SUBSTRATE COMPOSITION MENSURATION INCLUDING MCNEIL CORING, FREEZE CORING AND INTERSTITIAL DISSOLVED OXYGEN MEASUREMENT OF THREE SPAWNING REDDS ON THE UPPER BULKLEY RIVER AND MAXAN CREEK IN OCTOBER & NOVEMBER 1998

Prepared for:

Community Futures Development Corporation of Nadina

Houston, British Columbia

Prepared by:

AGRA Earth & Environmental Limited

Smithers, British Columbia

KS00063

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March 22, 1999,
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Attention: Mr. Angus Glass

Dear Angus:

RE:DISSOLVED OXYGEN, MCNEIL CORES AND FREEZE CORES, UPPER BULKLEY RIVER

Enclosed is the report for the substrate composition measurement program conducted in the Upper Bulkley River and Maxan Creek in 1998.

If you have any questions, please call Jessica Harper at 250-847-8783 or email agra@bulkley.net

Respectfully Submitted,

AGRA Earth & Environmental Limited

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1.0 INTRODUCTION

AGRA Earth & Environmental Limited (AEE) was retained by Community Futures Development Corporation of Nadina (CFDCN) to conduct streambed composition measurements and instream sediment and dissolved oxygen (DO) sampling of the Upper Bulkley River, as directed by Ms. Brenda Donas of the Department of Fisheries and Oceans (DFO), Smithers Region. Streambed composition measurements included installing DO tubes into the stream substrate and measuring bi-weekly, conducting McNeil coring during October and September, and conducting freeze core sampling of the stream substrate.

The Upper Bulkley River has been heavily impacted by urban and rural development, agriculture, ranching, forest harvesting, CN rail, Highway 16 and the construction of forest service roads within the watershed. Sediment inputs into the river may be causing a reduction in survival to emergence (STE) of salmonid fry. Changes in streambed substrate composition as a result of sedimentation have been directly related to reductions in survival to emergence (STE) for coho and chum salmon in Carnation Creek (Scrivner & Brownlee, 1989). Fine sediment deposition in salmonid redds during the period of egg incubation compromises salmonid survival rates (MacDonald & McDonald, 1987). Sediment composition affects two critical properties of spawning gravel: permeability and porosity. Permeability affects delivery and removal rates of oxygen, carbon-dioxide, and other metabolites which influence salmonid survival (McNeil and Anhell, 1964). Small pore sizes can restrict intergravel movement of alevins and create a barrier to emergence. The deposition of fines into salmon redds reduces dissolved oxygen concentrations by filling the interstitial spaces with fines and reducing water flow.

Three streambed substrate composition methods were chosen including stilling wells for dissolved oxygen, McNeil core sampling and freeze core sampling. The freeze core sampling allowed AEE to compare the 0-15 cm surface sediment to the sediment located below 15 cm. Four sampling sites were selected, three in spawning redds on the Bulkley River upstream of Knockholt, and one test site located on Maxan Creek, downstream of Maxan Lake (Figures 1 & 2).

2.0 METHODS AND PROCEDURES

The methods for McNeil and freeze core sediment sampling follow the recently published Resource Inventory Committee (RIC) standards (Rex, 1999). The methods for dissolved oxygen sampling follow those published in the Proceedings of the Takla Fishery/Forestry Workshop: A Two Year Review April 1, 1993, Prince George, BC (Macdonald, 1994).

Numerous published references regarding the sampling methods, protocol and rationale are available upon request from AEE.

2.1 DISSOLVED OXYGEN

Four locations to measure interstitial dissolved oxygen at two depths were chosen by Ms. Brenda Donas as follows: three of which were located in close proximity to salmon redds in the Upper Bulkley River, 13 km east of Houston, BC (Figure 3). The fourth location was chosen as a test, and was located in the Maxan watershed, between Maxan and Bulkley Lakes. At each site, six plastic stilling wells were installed into the streambed, three tubes submerged to a depth of 15 cm and three tubes at a depth of 30 cm. On three occasions (roughly bi-weekly), a YSI dissolved oxygen meter was inserted into each tube, and left for 15 minutes to equilibriate. After 15 minutes, dissolved oxygen, percent saturation and water temperature were recorded for each tube. A Student's T-test was used to compare dissolved oxygen concentrations between the 15 and 30 cm depths, sites and times (Zar, 1984).

2.2 MCNEIL CORES

Water velocity and water depth were measured for each McNeil core sampled. The sample sites chosen were in the riffle zone, preferably at the riffle crest that occurs behind pool tailouts, a location preferred by spawning salmon. McNeil core samples were collected at each site in October and November of 1998. Placement of the McNeil corer was marked in the field with flagging tape so that samples were taken in the same location in each month, and the velocity and water depth were collected for each McNeil core site (Appendix 3). Sampling methods follow those described in the RIC manual for sediment sampling (Rex, 1999). A short description of the McNeil core methods are as follows:

1. The McNeil corer was placed on the selected substrate and the weight of the collector's body and a firm grip on the core handles was used to maintain corer position.
2. While keeping the McNeil corer perpendicular to the streambed, the collector turned the sampler back and forth while applying force and body weight to drive the corer into the streambed. Rocking of the corer had to be avoided.
3 .Weight and force were applied until standard core depth was reached, ensuring that the catch basin was flush to the streambed.
4. The gravel sample was removed by hand. This was done with care because sharp grains can cut fingertips and lodge under fingernails. The sample was drawn from the core and placed in a properly labelled bucket.
5. Gravel removal continued until the top of the core teeth was contacted.
6. Once gravel collection was finished, infiltrating water was allowed to rise in the inner tube so that a 1 Litre grab sample could be collected for total suspended solids analysis. When the inner tube water level was sufficient to take a grab sample, water was stirred to resuspend settled fines, depth was measured for later volume calculation and the sample was taken.

McNeil core samples were analyzed in the AEE laboratory, according to the American Society for Testing Materials, 1984 (ASTM), Standard method for sieve analysis of fine and coarse aggregates C136-84A. Samples were oven dried at 110 ± 5 degrees Celsius, then shaken through a specified sieve set for 15 ± 5 minutes. The sieve set is described in Table 1.

Table 1. Sieve set used for McNeil cores and freeze cores on the Bulkley River and Maxan Creek

SIEVE SIZE	GRAIN CLASS	MELP GUIDELINES (CRITERIA) FOR TURBIDITY, SUSPENDED AND BENTHIC SEDIMENTS (1999)
<9.5 x<6.3		
<6.3 x<4	Fine Gravel	fines not to exceed 25 % less than 6.35 mm
<4x<2.8	Very Fine Gravel	
<2.8 x<2	very Fine Gravel	fines not to exceed 19% less than 3.0 mm
<2 x<0.5	Coarse Sand	fines not to exceed 10 % less than 2.0 mm
<0.5 x<0.25	Medium Sand	
<0.25 x<0.106	Fine Sand	
<0.106 x<0.063	Very Fine Sand	
<0.063	Silt/Clay	

2.3 FREEZE CORES

Two methods of freeze coring were tested on this project. The first method was a steel corer which used liquid nitrogen as the freezing mechanism. This method was field tested in October, however only one sample was obtained. This sample was split into two fractions, 0-15 cm deep and 15+ cm deep. Two aluminium freeze corers were obtained from Mr. Herb Herunter, DFO Research Office, which utilized methanol and dry ice as the freezing mechanism (Herunter, 1999). The methanol/dry ice freeze corer was used to collect three samples from each of Riffles 1,2,3 and Maxan Creek (Figure 4). The methods for freeze coring are described in Appendix 5. Freeze core samples were analyzed in the AEE laboratory, according to the American Society for Testing Materials, (ASTM), Standard method for sieve analysis of fine and coarse aggregates C136-84A (ASTM, 1984). Samples were oven dried at 110±5 degrees Celsius, then shaken through a specified sieve set for 15±5 minutes. Results were presented as weight retained on each sieve, and as the percentage by weight retained on each sieve of the total sample weight. The sieves used were the same as for the McNeil cores.

3.0 RESULTS

3.1 DISSOLVED OXYGEN

The Ministry of Environment, Lands and Parks (MELP), has recommended the following ambient water quality criteria for dissolved oxygen for the protection of aquatic life (MELP, 1997):

> "Buried embryo/alevin life stages interstitial dissolved oxygen (mg/L) as an instantaneous minimum must be no lower than 6 mg/L. As a 30-day mean, dissolved oxygen concentrations must not be lower than 8 mg/L. Water column dissolved oxygen must be no lower than an instantaneous minimum of 9 mg/L, or a 30-day mean of 11 mg/L" (MELP, 1997).

The dissolved oxygen tubes were installed in salmon redds or at salmon redd locations. Salmon ova were present in the redds during the sampling periods, therefore the most stringent criteria interstitial buried embryo/alevin life stages were used to compare the dissolved oxygen results.

The results indicate that at Bulkley Riffle 1, the dissolved oxygen concentrations fell below the minimum criteria of 6 mg/L three times at the 30 cm depth (Appendix 1). The dissolved oxygen concentration at Bulkley Riffle 2 was below the minimum criteria of 6 mg/L twice at the 30 cm depth. In one instance, a layer of ice formed on the DO probe, causing a low dissolved oxygen reading. Bulkley Riffle 3 dissolved oxygen concentration was below the minimum criteria one time at the 30 cm depth. The concentrations of dissolved oxygen at Maxan Creek were above the minimum dissolved oxygen criteria for all samples.

Statistical analysis using a students t test was used to identify significant differences between the sample locations and to identify changes over time of the temperature and dissolved oxygen concentrations in the streambed. The following trends were observed:

- There was no significant difference in water temperature taken October 22nd between the 15 and 30 cm tubes at the four sites, however, the temperature in the 30 cm tubes was slightly higher than in the 15 cm tubes at all sites on November 12th and November 18th. Stream temperature decreased at all sites from October 22nd to November 18th;

- At the Bulkley River, there was significantly less dissolved oxygen on October 22nd at 30 cm than at 15 cm depth ($P=0.007$). There was significantly less dissolved oxygen on November 13th at 30 cm than at 15 cm depth ($P=0.001$). There was significantly less dissolved oxygen on November 18th at 30 cm than at 15 cm depth ($P=0.003$); and

- There was no significant difference between the mean dissolved oxygen concentrations at the Bulkley sites ($n=9$) and the mean dissolved oxygen concentrations at the Maxan site ($n=3$) at 15 cm and 30 cm, on October 22nd and November 12th.

Table 2 presents the comparisons between the sampling dates. The results indicate that there was a significant decrease in dissolved oxygen concentrations at the 30 cm depth from the October 22nd to November 13th sampling periods ($n=9$).

Table 2. Bulkley River and Maxan Creek interstitial dissolved oxygen study results, showing the statistical comparisons between the 15 and 30 cm depths and dates sampled.

15 cm	OCTOBER 22	NOVEMBER 12
October 22	X	X
November 12	no significant difference (P=0.77)	X
November 18	no significant difference (P=0.43)	no significant difference (P=0.66)

30 cm	OCTOBER 22	NOVEMBER 12
October 22	X	X
November 12	Significant difference (P=0.02)	X
November 18	Significant difference(P=0.003)	No significant difference (P=0.75)

3.2 MCNEIL CORES

Data from the McNeil cores indicates that the sediment composition of the Bulkley River at Riffles 1,2 and 3 exceeded the BC Ambient Water Quality Guidelines for Turbidity, Suspended and Benthic Sediments (MELP, 1999). The guidelines state that fines are not to exceed 10% as less than 2 mm, 19% as less than 3 mm and 25% as less than 6.35 mm at salmonid spawning sites. The average substrate composition for each site is summarized in Table 3.

For this project, the sieves sizes to fit the criteria of less than 6.35 mm and less than 3.0 mm were not available. The less than 2.0 mm was available. Therefore, the less than 6.35 mm fraction is an underestimate including all material less than 6.3 mm, and the less than 3.0 mm fraction includes all material less than 2.8 mm. The <2.0 mm fraction is accurate.

Table 3. Average substrate composition by percent for McNeil cores collected from three spawning sites on the Bulkley River and a test site in Maxan Creek.

SITE	AVERAGE PERCENT COMPOSITION (N=6 SITES). BOLD INDICATES THAT THE GUIDELINES ARE EXCEEDED	BC CRITERIA GUIDELINES FOR FINES PRESENT IN BENTHIC SEDIMENT SAMPLES (MAX)
Bulkley River Riffle 1	**29.7%, 23.4%, 13.3%**	25%*,19%**,10%***
Bulkley River Riffle 2	23.9%, **19.2%, 11.9%**	25%,19%,10%
Bulkley River Riffle 3	14.6%, 11.9%, 9.0%	25%,19%,10%
Maxan Creek	18.8%, 14.4%, 8.1%	25%,19%,10%

*maximum of 25% of fines less than 6.35 mm in diameter.
**maximum of 19% of fines less than 3.0 mm in diameter.
***maximum of 10% of fines less than 2.0 mm in diameter.

A graph of each McNeil core showing a breakdown by grain size of the fraction of the samples (percent composition) that are <6.35 mm, are provided for each riffle in the Bulkley River and for Maxan Creek. Raw data is provided in Appendix 2. Bulkley Riffle 1, shows that an average 10.3% of the total McNeil core sampled consisted of coarse sand (2<x<0.5 mm), and that there was very little very fine sand or silt/clay present in the sample (Figure 5). Bulkley Riffle 2 shows the same trend, that and average 10.4% of the total McNeil core sample consisted of coarse sand (Figure 6). Less than 1% of the total sample in Riffle 2 consisted of very fine sand or silt/clay. Bulkley Riffle 3 shows that an average 6.4% of the total sample consisted of coarse sand (Figure 7). The graph of Maxan Creek indicates that 8.1% of the sample consists of coarse sand (Figure 8).

There was no significant difference between the percent composition of McNeil core samples collected from Bulkley Riffle sites and the Maxan site. A two way ANOVA with replication was used to calculate the statistical significance with a confidence level of 0.5. There was no significant difference between the Bulkley Riffle sites (n=18) and the Maxan site (n=6). There was no significant difference between the McNeil cores collected on October 16th and November 18th, at any of the four sites. The coarse sand fraction of the Bulkley Riffle samples was significantly greater than the proportions in the other size classes, determined by a Student's T-test with equal variance.

There was no significant difference between the McNeil core samples (n=6) and the freeze core samples by percent composition.

3.3 FREEZE CORES

Three freeze core samples were collected at each site on the Bulkley River and at Maxan

Creek. Each freeze core was divided into an upper and lower sample, with the upper sample containing sediment from 0-15 cm and the lower sample containing sediment from 15+ to the bottom of the core. Freeze cores do not have a specified sample mass or rate of freezing so the percent composition of each sample was used to statistically compare the upper and lower portions of the freeze cores rather than the mass of each grain size fraction.

Data from the freeze cores indicated that the sediment composition of the Bulkley River at Riffle 1,2 and 3 exceeded the BC Ambient Water Quality Guidelines for Turbidity, Suspended and Benthic Sediments (MELP, 1999). The guidelines state that fines are not to exceed 10% as less than 2 mm, 19% as less than 3 mm and 25% as less than 6.35 mm at salmonid spawning sites. The average substrate composition for each site is presented in Table 4.

Table 4. Average substrate composition by percent composition for freeze cores collected from three spawning sites on the Bulkley River and a test site in Maxan Creek.

SITE	AVERAGE GRAIN SIZE BY WEIGHT (N=3 SITES). BOLD INDICATES THAT THE GUIDELINES ARE EXCEEDED.	BC CRITERIA GUIDELINES FOR BENTHIC SEDIMENTS
Bulkley River Riffle 1 0-15 cm	24%, 15.8%, **12.9%**	25%*,19%**,10%***
Bulkley River Riffle 1 15 + cm	**32.1%, 22.4%, 19.0 %**	25%,19%,10%
Bulkley River Riffle 2 0-15 cm	21.4%, 16.2%, **14.4%**	25%,19%,10%
Bulkley River Riffle 2 15 + cm	18.9%, 13.4%, **12.0%**	25%,19%,10%
Bulkley River Riffle 3 0-15 cm	16.7%, 11.9%, 10.4%	25%,19%,10%
Bulkley River Riffle 3 15 + cm	**49.2%, 37.3%, 33.2%**	25%,19%,10%
Maxan Creek 0-15 cm	21.7%, 14.7%, **12.3%**	25%,19%,10%
Maxan Creek 15 + cm	24.8%, 14.3%, **10.7%**	25%,19%,10%

*maximum of 25% of fines less than 6.35 mm in diameter.
**maximum of 19% of fines less than 3.0 mm in diameter.
***maximum of 10% of fines less than 2.0 mm in diameter.

There were significant differences between the percent composition of the fractions less than 6.35 mm in the Bulkley Riffle 1 upper 0-15 cm and lower 15+cm substrate samples (P=0.04). Significantly less material <6.35 mm in size was contained in the 0-15 cm sample (P=0.02). No significant differences were found between the upper and lower samples from Bulkley Riffle 2. Significant differences were found between the percent composition of the <6.35 mm size fractions in the Bulkley Riffle 3 upper 0-15 cm and lower 15+ cm substrate samples. Significantly less material <6.35 mm in size was in the 0-15 cm sample (P=0.07). Significantly less material <3 mm in size was in the 0-15 cm sample (P=0.09). No significant differences were found between the upper and lower samples from Maxan Creek. The freeze core data is provided in Appendix 4.

