Scully Creek Sockeye Egg Incubation Assessment 2008-2009

Prepared For

Fisheries and Oceans Canada
North Coast Resource Restoration Division

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By

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EXECUTIVE SUMMARY

The middle channel of Schulbuckhand (alias Scully) Creek, downstream of Highway 37, was the focus of a sockeye spawning habitat restoration project which saw the addition of approximately 750 square metres of spawning gravel in July 2008. This project was part of a larger ongoing habitat project in the Lakelse Lake Watershed in efforts to reverse the declining trend of the sockeye salmon population.

In order to determine the effectiveness of the July gravel enhancement project, a follow-up monitoring program was initiated in October of 2008. Monitoring focussed on the incubation success of sockeye salmon eggs at 4 sites; two were sites located on the recently constructed spawning gravel platforms in Scully Creek mid channel, another in a natural spawning site in mid Scully (control), and a fourth site was located in a natural spawning site in South Scully Creek. At each site, 8 Jordan-Scotty incubation cassettes containing 100 eyed sockeye eggs, obtained from Snootli Hatchery, were buried in the streambed. Incubation success was assessed by removing and examining 4 cassettes from each site both at the ‘hatch’ stage and at the ‘emergence’ (button-up) stage.

Surface and intergravel water temperature were continuously recorded at the two Scully Creek channels adjacent to the incubation sites using Onset Tidbit temperature data loggers. The loggers were downloaded in December to provide an estimate of egg development (Accumulated Temperature Units or ATU’s) in order to schedule incubation assessments. Other environmental variables were monitored periodically throughout the incubation study. These variables included depth and velocity, intergravel and water column dissolved oxygen (DO), conductivity, and pH. Substrate composition of the screened spawning gravel was assessed by washed sieve analysis before placement in July 2008, and again at the end of the incubation period in April 2009. Samples from the two natural spawning sites were analysed in April only. Discharge data for Scully Mid and South channels was provided by Ministry of Environment as part of the “Lakelse Suspended Sediment Monitoring Program” (Leggat 2009a).

Discharge for Scully Creek mid channel during the incubation period (October 2008 – April 2009) ranged from 0.03 m^3/s to 4.35 m^3/s. The Scully Creek mid channel hydrograph shows that two high flow events occurred soon after the installation of the incubation cassettes on Oct. 15, 2008. Substrate assessments conducted before and after the incubation period showed the total percentage of grains finer than 9.5 mm at Site 2 and 3 was 1.7 % and 0.85 % respectively in July 2008, compared to 20 % and 34 % respectively in April 2009. Site 4 in Scully mid channel had the greatest amount of fine particles < 9.5 mm (68 %) followed by Site 1 in Scully south channel (42 %).

Environmental variables were monitored during four visits to the incubation sites. Average intergravel DO ranged from 6.5 to 11.7 mg/l for the 4 sites throughout the incubation period, with the lowest DO observed at Site 4.

Average incubation survival ranged from 0 to 45% at the 4 sites for the eyed egg-to-hatch stage, and from 0 to 12 % for the eyed egg-to-fry stage. There was no significant difference among sites for the eyed egg-to-fry stage, however survival at Site 1 was significantly different than at Site 2 for the eyed egg-to-hatch stage. Analysis of the data did not attempt to determine any relationships between survival and either intergravel DO or percent fines. Hydrogen sulphide (H_2S), a highly soluble and toxic gas, was detected by odour at some sites during assessment at the hatch stage. Our ability to detect this gas may be indicative of levels high enough to be lethal to developing embryos. Further water sample collection and analysis for the presence of H_2S may provide more concrete evidence of the relationship this variable may have on the incubation survival of salmonid eggs at the restored spawning habitat in mid Scully creek.

CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACKNOWLEDGEMENTS

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1. INTRODUCTION

In July 2008, Fisheries and Oceans Canada (DFO) North Coast Resource Restoration Unit completed a spawning habitat enhancement project in the Mid channel of Schulbuckhand (alias Scully) Creek on the Mount Layton Hot Springs property at Lakelse Lake. This project was part of a larger ongoing habitat project in the Lakelse Lake Watershed in efforts to reverse the declining trend of the sockeye salmon population. The spawning enhancement project included the addition of screened gravel in 4 discrete locations along a 400 m stretch of the Mid Scully Creek channel, for a total of approximately 750 m^2 of spawning habitat area. A sockeye incubation study was implemented in October 2008 in order to determine the effectiveness of this spawning habitat enhancement project. Information gained from this monitoring program will be useful for developing future habitat restoration options in the Lakelse Watershed.

2. STUDY AREA

Scully Creek is located near the city of Terrace, on the southeast side of Lakelse Lake. It drains a watershed area of approximately 29 km^2. Much of the drainage is within a large low gradient alluvial fan containing many hot springs on the lake floodplain. As a result of past flood events, Scully Creek enters Lakelse Lake though three branches. The historic main South channel is now mainly groundwater fed, while the Middle and North channels receive 55% and 45% respectively of the surface flow (Leggat 2009a). The latter two channels flow through a large wetland complex, much of which has been drained for agricultural development downstream of Highway 37 (Figure 1; Appendix A).

3. METHODS

3.1 Site Selection

Three sites were selected in Scully Creek mid channel downstream of Highway 37 and a fourth site in Scully Creek south channel just upstream of the Highway 37 culvert. Two of the three sites in Scully Creek mid channel were located on recently constructed spawning gravel platforms, while the third site in Scully mid, and the fourth site in Scully south channel were located in unenhanced 'natural' spawning gravel as control sites (the latter site is utilized frequently by sockeye adults). Locations of the four incubation sites are described in Table 1 and illustrated in Figure 1.

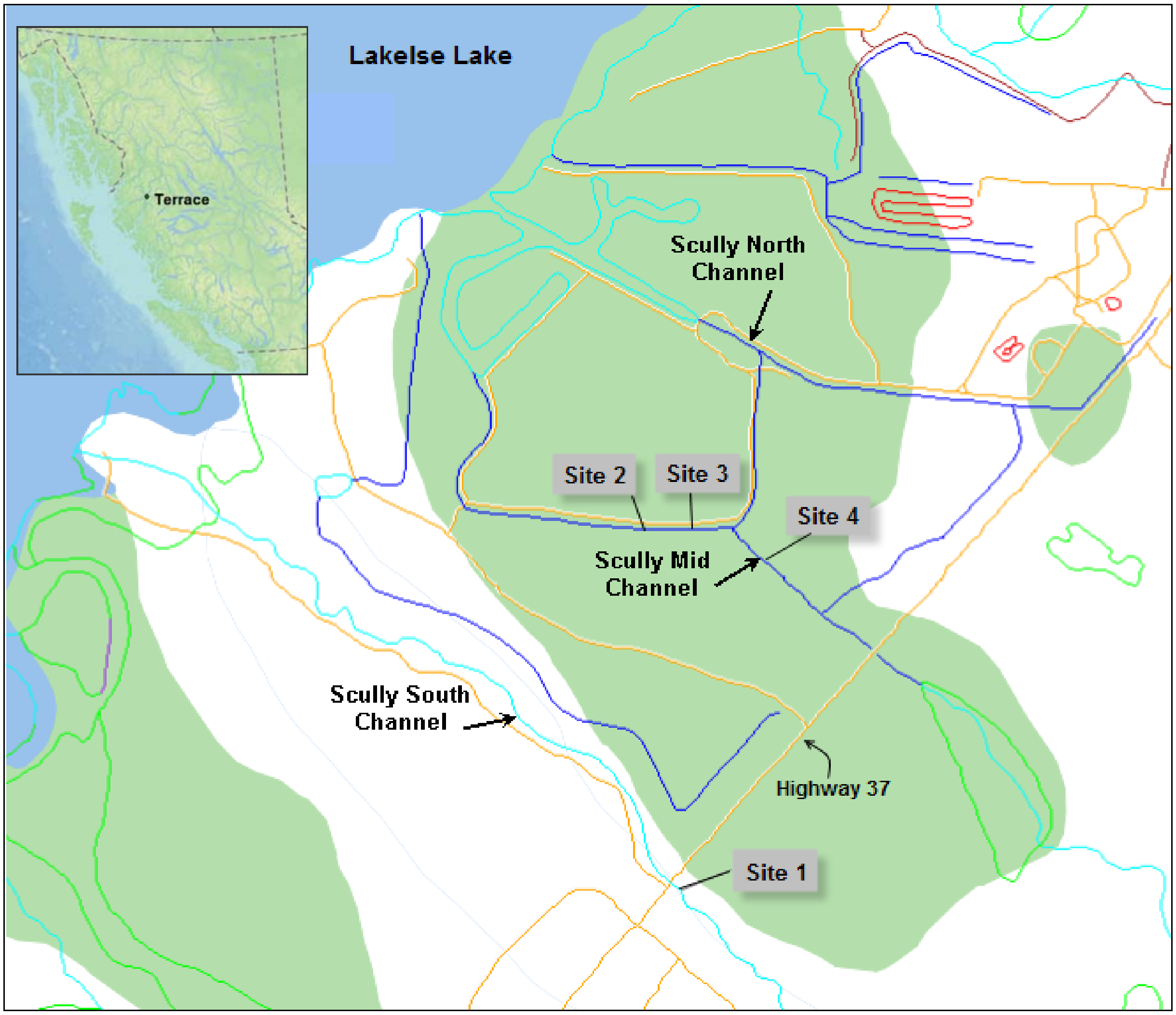


Figure 1. Scully Creek channels downstream of Highway 37.

Table 1. Incubation sites in Scully Creek Mid and South channels.

Incubation Site	Location	# of Incubators	Installation Description
Site 1	Scully Creek South Channel (groundwater)	8	Due to the small area of suitable spawning gravel, cassettes were buried in pairs, ~12 inches apart, in 4 locations
Site 2	Scully Creek Mid Channel Spawning Platform #2	8	Cassettes were buried along two transects across the spawning pad, 4 in each transect
Site 3	Scully Creek Mid Channel Spawning Platform #3	8	Cassettes were buried randomly within the spawning pad, 4 located in optimum locations, and 4 in marginal locations
Site 4	Scully Creek Mid Channel Unenhanced (Control)	8	Cassettes were buried along two transects across the channel, 4 in each transect

3.2 Installation and Monitoring of Incubators

On October 15, 2008, eyed sockeye salmon eggs from Snootli Hatchery (Bella Coola) were transported to the Scully Creek project site. Approximately 400 eggs each from eight females were packed separately in specially designed egg transport containers (Appendix B - Photo 1) and shipped to Terrace by charter plane in a cooler with ice. Once at the Scully site, all eggs were pooled in a basin and then loaded into the lower half of Jordan-Scotty cassette incubators at 100 eggs per cassette (Appendix B - Photo 2). Eight incubation cassettes were buried at each incubation site. Each cassette location was characterized as either optimum or marginal quality based on visual appearance (i.e. optimum areas had higher velocities, and/or less fines than marginal areas). Incubators were buried in the stream bed at a depth of 20-30 cm. At two of the four incubation sites, cassettes were placed along two transects (4 in each transect) across the channel while at the other two incubation sites, cassette locations were more randomly distributed within the site. Incubators were flagged with an 18” piece of ¼“ poly rope and a length of flagging tape to identify locations. Cassettes were also identified from a marker on the bank in case flagging was lost or buried.

A control group of eggs remained at Snootli Hatchery. The primary purpose of this group was to demonstrate that there were no fertilization or survival issues with the batch of eggs used in the study when incubated in an ideal environment. The remaining eggs from each of the females used in the study group were incubated separately at the hatchery and survival monitored to the hatch and fry (ponding) stages.

Assessment of incubation success was checked during two stages: 12 weeks after installation at the hatching stage; and 25 weeks after installation at the fry/emergence stage. The incubators used in this study (Jordan-Scotty incubators) have blocked escape holes which permits assessment to the fry stage. For each developmental stage inspection, four cassettes from each incubation site were removed and assessed. The contents of the incubator were emptied into a shallow basin and the number of dead and live eggs/alevins and fry were enumerated. Cassettes were not replaced in the gravel after assessment due to the amount of disturbance that would be required to excavate and replant the incubators. This disturbance could adversely affect the embryos in the cassette, as well as alter the intergravel conditions of flow, permeability and dissolved oxygen delivery within the ‘egg pocket’ or the surrounding environment of other nearby cassettes, thereby skewing results for the final stage of development. Live eggs and alevins were buried in an artificial redd excavated in the streambed utilizing a 2” PVC pipe.

3.3 Environmental Monitoring

Temperature

Onset Tidbit® v2 temperature data loggers were used to continuously record intergravel and water column temperature at each of the Scully Creek channels (Scully mid channel and Scully south channel) for the duration of the study. At Scully mid, the two temperature loggers were located just downstream of Incubation Site 4, while at Scully Creek south, one Tidbit® was buried in proximity to the incubators, while the second was located on the downstream side of the Highway 37 culvert. The data loggers were downloaded in December to calculate the Accumulated Thermal Units (ATUs; daily mean temperature multiplied by the number of days of incubation) which was used to estimate the rate of development of eggs and schedule the incubator checks during the study.

Water Column and Intergravel Parameters

Water column and intergravel water quality parameters were assessed during four environmental monitoring visits to the 4 incubation sites – December 2, 2008, January 7/8, March 12, and April 7, 2009.

Collection of intergravel water samples

To monitor environmental conditions in the gravel, three mini-piezometers were installed at each incubation site. Piezometers were constructed of a 0.6 m long section of 15 mm (inner diameter) polyvinylchloride (PVC) pipe with a four 8 mm diameter holes drilled on each side in the lower 100 mm (4 inches) of the pipe. The end of the pipe was plugged and fitted with an anchor (drywall) that would help maintain its position in the gravel. The piezometers were planted with the permeable openings at approximately 0.25m depth in the undisturbed gravel, to compare with conditions in the water column. The top of the piezometer was capped to prevent surface water entry into the pipe. A hand pump was used to extract water from the piezometer during sampling.

For the last two monitoring events, water samples were extracted from the gravel using a metal syringe apparatus. The syringe (narrow insertion end) is approximately 30 cm long and contains small perforations approximately 10 cm from the tip. A water sample from 20-30 cm below the streambed was extracted from the intergravel environment and collected in the larger chamber by pulling up on the plunger (Appendix B - Photo 3). The water sample was then extruded into a graduated cylinder for measurement of water quality parameters.

Dissolved Oxygen (DO) – intergravel dissolved oxygen (in mg/L and percent saturation) was measured at each Piezometer location (3 per incubation site) and water column DO was measured from one representative location at each incubation site using an OxyGuard Handy Polaris oxygen meter. The meter was calibrated in air in the field as per the meter's instructions prior to each monitoring visit.

Conductivity — intergravel and water column specific conductivity ($\mu S \cdot cm^{-1}$) was measured at each Piezometer location (3 per incubation site) and from one representative location at each incubation site respectively, using YSI Pro Multi-Parameter Water Quality Meter.

pH — intergravel and water column pH was measured at each Piezometer location (3 per incubation site) and from one representative location at each incubation site respectively, using a YSI 63 multi-meter (first two monitoring visits) and an Oakton ® waterproof pHTestr (last two monitoring visits).

Depth and Velocity — Water column depths and velocities were measured at the same location at each cassette burial site. This location was identified as where the poly rope attached to the cassette incubator exited the gravel. Velocity was measured with a Swoffer® Model 2100 propeller type flow meter mounted to a 1.5 m top-setting rod. Readings were taken at 0.6 of the depth with the meter set to display a 20-second average. Depth was measured using the graduations on the top-setting rod.

Substrate Composition

The grading limits for the screened spawning gravel were to meet the specifications outlined in Table 2. Prior to placement in Mid Scully Creek, samples of the gravel were sent to a geotechnical testing laboratory for washed sieve analysis, to ensure the grading limits were within the requested specifications. The test results would also be used as a baseline to assess the accumulation of fines in the gravel and its impacts on the survival of salmon embryos.

Following the completion of the incubation study in April 2009, the placed spawning gravel in Mid Scully Creek was sampled again, as were the two “natural” spawning sites in Mid and South Scully Creek. Samples were collected using a freeze core sampler (Devcic 2009) and sent to the same geotechnical testing laboratory as the baseline sample for analysis (see Appendix D for analysis results from the geotechnical lab).

Table 2. Grading limits for the screened spawning gravel for the Scully Creek Spawning Habitat Enhancement Project.

