Oxygen and temperature	nursery	15				Hach Lange	
Oxygen and temperature	smolt	18				Hach Lange	
Oxygen/temp water re-use	nursery	3				Hach Lange	
Oxygen/temp water re-use	smolt	3				Hach Lange	
Oxygen and temperature	nursery denitrification	4	0-20 ppm			Hach Lange	
Oxygen and temperature	smolt denitrification	4	0-20 ppm			Hach Lange	
Oxygen and temperature	nursery denitrification	4	0 - 70 ppm			Hach Lange	
Oxygen and temperature	smolt denitrification	4	0 - 70 ppm			Hach Lange	
Alkalinity Analyser	nursery denitrification	1	0 - 200 mg/l	0-2 bar		Hach Lange	
Alkalinity Analyser	smolt denitrification	1	0 - 200 mg/l	0-2 bar		Hach Lange	

TSS Sensor	nursery denitrification	1	0 - 15000 mg/litter			Partech	
TSS Sensor	smolt denitrification	1	0 - 15000 mg/litter			Partech	
NO3 - N sensor	nursery denitrification	1	0 - 1000 mg/litter			Hach Lange	
NO3 - N sensor	smolt denitrification	1	0 - 1000 mg/litter			Hach Lange	

Equipment specifications	**building**	**number**	**size**		**head pressure**	**Manufacture**	**Model**
NO2 sensor	nursery denitrification	1	0 - 50 mg/litter				
NO2 sensor	smolt denitrification	1	0 - 50 mg/litter				
Hydrogen sulfide (h2s) analyser	nursery denitrification	2	0.005 - 2.0 mg/litter			ATI	
Hydrogen sulfide (h2s) analyser	smolt denitrification	2	0.005 - 2.0 mg/litter			ATI	

Humidity & Temp Analysers	hatchery	2	10+50 Deg.C	0-100% rh		Rotronic	
	hatchery	1	-25+50 Deg.C	0-100% rh		Rotronic	
	nursery	1	10+50 Deg.C	0-100% rh		Rotronic	
	nursery	1	-25+50 Deg.C	0-100% rh		Rotronic	
	smolt	2	10+50 Deg.C	0-100% rh		Rotronic	
	smolt	1	-25+50 Deg.C	0-100% rh		Rotronic	
Oxygen & Ozone Impeller flowmeter	hatchery	24				Flowtech + Stubbe	
	nursery	48				Flowtech + Stubbe	
	smolt	95				Flowtech + Stubbe	

Equipment specifications	building	number	size		head pressure	Manufacture	Model
Level transmitter - Pressure	hatchery	1	0-6 / 0-10 m			Siemens	
	nursery	2	0-6 / 0-10 m			Siemens	
	smolt	3	0-6 / 0-10 m			Siemens	
Magnetic flowmeter	hatchery	1	0 - 200,000 kg/h , 8" Pipe			Siemens	
	nursery	1	0 - 200,000 kg/h , 12" Pipe			Siemens	
	smolt	2	0 - 200,000 kg/h , 12" Pipe			Siemens	
Pressure transmitter	hatchery	4				Siemens	
	nursery	6				Siemens	
	smolt	9				Siemens	
Temperature transmitter	hatchery	1	PT-100			Siemens	
	nursery	2	PT-100			Siemens	
	smolt	3	PT-100			Siemens	
CompHatch	hatchery	12				Alvestad	
Kube Hatch	hatchery	2				Alvestad	

Appendix B-Equipment Brochures and Data Sheets

All relevant datasheets are available to view & download from the following link:

https://www.dropbox.com/s/kk0u3gufwclujfw/Appendix%20B%20-%20Datasheets.pdf?dl=0

Appendix C-Company Profile

AQUA MAOF GROUP

Group Overview / May 2015

AQUA MAOF

THE WORLD'S MOST ADVANCED INDOOR AQUACULTURE FACILITIES

AQUA MAOF

INNOVATIVE
EXPERIENCED
PASSIONATE
TEAM

AQUA MAOF

DELIVERING SUSTAINABLE AND OPTIMAL RESULTS YEAR-ROUND

AQUA MAOF

GLOBAL PRESENCE: RUSSIA, POLAND, SLOVAKIA, ISRAEL, INDONESIA, CHINA AND THE US

AQUA MAOF

Comprehensive integrated aquaculture solutions for the entire fish production cycle, is the heart of Aqua Maof's expertise. Providing a complete package from business development concept, through system and production line, engineering design and set-up, operation and maintenance.