Each freeze core sample was separated into the upper and lower substrate fraction at 15 cm depth. Figure 9 shows the average (n=3) results by the weight of each grain class for the freeze cores sampled at Bulkley Riffle 1. When the percent composition of the upper and lower substrate is compared, the coarse sand fraction was significantly greater than the other fractions, and the proportion of the coarse sand was higher in the 15+ cm (lower) zone (Figure 10). Very little silt/clay or very fine sand was present in the sample. Bulkley Riffle 2 shows very large mass of coarse sand in the 0-15 cm zone, compared to the 15+ cm lower zone. (Figure 11). However, the percent composition of the coarse sand fraction within the 0-15 cm upper zone was significantly higher than the 15+cm lower zone (Figure 12). In Bulkley Riffle 3, the weight of coarse sand is significantly higher in the 15+cm lower zone (Figure 13). Very little silt/clay or very fine sand was present in the sample. The graph of percent composition for Bulkley Riffle 3 shows significantly greater proportion of coarse sand in the 15+ cm lower zone (Figure 14). The Maxan Creek graph of grain size by weight indicates that the weight of the different grain classes are similar, but more coarse sand by weight was found in the 0-15 cm upper zone (Figure 15). The graph of percent composition of the Maxan Creek freeze core results show that the 0-15 cm upper zone contained higher proportions of silt/clay fine sand and medium sand (Figure 16).

4.0 DISCUSSION

4.1 DISSOLVED OXYGEN DISCUSSION

The results of the dissolved oxygen study show that at a depth of 15 cm, the concentration of interstitial dissolved oxygen at three spawning redds on the Bulkley river during the buried embryo/alevin life stages of salmon are not significantly lower than the proposed BC Criteria. However, at a depth of 30 cm, dissolved oxygen concentrations are less than the BC Criteria for the protection of aquatic life in Bulkley Riffles 1, 2, and 3. The dissolved oxygen concentrations for this time period at Maxan Creek were higher than the BC Criteria.

Decreases in dissolved oxygen concentrations are primarily caused by decreases in stream temperature (stream temperature is directly proportional to the solubility of oxygen in water). However, increases in layers of fines (silt and sand) in streambeds have been shown to reduce interstitial dissolved oxygen concentrations below the layer of fines. Therefore, McNeil cores and freeze cores have been incorporated into this project to determine if the concentration of fines is increased in the salmon redds, and if the "layering" of fines is creating an impermeable layer causing reduced interstitial oxygen concentrations at depths of 15 to 30 cm in the streambed.

4.2 MCNEIL & FREEZE CORE DISCUSSION

In summary, the BC criteria for the proportion of fines in streambed substrate composition was exceeded for each McNeil and freeze core sample (upper and lower zones). In Bulkley Riffle 1 and 3, there were significantly more fines <6.35 mm in the 0-15 cm upper substrate zone. A two-way ANOVA with replication showed that there were significant differences in the percent compositions between the upper and lower freeze core samples in the Bulkley Riffles. Every McNeil and freeze core sample had concentrations of coarse sand, in most cases significantly higher than the other grain size fractions by weight and by percent composition of the sample. Student's T-tests indicated that the McNeil cores were not significantly different in percent composition when sampled October 16 and November 18th. McNeil cores and freeze cores showed no significant differences when the percent composition of each grain size class was compared. Freeze core results showed significantly higher concentrations of coarse sand than other size fractions when compared by weight. Less than 0.5% of the silt/clay size fraction was present in the Bulkley Riffle freeze core and McNeil core samples. Slightly more silt/clay was found in the Maxan Creek samples.

The proportion of fines less than 6.35 mm in the Bulkley River exceeds the BC ambient water quality guidelines for benthic sediments. The sample sieving identified the largest grain size fraction to be coarse sand (2.0mm>x <0.5 mm). The coarse sand was found predominantly in the lower freeze core samples (15+cm), with the exception of Bulkley Riffle 2.

5.0 CONCLUSIONS AND RECOMMENDATIONS

DFO wanted to test the hypothesis that a layer of impermeable fines formed over incubating salmon eggs in the Bulkley River would prevent the eggs from receiving dissolved oxygen and sufficient water flow for development. There was little evidence of the silt/clay fraction within the McNeil and freeze core samples, however, there were large concentrations of coarse and medium sand in each sample. Previous studies measured the effects of sand on coho emergence success and determined that coho survival from the eyed stage to emergence declined significantly with increased sand concentration, averaging 41% in a 9% sand mixture and 16, 7 and 5% in the 14, 28 and 39% sand mixtures respectively (Figure 17)(Tripp & Poulin, 1986). It appears that the concentration of coarse sand in the Bulkley River riffles (and to a lesser extent in Maxan Creek) is causing a reduction in survival to emergence rates of coho salmon, by forming an impermeable layer between the incubating salmon eggs, the overlying surface substrates and oxygen saturated water.

Dissolved oxygen concentrations were significantly different lower at depths of 30 cm than at 15 cm, which indicates that the large volume of coarse sand in the streambed may be filling the interstitial spaces between the spawning gravels and forming a barrier between oxygen saturated fresh water and incubating salmon eggs.

AEE provides the following recommendations for future work in the Bulkley River:

A. Reduce Sediment Input

1. Reduce further sediment input into the Bulkley River and tributaries. Use standardized watershed restoration methods and procedures.
2. Monitor suspended sediment concentrations in the Bulkley River to ensure that further

sediment input is not occurring. Monitor to determine sources of sediment within the bankfull channel and on-going instream erosion.

3. Use gravel buckets, infiltration bags, WRP evaluation methods, continuous automated and event-based monitoring for monitoring turbidity and TSS.
4. Use annual helicopter/fixed wing overflights to track sediment sources.

B. Quantify Instream Sediment

1. Develop a monitoring program to determine the levels of fine sediments in the Bulkley River and tributaries exceeding the provincial criteria.
2. Use McNeil cores, freeze cores, substrate composition analysis, pebble counts and detailed sediment mapping within the bankfull width.

C. Reduce impacts of sediment on salmon redds

1. Monitor survival to emergence (STE) rates in salmonid habitat on the Bulkley River, in redds which have been heavily impacted and in redds impacted to a lesser extent. Measure substrate composition, suspended sediment deposition, interstitial dissolved oxygen groundwater inputs and STE in different redds.

2. Calculate the residence time of sediment transport through the Bulkley system. Accelerate the rate of watershed recovery by developing land management standards which apply to the entire watershed to control and reduce sediment inputs (Passive Restoration).

3. Design and implement instream watershed restoration prescriptions to trap coarse and medium sands and remove them from the river system (Active Restoration).

Combine passive and active restoration strategies on the Bulkley River with frequent fish presence/absence and abundance monitoring to chart the recovery rate of the watershed. Conduct annual or semi-annual monitoring on watershed restoration structures. Conduct annual overview flights to identify new or continuing sediment sources.

6.0 CLOSURE

AEE thanks you for the opportunity to have worked on this stream substrate composition project and we look forward to working with you on future projects. Should you have any questions, please call Jessica Harper at 250-847-8783.

Respectfully Submitted,

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7.0 REFERENCES

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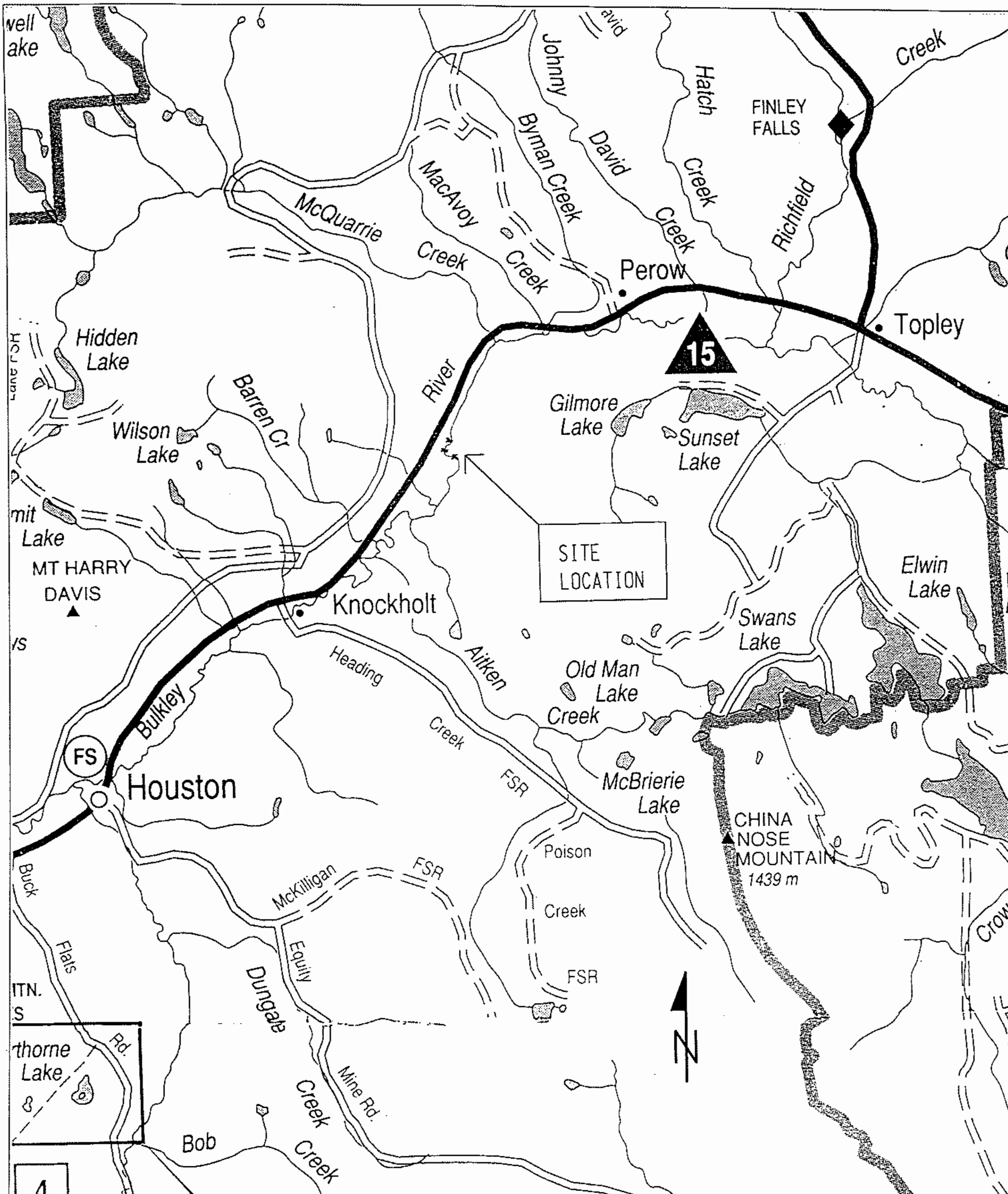

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BULKLEY RIVER
COMMUNITY FUTURES DEVELOPMENT
CORPORATION OF NADINA
MORICE FOREST DISTRICT

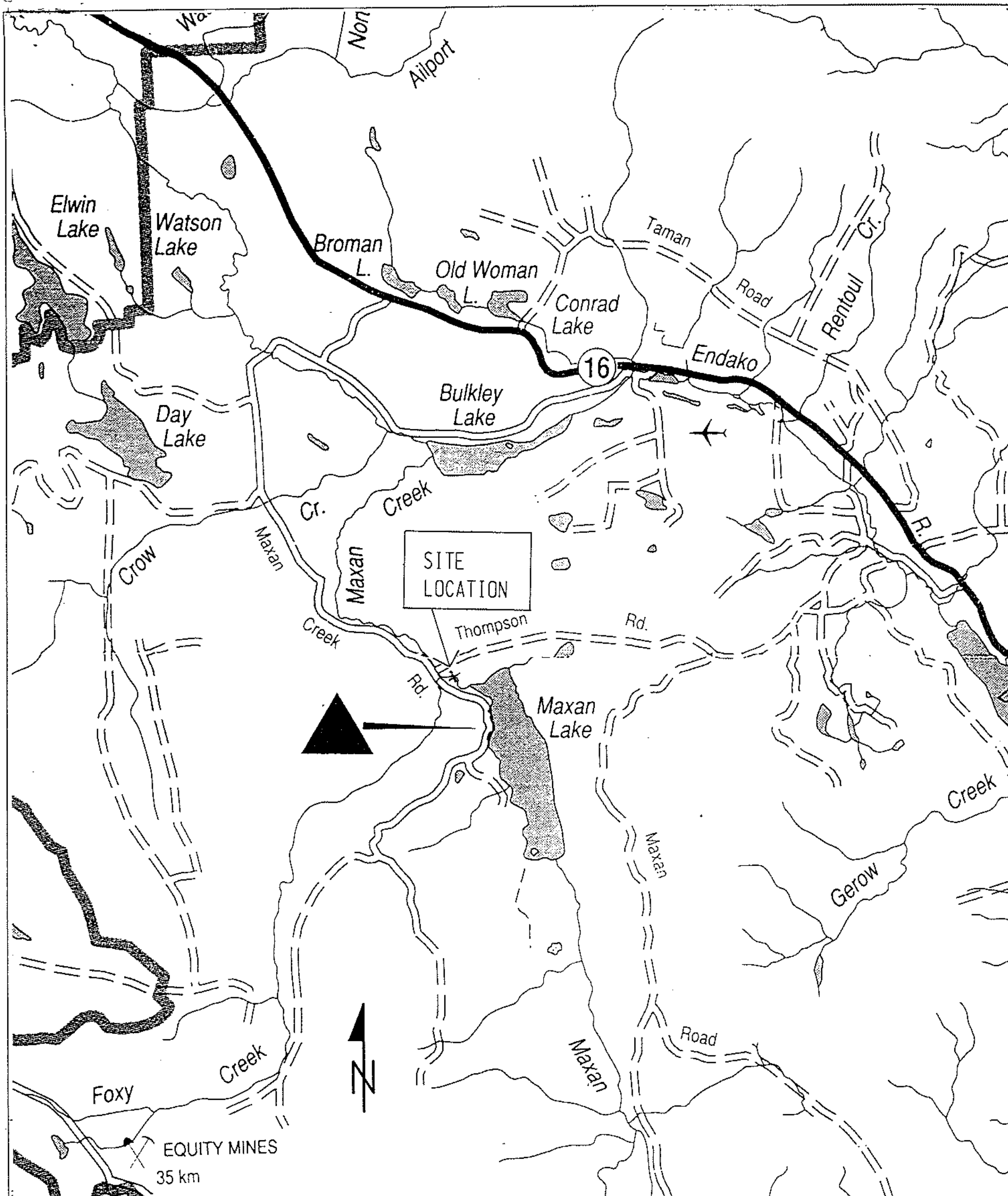
KS00063 SITE MAP

FIGURE 1

DATE: 02/25/99

DRAWN: RLT

SCALE:
N.T.S.

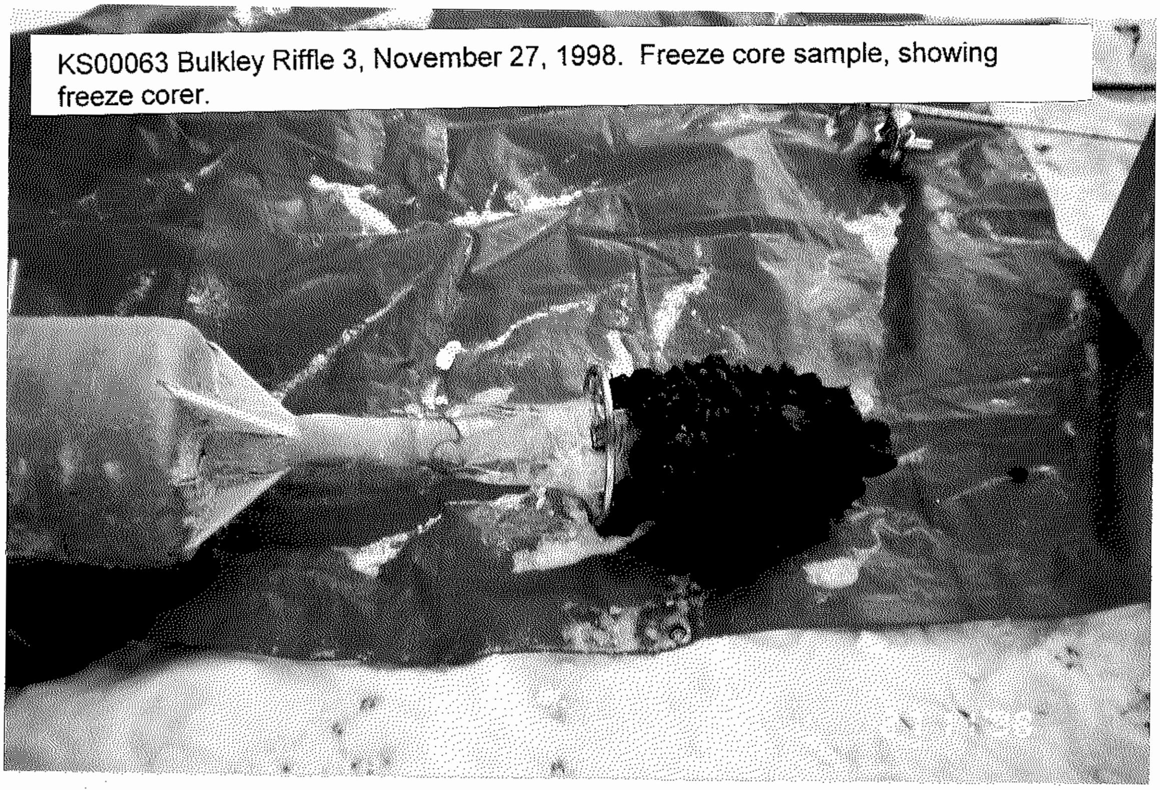


AGRA Earth & Environmental Limited ENGINEERING GLOBAL SOLUTIONS	MAXAN CREEK COMMUNITY FUTURES DEVELOPMENT CORPORATION OF NADINA LAKES FOREST DISTRICT	DATE: 02/25/99 DRAWN: RLT
	KS00063 SITE MAP — FIGURE 2	SCALE: N.T.S.