Sieve Size (Square Opening)	Total Passing Sieve (Percent by Weight)
75mm (3 in)	100%
50mm (2 in)	75% - 85%
38mm (1 ½ in)	50% - 75%
25mm (1 in)	30% - 50%
20mm (3/4 in)	10% - 30%
12mm (1/2 in)	0% - 10%

4. RESULTS

4.1 Environmental Monitoring Results

Stream Discharge

Stream discharge rating curves were developed for Scully Creek mid channel (and other Lakelse Lake tributaries) as part of the "Lakelse Suspended Sediment Monitoring Program" (Leggat 2009a). The rating curve was used to generate a hydrograph for Scully Creek Mid channel (Figure 2) for the 'snow free period' of 2008, from hourly water level data collected with a WDP pressure transducer (barometrically corrected); Leggat 2009a). Maximum discharge in Scully Mid for the 2008 'snow free' period peaked at 4.1 m^3/s on October 22, 2008 immediately following installation of the incubation cassettes. Discharge data for the remainder of the incubation period, (referred herein as 'winter flows') in Scully mid channel, from Nov 2008 to April 2009, is provided in Figure 3. This hydrograph shows a second high flow event of similar magnitude occurring in Scully mid channel on Nov 30/Dec 1, 2008. These two events were likely responsible for the scouring of cassettes and piezometers and deposition of sediment at some cassette locations observed at Sites 2 ands 3.

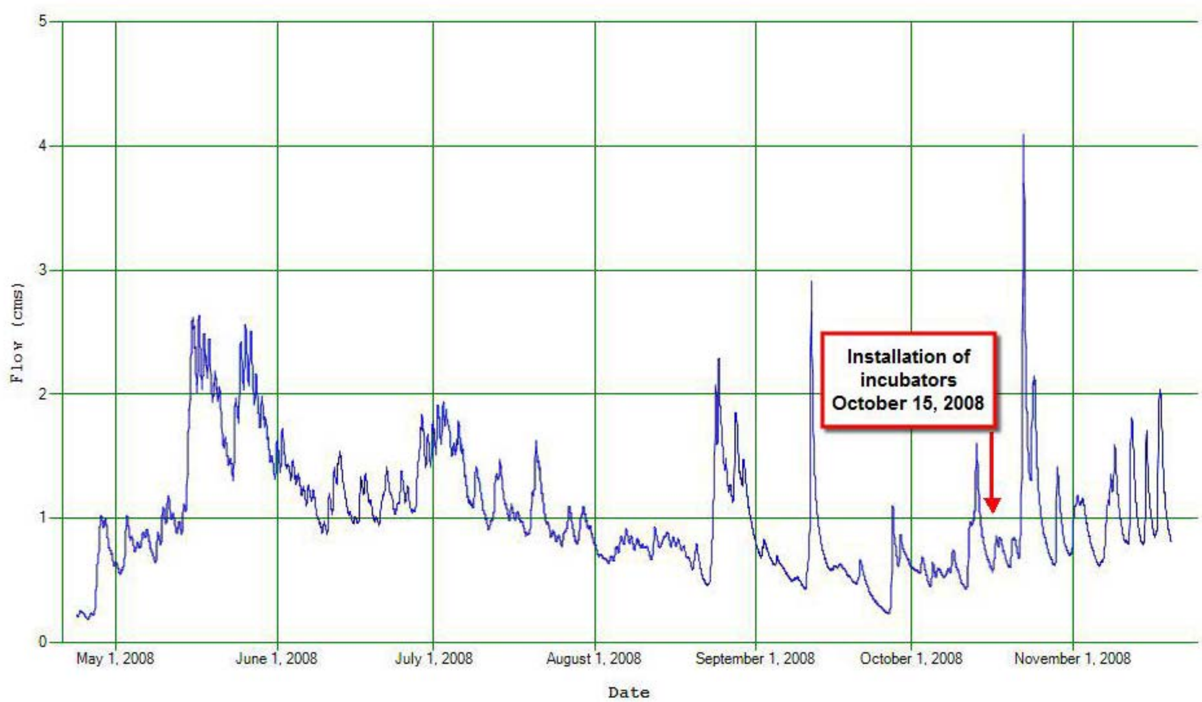


Figure 2. Scully Mid hydrograph: 2008 snow free period April 24 to November 19 (from Leggat 2009a).

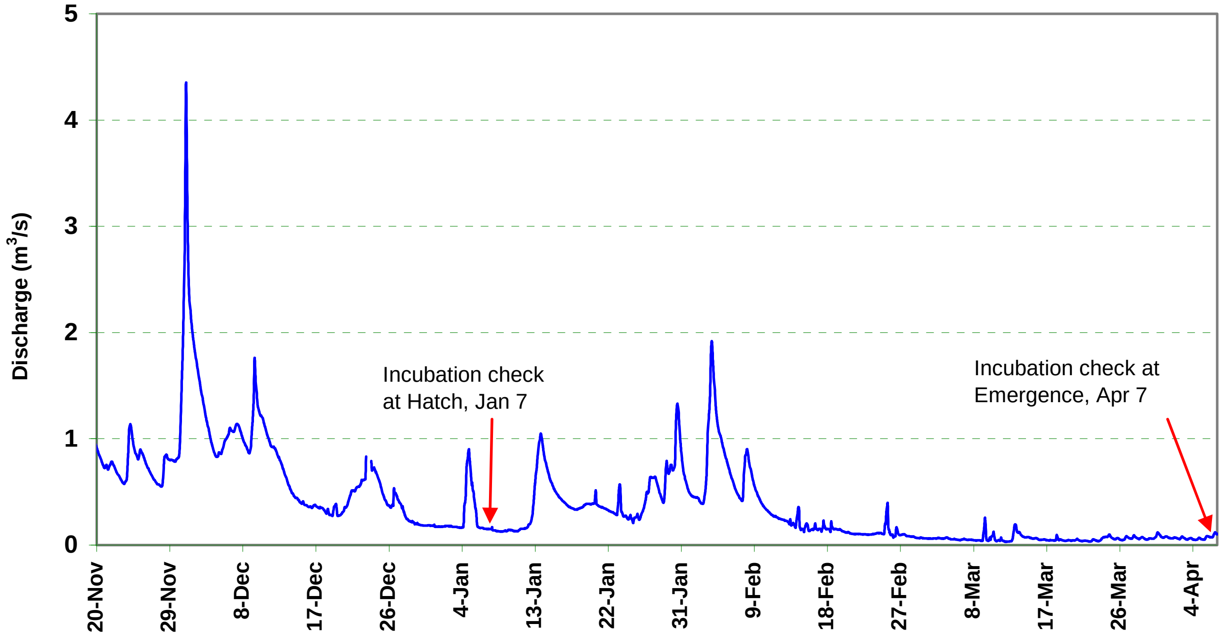


Figure 3. Scully Mid channel hydrograph for the period November 2008 - April 2009 generated from hourly water level data and rating curve calculated in Leggat 2009a.

Table 3 provides a summary of the mean, maximum and minimum discharges for Scully Mid and South channels (2008 snow free period) and for the winter period (Nov 2008 - Apr 2009) for Scully mid channel. In comparison, flows in Scully South channel were much less and the magnitude of the flood flows were greatly diminished. For the last two months of the incubation period, mean winter flow in Scully mid channel was less than 0.2 m^3/s which was the minimum flow recorded during the snow free period.

Table 3. Minimum, maximum and mean discharge for Scully mid and south channels for the snow free period (from Leggat 2009a), and for the remainder of the incubation period (Scully Mid only).

	Scully Mid	Scully South	Scully Mid Nov 20 - Apr 7
Min (m^3/s)	0.2	0.2	0.03
Max (m^3/s)	4.1	0.8	4.35
Mean (m^3/s)	1.0	0.3	0.40

Substrate Assessments

The cumulative particle size distribution for the 4 incubation sites prior to (July 2008) and immediately following (April 2009) the incubation monitoring period are shown in Figure 4. For Sites 1 and 4, gravel analyses were completed in April 2009 only. Analysis of the spawning gravel shows an increase in the amount of fines at the two spawning pads (Sites 2 and 3), during the incubation period.

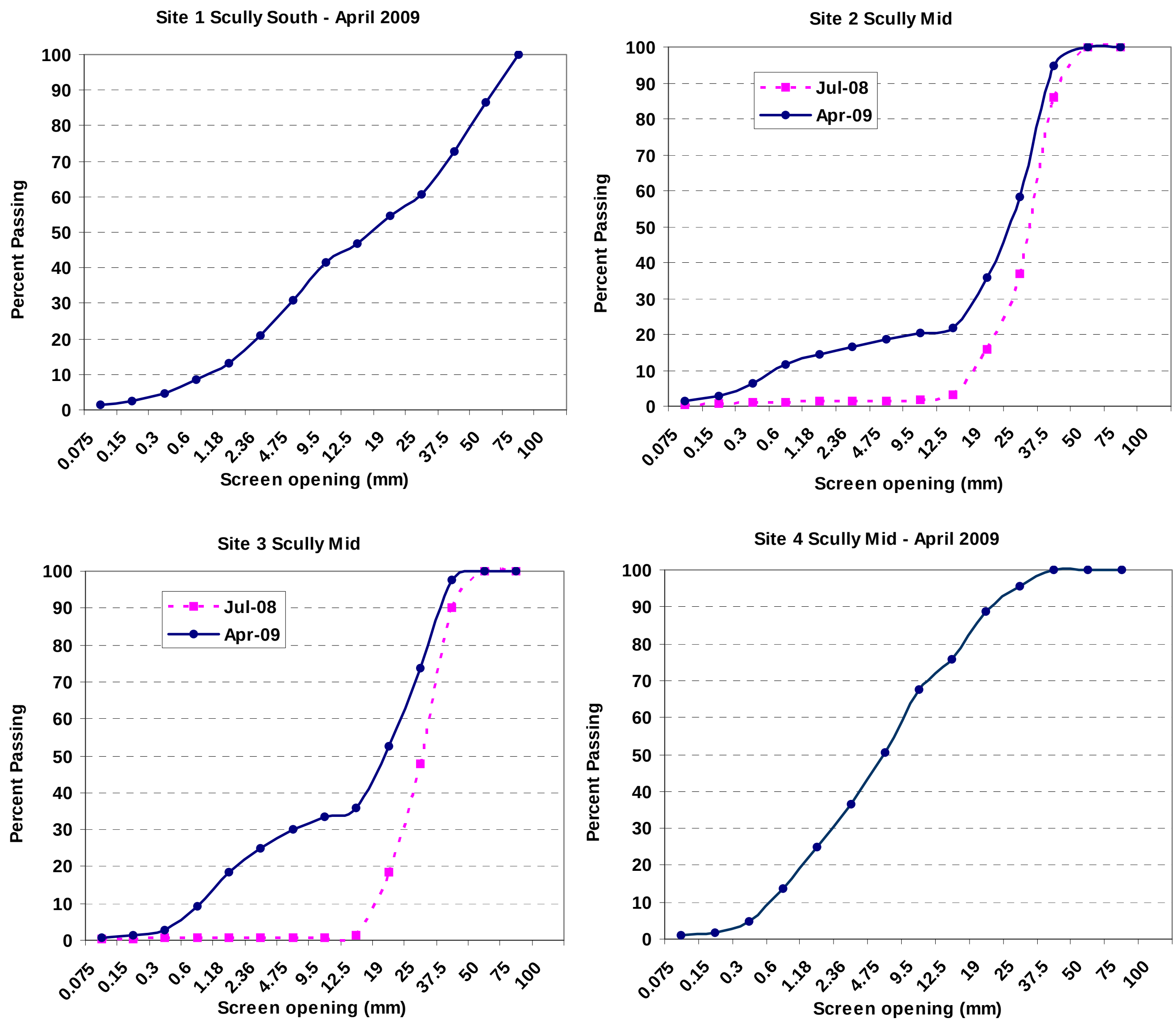


Figure 4. Cumulative particle size distribution for the 4 incubation sites from samples collected before the incubation study (July 2008) and after (April 2009).

Site 1 had widest range of particle sizes sampled (0.075 – 75 mm) while Sites 2 and 3 sampled in July 2008 had the narrowest range (12.5 – 50 mm) as would be expected for screened and graded spawning gravel. Total percentage of grains finer than 9.5 mm at Site 2 and 3 was < 2% and <1% respectively in July 2008. This amount increased substantially over the incubation period to 20% and 34% respectively in April 2009 (Figure 4; Appendix B - Photo 7 & 8)

Various descriptors of streambed composition at each incubation site are provided in Table 4. The median particle diameter (D_{50}), the 16th percentile (D_{16}) and the 84th percentile (D_{84}) particle sizes (the sizes at which 16% and 84% of the sample, respectively, are finer) are commonly used to describe streambed composition, and to facilitate comparison between samples, or in this case, between the sites and sampling dates. An alternative measure is the geometric mean Dg = $(D_{84}*D_{16})^{0.5}$ which describes the central tendancy of the distribution, but is typically less than the D_{50} because gravel size distribution tends to be negatively skewed (i.e. the distribution tail extends into the smaller particle sizes; Kondolf 1988). The percentage of fines less than 0.85 mm and less than 6.4 mm are provided as an appraisal of the quality of the spawning gravel for incubation and emergence.

Spawning gravel containing high levels of fines has been demonstrated to adversely affect the survival of salmonid eggs and alevins (Chapman 1988). As fine sediments infill the interstitial spaces within the redd, permeability decreases thereby reducing the delivery of oxygenated water to the embryos and removal of wastes, and causing entombment of alevins. Several studies suggest that substrates should not contain more than 12-14% of fine sediments smaller than 0.85 mm in diameter for successful incubation (Kondolf 2000). For emergence, the upper threshold of the fine sediment sizes affecting emergence is more variable, and particle sizes of 3 mm, 6.35 mm and 9.52 mm are commonly reported in the literature (CCME 1999). Generally, less than 28-30% of gravels should be smaller than 6.35 mm in diameter (MOE 1998, CCME 1999). Based on these guidelines, our results of substrate composition analysed in April 2009 suggest that the percent fines content at all sites could have reduced incubation success.

Table 4. Summary of particle size descriptors (mm) based on averaged sieve analysis data for the 4 incubation sites.

Date	Site	Median Diameter (D_{50})	Upper - 84th percentile (D_{84})	Lower - 16th percentile (D_{16})	Geometric Mean (Dg)	Percentage of grains < 0.85 mm	Percentage of grains < 6.40 mm
Apr-09	Site 1	16	47	2	9.7	11	35
Jul-08	Site 2	28	36.5	19	26.3	1	1.5
Apr-09	Site 2	22.5	33	2	8.1	13	19
Jul-08	Site 3	26	35	18	25.1	1	1
Apr-09	Site 3	18	29.5	1	5.4	14	31
Apr-09	Site 4	4.7	16.5	0.8	3.6	19	58

Intergravel and Water Column Temperatures

Hourly intergravel water temperatures during the study period are shown for Scully South channel, and for the 2009 portion of the study only for Scully mid channel in Figure 5. Data from both the surface and intergravel water level recorders are illustrated; however the intergravel recorder at Scully mid channel became buried by snow and ice during the winter. The sub zero temperatures recorded by this logger for much of the winter may have been due to the influence of the ice shelf, or a malfunctioning of the logger. Spot measurements of intergravel temperature taken with the Temp function on the dissolved oxygen meter, on the last monitoring visit in April recorded values of 4.4 - 5.9 ^{o}C in Scully mid channel. However, data downloaded from the recovered buried temperature logger recorded temperatures near 0 ^{o}C giving doubt to the accuracy of this data. The temperature logger may have been damaged over the winter. Water column temperature data, therefore, was used to calculate the ATUs for each developmental stage assessed during the study at the two Scully Creek channels (Table 5). Due to the slight differences in surface versus intergravel temperatures recorded by the loggers, and the need to extrapolate data through December due to some missing data, the calculated ATUs are approximate. Surface temperatures in Scully mid channel were cooler than in Scully south channel, thus egg development was slower.