Aqua Maof establishes a truly integrated approach for business success. For more than 20 years, the company's large team of technology and aquaculture experts has been providing research and development, professional consulting and outsourcing services for aqua farming in over 50 locations around the world. Aqua Maof's total package approach is the key to its ongoing project management success.

To date, many client sites have become self-sufficient profit-making projects due to Aqua Maof's dedication to superior technology development, service and support.

AQUA MAOF

The Indoor Recirculating Aquaculture System, a land-based RAS, allows fish growers complete year round control over all growing conditions.

The advantage of a well-designed and well-executed Indoor Recirculating Aquaculture System cannot be underestimated. In areas where the amount of available water is low or for projects where the cost of warm or cold water is high, this model excels. Aqua Maof is the leader in Industrial RAS technology, equipment, and system set-up.

Gaining in popularity over the last 20 years, the rate of adoption in the aquaculture industry has been growing. Indoor RAS systems are flexible and energy efficient, and can be used as a tool in every phase of production from hatcheries and nurseries through the growing out phase.

AQUA MAOF

Aqua Maof provides a specific design for each project to attain optimum fish production economics. The modular equipment can be purchased as a basic equipment package with add-ons for monitoring and automatic feeding.
The Mini Indoor RAS is a perfect solution for utilizing existing facilities as well as nursery for fry and fingerling production.

Optimum water conditions, simplicity of design, and low energy consumption remain key features of Aqua Maof's technology. The specialized water treatment components are modular and the water treatment capacity can be adjusted to the specific requirements of each fish species and production volume. One pumping cycle provides water circulation, bio filtration, aeration or pure oxygen, degassing and solids removal.

This design uses "off-the-shelf" components from Aqua Maof for fast response in project development. These "off-the-shelf" components are of a standard size, however the number of each component is increased or decreased according to the requirements of each project.

Aqua Maof Aquaculture Technologies' extensive worldwide experience has resulted in the development of our acclaimed AOPS facilities. The modular engineering design is easily and effectively adapted to local requirements so as to reduce owner's initial cost as well as to ensure the highest fish output at the lowest operating cost on the market.

Aqua Maof Aquaculture Technologies' in-house team has all the know-how and hands-on experience to supply a comprehensive A-Z turn-key package starting from project concept through product marketing. Of course we can provide any part of the program under warranty to suit your particular situation if you do not need us to supply the complete facility.

We are a proven company that is capable of delivering the full range of services and equipment needed for implementing a successful project