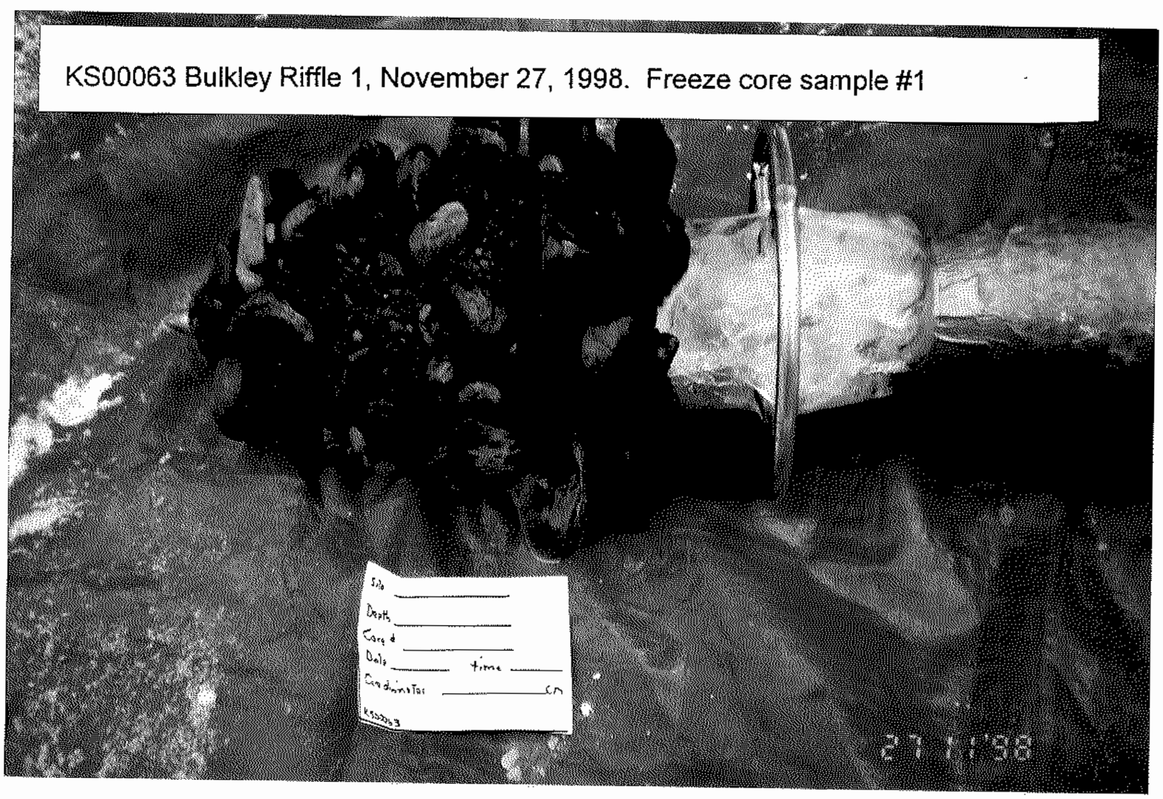
KS00063 Bulkley Riffle 1, November 13, 1998. Dissolved oxygen sampling tubes, view downstream.

KS00063 Maxan Creek control site, November 13, 1998. Dissolved oxygen sampling tubes, view upstream.

Figure 3. Photos of dissolved oxygen stilling tubes in the Bulkley River Riffles



KS00063 Bulkley Riffle 3, November 27, 1998. Freeze core sample, showing freeze corer.



KS00063 Bulkley Riffle 1, November 27, 1998. Freeze core sample #1

Figure 4. Photos of freeze core sampler and freeze core from the Bulkley Riffles

Figure 5. Bulkley Riffle 1 graph of McNeil core substrate composition data plotted by the percent mass of each sieve.

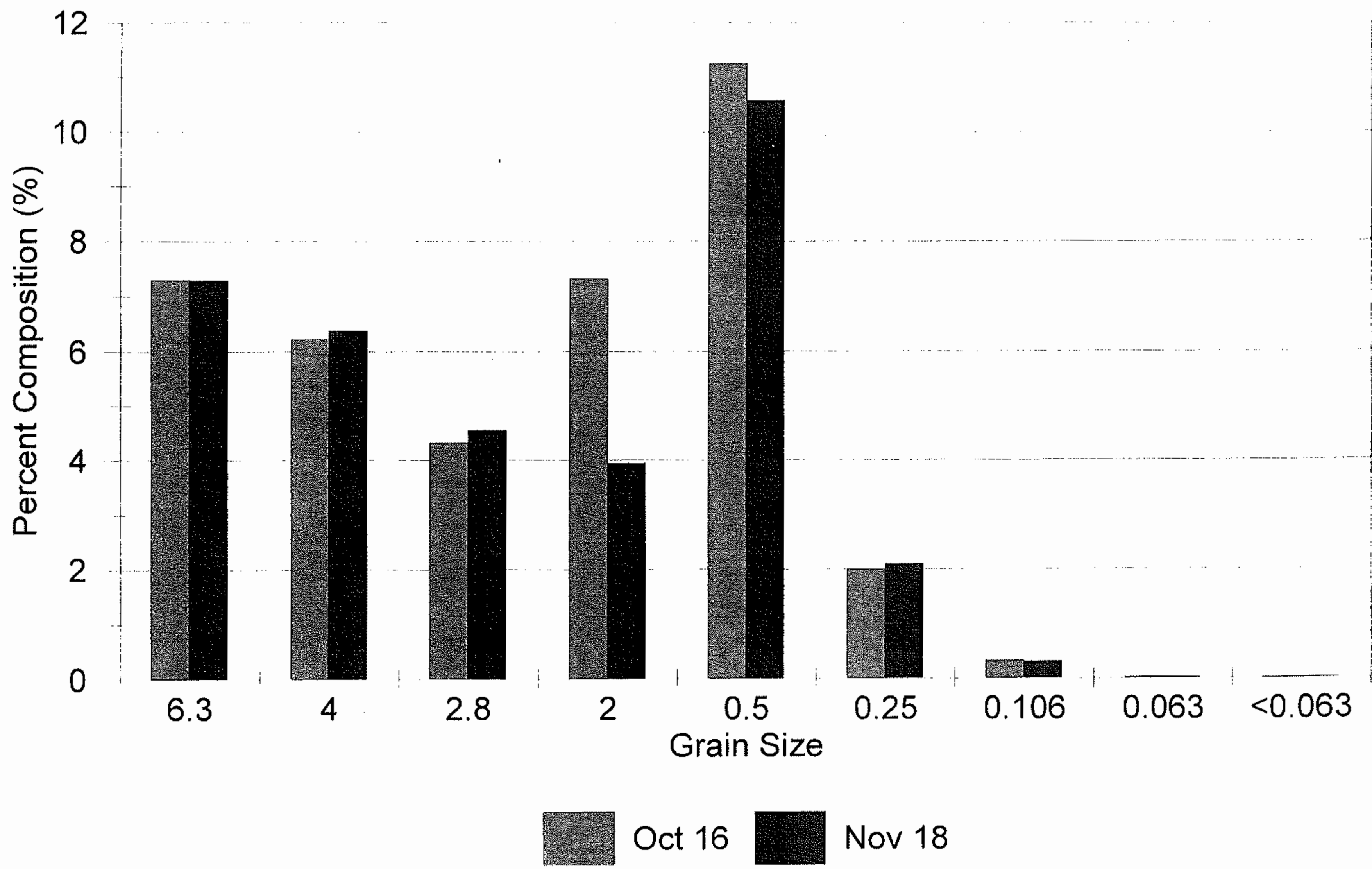


Figure 6. Bulkley Riffle 2 graph of McNeil core substrate composition data plotted by the percent mass of each sieve.

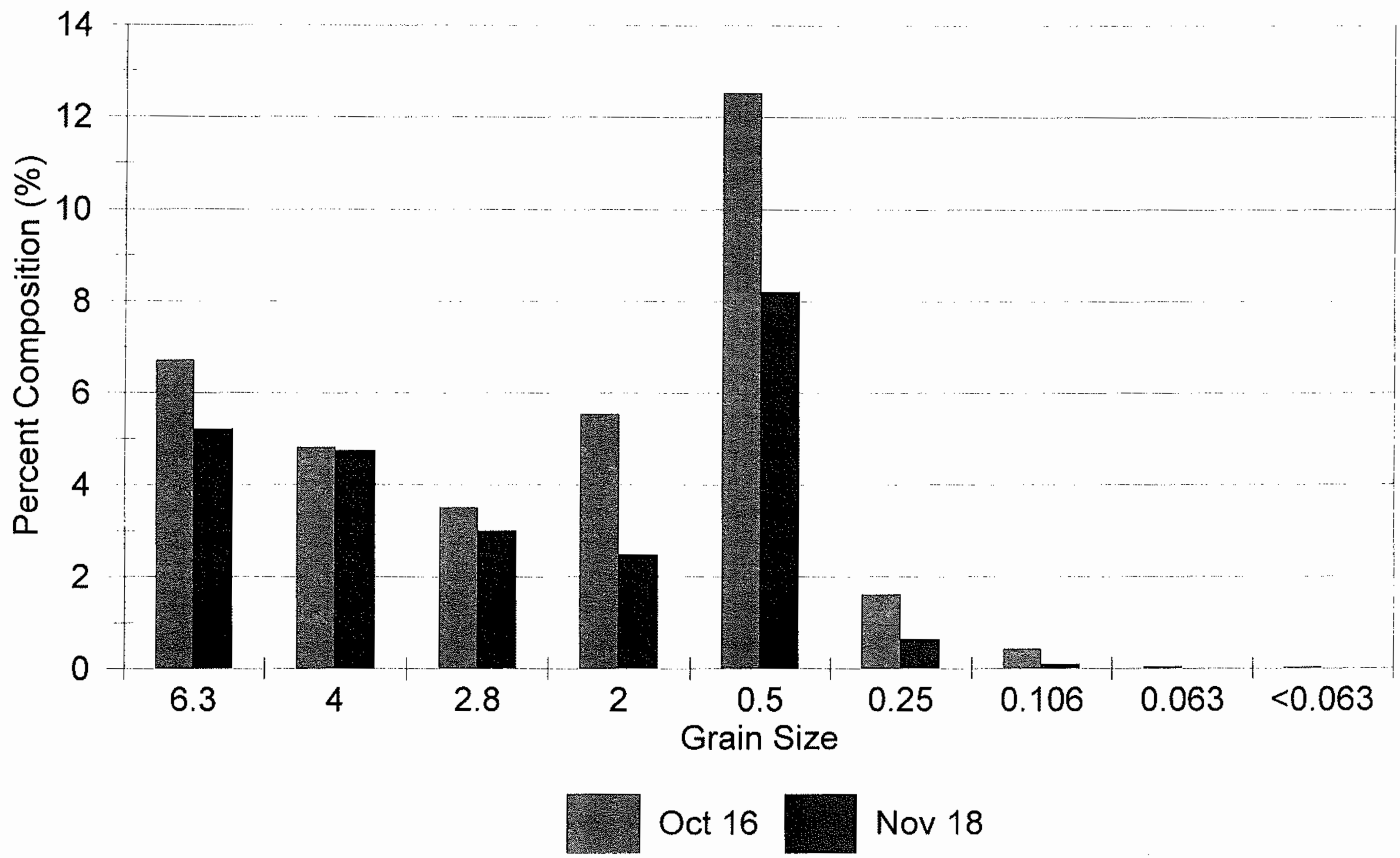


Figure 7. Bulkley Riffle 3 graph of McNeil core substrate composition data plotted by the percent mass of each sieve.

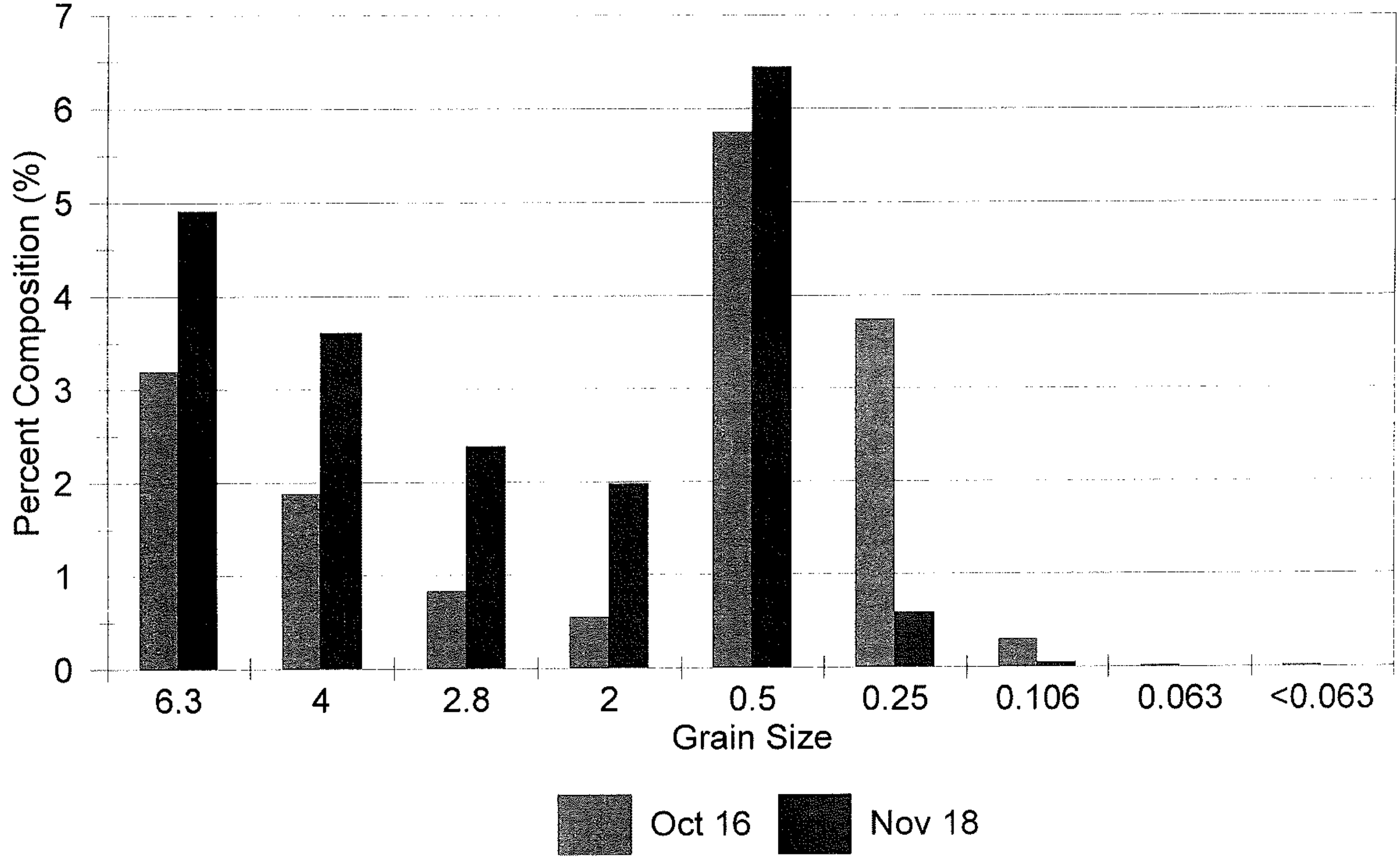


Figure 8. Maxan Creek graph of McNeil core substrate composition data plotted by the percent mass of each sieve.