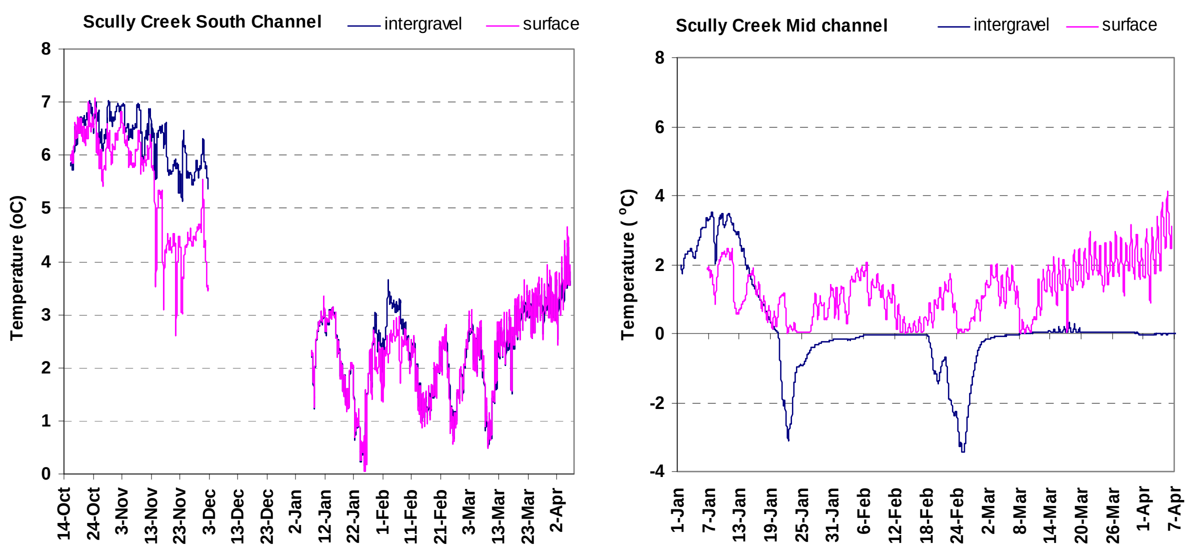


Figure 5. Comparison of hourly intergravel and water column (surface) temperatures at Scully South Channel for the duration of the incubation study, and at Scully Mid channel for the period Jan – April 2009.

Table 5. Calculated ATUs for each development stage assessed at incubation sites in the two channels of Scully Creek (South and Middle) using surface temperature data. ATUs for eyed stage provided by Snootli Hatchery**.**

	ATUs at Eyed Stage (Installation) Oct 15	ATUs at Hatch Jan 7 (approx)	ATUs for period Jan 6 - Apr 6	ATUs at Fry Stage (final check) Apr 7
Scully South (surface)	357	751	205.97	956.97
Scully Mid (surface)	357	~ 675	111.36	786.36
Lakelse Sockeye range from Snootli Hatchery	280 - 310	610 - 670	-	1050 - 1150

Water Column and Intergravel Water Quality

Environmental monitoring was conducted during four visits to the sites during the incubation period. During the first two visits (Dec and Jan) collection of intergravel water samples from the piezometers proved to be difficult. In some cases, the amount of water extracted from the piezometer was insufficient for measuring with the DO or conductivity meters. We suspect the small water samples from the piezometers was due to the infiltration of sand and fines into the lower section of the piezometer through the perforations, and the poor hyporheic exchange. Other times, water inside the piezometer had frozen making sample extraction impossible. Several of the piezometers had shifted during previous high flow events and were no longer vertical, and one piezometer from Site 3 was lost (scoured). In order to try and collect some intergravel data for the remainder of the study period, a “syringe-type” sampling apparatus was used on the final two monitoring events (March and April). Though this method also has some issues with data quality, it provided some comparative estimates of intergravel environmental conditions at the 4 sites. One concern with this method is the risk that intergravel measurements may be overestimated due to entrainment of surface water down the insertion point of the syringe in the gravel (Guimond and Burt 2007). However, it at least provides a rough estimate of intergravel DO conditions and enables a comparison among sites.

Results for water column and intergravel dissolved oxygen, conductivity and pH are summarized in Table 6. Values are averaged for each site over the study period using both methods of sample collection. Site 4 had the lowest average intergravel DO value overall, however both of the enhanced spawning gravel sites (Site 2 and 3) also had minimum DO values at or below the instantaneous minimum oxygen criteria level of 6 mg/l (MOE 1998).

Results for water column depth and velocity over the individual incubators (averaged for each site), measured immediately after installation (Oct 16, 2008) are summarized in Table 7.

Table 6. Average and range for intergravel and water column parameters: dissolved oxygen (DO), specific conductivity and pH.

	Water Column DO (mg/l)			Water Column DO (%)			Intergravel DO (mg/l)			Intergravel DO (%)		
	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Site 1	12.46	12	13.2	92.2	87.6	96	9.05	1.3	12.3	67.27	9.7	96.8
Site 2	13.19	12.2	13.8	96.1	84.6	103	11.73	6	13.7	88.64	47.4	106.6
Site 3	13.52	13.2	14.5	97.7	91.5	102	10.20	3.5	14.8	77.27	28.5	106
Site 4	13.39	12.8	14.3	96.5	88.5	101	6.52	2.7	10.6	46.47	21.2	74

	Water Column Specific Conductivity (µS•cm-1)			Intergravel Specific Conductivity (µS•cm^{-1})			Water Column pH			Intergravel pH		
	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max	Avg	Min	Max
Site 1	58.07	54.5	60.3	80.15	59.2	126.8	6.8	5.9	8	7.4	6.4	8.1
Site 2	32.03	28.5	36.2	45.23	37.7	54.2	6.8	5.5	8.1	7.5	6.4	8.3
Site 3	30.43	27.1	35.6	78.43	56.8	101.4	7.4	6.4	8.4	7.0	6.1	8.3
Site 4	31.25	28.5	35.3	53.97	35.7	90	7.5	6.5	8.5	7.5	6.2	8.7

Table 7. Average and range for water column depth and velocity as measured over each incubator site on October 16, 2008.

	Depth (m)			Avg_Vel (m/s)		
	Avg	Min	Max	Avg	Min	Max
Site 1	0.09	0.02	0.15	0.48	0.44	0.51
Site 2	0.17	0.12	0.25	0.37	0.23	0.60
Site 3	0.20	0.09	0.30	0.27	0.11	0.60
Site 4	0.24	0.14	0.35	0.21	0.15	0.29

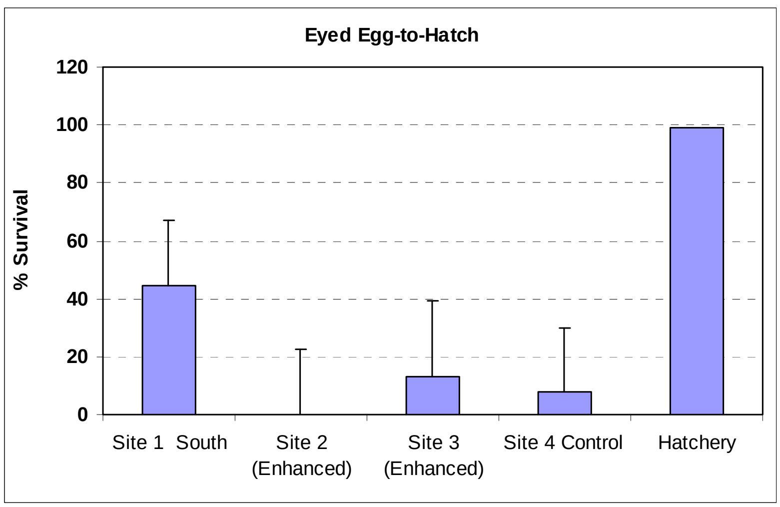
4.2 Incubation Success

Due to the overall poor survival results in the cassettes planted in both the optimum quality sites and in marginal sites (Appendix C), survival results for cassettes assessed at each incubation site were pooled for each developmental stage. Means and 95% confidence limits for the pooled data are summarized by life stage in Table 8 and illustrated in Figure 6. Survival for eyed egg-to-hatch and eyed egg-to-fry was greatest at Site 1 (Scully south) while survival for the two developmental stages was poor at all three incubation sites in Scully mid channel. There was no significant difference among sites (ANOVA, $\alpha = 0.05$) for the eyed egg-to-fry-stage, however survival at Site 1 was significantly different than at Site 2 for the eyed egg-to-hatch stage (Tukey-Kramer comparison of means test; $\alpha = 0.05$). The high survival for the remainder of the eyed eggs incubated at the hatchery eliminates any uncertainty in egg survival due to egg viability.

Table 8. Mean survival (eyed egg-to-hatch and eyed egg-to-fry) from the 3 Scully Creek Mid channel and the Scully Creek South channel study sites. Values are averages for all cassette types per site with associated 95% confidence limits. Also shown are means for the control group at Snootli Hatchery.

Site	Mean Survival and 95% CL (%)			
	Eyed Egg to Hatch		Eyed Egg to Fry	
Site 1	44.8	± 22.34	12.0	± 11.28
Site 2 (Enhanced)	0.0	± 22.34	0.0	± 11.28
Site 3 (Enhanced)	13.3	± 25.8	0.0	± 15.96
Site 4 Control	7.8	± 22.34	0.0	± 11.28
Hatchery	99.24		98.04	

Notes:
1. 95% confidence limits for Sites 1-4 were based on a pooled variance for each developmental stage.



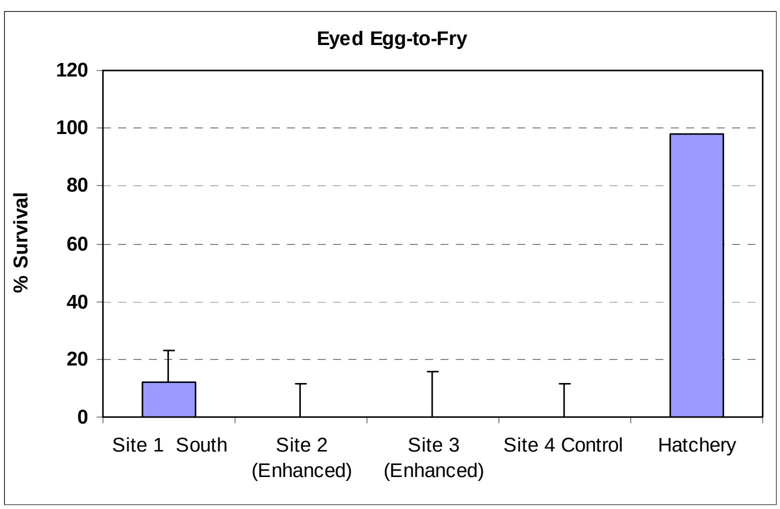


Figure 6. Survival from incubators at the 4 study sites in Scully mid and south channels and from the remaining eggs incubated at Snootli Hatchery.

5. DISCUSSION

The main objective of this study was to determine the effectiveness of the gravel additions to the mid channel of Scully Creek for sockeye salmon spawning. Based on results from incubation assessments in recently constructed spawning gravel placement projects in other areas, we would expect to see high incubation survival due to the high quality of the introduced gravels (Guimond 2006, 2007). Our results for the Scully Creek study showed poor survival rates overall with mean survival for the eyed egg-to-hatch stage ranging from zero to 44.8% (Figure 6). Eyed egg-to-fry survival was much poorer (range 0 - 12%). Most of the mortality in the individual incubation cassettes was at the eyed egg stage (mortality before hatch; Appendix B - Photo 9). Regrettably we did not retain any egg samples to determine the time/developmental stage of death. Site 1 in south Scully Creek had the best survival with 44.8% survival to the hatch stage and 12% survival to the fry stage. There was no significant difference in survival between the enhanced sites and the control site in mid Scully Creek.

Exposure to low levels of dissolved oxygen just before hatching has been found to reduce embryo survival (Alderdice et al. 1958). This period corresponds to the embryonic developmental stage requiring the highest oxygen levels (Rombough, *as cited in* Sigma Environmental Consultants Ltd. 1983). While this may have been a factor at some incubation sites, our results for intergravel DO measured during the first two monitoring visits do not reflect this (Table 6). Difficulties in obtaining adequate intergravel water samples from the piezometers at the sites may have resulted in overestimates of dissolved oxygen if air was artificially added to the samples from the manual pump while extracting the water sample. While it is dissolved oxygen that is the essential parameter for embryo survival and development, the function of the hyporheic environment to deliver the oxygen to the embryo and remove metabolic waste products also plays a key role (Coble 1961). In other words, incubation survival can be poor in situations of both low dissolved oxygen but high apparent velocity, and in high dissolved oxygen but low apparent velocity. Low DO measurements (at or less than 6 mg/l) were recorded at the four incubation sites on the final incubation check using the alternate sampling method (syringe).

Based on the results of the gravel sieve analysis conducted before and after the incubation period, the high percentage of fines may have also influenced incubation survival. At the incubation sites, the amount of fine sediments less than 0.85 mm in diameter ranged from 11% to 19%, with Scully South (Site 1) having the least amount of fines < 0.85 mm in diameter and the greatest survival overall (Table 4). Interestingly, the cassettes that had the greatest survival to hatch at South Scully were located in a shallow riffle area that had a high amount of fines but significant down-welling of surface water to the hyporheic environment. Therefore, this may have offset some of the negative affects of the low permeability from the high percentage of fines at this site.

During the first incubation assessment at the hatch stage (January), a sulphurous odour (i.e. rotten egg smell) was noted when some of the incubation cassettes were removed from the gravel, particularly at Site 2. Hydrogen sulphide (H_2S) is a product of the anaerobic decomposition of organic matter, along with methane (CH_4), and carbon dioxide (CO_2). H_2S is a highly poisonous and soluble gas and an indicator of anoxic conditions. The toxicity of hydrogen sulphide to fish is caused by the undissociated form (H_2S) and is dependent on temperature, pH and dissolved oxygen. H_2S oxidizes readily when exposed to oxygen, in effect stripping oxygen from its surrounding environment. The eggs and fry of most species are very sensitive and can be affected at levels of H_2S as low as 0.001 mg/l (Wedemeyer, 1996). Levels between 0.002 and 0.005 mg/l are often more easily detectable by odour than by laboratory means (Groves and Chandler 2005). Soil pits excavated adjacent Scully Creek Mid channel downstream of our incubation sites exposed an organic layer overlain with fine sediments and coarser fluvial sediment near the surface (Leggat 2009b). Both the mid and north channels of Scully Creek have been dug into this organic layer during the conversion of the surrounding land for agriculture. Furthermore, the influx of agricultural run-off from adjacent land use may also affect water quality during certain times of the year. Additional water quality monitoring and water sample collection at the Scully mid channel spawning gravel pads should be conducted to determine whether H_2S may have been a contributing factor to the poor incubation survival observed during our incubation assessment.

6. REFERENCES

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APPENDICES

Appendix A. Photo mosaic of Mid Scully Creek showing locations of the incubation sites.

CAMBRIA GORDON
STRATEGIC EXPERTISE IN THE NORTHWEST
SCIENCE ▪ TECHNICAL ▪ ENVIRONMENTAL MANAGEMENT ▪ GRAPHIC MEDIA

SCULLY CREEK - BERT'S CHANNELS

Photographed: April 23, 2008

Main channel Page 3 of 10

Appendix A. Photo mosaic of Mid Scully Creek showing locations of the incubation sites.

CAMBRIA GORDON
STRATEGIC EXPERTISE IN THE NORTHWEST
SCIENCE ▪ TECHNICAL ▪ ENVIRONMENTAL MANAGEMENT ▪ GRAPHIC MEDIA

SCULLY CREEK - BERT'S CHANNELS

Photographed: April 23, 2008

Main channel Page 4 of 10

Appendix B. Selected photos from the incubation study.

Photo 1. Pooling eyed sockeye eggs after delivery from Snootli Hatchery to Scully Creek. Eyed eggs were transported in specially designed egg tubes.

Photo 2. Loading eyed sockeye eggs into Jordan-Scotty incubation cassette loaders prior to transfer into yellow incubation cassettes (100 eggs per cassette).