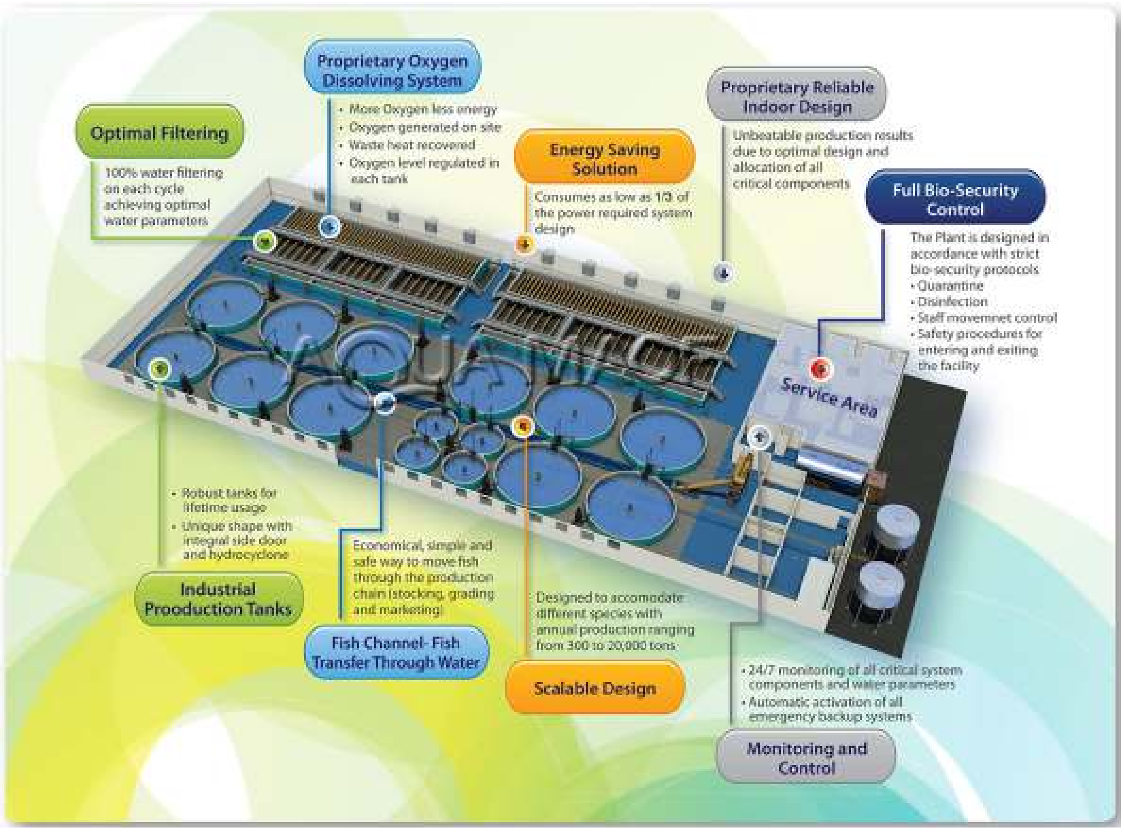
AQUA MAOF


AQUA MAOF
AQUACULTURE BUSINESSES
info@aquamaof.com

Appendix D-AquaMaof System Descriptions

View of aquaculture complex with offices, production, feed silos, and liquid oxygen tanks.

Interior view of an AquaMaof trout facility in Russia.



Components of the AquaMaof indoor aquaculture system.

Concrete fish production tanks with dimensions designed for the specific production capacity and stock management plan of each project. Interior walls are coated as required for each fish species.

AquaMaof oxygen dissolving system (ODS) showing duplicate water supply from the pipes on lower portion. The duplicate water supply pipes are connected separately to duplicate water pumps. The pipe extending to the top is for adding new water as required. Oxygenated water flows from the ODS through the tank sidewall. The pipe extending from the ODS over the tank sidewall is an overflow pipe.

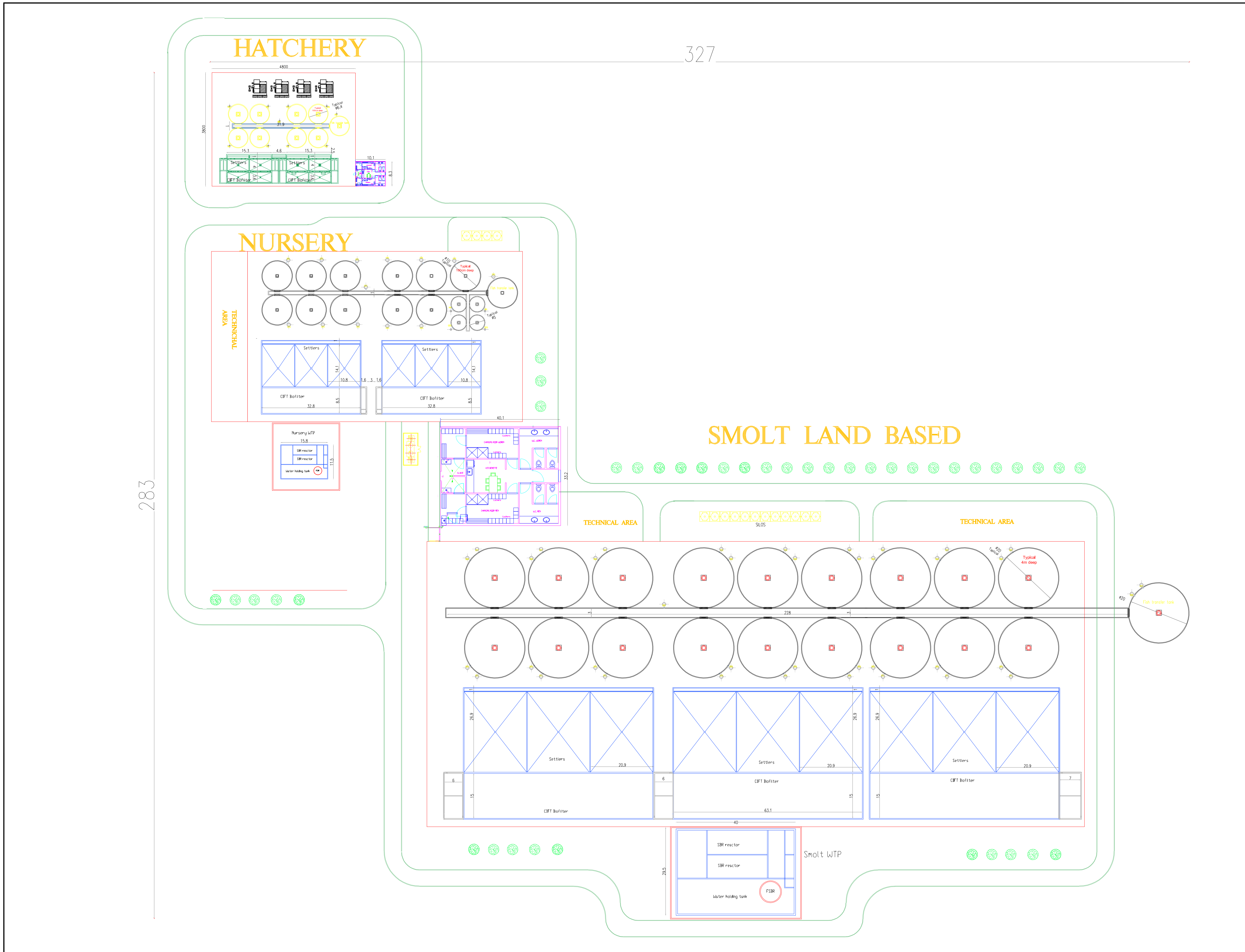
Example of water circulation pumps used in AquaMaof systems.