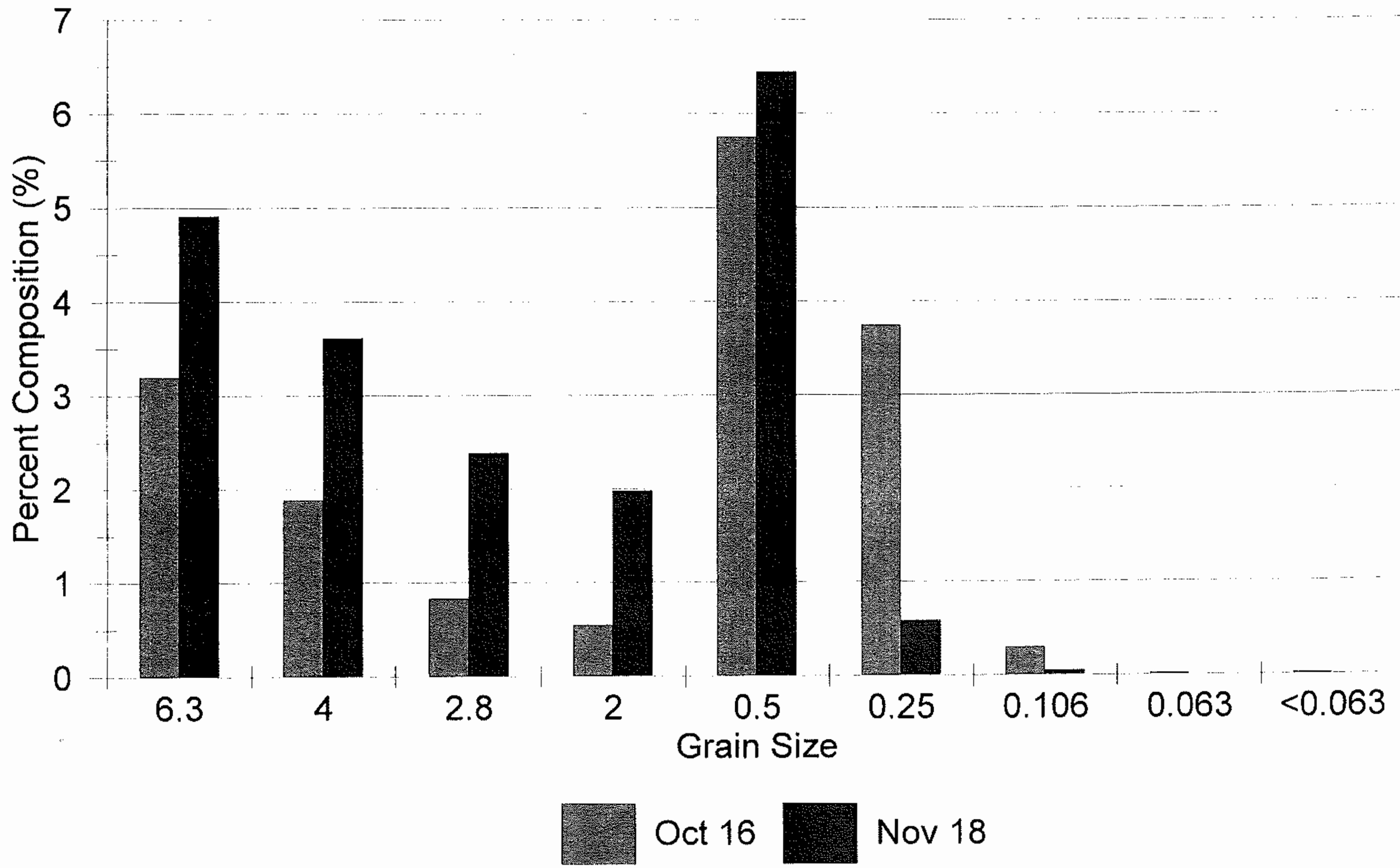


Figure 9. Bulkley Riffle 1 graph of freeze core substrate composition data plotted by the weight of each sieve.

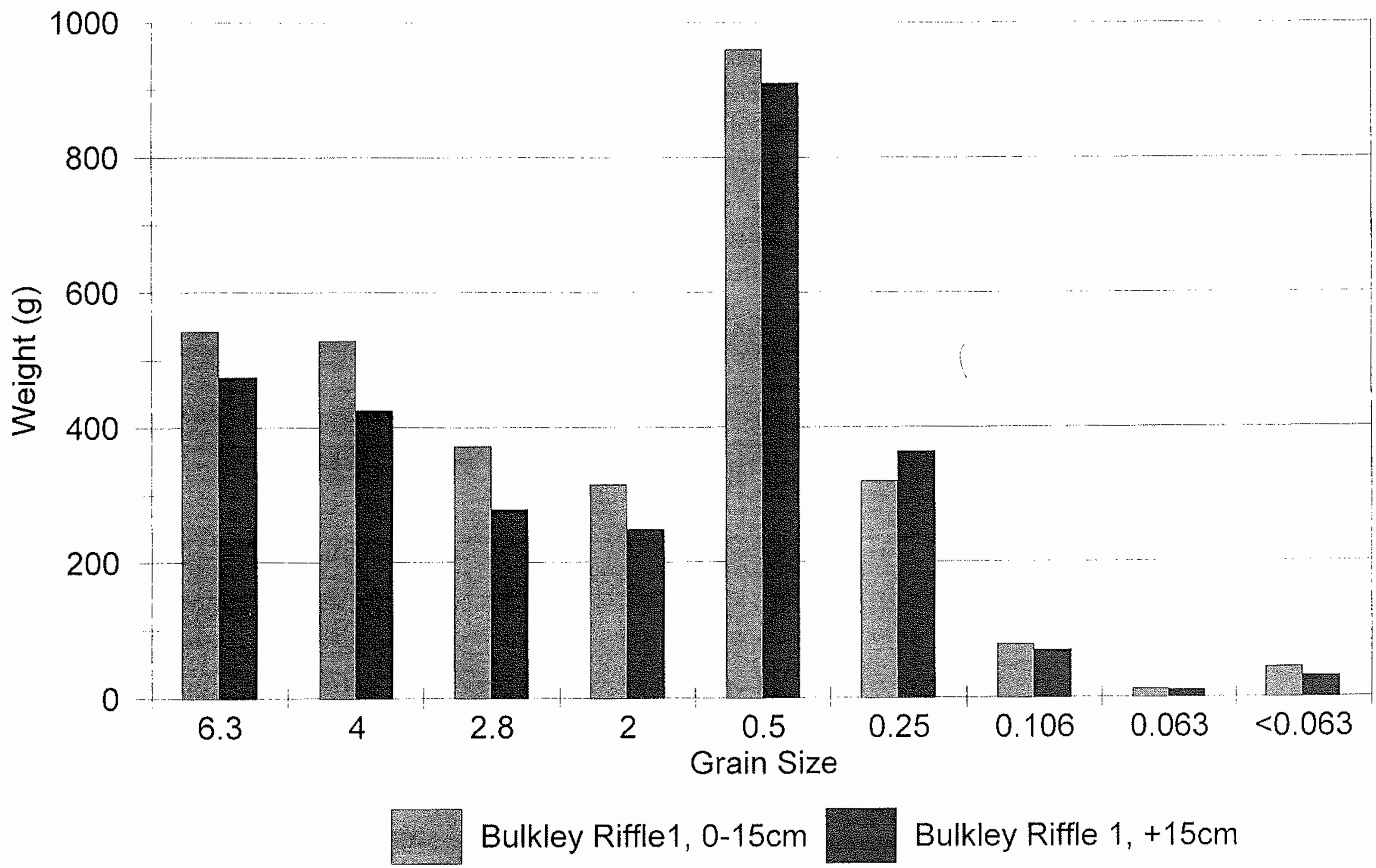


Figure 10. Bulkley Riffle 1 graph of freeze core substrate composition data plotted by the percent mass of each sieve.

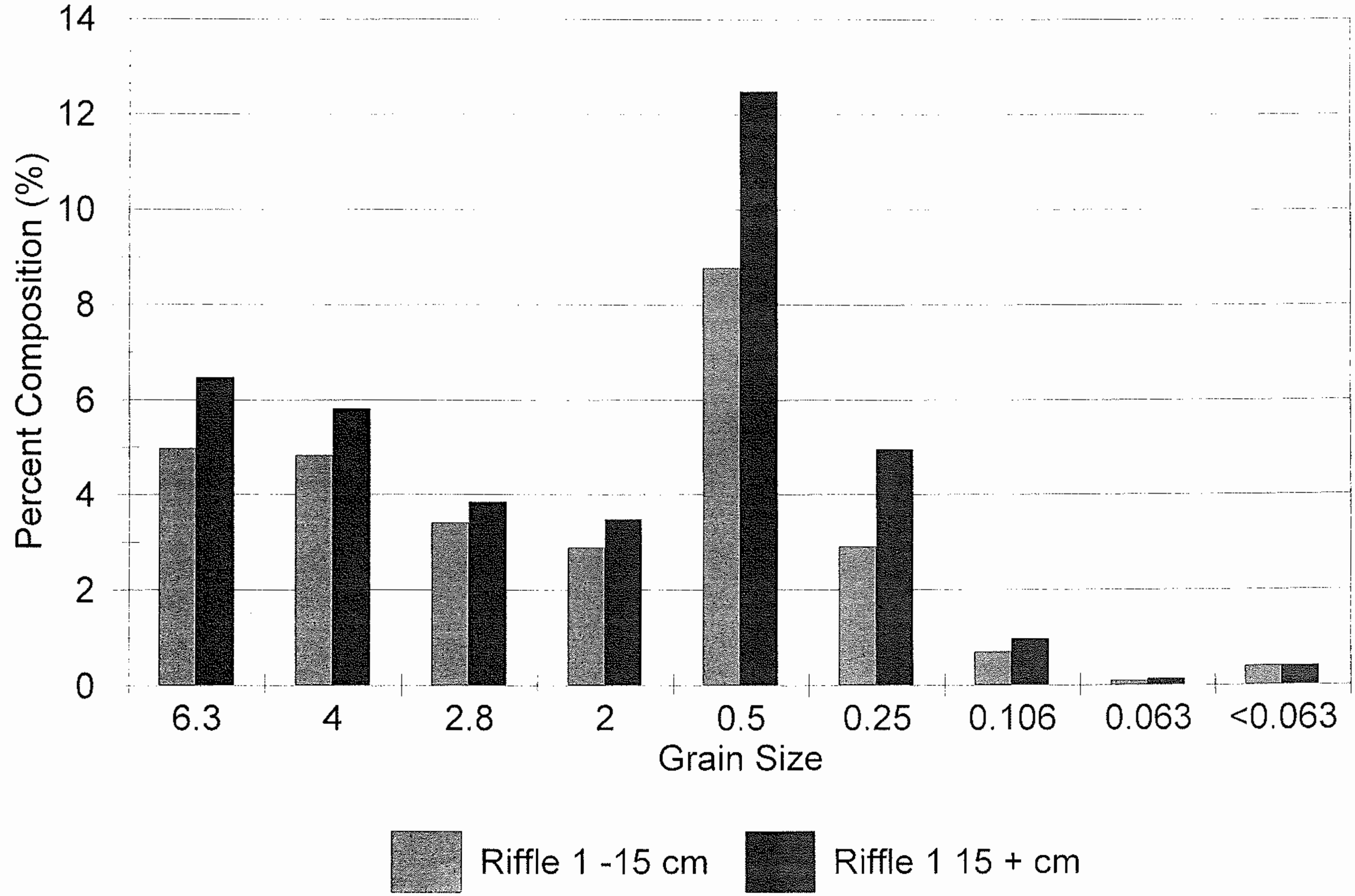


Figure 11. Bulkley Riffle 2 graph of freeze core substrate composition data plotted by the weight of each sieve.

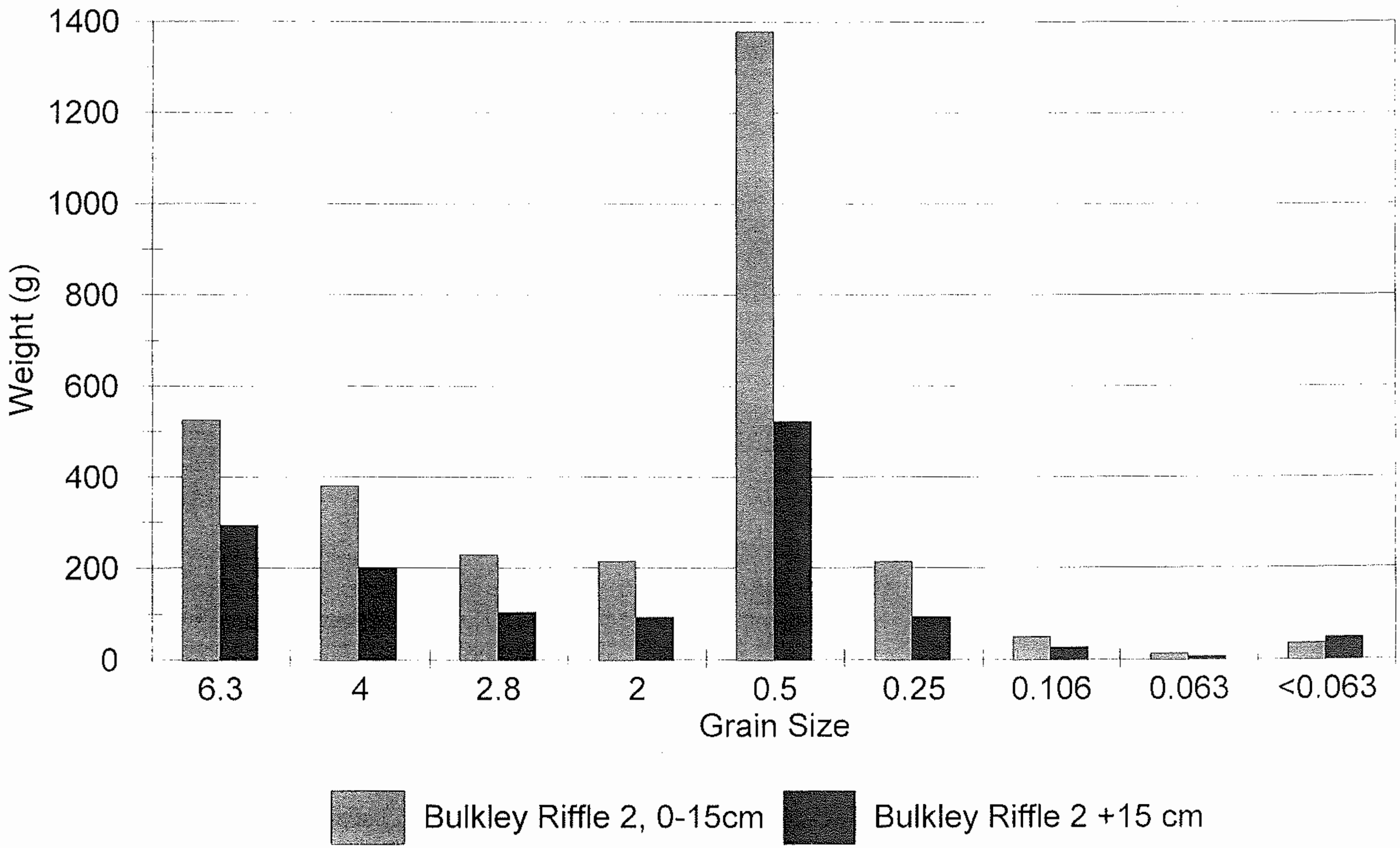


Figure 12. Bulkley Riffle 2 graph of freeze core substrate composition data plotted by the percent mass of each sieve.