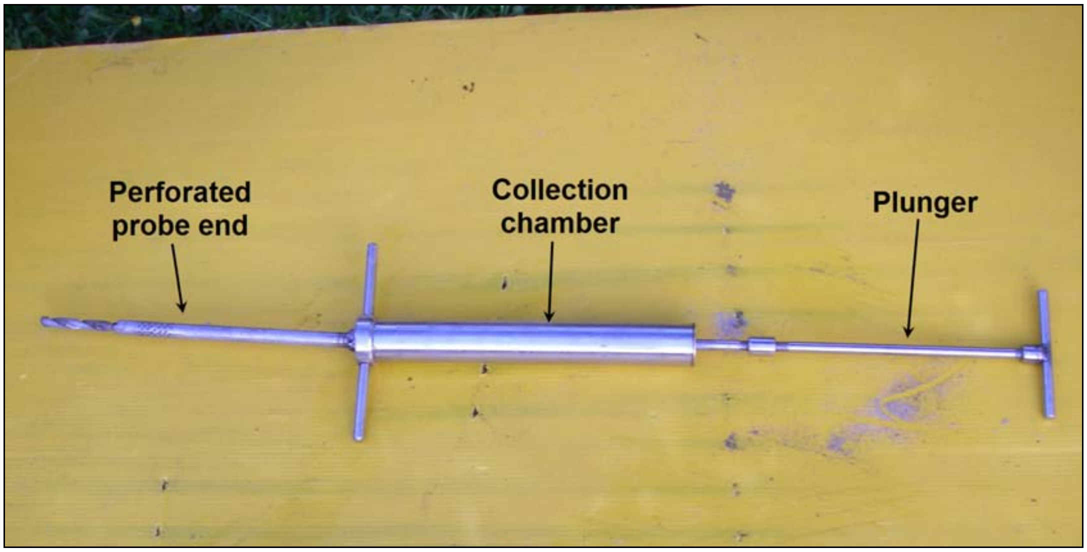


Photo 3. Syringe apparatus used to extract intergravel water samples. The narrow probe end is inserted into the gravel with the help of the foot pedal, to its full length. The plunger is pulled, drawing the water sample into the collection chamber.

Photo 4. Completed installation of piezometers and buried incubation cassettes, flagged with poly rope and tape to facilitate locating for incubation assessments, at Site 4 in Scully Creek mid channel.

Photo 5. Site 3 in Scully Creek mid channel at spawning platform #3 looking upstream.

Photo 1. Site 1 at Scully South channel upstream of the Highway 37 culvert.

Photo 7. Screened spawning gravel at Scully Mid channel, October 15, 2008.

Photo 8. Spawning gravel at Scully Mid channel, January 7, 2009. Note sand and fines within interstitial spaces.

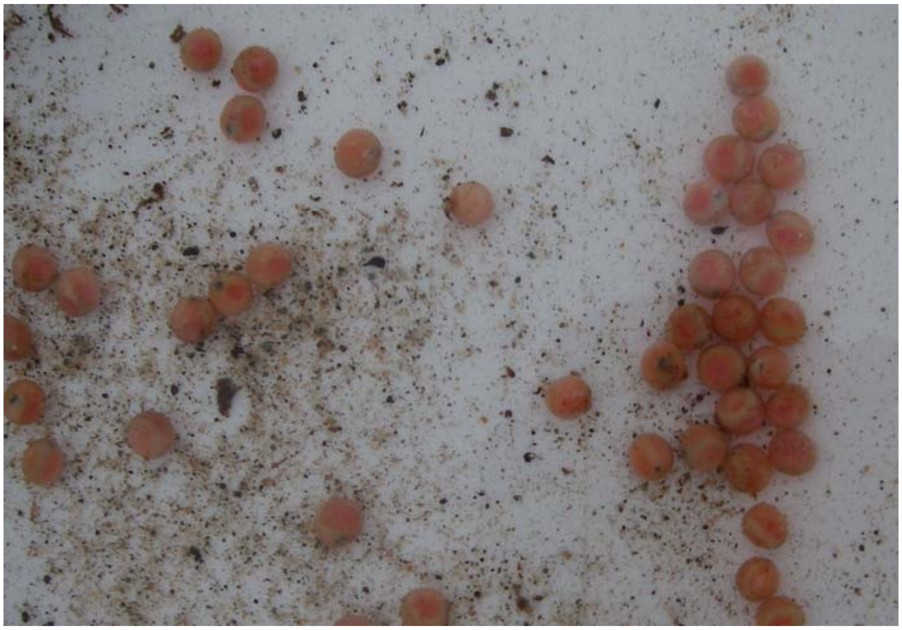


Photo 9. Mortality in one of four cassettes removed at Site 2 in Scully mid channel to assess survival to hatch stage.

Photo 10. Mortality in one of four cassettes removed at Site 2 in Scully mid channel to assess survival to the fry stage.

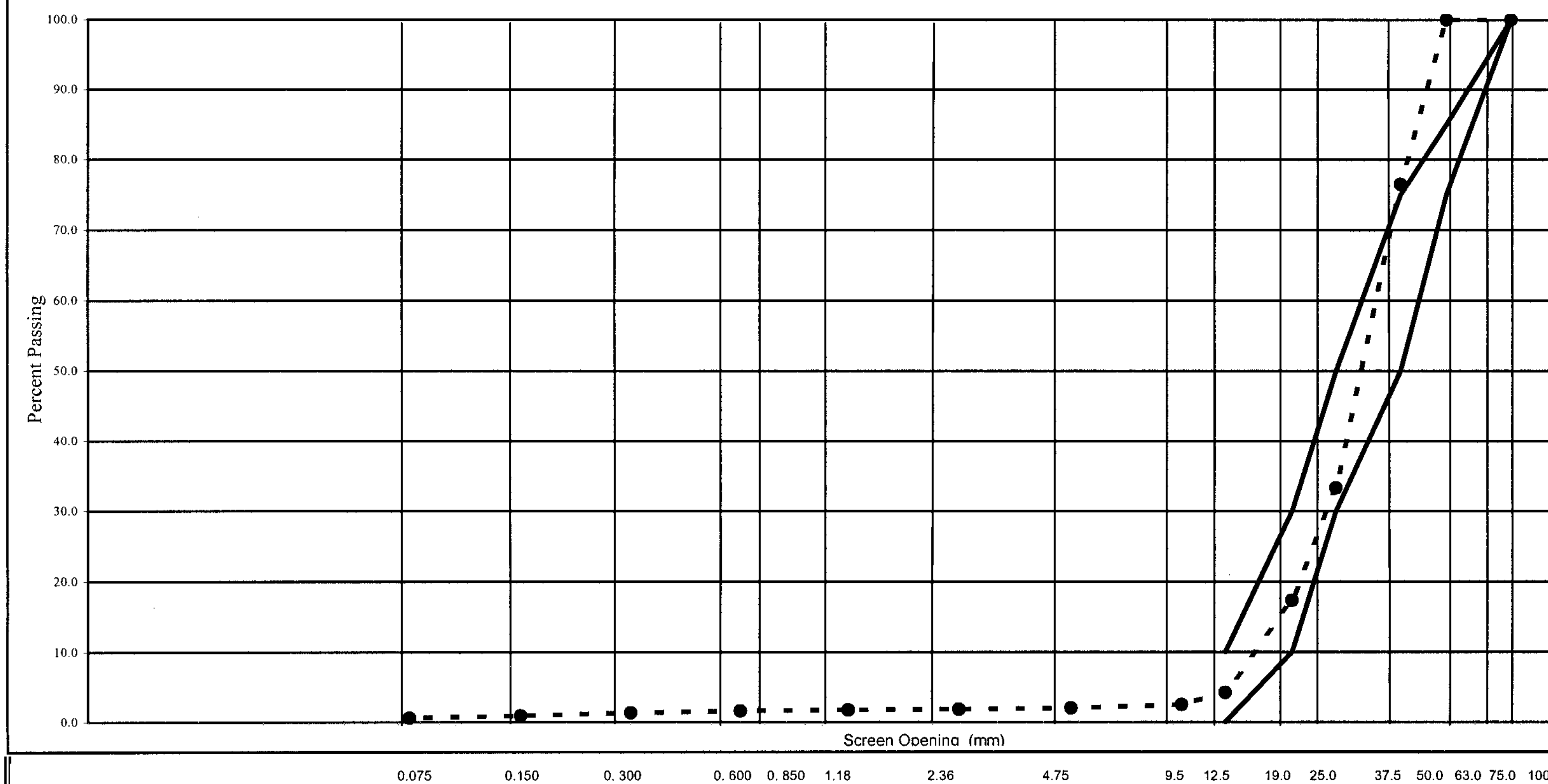
Appendix C. Survival rates for each incubation cassette assessed at hatch stage (January 2009) and fry stage (April 2009).

Site	Cassette #	Percent Survival to Hatch Stage	Percent Survival to Fry Stage
1	1A	100	39
	2A	97	9
	3B	0	0
	4B	0	0
	5A	3	
	6A	0	
	7B	79	
	8B	79	
	Mean	**44.8**	**12.0**
2	1B	2	
	2A	0	
	3A	0	
	4B	0	
	5B	0	0
	6A	0	0
	7A	0	0
	8B	0	0
	Mean	**0.3**	**0.0**
3	1A	n/a - scoured	
	2B	0	
	3B	0	
	4B	0	0
	5A	0	0
	6A	n/a missing	
	7B	0	
	8A	80	
	Mean	**13.3**	**0.0**
4	1B	0	
	2B	0	
	3A	0	
	4A	0	
	5B	0	0
	6B	0	0
	7A	0	0
	8A	62	0
	Mean	**7.8**	**0.0**

Appendix D. Aggregate sieve analysis results for incubation sites in Scully Creek mid and south channels, July 24, 2008 and April 1, 2009.

Client: DFO		Project No:	2321-22223-0
cc:		Location:	Scully Mid, Site2
cc:		Date of Report:	24-Jul-08

Type of Sample:	Spawning gravel	Sampled by:	Client	Date:	07-15	Washed Analysis
Sample No:	3	Tested by:	GS/VW	Date:	07-23	Dry Analysis
Source:	Scully Mid, Site 2 Bag A	MATERIAL:	Native Fill		Native	
Specified Limits:	As Shown		Imported Fill			



Screen Opening (mm)	Percent Passing Total	Speci Lim Lower
100.0		
75.0	100.0	100.0
63.0		
50.0	100.0	75.0
37.5	76.5	50.0
25.0	33.3	30.0
19.0	17.3	10.0
12.5	4.2	0.0
9.50	2.5	
4.75	2.0	
2.36	1.8	
1.180	1.7	
0.600	1.6	
0.300	1.3	
0.150	0.9	
0.075	0.6	

Remarks:

Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

Sieve C

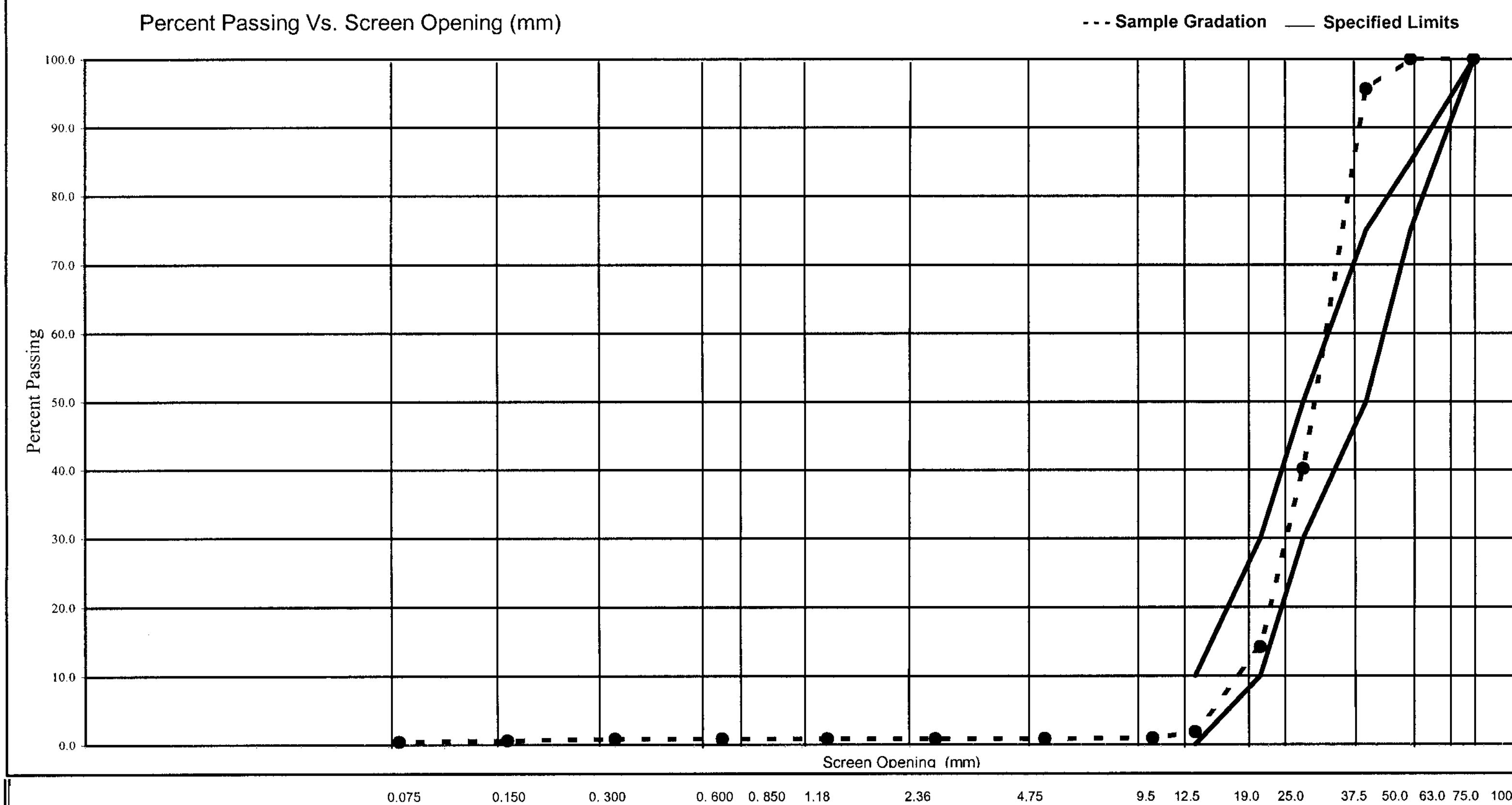
Client:	DFO
cc:	
cc:	

Project No:	2321-22223-0
Location:	Scully Mid, Site2
Date of Report:	24-Jul-08

Type of Sample:	Spawning gravel
Sample No:	4
Source:	Scully Mid, Site 2 Bag B
Specified Limits:	As Shown

Sampled by:	Client	Date:	07-15	Washed Analysis
Tested by:	GS/VW	Date:	07-23	Dry Analysis

MATERIAL: Native Fill | Native | Imported Fill



Screen Opening (mm)	Percent Passing Total	Speci Lim Lower
100.0		
75.0	100.0	100.0
63.0		
50.0	100.0	75.0
37.5	95.6	50.0
25.0	40.2	30.0
19.0	14.2	10.0
12.5	1.8	0.0
9.50	0.9	
4.75	0.8	
2.36	0.8	
1.180	0.8	
0.600	0.8	
0.300	0.8	
0.150	0.6	
0.075	0.4	

Remarks:

Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

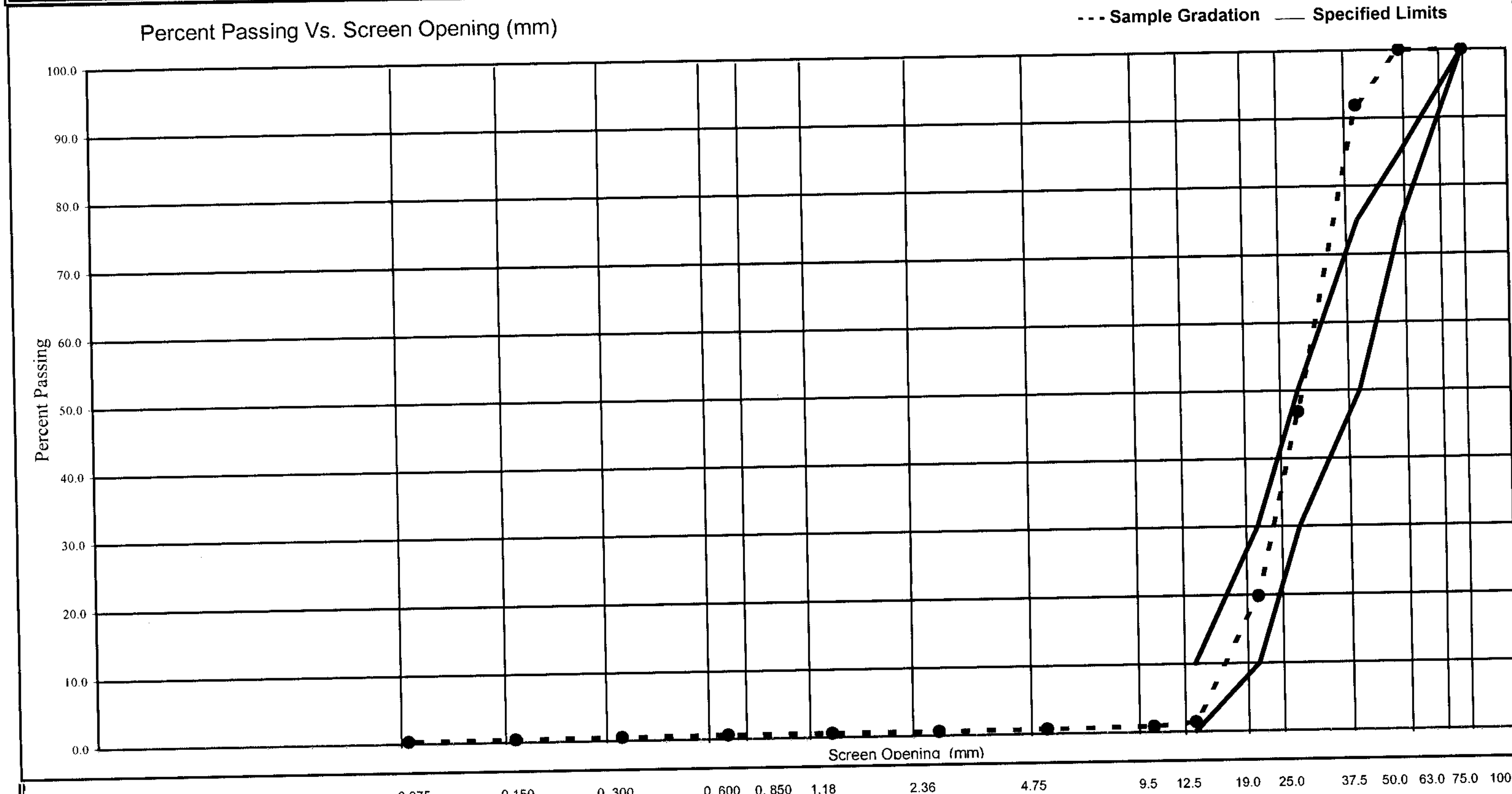
Client: DFO
cc:
cc:

Project No: 2321-22223-0
Location: Scully Mid, Site 3
Date of Report: 24-Jul-08

Type of Sample: Spawning gravel
Sample No: 5
Source: Scully Mid, Site 3 Bag A
Specified Limits: As Shown

Sampled by: Client Date: 07-16 Washed Analysis
Tested by: GS/VW Date: 07-23 Dry Analysis

MATERIAL: Native Fill Native
Imported Fill



Screen Opening (mm)	Percent Passing Total	Speci[fied] Lim[its] Lower
100.0		
75.0	100.0	100.0
63.0		
50.0	100.0	75.0
37.5	91.9	50.0
25.0	46.9	30.0
19.0	19.8	10.0
12.5	1.4	0.0
9.50	0.8	
4.75	0.7	
2.36	0.6	
1.180	0.6	
0.600	0.6	
0.300	0.5	
0.150	0.4	
0.075	0.3	

Remarks:

Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

Siev

Client:	DFO
cc:	
cc:	

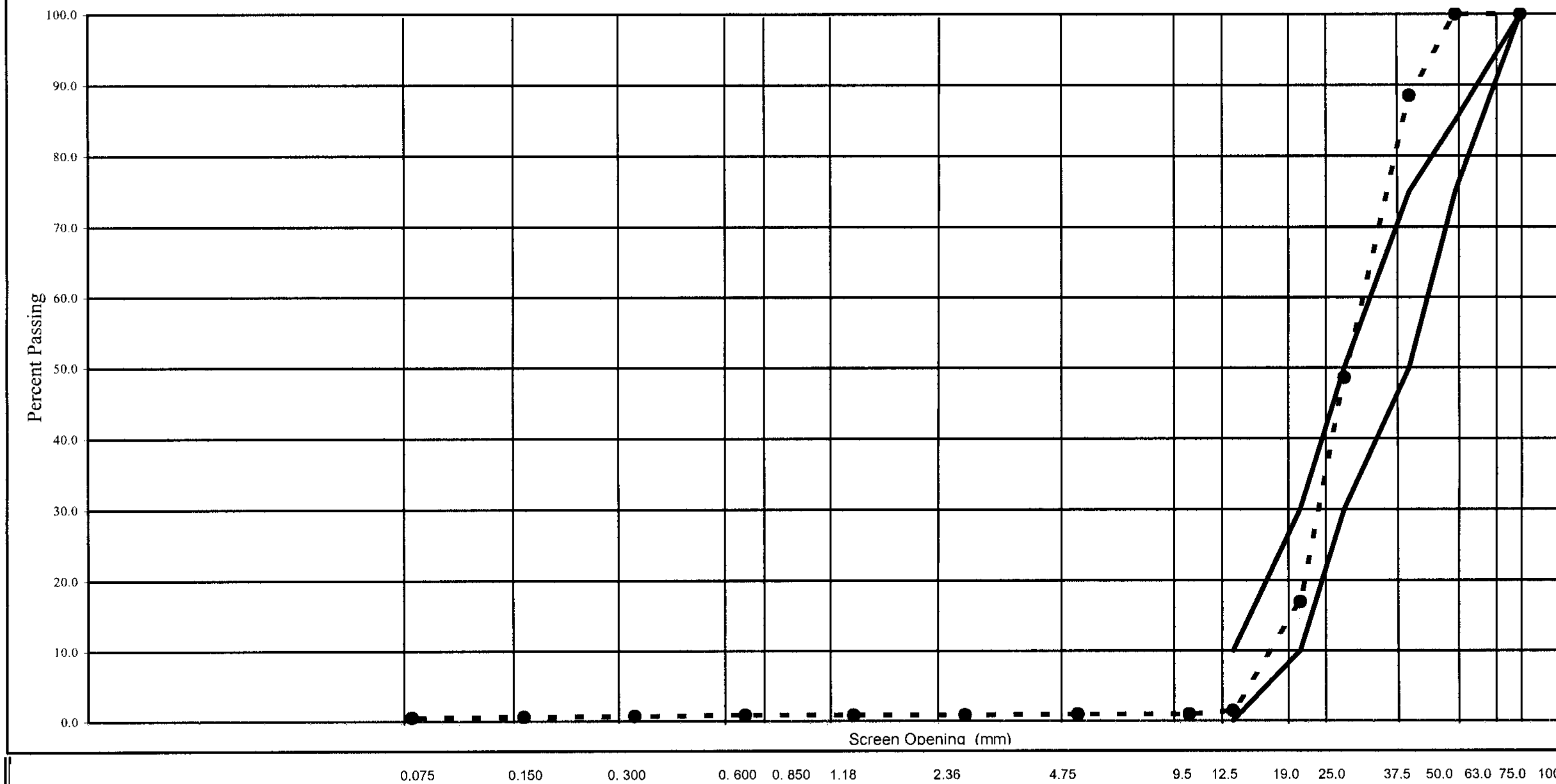
Project No:	2321-22223-0
Location:	Scully Mid, Site 3
Date of Report:	24-Jul-08

Type of Sample:	Spawning gravel
Sample No:	6
Source:	Scully Mid, Site 3 Bag B
Specified Limits:	As Shown

Sampled by:	Client	Date:	07-16	Washed Analysis
Tested by:	GS/VW	Date:	07-23	Dry Analysis

MATERIAL: Native Fill — Native
Imported Fill

Percent Passing Vs. Screen Opening (mm)



Screen Opening (mm)	Percent Passing Total	Speci Lim Lower
100.0		
75.0	100.0	100.0
63.0		
50.0	100.0	75.0
37.5	88.5	50.0
25.0	48.6	30.0
19.0	16.9	10.0
12.5	1.4	0.0
9.50	0.9	
4.75	0.9	
2.36	0.8	
1.180	0.8	
0.600	0.8	
0.300	0.7	
0.150	0.6	
0.075	0.5	

Remarks:

Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

McElhanney

Aggregate Sieve Analysis

Client: DFO
cc:
cc:

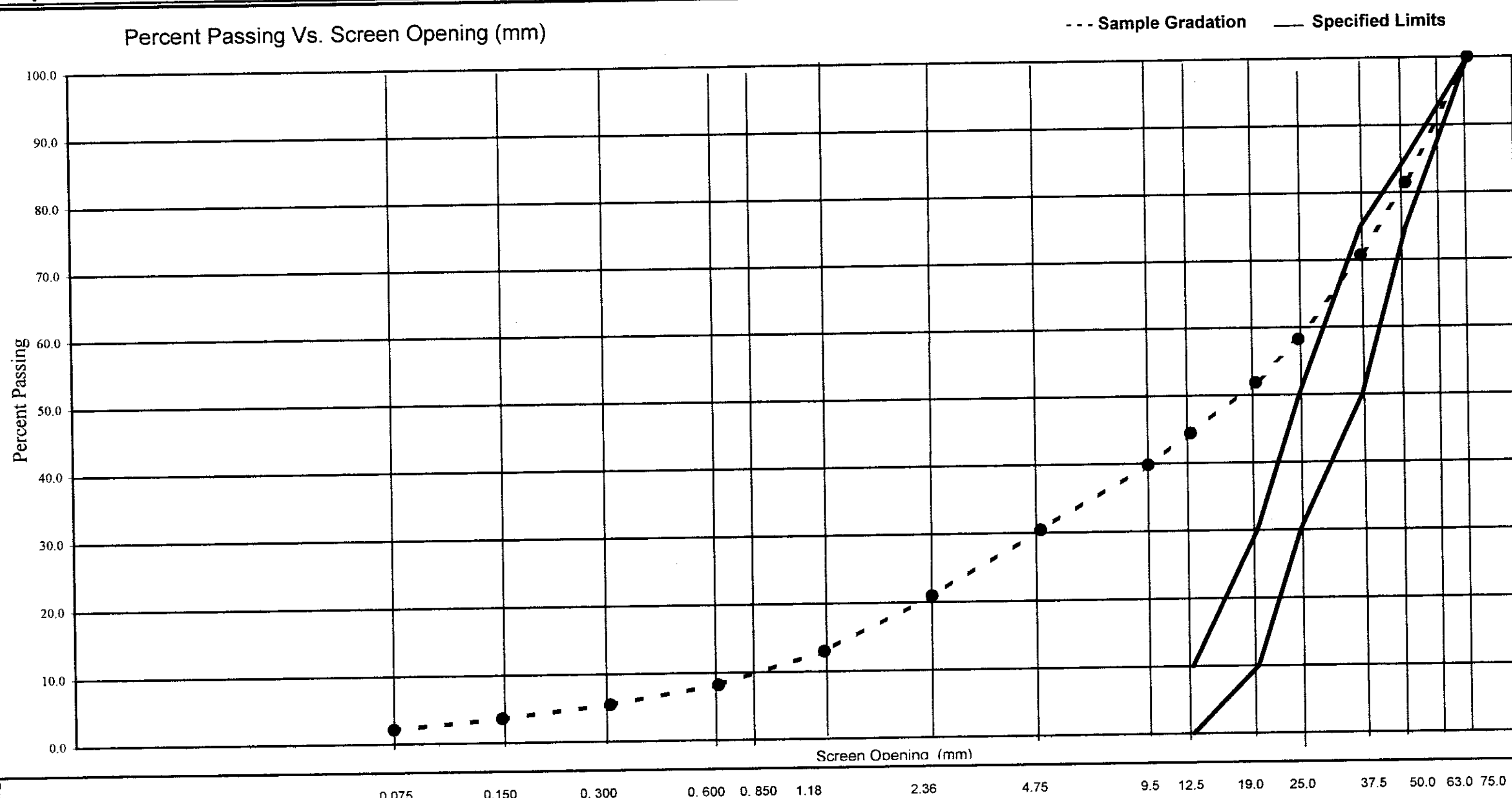
Project: DFO Sieve Analysis
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Type of Sample: Spawning gravel
Sample No: 1
Source: South, Highway Culvert Inlet, #1
Specified Limits: As Shown

Sampled by: Client   Date: 23-Mar-09   Washed Analysis X
Tested by: GS   Date: 25-Mar-09   Dry Analysis

MATERIAL: Native Fill   Native
Imported Fill

Percent Passing Vs. Screen Opening (mm)



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	81.5	75.0	85.0
37.5	70.7	50.0	75.0
25.0	58.2	30.0	50.0
19.0	51.8	10.0	30.0
12.5	44.4	0.0	10.0
9.50	39.8		
4.75	30.4		
2.36	20.9		
1.180	13.0		
0.600	8.2		
0.300	5.5		
0.150	3.6		
0.075	2.1		

Remarks:

Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

McElhanney

Aggregate Sieve Analysis

Project: DFO Sieve Analysis

Client: DFO
cc:
cc:

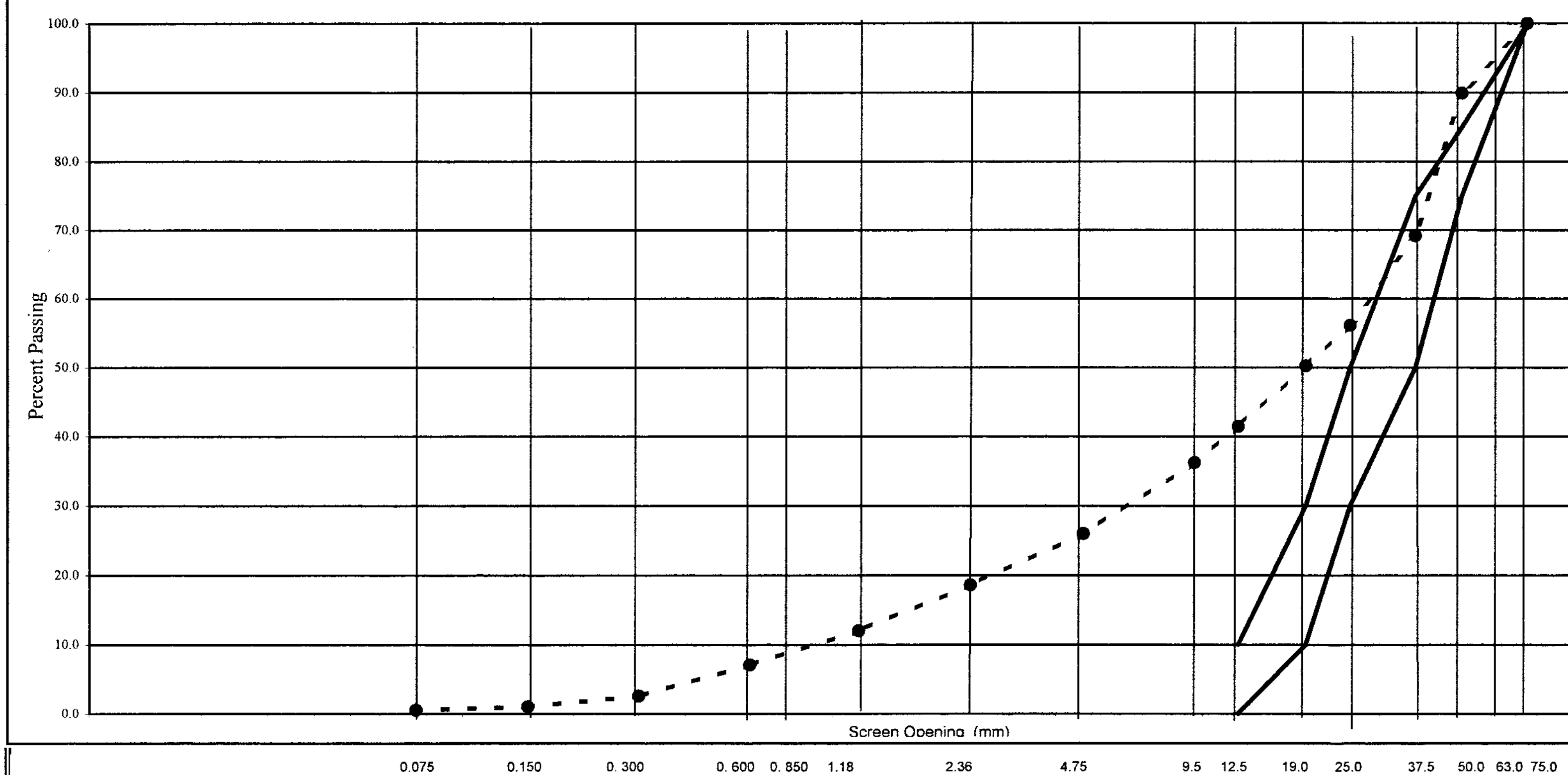
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Type of Sample: Spawning gravel
Sample No: 2
Source: South, Highway Culvert Inlet, #2
Specified Limits: As Shown