Water circulation pumps can be coated with ceramic coating for stability in seawater applications and also improving pumping efficiency.

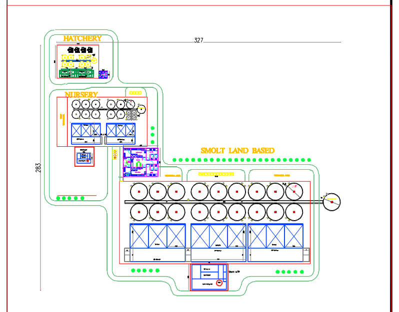
AquaMaof solid waste settler in operation. The pipes visible below the water surface are the water collection pipes distributing water to the biofilter spray nozzles. Water pressure for the spray nozzles is supplied by gravity flow.

Entrance to fish production hall, biosecurity planning and design are important for AquaMaof indoor aquaculture facilities.

Biofilter spray nozzles distributing water over media of the trickling filter in a trout production facility. Note the air blower for CO2 degassing at middle left side of biofilter. Multiple blower fans supply water to an air space below the media stack. Technicians adjusting the controls for water flow to the biofilter nozzles. View of the tube settler on the far right that supplies water to the nozzles with gravity flow.



KEY PLAN



GENERAL NOTES

A. CONTRACTOR SHALL FIELD VERIFY ALL EQUIP. LOCATIONS, ELEVATIONS AND DIMENSIONS IT IS THE CONTRACTOR'S RESPOSIBILITY TO NOTIFY OF AN MISSMATCH TO THE PLAN

B. ALL DIMENSIONS ARE IN METERS, UNLESS OTHERWISE NOTED.

C. ALL LEVELS ARE IN METERS, UNLESS OTHERWISE NOTED.

REV. NO.	REVISION DESCRIPTION	APPROVED	DATE	BY
V2	PRILIMINAARY-FOE APPROVAL	NEDER	2015.04.26	AQUAMAOF
P0	PRILIMINAARY-FOE APPROVAL	YOAV	2014.02.27	AQUAMAOF

SIGNATURE

AQUA MAOF AQUACULTURE BUSINESSES

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APPROVALS		DATE
DRAWN	URIAH	26.04.2015
CHECKED	NEDER	26.04.2015
CROSSCHECK		
SAFETY		
PLANNING		
ENGINEERING		
APPROVED		
EQT CODE		

AQUAMAOF NEWFOUNDLAND ARCHITECTURAL CONCEPTUAL LAYOUT

WORK ID NO.	FILE NAME	DRAWING NO.
	165-pl-010	165-PL-010-VER2

SHEET	PLOT SCALE	DRAWING SCALE	SHEET OF
	1:1	N/A	