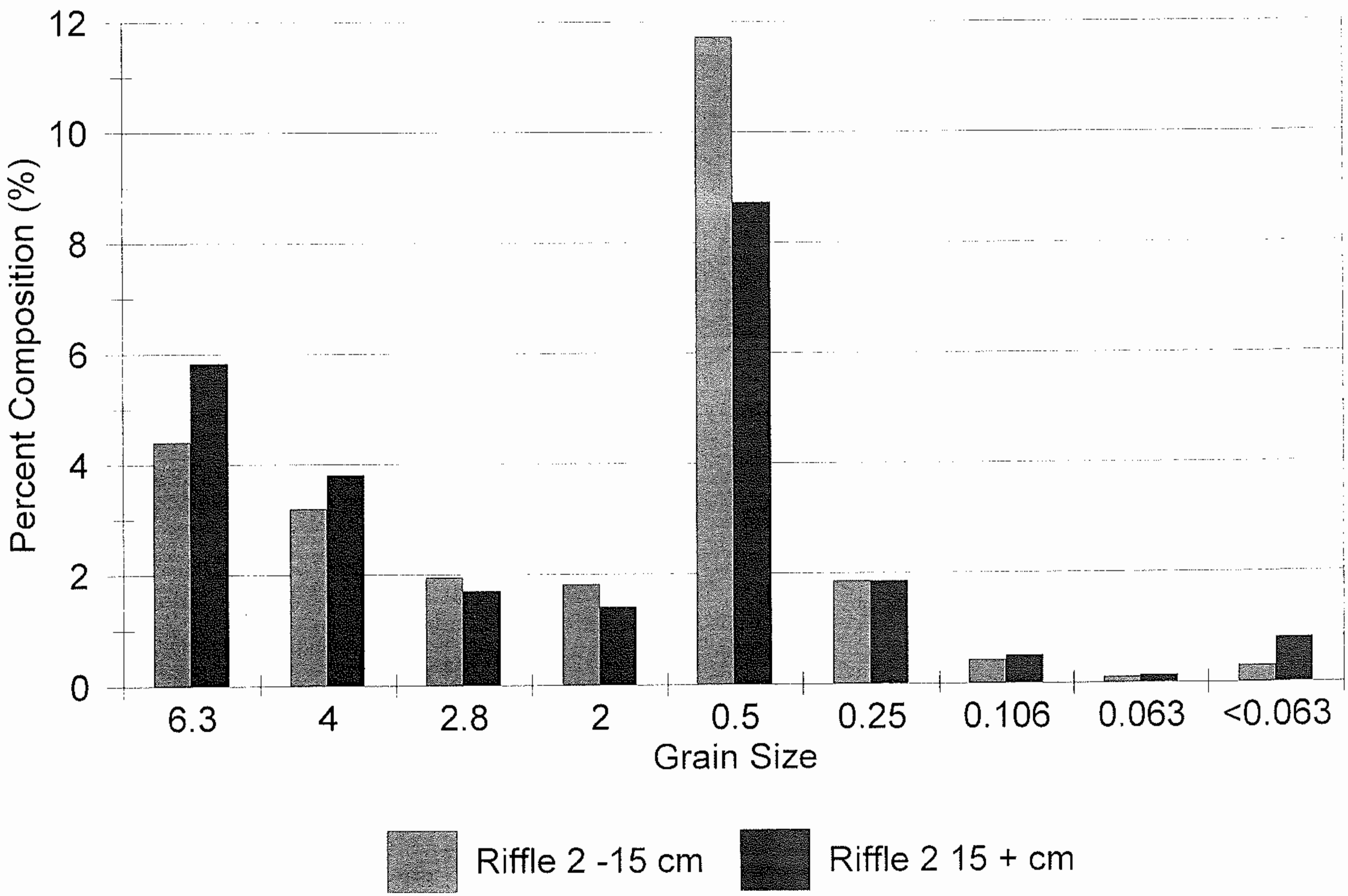


Figure 13. Bulkley Riffle 3 graph of freeze core substrate composition data plotted by the weight of each sieve.

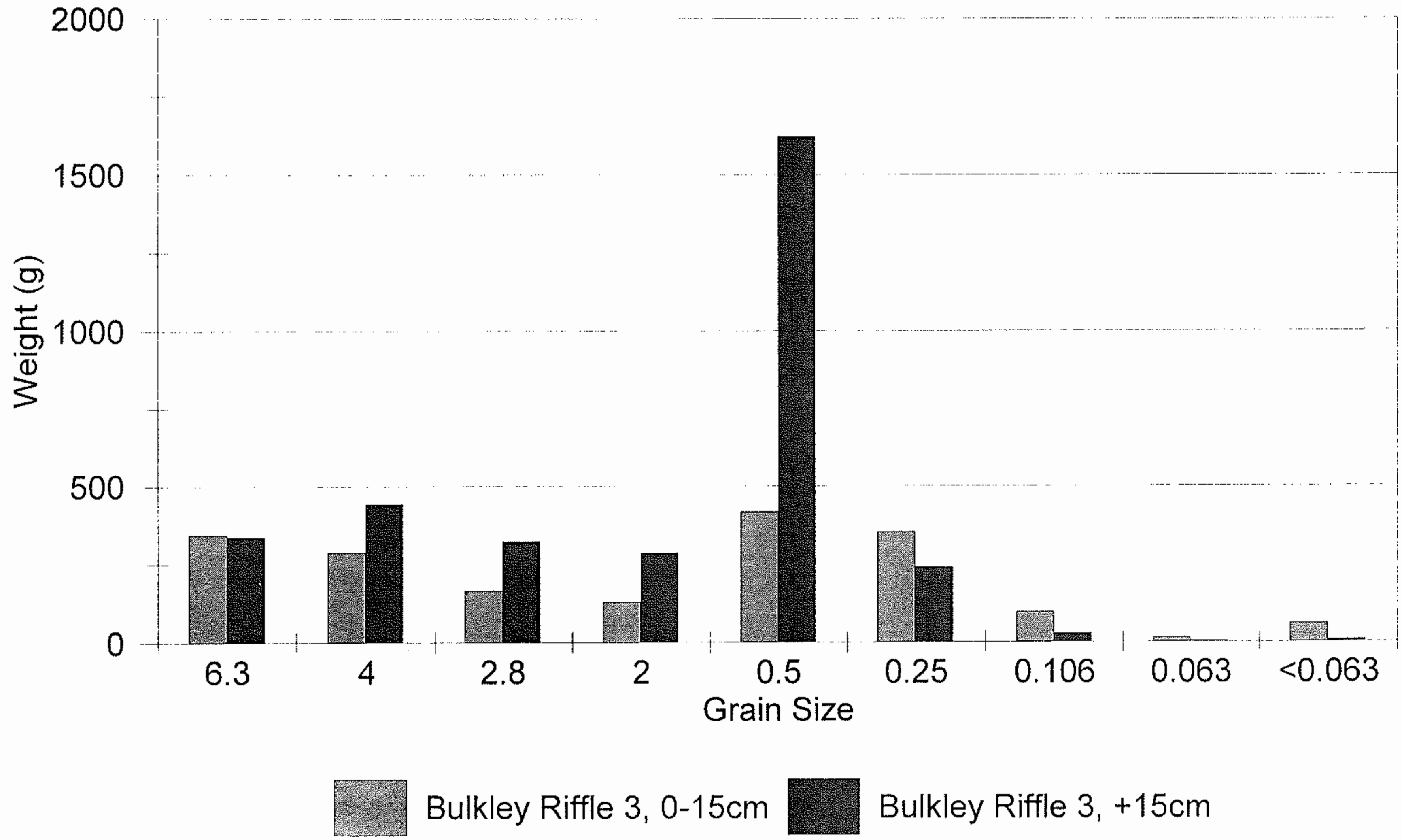


Figure 14. Bulkley Riffle 3 graph of freeze core substrate composition data plotted by the percent mass of each sieve.

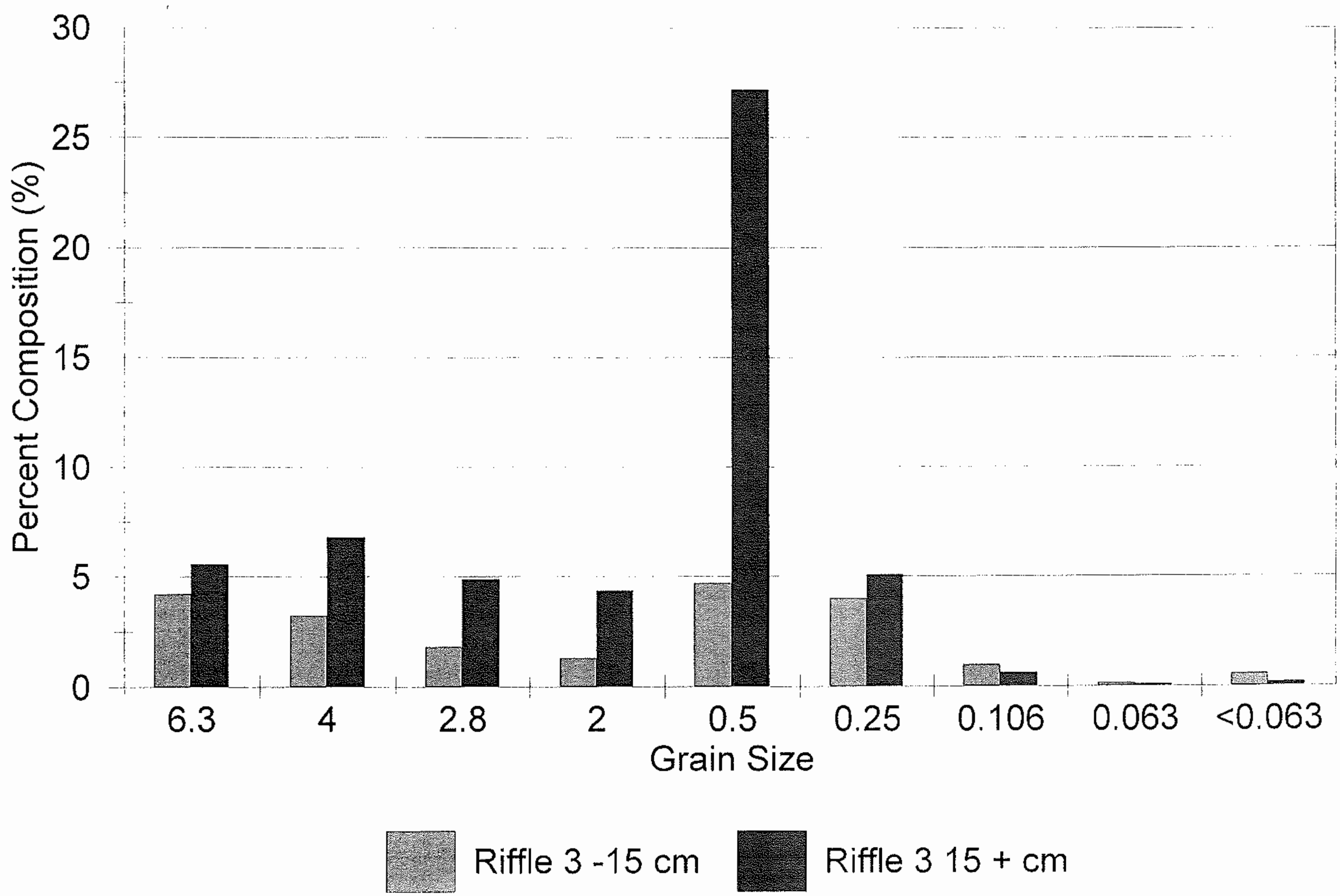


Figure 15. Maxan Creek graph of freeze core substrate composition data plotted by the weight of each sieve.

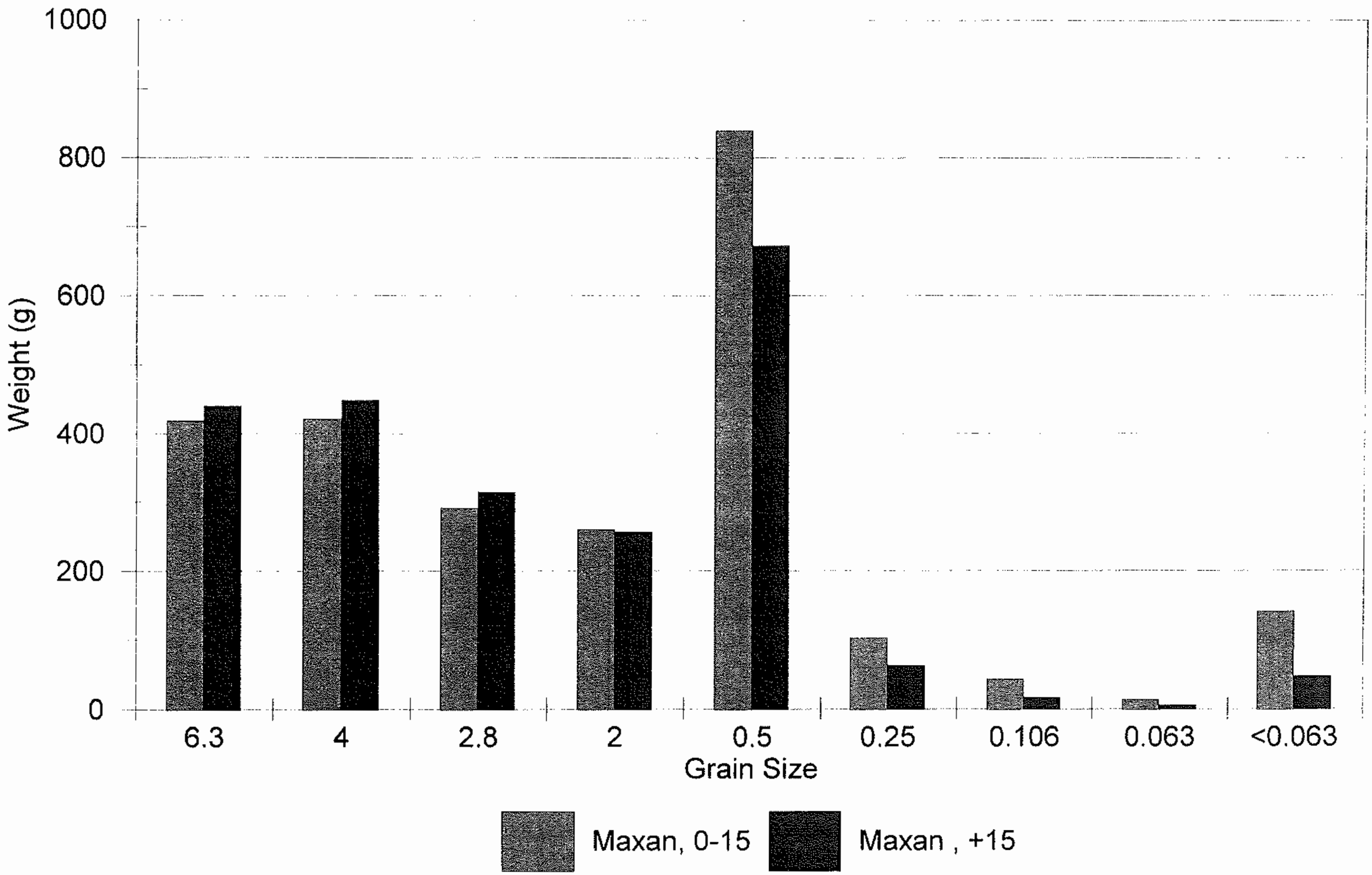


Figure 16. Maxan Creek graph of freeze core substrate composition data plotted by the percent mass of each sieve.

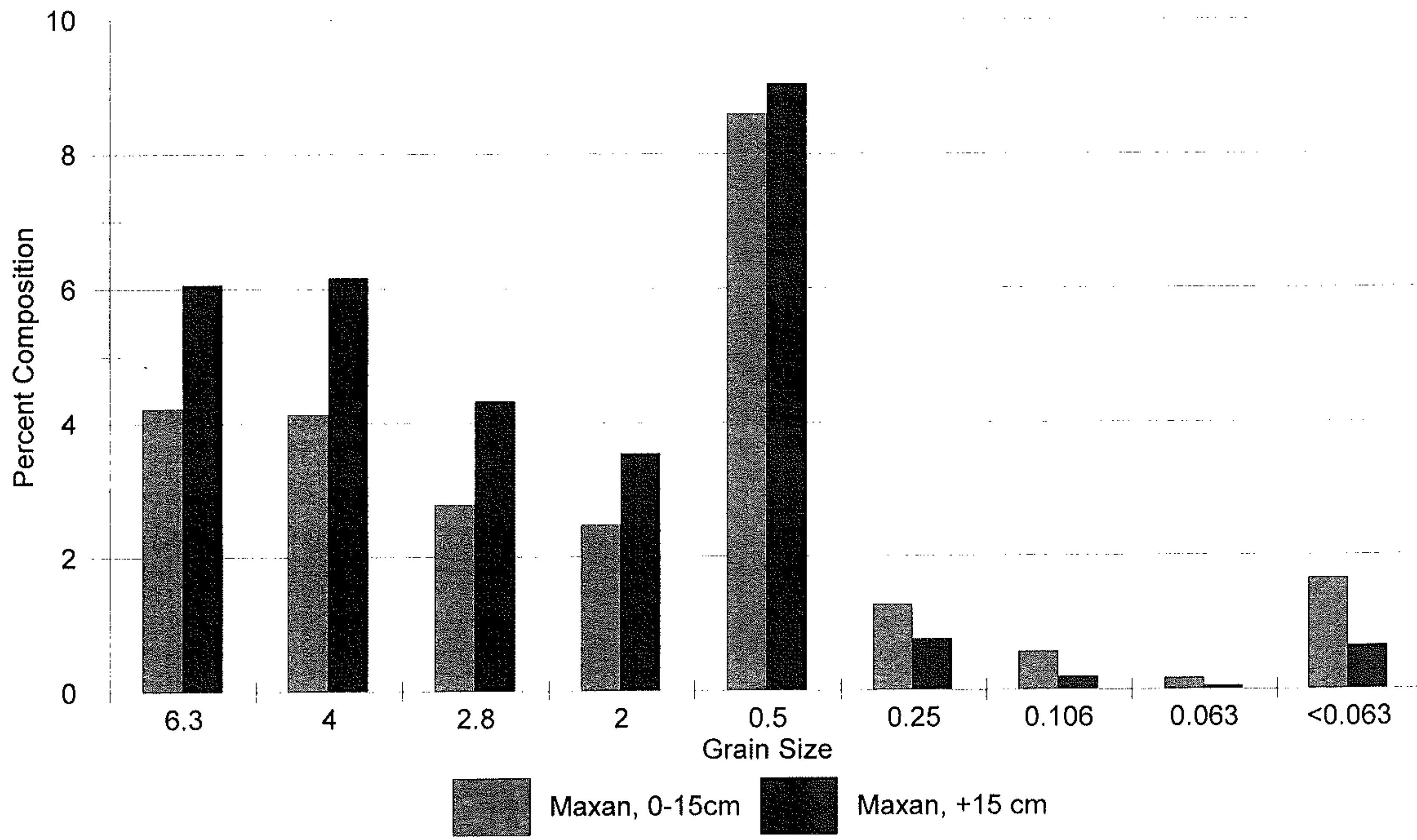


Figure 17. Excerpt from Tripp & Poulin (1986) Coho fry emergence patterns in relation to four different concentrations of sand (particles <3.36 mm) in upwelling type incubation boxes.