Sampled by: Client **Date:** 23-Mar-09 **Washed Analysis** X
Tested by: GS **Date:** 25-Mar-09 **Dry Analysis**

MATERIAL: Native Fill / Imported Fill / Native

Percent Passing Vs. Screen Opening (mm)



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	89.9	75.0	85.0
37.5	69.2	50.0	75.0
25.0	56.1	30.0	50.0
19.0	50.2	10.0	30.0
12.5	41.4	0.0	10.0
9.50	36.2		
4.75	26.0		
2.36	18.6		
1.180	12.0		
0.600	7.1		
0.300	2.6		
0.150	1.0		
0.075	0.5		

Remarks:

Reviewed by: G. Maltin CTech

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McElhanney

Aggregate Sieve Analysis

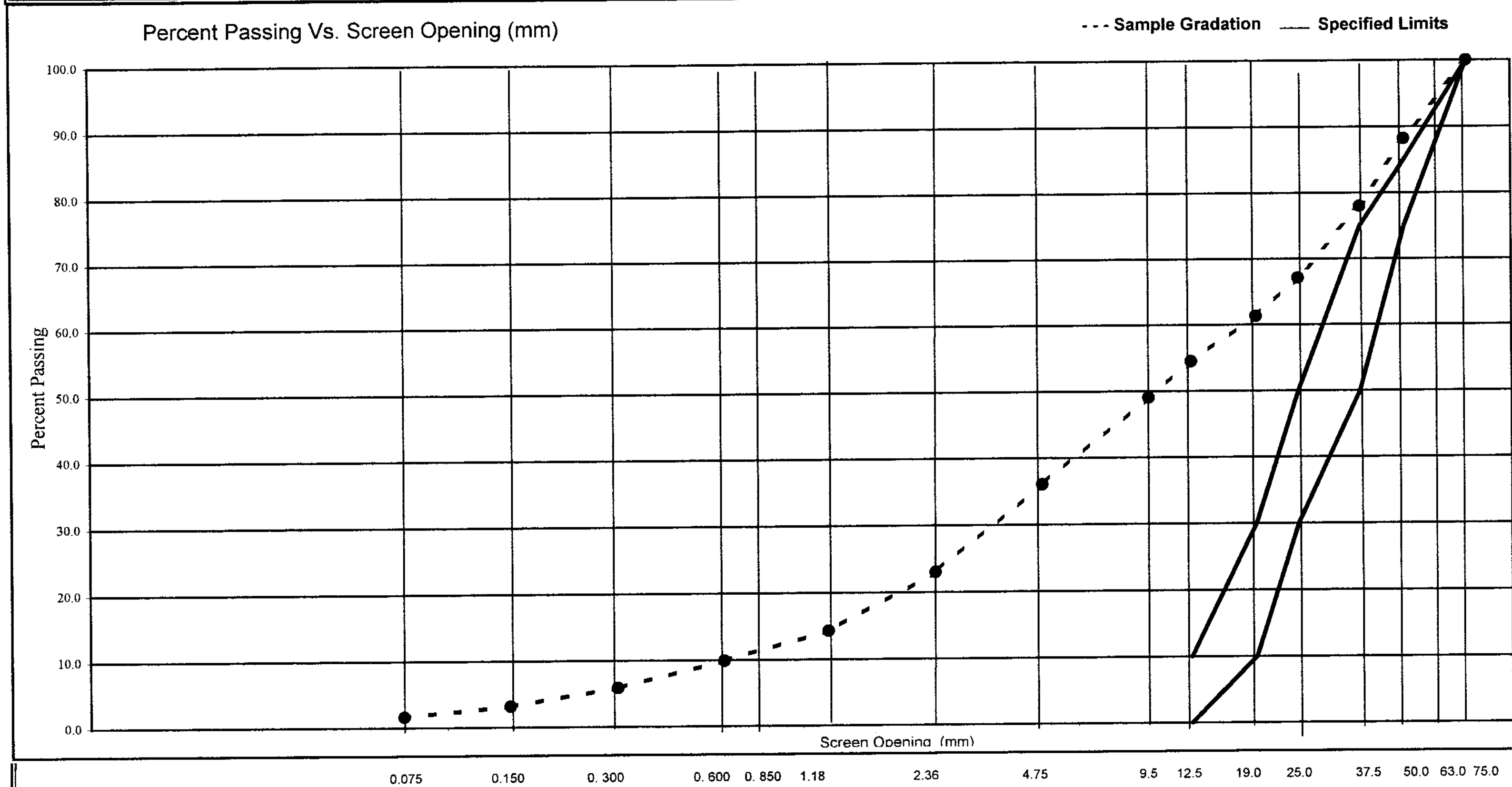
Client: DFO
cc:
cc:

Project: DFO Sieve Analysis
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Type of Sample: Spawning gravel
Sample No: 3
Source: South, Highway Culvert Inlet, #3
Specified Limits: As Shown

Sampled by: Client **Date:** 23-Mar-09 **Washed Analysis** X
Tested by: GS **Date:** 25-Mar-09 **Dry Analysis**

MATERIAL: Native Fill / Imported Fill — Native



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	88.2	75.0	85.0
37.5	78.0	50.0	75.0
25.0	67.1	30.0	50.0
19.0	61.3	10.0	30.0
12.5	54.5	0.0	10.0
9.50	49.0		
4.75	36.0		
2.36	23.0		
1.180	14.3		
0.600	9.9		
0.300	5.9		
0.150	3.2		
0.075	1.6		

Remarks:

Reviewed by: G. Maltin CTech

McElhanney

Aggregate Sieve Analysis

Project: DFO Sieve Analysis

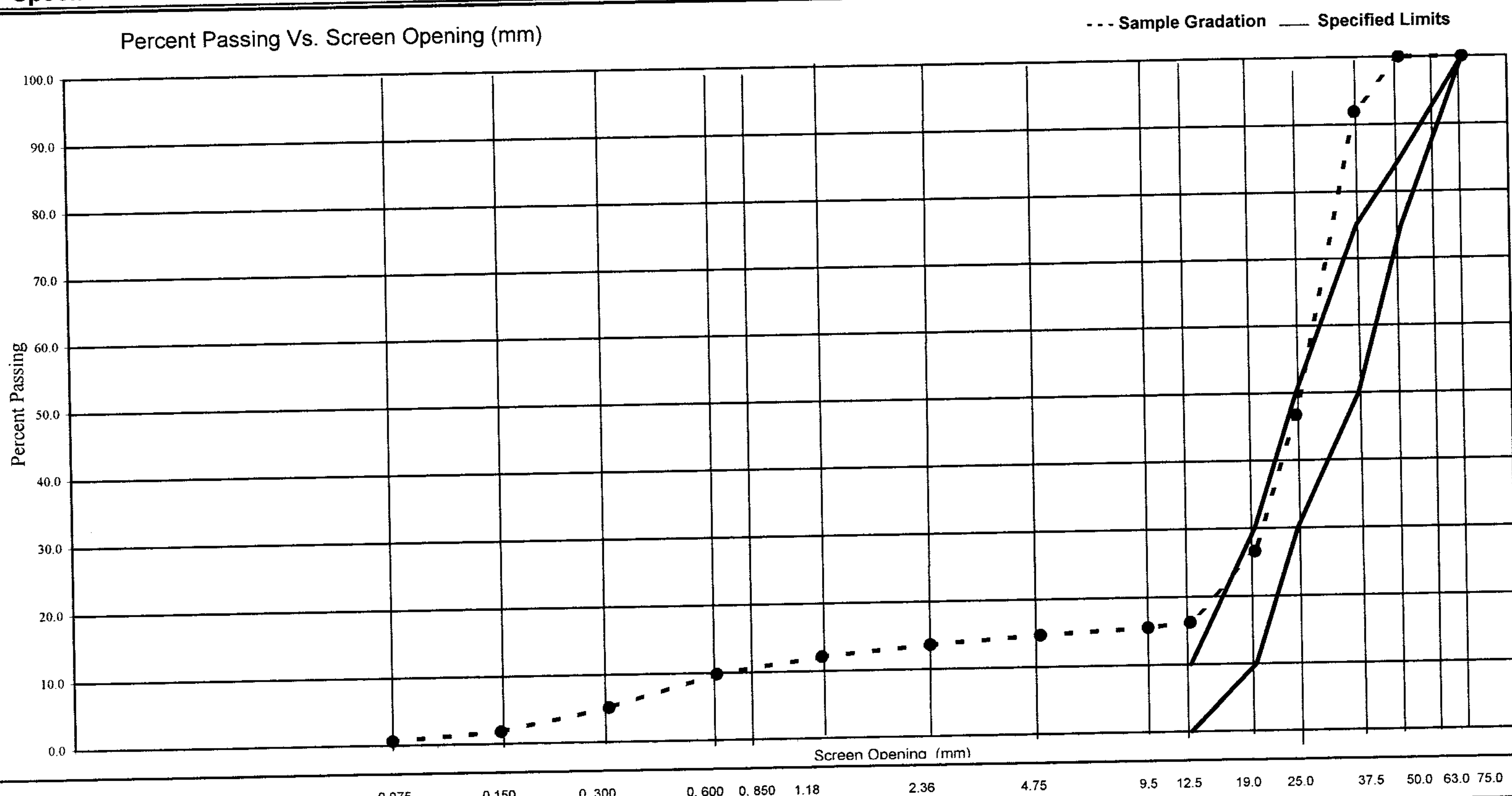
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Client: DFO
cc:
cc:

Sampled by: Client — **Date:** 25-Mar-09 — **Washed Analysis** X
Tested by: GS — **Date:** 28-Mar-09 — **Dry Analysis**

Type of Sample: Spawning gravel
Sample No: 7
Source: Mid-channel, 0-0.25m
Specified Limits: As Shown

MATERIAL: Native Fill — Native
Imported Fill



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	91.9	50.0	75.0
25.0	46.7	30.0	50.0
19.0	26.6	10.0	30.0
12.5	16.2	0.0	10.0
9.50	15.5		
4.75	14.7		
2.36	13.6		
1.180	12.1		
0.600	9.8		
0.300	5.1		
0.150	1.8		
0.075	0.6		

Remarks:
Sample #1, Spawning Platform #2, Stn 0+527 - 0+570, Freeze Core

Reviewed by: G. Maltin CTech

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McElhanney

Aggregate Sieve Analysis

Project: DFO Sieve Analysis

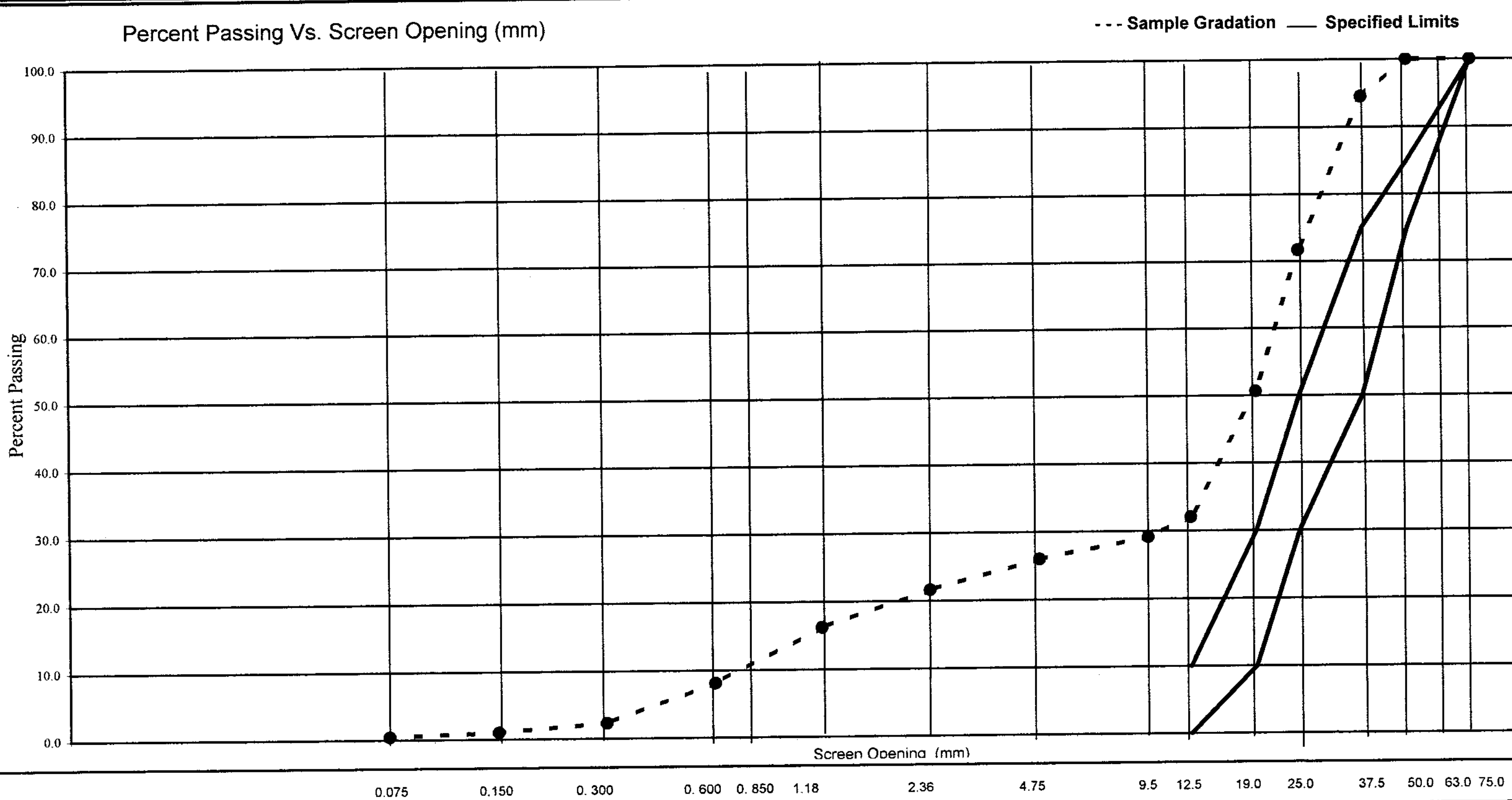
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Client: DFO
cc:
cc:

Sampled by: Client **Date:** 25-Mar-09 **Washed Analysis** X
Tested by: GS **Date:** 27-Mar-09 **Dry Analysis**

Type of Sample: Spawning gravel
Sample No: 8
Source: Mid-channel, 0-0.15m
Specified Limits: As Shown

MATERIAL: Native Fill Native
Imported Fill



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	94.5	50.0	75.0
25.0	71.7	30.0	50.0
19.0	50.6	10.0	30.0
12.5	32.0	0.0	10.0
9.50	29.1		
4.75	26.0		
2.36	21.6		
1.180	16.2		
0.600	8.1		
0.300	2.3		
0.150	1.0		
0.075	0.4		

Remarks:
Sample #1, Spawning Platform #3, Stn 0+420 - 0+475

Reviewed by: G. Maltin CTech [signature]