Effects of Sand on Coho Emergence Success

In the egg incubation study, coho fry emergence commenced on April 14 and was concluded by May 23 (Fig. 9). A total of 598 fry emerged from the 3300 eggs planted. This included 366, 141, 63, and 28 fry that emerged from the 9, 14, 28, and 39% sand mixtures, respectively. One of the 39% sand replicates had an early emergence of 148 premature sac fry and consequently it was excluded from any further analysis.

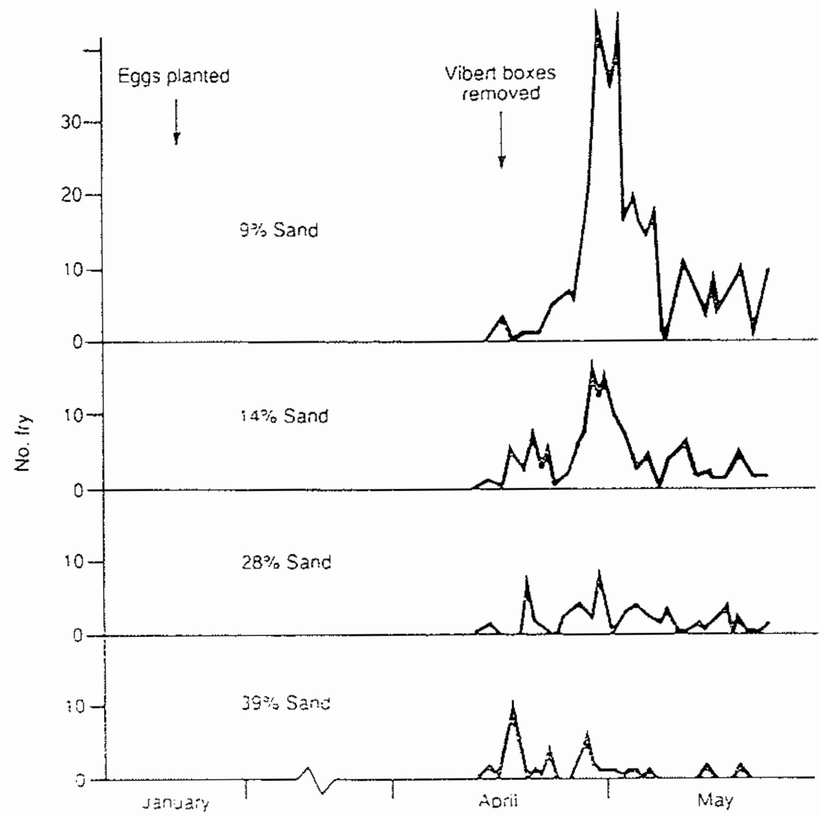


FIGURE Coho fry emergence patterns in relation to four different concentrations of sand (particles <3.36 mm) in upwelling-type egg incubation boxes.

Composition and characteristics of the sand-gravel mixtures used to assess effects of sand (particles <3.36 mm in diameter, including fines) on coho hatching and emergence success in upwelling-type incubation boxes. Values are mean ± 1SD.

	Sand (<3.35 mm) concentration tested			
	9%	14%	28%	39%
% Fines (<0.85 mm)	3.9±1.7	3.0±1.2	6.5±1.6	7.1±3.1
% Sand (0.85-3.35 mm)	5.2±1.6	11.1±4.0	21.9±0.3	31.9±5.1
% Pea gravel (3.36-9.5 mm)	8.3±2.3	8.0±1.2	7.3±0.3	4.1±1.0
% Medium gravel (9.51-24.9 mm)	13.1±3.5	10.2±3.0	9.9±2.9	4.9±0.5
% Coarse gravel (25.0-62.9 mm)	54.1±5.6	47.1±8.8	44.7±5.8	41.0±2.5
Geometric mean (Dg)	19.9±2.4	16.2±4.5	11.0±1.9	8.4±0.2
Sorting coefficient (S_o)	2.0±0.2	2.2±0.7	4.0±0.3	4.6±0.6
Fredle index (Dg/S_o)	10.1±1.4	8.5±5.6	2.8±0.7	1.9±0.2

Appendix 1. Bulkley River and Maxan Creek dissolved oxygen sample data, October and November, 1998.

Dissolved Oxygen Data 1998
Bulkley River at km 14 east of Houston, BC.

Meter: YSI Dissolved Oxgyen meter

Instruction: Riffles are labelled from upstream to downstream (Riffle 1 is the furthest upstream)
Tubes are labelled from upstream to downstream (Tube 1 is the furthest upstream)

Pipes installed on 10/17/98, water level down 2-3 cm.
Riffle #3, 15 cm pipe not in securely, may need to be moved.

Riffle #1 (B1)

Tube #	Date	Depth	mg/L O2	% sat	Temp C	Tube #	Depth	mg/L O2	% sat	Temp C
1	Oct 22	15 cm	9.2	71	4.5	1	30 cm	7.8	60	4.5
2	Oct 22	15 cm	10.6	82	4.5	2	30 cm	9.6	74	4.6
3	Oct 22	15 cm	10.5	81	4.5	3	30 cm	8.2	63	4.5

Riffle #1, 15 cm pipe not in securely, may need to be moved.

Riffle #2 (B2)

Tube #	Date	Depth	mg/L O2	% sat	Temp C	Tube #	Depth	mg/L O2	% sat	Temp C
1	Oct 22	15 cm	11.1	86	4.5	1	30 cm	9.6	74	4.6
2	Oct 22	15 cm	11.4	88	4.4	2	30 cm	11.1	86	4.5
3	Oct 22	15 cm	11	85	4.4	3	30 cm	6.6	52	5.1

Riffle #3 (B3)

Tube #	Date	Depth	mg/L O2	% sat	Temp C	Tube #	Depth	mg/L O2	% sat	Temp C
1	Oct 22	15 cm	11.8	91	4.3	1	30 cm	8.7	67	4.4
2	Oct 22	15 cm	11.8	91	4.3	2	30 cm	11.1	85	4.3
3	Oct 22	15 cm	11.8	91	4.3	3	30 cm	11.2	86	4.3

Maxan Creek 10/22/98

Tube #	Date	Depth	mg/L O2	% sat	Temp C	Tube #	Depth	mg/L O2	% sat	Temp C
1	Oct 22	15 cm	9.5	71	3.5	1	30 cm	8.9	67	3.4
2	Oct 22	15 cm	11.2	84	3.5	2	30 cm	10.9	82	3.5
3	Oct 22	15 cm	10.1	76	3.6	3	30 cm	9.5	71	3.6

Bulkley River at km 14 east of Houston, BC.

Meter: YSI Dissolved Oxgyen meter

Instruction: Riffles are labelled from upstream to downstream (Riffle 1 is the furthest upstream)
Tubes are labelled from upstream to downstream (Tube 1 is the furthest upstream)

Pipes installed on 10/17/98

Riffle #1 (B1)

Tube #	Date	Depth	mg/L O2	% sat	Temp dC		Tube #	Depth	mg/L O2	% sat	Temp C
1	Nov 13	15 cm	9.3	66	1.2		1	30 cm	8.2	58	1.3
2	Nov 13	15 cm	7.4	52	1.1		2	30 cm	4.3	31	1.8
3	Nov 13	15 cm	10.3	73	1.1		3	30 cm	9.4	66	1.4

t in securely, may need to be moved.

Riffle #2 (B2)

Tube #	Date	Depth	mg/L O2	% sat	Temp dC		Tube #	Depth	mg/L O2	% sat	Temp C
1	Nov 12	15 cm	10.2	72	1		1	30 cm	0.2	1	2.8
2	Nov 12	15 cm	8.9	62	1		2	30 cm	11.7	83	1.3
3	Nov 12	15 cm	12.2	86	1		3	30 cm	6.2	n/a	1.1

Riffle #3 (B3)

Tube #	Date	Depth	mg/L O2	% sat	Temp dC		Tube #	Depth	mg/L O2	% sat	Temp C
1	Nov 12	15 cm	12.8	94	1.1	*	1	30 cm	5.2	37	0.8
2	Nov 12	15 cm	13.1	94	0.8	*	2	30 cm	5.3	37	1.1
3	Nov 12	15 cm	13	93	0.8	*	3	30 cm	5.3	39	2.6

ıard DO meter brand MIK 3

Maxan Creek

Tube #	Date	Depth	mg/L O2	% sat	Temp dC	Tube #	Depth	mg/L O2	% sat	Temp C
1	Nov 13	15 cm	10.7	77	1.8	1	30 cm	8.9	64	1.9
2	Nov 13	15 cm	12.2	88	1.9	2	30 cm	11.3	81	1.9
3	Nov 13	15 cm	12.2	87	1.8	3	30 cm	9.4	68	1.8

Note: water level dropped 5 cm since installation

Oxyguard (MELP) and YSI (AEE) comparison Nov 12/98

Riffle 2

Meter	Tube	Depth	DO	% sat	Temp	Tube	Depth	DO	% sat	Temp
Oxy	1	15 cm	13.5	97	0.7	1	30 cm	11	82	1.6
Oxy	2	15 cm	13.3	95	0.7	2	30 cm	13	94	1.1
Oxy	3	15 cm	13.6	97	0.7	3	30 cm	7.1	51	0.7
YSI	1	15 cm	10.2	72	1	1	30 cm	0.2	1	2.8
YSI	2	15 cm	8.9	62	1	2	30 cm	11.7	83	1.3
YSI	3	15 cm	12.2	86	1	3	30 cm	6.2	n/a	1.1

Bulkley River at km 14 east of Houston, BC.

Meter: YSI Dissolved Oxgyen meter

Instruction: Riffles are labelled from upstream to downstream (Riffle 1 is the furthest upstream)
Tubes are labelled from upstream to downstream (Tube 1 is the furthest upstream)

Pipes installed on 10/17/98

Riffle #1 (B1)

Tube #	Date	Depth	mg/L O2	% sat	Temp C		Tube #	Depth	mg/L O2	% sat	Temp C
1	Nov 18	15 cm	7.8	54	0.1		1	30 cm	4.9	34	0.7
2	Nov 18	15 cm	7.8	53	0.1		2	30 cm	7.9	56	0.8
3	Nov 18	15 cm	12.4	71	0.1	*	3	30 cm	3.6	25	0.4

* ice in tube 3 had to be broken with a stick, DO may be higher due to mixing

Riffle #2 (B2)

Tube #	Date	Depth	mg/L O2	% sat	Temp C	Tube #	Depth	mg/L O2	% sat	Temp C	
1	Nov 18	15 cm	9.2	63	0.1	1	30 cm	1.8	14	4	*
2	Nov 18	15 cm	7.4	51	0.2	2	30 cm	4.1	30	2.1	**
3	Nov 18	15 cm	9.2	64	0.6	3	30 cm	5.9	41	0.5	

* probe froze to bottom at 12 min

** probe froze to bottom at 14 min, DO to 0.00mg/L

Riffle #3 (B3)

Tube #	Date	Depth	mg/L O2	% sat	Temp C	Tube #	Depth	mg/L O2	% sat	Temp C	
1	Nov 18	15 cm	13.2	91	0.3	1	30 cm	5.8	42	2.3	
2	Nov 18	15 cm	12.8	88	0.3	2	30 cm	6.8	47	0.3	
3	Nov 18	15 cm	13	90	0.2	3	30 cm	10.9	75	0.3	*

* frozen at 18 min was 0.7 mg/L, 5% sat and 0.30 C

DID NOT COMPLETE THE MAXAN SITE ON NOVEMBER 18/98

Maxan Creek

Tube #	Date	Depth	mg/L O2	% sat	Temp C	Tube #	Depth	mg/L O2	% sat	Temp C
1	Nov 18	15 cm				1	30 cm			
2	Nov 18	15 cm				2	30 cm			
3	Nov 18	15 cm				3	30 cm			

Maxan Creek downstream of Maxan Lake

Meter: YSI Dissolved Oxgyen meter

Instruction: Riffles are labelled from upstream to downstream (Riffle 1 is the furthest upstream)
Tubes are labelled from upstream to downstream (Tube 1 is the furthest upstream)

Pipes installed on 10/17/98
left probe in tube for 15 min. Then measured DO and temp

Riffle #1 (M1)

Tube #	Date	Depth	mg/L O2	% sat	Temp C
1	Nov 27	15 cm	6.6	46	0.9
2	Nov 27	15 cm	9.0	63	0.9
3	Nov 27	15 cm	8.1	57	1.0

Tube #	Depth	mg/L O2	% sat	Temp C
1	30 cm	7.1	50	0.9
2	30 cm	6.4	59	0.9
3	30 cm	7.2	51	1.0

Appendix 2. Bulkley River and Maxan Creek McNeil core sample data, October and November, 1998.

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Bulkley River Riffle 1, October - November 1998. McNeil Core substrate composition data

Sample Data by Weight

				Sieve Size															
	Date	Site	Core #	total wt.	100	75	50	37.5	25	16	9.5	6.3	4	2.8	2	0.5	0.25	0.106	0.063	<0.063
9	98/10/16	Bulkley R. Riff 1	Mc #1	5743.2	0.0	0.0	1344.7	261.3	702.8	932.0	593.5	434.6	389.3	248.6	206.4	556.7	63.9	8.5	0.6	0.3
10	98/10/16	Bulkley R. Riff 1	Mc #2	5684.8	0.0	0.0	216.5	663.9	1039.8	622.3	427.4	399.9	283.4	248.1	831.4	744.0	175.6	29.5	2.0	1.0
15	98/10/16	Bulkley R. Riff 1	Mc #3	5026.1	0.0	0.0	768.4	800.8	781.2	424.4	471.7	366.6	346.9	216.3	188.5	551.9	88.8	17.6	1.8	1.2
5	98/11/18	Bulkley R. Riff 1	Mc #1	6165.0	0.0	0.0	1782.6	1004.2	536.9	448.0	470.4	394.2	365.1	246.3	227.0	592.3	83.1	12.1	1.7	1.1
16	98/11/18	Bulkley R. Riff 1	Mc #2	5348.3	0.0	730.6	239.1	519.5	569.6	593.0	575.9	414.7	393.0	301.8	265.5	643.3	87.9	12.4	1.1	0.9
6	98/11/18	Bulkley R. Riff 1	Mc #3	5604.8	0.0	0.0	1140.4	683.3	572.1	628.5	628.3	432.9	328.2	225.2	179.9	566.7	186.3	29.7	1.9	1.4
			Average	5595.4	0.0	121.8	915.3	655.5	700.4	608.0	527.9	407.2	351.0	247.7	316.5	609.2	114.3	18.3	1.5	1.0

Sample Data by percent composition

				Sieve Size															
	Date	Site	Core #	total wt.	100	75	50	37.5	25	16	9.5	6.3	4	2.8	2	0.5	0.25	0.106	0.063	<0.063
9	98/10/16	Bulkley R. Riff 1	Mc #1	100	0	0.0	23.4	4.5	12.2	16.2	10.3	7.6	6.8	4.3	3.6	9.7	1.1	0.1	0.0	0.0
10	98/10/16	Bulkley R. Riff 1	Mc #2	100	0	0.0	3.8	11.7	18.3	10.9	7.5	7.0	5.0	4.4	14.6	13.1	3.1	0.5	0.0	0.0
15	98/10/16	Bulkley R. Riff 1	Mc #3	100	0	0.0	15.3	15.9	15.5	8.4	9.4	7.3	6.9	4.3	3.8	11.0	1.8	0.4	0.0	0.0
5	98/11/18	Bulkley R. Riff 1	Mc #1	100	0	0.0	28.9	16.3	8.7	7.3	7.6	6.4	5.9	4.0	3.7	9.6	1.3	0.2	0.0	0.0
16	98/11/18	Bulkley R. Riff 1	Mc #2	100	0	13.7	4.5	9.7	10.7	11.1	10.8	7.8	7.3	5.6	5.0	12.0	1.6	0.2	0.0	0.0
6	98/11/18	Bulkley R. Riff 1	Mc #3	100	0	0.0	20.3	12.2	10.2	11.2	11.2	7.7	5.9	4.0	3.2	10.1	3.3	0.5	0.0	0.0
			Average	100	0	2.2	16.4	11.7	12.5	10.9	9.4	7.3	6.3	4.4	5.7	10.9	2.0	0.3	0.0	0.0

Bulkley River Riffle 2, October - November 1998. McNeil Core substrate composition data

				Sieve Size															
Date	Site	Core #	total wt.	100	75	50	37.5	25	16	9.5	6.3	4	2.8	2	0.5	0.25	0.106	0.063	<0.063
21 98/10/16	Bulkley R. Riff 2	Mc #1	5211.0	0.0	0.0	1065.6	706.6	680.7	744.5	531.7	377.8	278.1	165.5	143.3	451.3	50.7	12.5	1.5	1.2
22 98/10/16	Bulkley R. Riff 2	Mc #2	5881.3	0.0	816.2	460.8	680.0	537.2	555.6	319.2	305.4	216.8	214.4	608.3	1006.5	124.5	30.4	3.4	2.6
19 98/10/16	Bulkley R. Riff 2	Mc #3	4068.9	0.0	438.9	0.1	205.9	1068.2	529.1	417.6	313.0	221.8	152.1	145.5	481.1	71.2	21.5	1.7	1.2
17 98/11/18	Bulkley R. Riff 2	Mc #1	5617.1	0.0	1299.7	0.1	466.5	977.8	783.0	456.8	347.1	259.6	141.6	114.7	681.5	76.6	9.8	1.2	1.1
1 98/11/18	Bulkley R. Riff 2	Mc #2	5709.3	0.0	1880.3	702.8	509.4	660.6	483.0	348.7	221.5	188.9	127.4	126.4	434.3	20.6	3.9	0.8	0.7
2 98/11/18	Bulkley R. Riff 2	Mc #3	5164.8	0.0	0.0	2040.0	411.1	540.2	437.8	468.4	289.4	327.2	220.4	165.0	251.4	10.1	3.1	0.4	0.3
		Average	5275.4	0.0	739.2	711.6	496.6	744.1	588.8	423.7	309.0	248.7	170.2	217.2	551.0	59.0	13.5	1.5	1.2

Sample Data by percent composition				Sieve Size															
Date	Site	Core #	total wt.	100	75	50	37.5	25	16	9.5	6.3	4	2.8	2	0.5	0.25	0.106	0.063	<0.063
9 98/10/16	Bulkley R. Riff 2	Mc #1	100	0.0	0.0	20.4	13.6	13.1	14.3	10.2	7.3	5.3	3.2	2.7	8.7	1.0	0.2	0.03	0.02
10 98/10/16	Bulkley R. Riff 2	Mc #2	100	0.0	13.9	7.8	11.6	9.1	9.4	5.4	5.2	3.7	3.6	10.3	17.1	2.1	0.5	0.06	0.04
15 98/10/16	Bulkley R. Riff 2	Mc #3	100	0.0	10.8	0.0	5.1	26.3	13.0	10.3	7.7	5.5	3.7	3.6	11.8	1.7	0.5	0.04	0.03
5 98/11/18	Bulkley R. Riff 2	Mc #1	100	0.0	23.1	0.0	8.3	17.4	13.9	8.1	6.2	4.6	2.5	2.0	12.1	1.4	0.2	0.02	0.02
16 98/11/18	Bulkley R. Riff 2	Mc #2	100	0.0	32.9	12.3	8.9	11.6	8.5	6.1	3.9	3.3	2.2	2.2	7.6	0.4	0.1	0.01	0.01
6 98/11/18	Bulkley R. Riff 2	Mc #3	100	0.0	0.0	39.5	8.0	10.5	8.5	9.1	5.6	6.3	4.3	3.2	4.9	0.2	0.1	0.01	0.01
		Average	100	0.0	14.0	13.5	9.4	14.1	11.2	8.0	5.9	4.7	3.2	4.1	10.4	1.1	0.3	0.03	0.02

Bulkley River Riffle 3, October - November 1998. McNeil Core substrate composition data

Sample Data by Weight

Date	Site	Core #	total wt.	100	75	50	37.5	25	16	9.5	6.3	4	2.8	2	0.5	0.25	0.106	0.063	<0.063
				Sieve Size															
18 98/10/16	Bulkley R. Riff 3	Mc #1	5154.5	0.0	0.0	1547.1	758.3	1119.2	748.9	284.8	121.2	63.3	21.7	14.4	263.5	191.0	19.3	0.9	0.9
12 98/10/16	Bulkley R. Riff 3	Mc #2	4776.3	0.0	0.0	1218.7	888.7	1076.2	804.3	356.5	137.1	101.4	43.1	26.9	85.4	31.7	5.4	0.4	0.5
14 98/10/16	Bulkley R. Riff 3	Mc #3	6966.7	0.0	0.0	0.0	1241.5	1984.0	1074.8	834.2	303.7	160.2	81.7	55.6	721.5	478.2	28.3	1.5	1.5
8 98/11/18	Bulkley R. Riff 3	Mc #1	5257.2	0.0	724.9	682.9	560.3	873.8	1018.7	578.3	285.2	200.7	102.0	63.7	136.7	25.5	3.8	0.3	0.4
4 98/11/18	Bulkley R. Riff 3	Mc #2	5246.0	0.0	0.0	2059.6	630.3	222.5	207.4	277.5	249.0	251.8	224.8	222.4	837.0	60.0	3.2	0.3	0.2
3 98/11/18	Bulkley R. Riff 3	Mc #3	5343.0	0.0	0.0	611.8	1347.0	1235.0	1221.4	440.1	243.5	118.5	50.3	25.6	42.2	6.5	0.9	0.1	0.1
		Average	5457.3	0.0	120.8	1020.0	904.4	1085.1	845.9	461.9	223.3	149.3	87.3	68.1	347.7	132.2	10.2	0.6	0.6

Sample Data by percent composition

Date	Site	Core #	total wt.	100	75	50	37.5	25	16	9.5	6.3	4	2.8	2	0.5	0.25	0.106	0.063	<0.063
				Sieve Size															
18 98/10/16	Bulkley R. Riff 3	Mc #1	100	0.0	0.0	30.0	14.7	21.7	14.5	5.5	2.4	1.2	0.4	0.3	5.1	3.7	0.4	0.0	0.0
12 98/10/16	Bulkley R. Riff 3	Mc #2	100	0.0	0.0	25.5	18.6	22.5	16.8	7.5	2.9	2.1	0.9	0.6	1.8	0.7	0.1	0.0	0.0
14 98/10/16	Bulkley R. Riff 3	Mc #3	100	0.0	0.0	0.0	17.8	28.5	15.4	12.0	4.4	2.3	1.2	0.8	10.4	6.9	0.4	0.0	0.0
8 98/11/18	Bulkley R. Riff 3	Mc #1	100	0.0	13.8	13.0	10.7	16.6	19.4	11.0	5.4	3.8	1.9	1.2	2.6	0.5	0.1	0.0	0.0
4 98/11/18	Bulkley R. Riff 3	Mc #2	100	0.0	0.0	39.3	12.0	4.2	4.0	5.3	4.7	4.8	4.3	4.2	16.0	1.1	0.1	0.0	0.0
3 98/11/18	Bulkley R. Riff 3	Mc #3	100	0.0	0.0	11.5	25.2	23.1	22.9	8.2	4.6	2.2	0.9	0.5	0.8	0.1	0.0	0.0	0.0
		Average	100	0.0	2.2	18.7	16.6	19.9	15.5	8.5	4.1	2.7	1.6	1.2	6.4	2.4	0.2	0.0	0.0

Maxan Creek site , October - November 1998. McNeil Core substrate composition data

Sample Data by Weight

				Sieve Size															
Date	**Site**	**Core #**	**total wt.**	**100**	**75**	**50**	**37.5**	**25**	**16**	**9.5**	**6.3**	**4**	**2.8**	**2**	**0.5**	**0.25**	**0.106**	**0.063**	**<0.063**
13 98/10/16	Maxan Cr	Mc #1	6308.2	0.0	1284.7	1442.7	274.6	1007.0	474.4	363.1	279.7	258.1	167.4	152.3	561.8	36.0	5.0	0.7	0.7
7 98/10/16	Maxan Cr	Mc #2	5665.6	0.0	0.0	1016.3	1157.8	881.7	598.6	431.5	299.9	294.3	199.9	165.3	555.4	54.1	8.5	1.1	1.2
20 98/10/16	Maxan Cr	Mc #3	5033.9	0.0	0.0	1364.2	900.4	757.4	593.1	354.1	235.0	212.4	140.6	104.2	328.6	37.6	4.6	0.7	1.0
25 98/11/27	Maxan Cr	Mc #1, 15:02	4293.9	0.0	1176.5	0.1	1173.0	599.3	552.8	356.5	172.0	103.1	60.4	40.7	57.0	1.8	0.5	0.1	0.1
24 98/11/27	Maxan Cr	Mc #2	3580.5	0.0	0.0	1077.6	610.4	198.9	403.4	357.7	289.7	213.5	122.8	77.8	200.7	23.0	4.0	0.6	0.4
23 98/11/27	Maxan Cr	Mc #3	6569.0	0.0	0.0	815.8	989.2	730.8	876.3	835.7	482.6	416.6	287.7	240.5	831.0	53.9	7.0	1.3	0.6
		Average	5241.9	0.0	410.2	952.8	850.9	695.9	583.1	449.8	293.2	249.7	163.1	130.1	422.4	34.4	4.9	0.8	0.7

Sample Data by percent composition

				Sieve Size															
Date	**Site**	**Core #**	**total wt.**	**100**	**75**	**50**	**37.5**	**25**	**16**	**9.5**	**6.3**	**4**	**2.8**	**2**	**0.5**	**0.25**	**0.106**	**0.063**	**<0.063**
13 98/10/16	Maxan Cr	Mc #1	100	0.0	20.4	22.9	4.4	16.0	7.5	5.8	4.4	4.1	2.7	2.4	8.9	0.6	0.1	0.01	0.01
7 98/10/16	Maxan Cr	Mc #2	100	0.0	0.0	17.9	20.4	15.6	10.6	7.6	5.3	5.2	3.5	2.9	9.8	1.0	0.2	0.02	0.02
20 98/10/16	Maxan Cr	Mc #3	100	0.0	0.0	27.1	17.9	15.0	11.8	7.0	4.7	4.2	2.8	2.1	6.5	0.7	0.1	0.01	0.02
25 98/11/27	Maxan Cr	Mc #1, 15:02	100	0.0	27.4	0.0	27.3	14.0	12.9	8.3	4.0	2.4	1.4	0.9	1.3	0.0	0.0	0.00	0.00
24 98/11/27	Maxan Cr	Mc #2	100	0.0	0.0	30.1	17.0	5.6	11.3	10.0	8.1	6.0	3.4	2.2	5.6	0.6	0.1	0.02	0.01
23 98/11/27	Maxan Cr	Mc #3	100	0.0	0.0	12.4	15.1	11.1	13.3	12.7	7.3	6.3	4.4	3.7	12.7	0.8	0.1	0.02	0.01
		Average	100	0.0	7.8	18.2	16.2	13.3	11.1	8.6	5.6	4.8	3.1	2.5	8.1	0.7	0.1	0.01	0.01

Appendix 3. Bulkley River and Maxan Creek McNeil core physical habitat parameters, October and November, 1998.

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Appendix 3.0 McNeil Core physical habitat data for three Bulkley River riffles and a site at Maxan Creek

MCNEIL CORES Date	Location	Core #	Water Depth (m)	Velocity (m/sec)	Water in barrel (m)	TSS mg/L
Oct 16/98	Bulkley Riffle 1	1	0.14	0.592	n/a	310
		2	0.14	0.618	n/a	340
		3	0.14	0.682	n/a	1610
Oct 15/98	Bulkely Riffle 2	1	0.19	0.686	0.002 above	2630
		2	0.20	0.611	level	1980
		3	0.21	0.632	0.025 above	1900
Oct 16/98	Bulkley Riffle 3	1	0.24	0.954	0.095 above	768
		2	0.24	0.933	0.1 above	1500
		3	0.25	0.912	0.24 above	750
Oct 22/98	Maxan Creek	1	0.20	0.9	0.005 above	1040
		2	0.16	0.8	0.019	1280
		3	0.18	0.825	0.033	2200

MCNEIL CORES Date	Location	Core #	Depth (m)	Velocity (m/sec)	Water in barrel (m)	Time of sample	TSS (mg/L)
Nov 18/98	Bulkley Riffle 1	1	0.16	0.786	0.08	15:14	2840
		2	0.14	0.651	0.9	15:32	1300
		3	0.16	1.047	0.17	15:44	1180
Nov 18/98	Bulkely Riffle 2	1	0.22	0.929	0.21	14:01	2010
		2	0.21	1.071	0.18	14:27	1380
		3	0.26	1.140	0.19	14:44	1140
Nov 18/98	Bulkley Riffle 3	1	0.24	0.976	0.22	n/a	1140
		2	0.22	0.952	0.14	n/a	218
		3	0.22	1.071	0.24	n/a	701
Nov 27/98	Maxan Creek	1	0.2	0.905	0.14	15:02	668
		2	0.2	0.739	0.1	15:20	1970
		3	0.16	0.818	0.15	15:30	842

		FREEZE CORES			
Date	Location	Core #	Depth (m)	(m/sec)	Comment
Oct 15/98	Bulkely Riffle 3	1	0.32	0.864	20 min N2, 4 PSI reduced pressure, core rejected-too small
		2	0.36	0.864	last flagging
		3	0.32	0.806	Used 8L N2, left for 1 hour. 2 samples one 15 and one 30 cm
		4	0.34	0.797	sampler broken

				FREEZE CORES			
Date	Location	Core #	Depth (m)	Velocity (m/sec)	Core length (m)	Core Diam (m)	Comment
Nov 27/98	Bulkley Riffle 1	1	0.24	1.360	0.32	0.2	11:20 to 12:15
Nov 27/98		2	0.28	1.085	0.4	0.2	12:05 to 12:55
Nov 27/98		3	0.12	0.139	0.35	0.22	12:25 to 13:15
Nov 27/98	Bulkely Riffle 2	1	0.18	1.102	0.32	0.14	9:40 to 10:30
Nov 27/98		2	0.2	0.514	0.35	n/a	9:45 to 10:45
Nov 27/98		3	0.24	0.901	0.34	n/a	10:45 to 11:35
Nov 18/98	Bulkely Riffle 3	1			as above		
Nov 27/98		2	0.22	0.723	0.45	n/a	8:12 to 9:00
Nov 27/98		3	0.3	1.526	0.3	0.19	8:20 to 9:10
Nov 27/98	Maxan Creek	1	0.21	1.115	0.37	n/a	14:50 to 15:40
Nov 27/98		2	0.22	1.054	0.33	n/a	15:00 to 15:40
Nov 27/98		3	0.2	0.937	0.38	0.23	15:55 to 16:45

Notes:

B1 FC1 hard to get freeze corer in, might be hitting bedrock. 32 cm long, diameter at 15 cm is 20 cm. at 0-15 and 15-32 cm.

B1 FC2 2 m u/s and nearer to right bank than FC1. 40 cm long, small cobble, sand, some lg cobble. F diameter 20 cm. Split core at 20 cm and 20 cm.

B1 FC3 3 m u/s of FC2. Hard to get corer in. 35 cm long, large cobble, small cobble, sand, gravel, no diameter at 15 cm depth is 22 cm

B2 FC1 32 cm long, large cobble, small cobble, 15 cm broke away clean. Diameter 14 cm plus metal t hard to pound in #1, 5 m d/s leading edge of riffle. Photo of MAB

B2 FC2 35 cm long, large cobble, small cobble, gravel, silt. Split into 0-15 and 15-35 cm.

B2 FC3 core 34 cm long, large cobble near surface. Finer at depth, sand. photo of ruler against core

B3 FC1 collected Nov 18/98. Smaller diameter than the ones collected Nov 27 but not considerably dif

B3 FC2 photo. 45 cm long. Split 0-20 cm, 20-45 cm with chisel. Great core! gravel 20-30 cm, cobble (

B3 FC3 mostly fines. Fewer small cobble 30 cm long. Split at 15 cm. Loer 15 cm sample diameter 19 end of core came away clean. Lots of sand. Core went in without rebar, pushed right in to str

Max FC1 length 37 cm. Lots of fines, some large cobble at top of core. Gravel present. Hard to get in

Max FC2 large core, cobbles on surface, increased fines on bottom, sand and gravel photo without label

Max FC3 38 cm long. Big core, lots of large cobble, rocks, gravel sand. Diameter 23 cm.

Appendix 4. Bulkley River and Maxan Creek freeze core sample data, October and November, 1998.