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

McElhanney

Aggregate Sieve Analysis

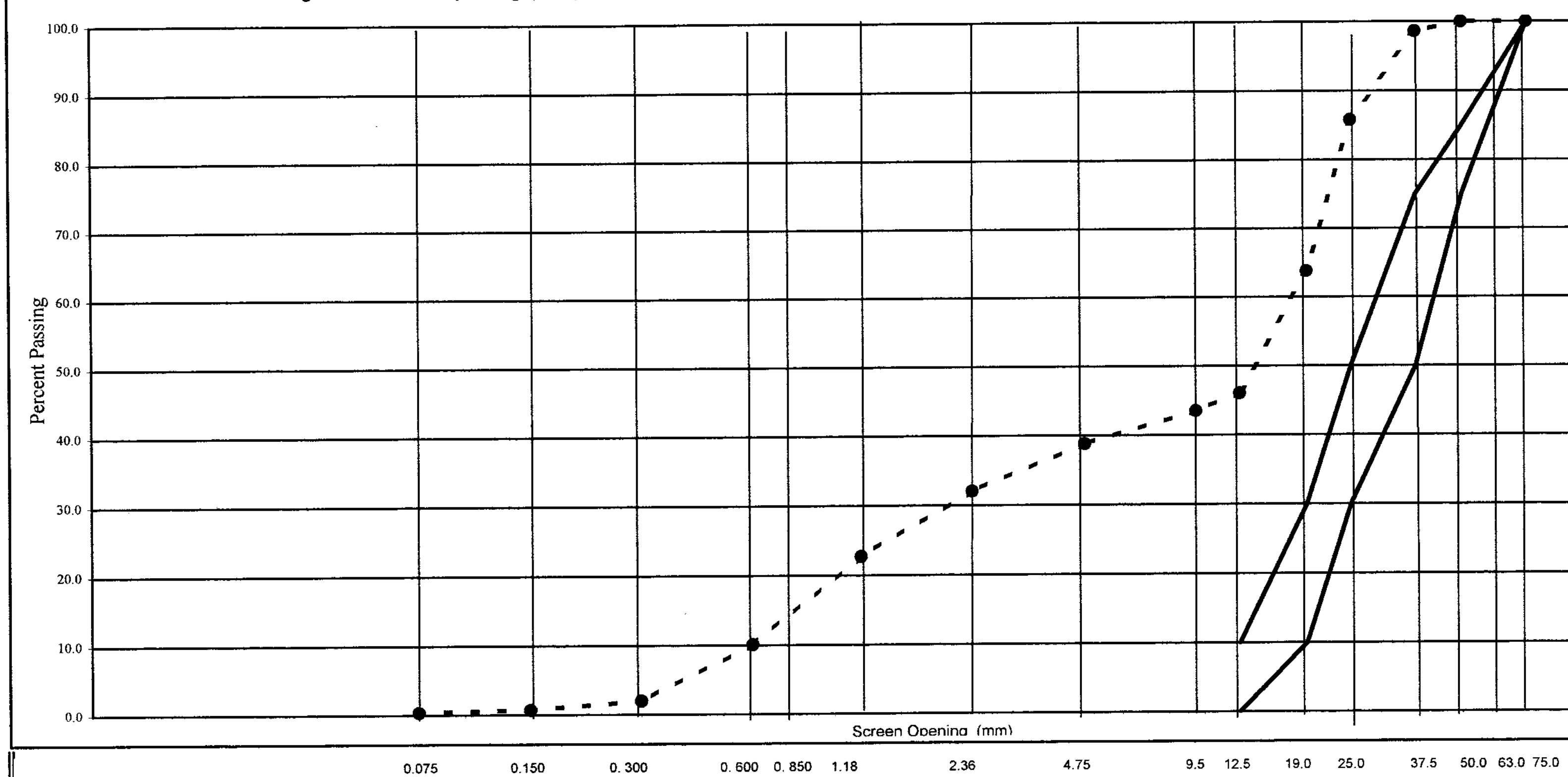
Client: DFO
cc:
cc:

Project: DFO Sieve Analysis
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Type of Sample: Spawning gravel
Sample No: 9
Source: Mid-channel, 0-0.15m
Specified Limits: As Shown

Sampled by: Client **Date:** 25-Mar-09 **Washed Analysis** X
Tested by: GS **Date:** 27-Mar-09 **Dry Analysis**

MATERIAL: Native Fill / Imported Fill / Native



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	98.6	50.0	75.0
25.0	85.8	30.0	50.0
19.0	63.8	10.0	30.0
12.5	46.0	0.0	10.0
9.50	43.5		
4.75	38.8		
2.36	32.0		
1.180	22.7		
0.600	10.1		
0.300	2.0		
0.150	0.7		
0.075	0.3		

Remarks:
Sample #2, Spawning Platform #3, Stn 0+420 - 0+475

Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

McElhanney

Aggregate Sieve Analysis

Client: DFO
cc:
cc:

Project: DFO Sieve Analysis

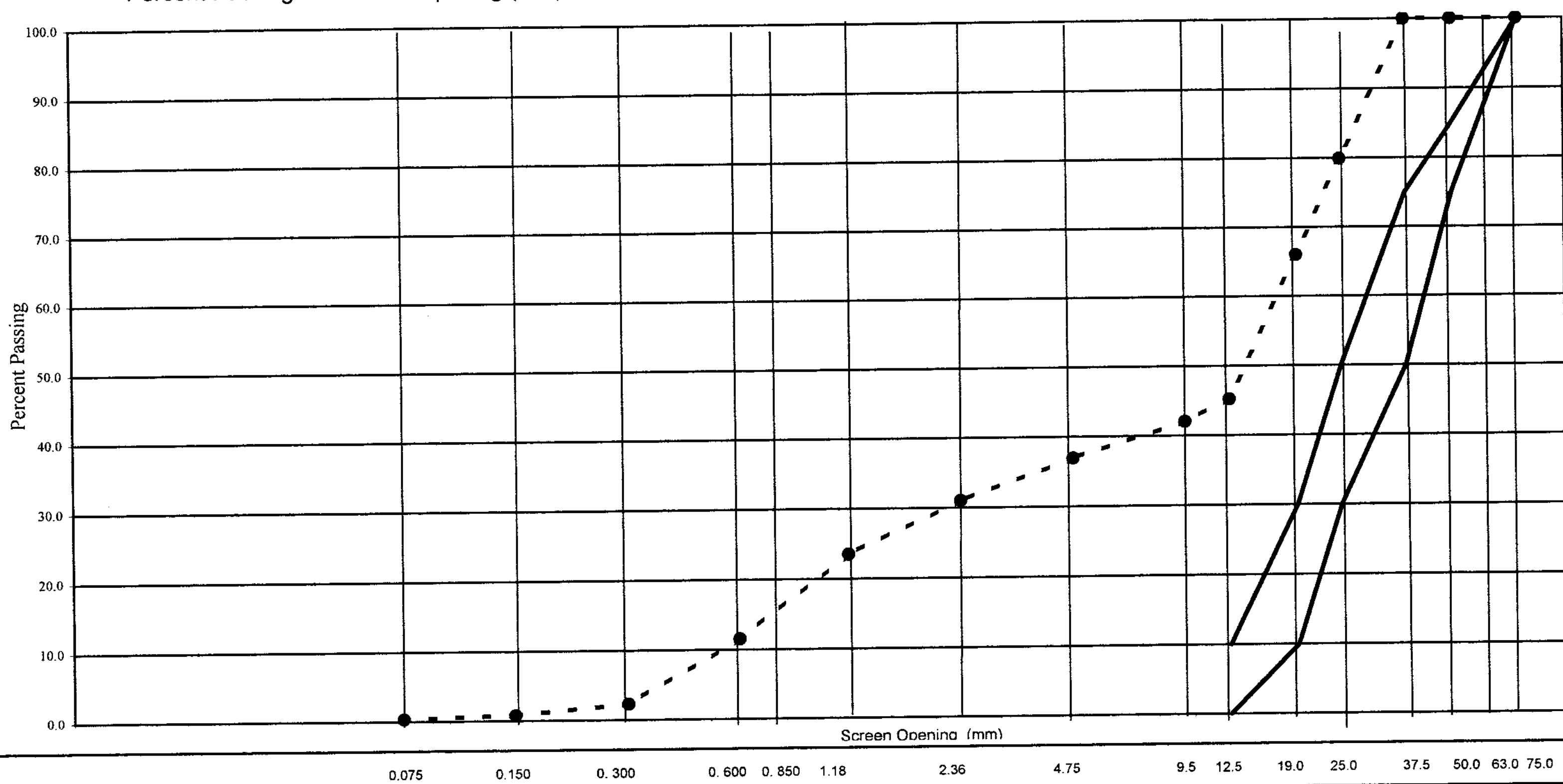
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Type of Sample: Spawning gravel
Sample No: 10
Source: Mid-channel, 0-0.15m
Specified Limits: As Shown

Sampled by: Client **Date:** 25-Mar-09 **Washed Analysis** X
Tested by: GS **Date:** 26-Mar-09 **Dry Analysis**

MATERIAL: Native Fill **Native**
Imported Fill

Percent Passing Vs. Screen Opening (mm)



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	100.0	50.0	75.0
25.0	79.9	30.0	50.0
19.0	66.0	10.0	30.0
12.5	45.2	0.0	10.0
9.50	42.0		
4.75	36.9		
2.36	31.0		
1.180	23.5		
0.600	11.5		
0.300	2.3		
0.150	0.8		
0.075	0.3		

Remarks:
Sample #3, Spawning Platform #3, Stn 0+420 - 0+475

Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

McElhanney

Aggregate Sieve Analysis

Project: DFO Sieve Analysis

Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

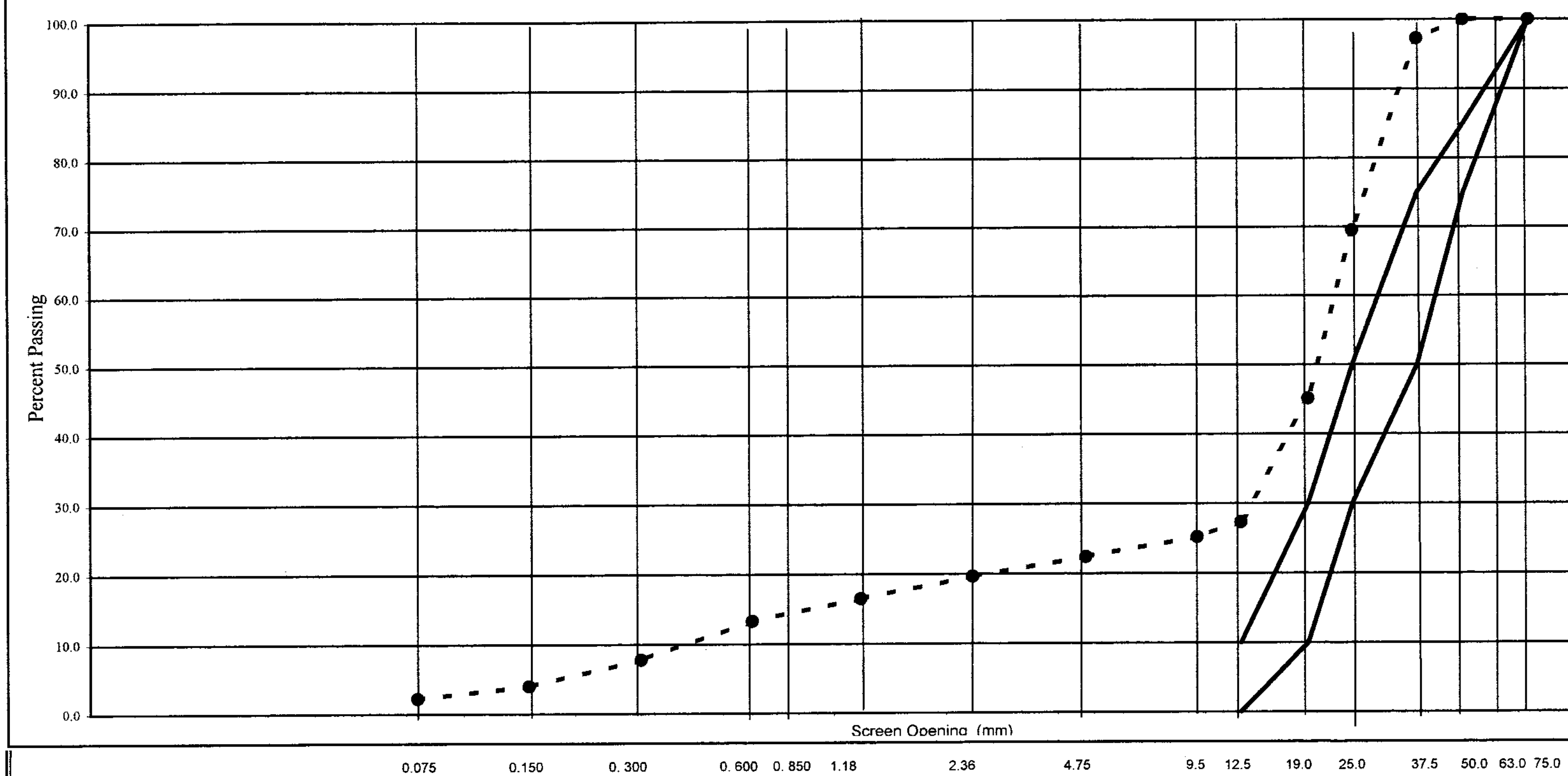
Client: DFO
cc:
cc:

Sampled by: Client **Date:** 6-Apr-09 **Washed Analysis** X
Tested by: VW **Date:** 7-Apr-09 **Dry Analysis**

Type of Sample: Spawning gravel
Sample No: 14
Source: Mid-channel, 0-0.3m
Specified Limits: As Shown

MATERIAL: Native Fill Native
Imported Fill

Percent Passing Vs. Screen Opening (mm)



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	97.3	50.0	75.0
25.0	69.5	30.0	50.0
19.0	45.1	10.0	30.0
12.5	27.3	0.0	10.0
9.50	25.2		
4.75	22.4		
2.36	19.6		
1.180	16.5		
0.600	13.3		
0.300	7.8		
0.150	4.0		
0.075	2.2		

Remarks:
Sample #2, Spawning Platform #2, Freeze Core, Stn 0+527 - 0+570
Client note - possible sample below new gravel.
Reviewed by: G. Maltin CTech

Reporting of these results constitutes a testing service only. Engineering interpretation or evaluation is availble upon written request

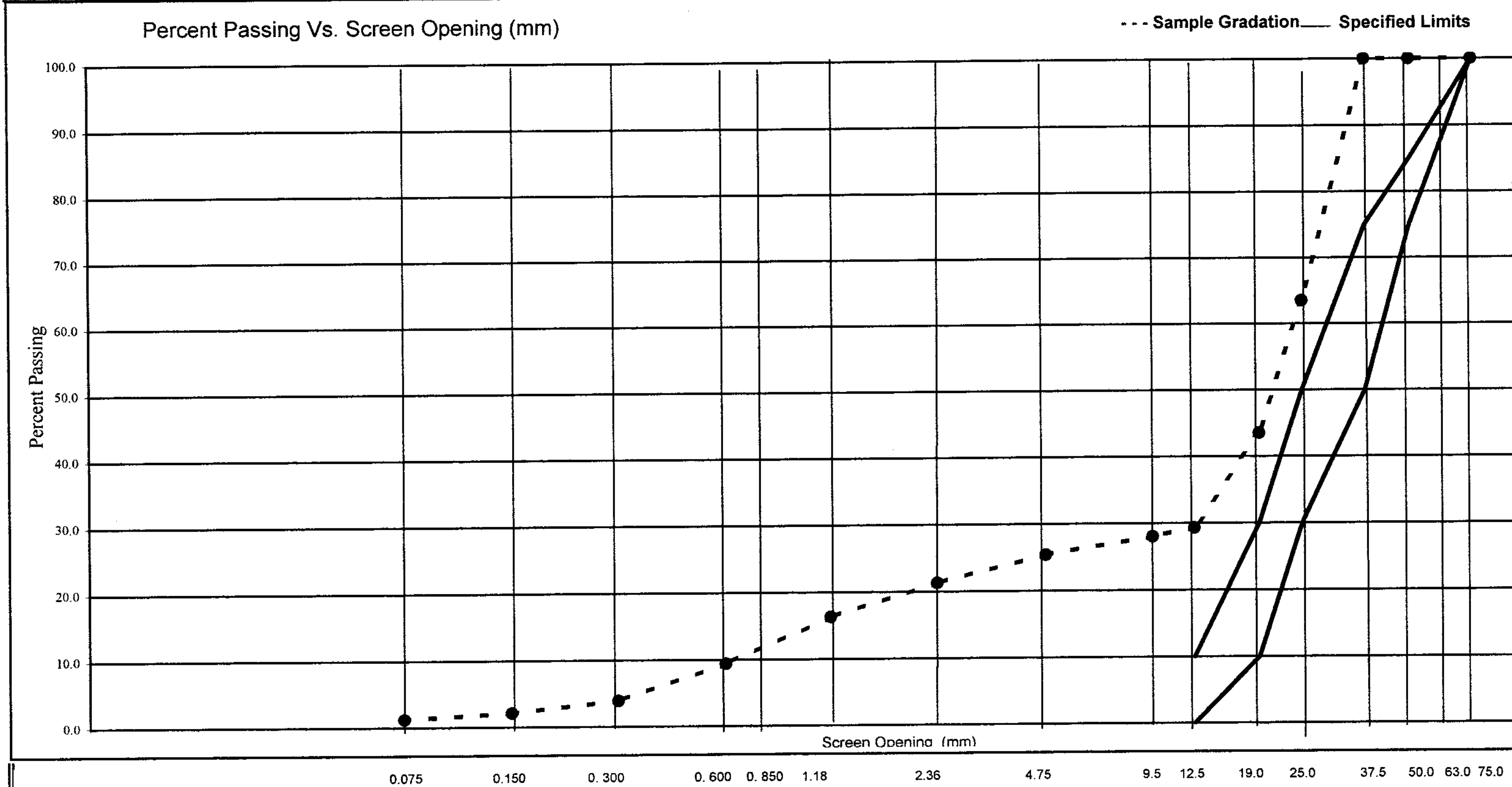
Aggregate Sieve Analysis

McElhanney

Client:	DFO
cc:	
cc:	
Type of Sample:	Spawning gravel
Sample No:	15
Source:	Mid-channel, 0-0.25m
Specified Limits:	As Shown

Project:	DFO Sieve Analysis				
Project No:	2321-22240-0				
Location:	Scully Creek				
Date of Report:	1-Apr-09				
Sampled by:	Client	Date:	6-Apr-09	Washed Analysis	X
Tested by:	VW	Date:	6-Apr-09	Dry Analysis	

MATERIAL: Native Fill   Native
Imported Fill



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	100.0	50.0	75.0
25.0	63.5	30.0	50.0
19.0	43.5	10.0	30.0
12.5	29.3	0.0	10.0
9.50	28.0		
4.75	25.4		
2.36	21.3		
1.180	16.3		
0.600	9.4		
0.300	3.9		
0.150	2.1		
0.075	1.2		

Remarks:

Sample #3, Spawning Platform #2, Freeze Core, Stn 0+527 - 0+570

Note: Ran out of C02 during the test (smaller sample).

Reviewed by: G. Maltin CTech

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McElhanney

Aggregate Sieve Analysis

Client: DFO
cc:
cc:

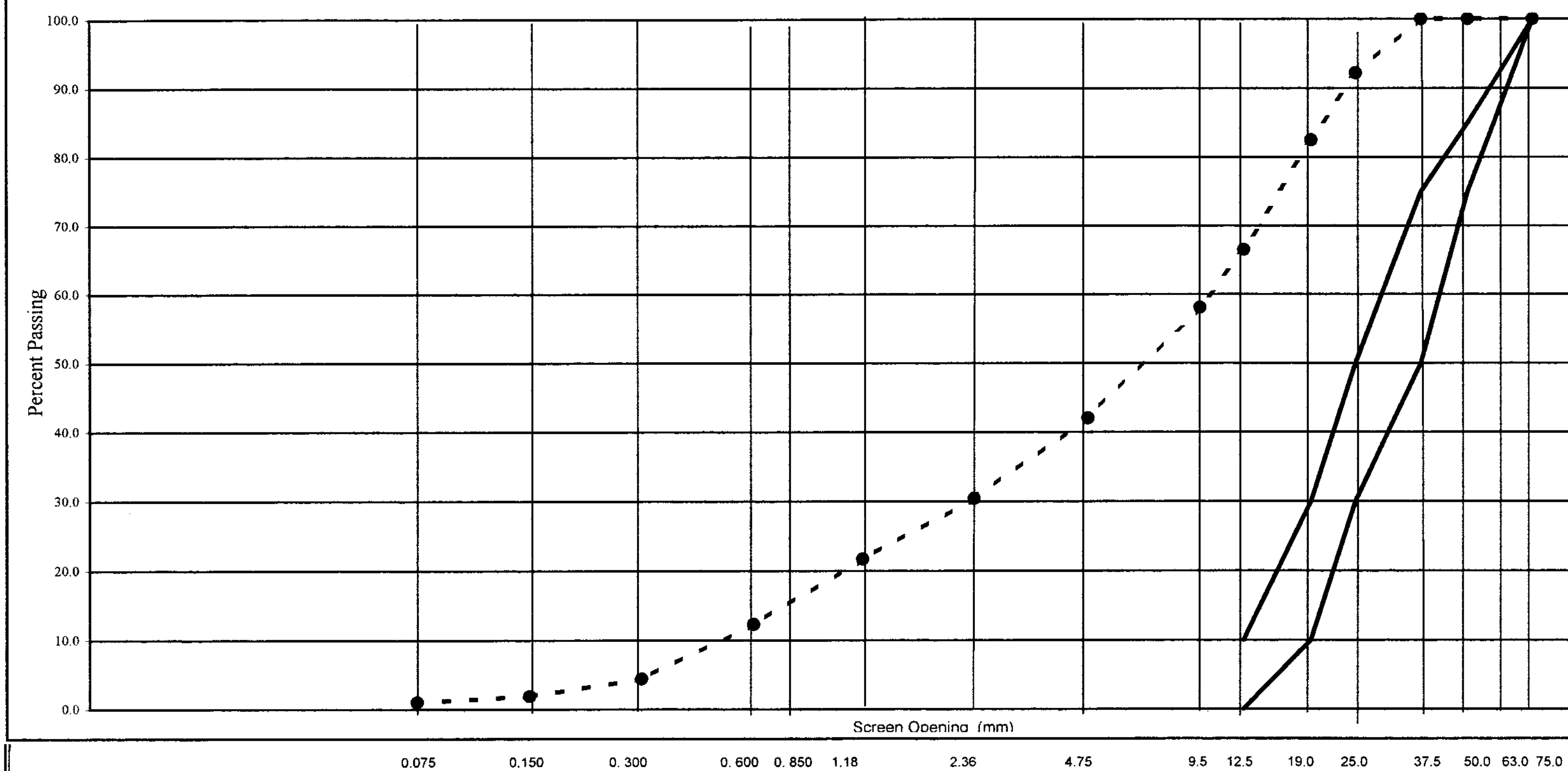
Project: DFO Sieve Analysis
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Type of Sample: Spawning gravel
Sample No: 16
Source: Mid-channel, 0-0.2m
Specified Limits: As Shown

Sampled by: Client **Date:** 6-Apr-09 **Washed Analysis** X
Tested by: VW **Date:** 7-Apr-09 **Dry Analysis**

MATERIAL: Native Fill / Imported Fill / Native

Percent Passing Vs. Screen Opening (mm)



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	100.0	50.0	75.0
25.0	92.2	30.0	50.0
19.0	82.5	10.0	30.0
12.5	66.5	0.0	10.0
9.50	58.1		
4.75	42.0		
2.36	30.4		
1.180	21.7		
0.600	12.3		
0.300	4.4		
0.150	1.9		
0.075	1.0		

Remarks:
Sample #1, Natural Spawning Platform, Freeze Core, Stn 0+286 - 0+316

Reviewed by: G. Maltin CTech

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McElhanney

Aggregate Sieve Analysis

Client: DFO
cc:
cc:

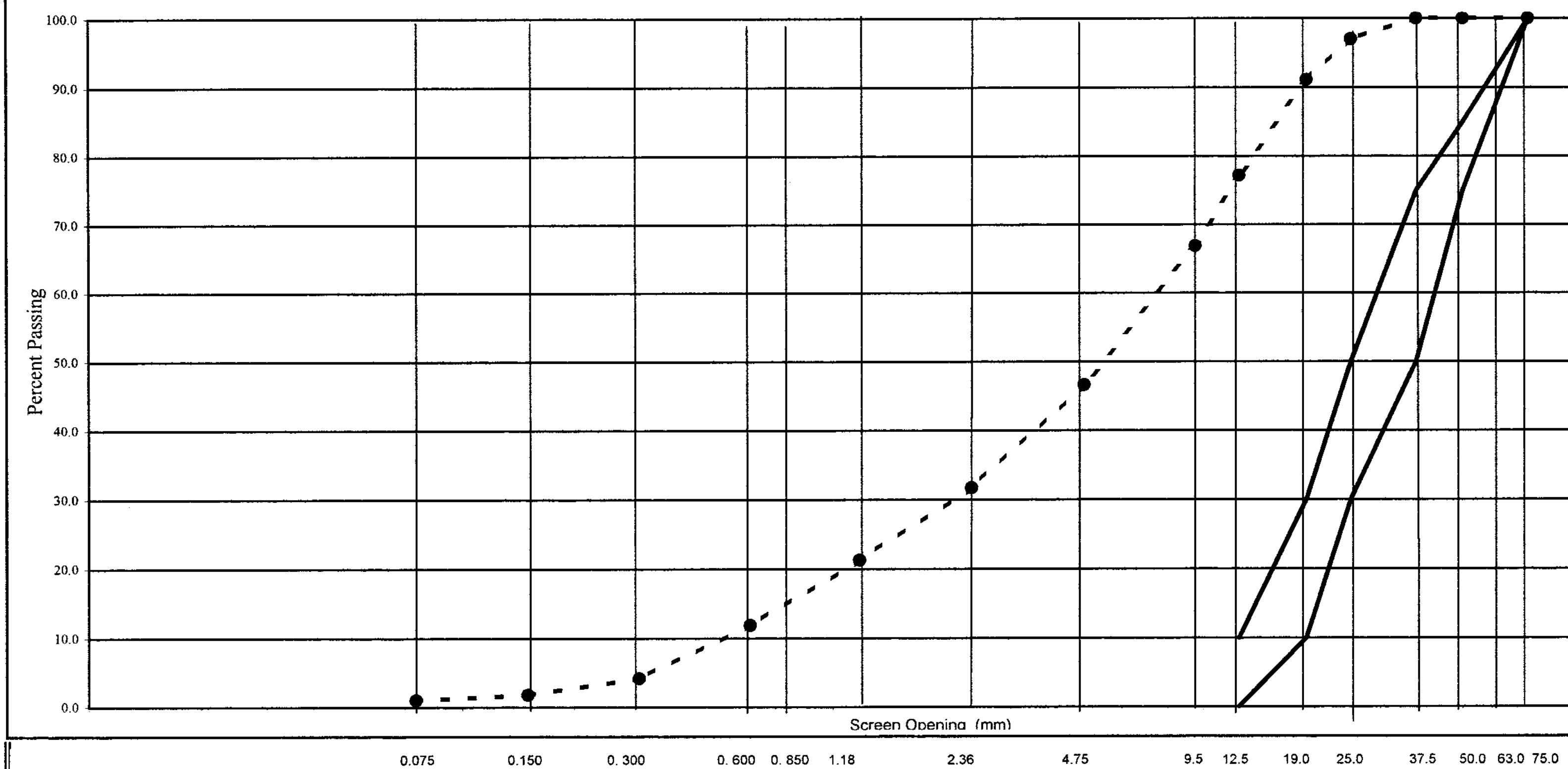
Project: DFO Sieve Analysis
Project No: 2321-22240-0
Location: Scully Creek
Date of Report: 1-Apr-09

Type of Sample: Spawning gravel
Sample No: 17
Source: Mid-channel, 0-0.2m
Specified Limits: As Shown

Sampled by: Client **Date:** 6-Apr-09 **Washed Analysis** X
Tested by: VW **Date:** 7-Apr-09 **Dry Analysis**

MATERIAL: Native Fill / Imported Fill — Native

Percent Passing Vs. Screen Opening (mm)



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	100.0	50.0	75.0
25.0	97.0	30.0	50.0
19.0	91.1	10.0	30.0
12.5	77.2	0.0	10.0
9.50	66.9		
4.75	46.6		
2.36	31.7		
1.180	21.3		
0.600	11.9		
0.300	4.2		
0.150	1.8		
0.075	1.0		

Remarks:
Sample #2, Natural Spawning Platform, Freeze Core, Stn 0+286 - 0+316

Reviewed by: G. Maltin CTech

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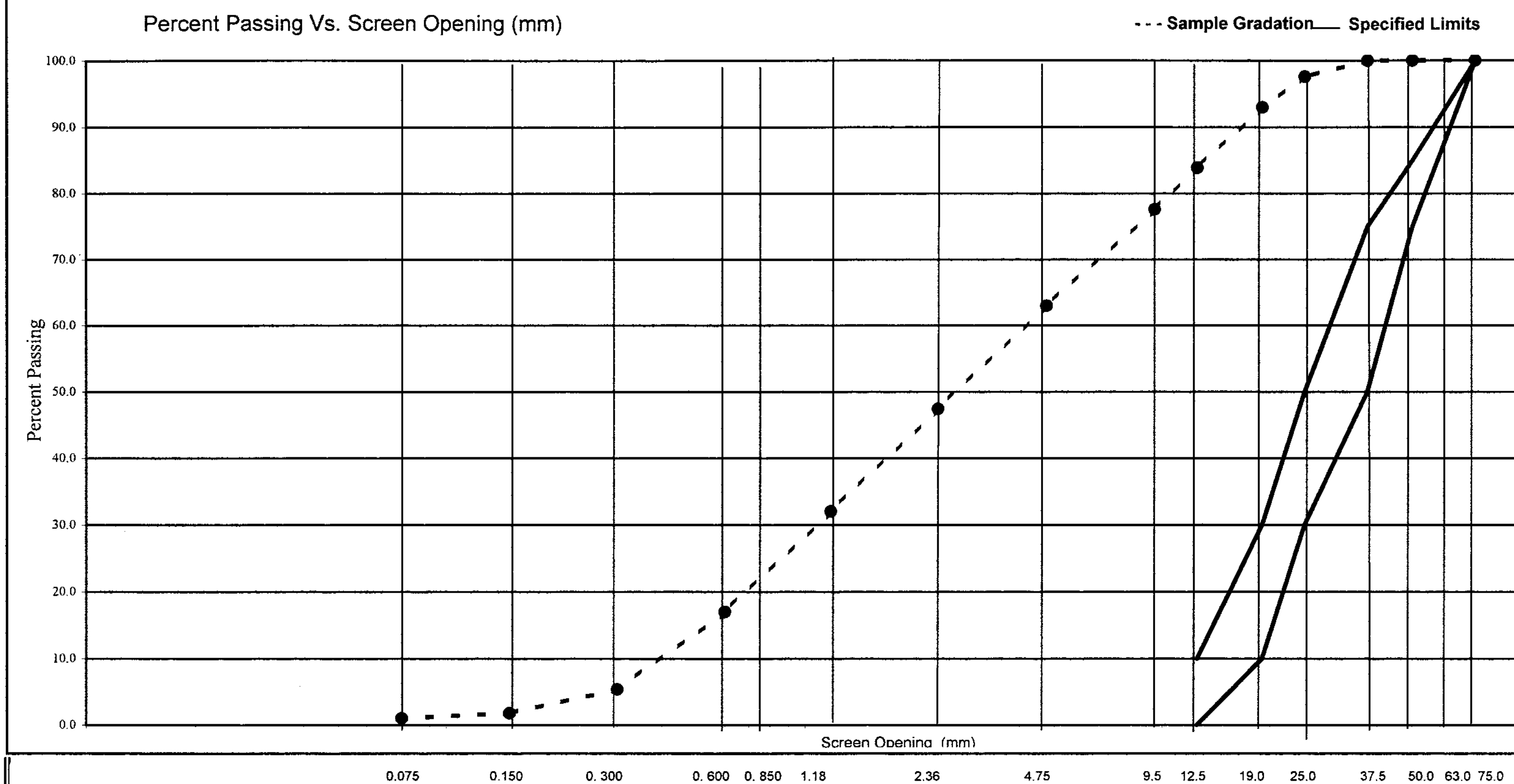
McElhanney

Aggregate Sieve Analysis

Client:	DFO	Project:	DFO Sieve Analysis
cc:		Project No:	2321-22240-0
cc:		Location:	Scully Creek
		Date of Report:	1-Apr-09

Type of Sample:	Spawning gravel	Sampled by:	Client	Date:	6-Apr-09	Washed Analysis	X
Sample No:	18	Tested by:	VW	Date:	7-Apr-09	Dry Analysis	
Source:	Mid-channel, 0-0.15m	MATERIAL:	Native Fill			Native	
Specified Limits:	As Shown		Imported Fill				

Percent Passing Vs. Screen Opening (mm)



Screen Opening (mm)	Percent Passing Total	Specified Limits Lower	Specified Limits Upper
100.0			
75.0	100.0	100.0	100.0
63.0			
50.0	100.0	75.0	85.0
37.5	100.0	50.0	75.0
25.0	97.6	30.0	50.0
19.0	93.0	10.0	30.0
12.5	83.9	0.0	10.0
9.50	77.6		
4.75	63.0		
2.36	47.4		
1.180	32.0		
0.600	17.0		
0.300	5.4		
0.150	1.8		
0.075	1.0		

Remarks:

Sample #3, Natural Spawning Platform, Freeze Core, Stn 0+286 - 0+316

Reviewed by: G. Maltin CTech

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