Bulkley River Riffle 1, October - November 1998. Freeze Core substrate composition data

Sample Composition by Weight				Sieve Size															
Date	Site	Core #	total wt.	100	75	50	37.5	25	16	9.5	6.3	4	2.8	2	0.5	0.25	0.106	0.063	<0.063
32 98/11/27	Bulkley R. Riff 1	Fc #1, 12:20, -15cm	9635.5	0.0	0.0	3451.6	1141.1	1097.1	755.7	671.1	443.3	419.5	301.6	247.4	779.8	222.1	61.1	8.7	35.4
35 98/11/27	Bulkley R. Riff 1	Fc #1, 12:15, +15cm	6028.7	0.0	0.0	453.3	1155.9	389.5	881.7	637.2	406.2	372.0	254.2	245.1	840.6	294.5	63.6	8.7	26.2
31 98/11/27	Bulkley R. Riff 1	Fc #2	12253.4	0.0	1100.9	2377.1	1449.1	1314	1155.8	867.2	642.4	669.5	454.6	395	1263	420.8	94.2	14	35.8
36 98/11/27	Bulkley R. Riff 1	Fc #2, 12:55, 15+ cm	6856.0	0.0	0.0	843.0	864.6	858.8	810.5	717.7	458.0	417.5	282.4	261.4	847.8	375.5	81.8	11.0	26.0
41 98/11/27	Bulkley R. Riff 1	Fc #3	10587.1	0.0	827.8	1924.4	1333.6	1230.2	1314.6	958.0	540.4	496.2	360.5	301.7	837.0	316.6	76.6	11.0	58.5
48 98/11/27	Bulkley R. Riff 1	Fc #3, 13:15, +15 cm	9345.9	0.0	0.0	1389.2	1124.3	1581.7	1178.2	913.0	560.9	487.8	299.6	238.7	1042.0	421.3	62.2	9.8	37.2
		Average	9117.8	0.0	321.5	1739.8	1178.1	1078.6	1016.1	794.0	508.5	477.1	325.5	281.6	935.0	341.8	73.2	10.5	36.5

Sample Data by percent composition				Sieve Size															
Date	Site	Core #	total wt.	100	75	50	37.5	25	16	9.5	6.3	4	2.8	2	0.5	0.25	0.106	0.063	<0.063
32 98/11/27	Bulkley R. Riff 1	Fc #1, 12:20, -15cm	100	0.0	0.0	35.8	11.8	11.4	7.8	7.0	4.6	4.4	3.1	2.6	8.1	2.3	0.6	0.1	0.4
35 98/11/27	Bulkley R. Riff 1	Fc #1, 12:15, +15cm	100	0.0	0.0	7.5	19.2	6.5	14.6	10.6	6.7	6.2	4.2	4.1	13.9	4.9	1.1	0.1	0.4
31 98/11/27	Bulkley R. Riff 1	Fc #2	100	0.0	9.0	19.4	11.8	10.7	9.4	7.1	5.2	5.5	3.7	3.2	10.3	3.4	0.8	0.1	0.3
36 98/11/27	Bulkley R. Riff 1	Fc #2, 12:55, 15+ cm	100	0.0	0.0	12.3	12.6	12.5	11.8	10.5	6.7	6.1	4.1	3.8	12.4	5.5	1.2	0.2	0.4
41 98/11/27	Bulkley R. Riff 1	Fc #3	100	0.0	7.8	18.2	12.6	11.6	12.4	9.0	5.1	4.7	3.4	2.8	7.9	3.0	0.7	0.1	0.6
48 98/11/27	Bulkley R. Riff 1	Fc #3, 13:15, +15 cm	100	0.0	0.0	14.9	12.0	16.9	12.6	9.8	6.0	5.2	3.2	2.6	11.1	4.5	0.7	0.1	0.4
		Average	100	0.0	3.5	19.1	12.9	11.8	11.1	8.7	5.6	5.2	3.6	3.1	10.3	3.7	0.8	0.1	0.4

Bulkley River Riffle 2, October - November 1998. Freeze Core substrate composition data

Sample Data by Weight				Sieve Size															
Date	Site	Core #	total wt.	100	75	50	37.5	25	16	9.5	6.3	4	2.8	2	0.5	0.25	0.106	0.063	<0.063
47 98/11/27	Bulkley R. Riff 2	Fc #1, 10:30, -15 cm	12087.2	0.0	3861.6	1493.1	551.0	1330.1	1106.6	808.8	460.1	364.8	262.5	270.5	1348.6	126.8	39.7	11.7	51.3
39 98/11/27	Bulkley R. Riff 2	Fc #1	7813.2	2673.9	0.1	928.4	304.8	847.8	756.0	445.8	268.0	217.5	161.8	182.2	855.9	58.0	20.2	6.7	86.1
43 98/11/27	Bulkley R. Riff 2	Fc #2, 10:50, -15 cm	13123.4	0	0	3503.4	1377.5	1747.6	1446.4	1188.1	758.5	516.1	268.1	224.3	1700.4	271.6	61.6	16.4	43.4
30 98/11/27	Bulkley R. Riff 2	Fc #2, 10:45, +15cm	3108.1	0	0	0	168.1	1162.4	753.2	335.4	230.3	128.6	28.8	13.1	189.5	62.4	12.4	4.3	19.6
34 98/11/27	Bulkley R. Riff 2	Fc #3, 11:40, -15cm	9873.9	0.0	753.0	2640.0	695.7	1537.0	1168.5	753.1	358.0	260.0	157.9	148.9	1090.4	242.4	47.4	8.9	12.7
33 98/11/27	Bulkley R. Riff 2	Fc #3	5735.6	0.0	0.0	649.7	825.1	1142.8	906.4	585.5	383.1	257.8	120.4	83.8	523.6	161.5	47.8	9.5	38.6
	Riffle 2	Average	8623.57	445.65	769.12	1535.77	653.70	1294.62	1022.85	686.12	409.67	290.80	166.58	153.80	951.40	153.78	38.18	9.58	41.95

Sample Data by percent composition				Sieve Size															
Date	Site	Core #	total wt.	100	75	50	37.5	25	16	9.5	6.3	4	2.8	2	0.5	0.25	0.106	0.063	<0.063
47 98/11/27	Bulkley R. Riff 2	Fc #1, 10:30, -15 cm	100	0	31.9	12.4	4.6	11.0	9.2	6.7	3.8	3.0	2.2	2.2	11.2	1.0	0.3	0.1	0.4
39 98/11/27	Bulkley R. Riff 2	Fc #1	100	34.2	0.0	11.9	3.9	10.9	9.7	5.7	3.4	2.8	2.1	2.3	11.0	0.7	0.3	0.1	1.1
43 98/11/27	Bulkley R. Riff 2	Fc #2, 10:50, -15 cm	100	0.0	0.0	26.7	10.5	13.3	11.0	9.1	5.8	3.9	2.0	1.7	13.0	2.1	0.5	0.1	0.3
30 98/11/27	Bulkley R. Riff 2	Fc #2, 10:45, +15cm	100	0.0	0.0	0.0	5.4	37.4	24.2	10.8	7.4	4.1	0.9	0.4	6.1	2.0	0.4	0.1	0.6
34 98/11/27	Bulkley R. Riff 2	Fc #3, 11:40, -15cm	100	0.0	7.6	26.7	7.0	15.6	11.8	7.6	3.6	2.6	1.6	1.5	11.0	2.5	0.5	0.1	0.1
33 98/11/27	Bulkley R. Riff 2	Fc #3	100	0.0	0.0	11.3	14.4	19.9	15.8	10.2	6.7	4.5	2.1	1.5	9.1	2.8	0.8	0.2	0.7
		Average	100	5.2	8.9	17.8	7.6	15.0	11.9	8.0	4.8	3.4	1.9	1.8	11.0	1.8	0.4	0.1	0.5

Bulkley River Riffle 3, October - November 1998. Freeze Core substrate composition data

Sample Data by Weight				Sieve Size																
	Date	Site	Core #	total wt.	100	75	50	37.5	25	16	9.5	6.3	4	2.8	2	0.5	0.25	0.106	0.063	<0.063
28	98/11/18	Bulkley R. Riff 3	Fc #1, 11:06, +13cm	1575.0	0	0	515.6	139.9	219.4	202.6	75	62.2	57.1	32.3	25.6	147.3	77.6	13.9	2.1	4.4
29	98/11/18	Bulkley R. Riff 3	Fc #1, 11:06, -13cm	2248.0	0	1227.7	0.1	115.3	182.5	181.4	129.5	108.9	73.2	39.9	19.5	94.5	62.7	9.3	1.1	2.4
40	98/11/27	Bulkley R. Riff 3	Fc# 2	15488.4	0.0	3626.4	2607.7	1157.0	2341.3	1845.3	981.0	539.2	520.9	311.9	244.6	660.8	419.6	123.6	21.1	88.0
49	98/11/27	Bulkley R. Riff 3	Fc #2, 08:20, +15 cm	4457.1	0.0	0	0	0	24.1	116.0	283.7	323.9	417.6	326.2	303.5	2279.6	345.6	26.6	2.3	8.0
37	98/11/27	Bulkley R. Riff 3	Fc# 3	11553.8	0.0	2675.8	1151.3	441.4	728.0	495.1	646.1	624.8	855.0	607.9	529.7	2437.7	297.1	43.6	9.7	10.6
38	98/11/27	Bulkley R. Riff 3	Fc# 3	8865.1	0.0	0.0	525.2	1772.8	2251.2	1371.0	681.3	383.9	267.4	145.7	126.6	497.2	575.2	154.1	22.2	91.3
			Average	7364.6	0.0	1255.0	800.0	604.4	957.8	701.9	466.1	340.5	365.2	244.0	208.3	1019.5	296.3	61.9	9.8	34.1

Sample Data by percent composition				Sieve Size																
	Date	Site	Core #	total wt.	100	75	50	37.5	25	16	9.5	6.3	4	2.8	2	0.5	0.25	0.106	0.063	<0.063
28	98/11/18	Bulkley R. Riff 3	Fc #1, 11:06, +13cm	100	0.0	0.0	32.7	8.9	13.9	12.9	4.8	3.9	3.6	2.1	1.6	9.4	4.9	0.9	0.1	0.3
29	98/11/18	Bulkley R. Riff 3	Fc #1, 11:06, -13cm	100	0.0	54.6	0.0	5.1	8.1	8.1	5.8	4.8	3.3	1.8	0.9	4.2	2.8	0.4	0.0	0.1
40	98/11/27	Bulkley R. Riff 3	Fc# 2	100	0.0	23.4	16.8	7.5	15.1	11.9	6.3	3.5	3.4	2.0	1.6	4.3	2.7	0.8	0.1	0.6
49	98/11/27	Bulkley R. Riff 3	Fc #2, 08:20, +15 cm	100	0.0	0.0	0.0	0.0	0.5	2.6	6.4	7.3	9.4	7.3	6.8	51.1	7.8	0.6	0.1	0.2
37	98/11/27	Bulkley R. Riff 3	Fc# 3,+15	100	0.0	23.2	10.0	3.8	6.3	4.3	5.6	5.4	7.4	5.3	4.6	21.1	2.6	0.4	0.1	0.1
38	98/11/27	Bulkley R. Riff 3	Fc# 3,-15	100	0.0	0.0	5.9	20.0	25.4	15.5	7.7	4.3	3.0	1.6	1.4	5.6	6.5	1.7	0.3	1.0
			Average	100	0.0	17.0	10.9	8.2	13.0	9.5	6.3	4.6	5.0	3.3	2.8	13.8	4.0	0.8	0.1	0.5

Maxan Creek control site. November 27, 1998. Freeze Core substrate composition data

Sample Data by Weight

	Date	Site	Core #	total wt.	100	75	50	37.5	25	16	9.5	6.3	4	2.8	2	0.5	0.25	0.106	0.063	<0.063
					Sieve Size															
26	98/11/27	Maxan Cr	Fc #3, -15 cm	14538.3	0.0	4996.1	2244.7	1504.3	1150.9	813.3	694.1	524.5	549.9	378.3	352.2	1090.5	104.7	40.1	14.7	80
27	98/11/27	Maxan Cr	Fc #3, 16:45, +15cm	9064.0	0.0	3709.7	882.6	660.8	778.1	491.6	570.9	408.3	406.7	294.2	238.3	526.7	46.8	15	5	29.3
44	98/11/27	Maxan Cr	Fc #2, 15:50, +15 cm	10251.9	0.0	0.0	3218.4	1166.1	1060.8	1058.5	845.4	525.2	545.9	375.1	301.8	941.9	108.9	28.1	8.3	67.5
45	98/11/27	Maxan Cr	Fc #2, 15:50, -15 cm	5168.6	0.0	0.0	564.4	1251.1	788.4	735.9	419.7	216.7	187.7	108.3	97.9	483.5	119.0	60.5	16.9	118.6
46	98/11/27	Maxan Cr	Fc #1, +15 cm	4505.4	0.0	0.0	439.4	373.7	754.4	621.9	405.3	386.0	391.6	273.2	227.0	547.7	32.4	6.7	2.3	43.8
42	98/11/27	Maxan Cr	Fc #1, -15 cm	10557.0	0.0	1154.8	2989.9	1025.1	920.5	832.3	590.9	513.7	526.1	385.8	329.4	943.7	84.1	27.9	8.8	224.0
		Maxan	Average	9014.2	0.0	1643.4	1723.2	996.8	908.9	758.9	587.7	519.1	538.0	382.1	340.8	1017.1	94.4	34.0	11.8	152.0

Sample Data by percent composition

	Date	Site	Core #	total wt.	100	75	50	37.5	25	16	9.5	6.3	4	2.8	2	0.5	0.25	0.106	0.063	<0.063
					Sieve Size															
26	98/11/27	Maxan Cr	Fc #3, -15 cm	100	0.0	34.4	15.4	10.3	7.9	5.6	4.8	3.6	3.8	2.6	2.4	7.5	0.7	0.3	0.1	0.6
27	98/11/27	Maxan Cr	Fc #3, 16:45, +15cm	100	0.0	40.9	9.7	7.3	8.6	5.4	6.3	4.5	4.5	3.2	2.6	5.8	0.5	0.2	0.1	0.3
44	98/11/27	Maxan Cr	Fc #2, 15:50, +15 cm	100	0.0	0.0	31.4	11.4	10.3	10.3	8.2	5.1	5.3	3.7	2.9	9.2	1.1	0.3	0.1	0.7
45	98/11/27	Maxan Cr	Fc #2, 15:50, -15 cm	100	0.0	0.0	10.9	24.2	15.3	14.2	8.1	4.2	3.6	2.1	1.9	9.4	2.3	1.2	0.3	2.3
46	98/11/27	Maxan Cr	Fc #1, +15 cm	100	0.0	0.0	9.8	8.3	16.7	13.8	9.0	8.6	8.7	6.1	5.0	12.2	0.7	0.1	0.1	1.0
42	98/11/27	Maxan Cr	Fc #1, -15 cm	100	0.0	10.9	28.3	9.7	8.7	7.9	5.6	4.9	5.0	3.7	3.1	8.9	0.8	0.3	0.1	2.1
			Average	107.69896	0.0	18.2	19.1	11.1	10.1	8.4	6.5	5.8	6.0	4.2	3.8	11.3	1.0	0.4	0.1	1.7

Appendix 5. Freeze Core Gravel Sampling Methodology (Herunter, 1998)

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FREEZE CORE GRAVEL SAMPLING METHODOLOGY

1. Ensure bottom ring fitting is secure to housing, clean and lubricate probe threads with vaseline, thread probe onto sampler and hand tighten.

2. Remove dry ice "basket" from sampler, place tip of sampler probe on sampling site, pound in sampler with a large pry bar (use hearing proctection) - a pry bar can be purchased from any hardware store. Pound sampler into subtrate until the bottom ring fitting is about 2cm above creek bed. Keep sampler as vertical as possible

3. Place dry ice basket in sampler, fill sampler with alcohol to a level just below holes in the basket (approx one third a can of alcohol). Place 2 quarter blocks of dry ice into sampler and place lid on top.

4. Check sampler frequently to ensure enough dry ice is in place, avoid placing dry ice on basket center hole. Alcohol should start circulating, coming up the outside of the basket, into the basket through the side holes and down through the center hole. Alcohol circulation should be very obvious. If not, you may have to "prime" the sample by gently lifting the basket up and down once or twice to encourage the cirulation.

5. Leave the sampler for about 50 minutes (the first samples of the day should take 60 minutes, to allow the samplers and alcohol to cool down)

6. To remove the sample and sampler: remove remaining dry ice (place in metal bucket), remove basket, have one person standing in front of sampler spout with an empty metal bucket, 2 people stand on either side of the sampler and rock it in 4 directions (i.e.NESW), pull the sampler straight up, grab the bottom ring and pour out alcohol into the bucket. Do not let the sample sit in the stream as it will start to melt. All three people should be wearing proctective gloves and eye glasses. Once the alcohol is poured out of the sampler the sampler can be placed upside down on the stream bank. While one person holds the sampler and the other unscrews the probe and attached sample. You should have a core approximately 20 cm in diameter.

7. The sample is removed from the probe by splitting with a hammer and chisel or thawing (this will take a while and you may need the probe to start another sample).

Notes:
-Ensure outer casing of sampler is well insulated
-We use about 10 blocks of dry ice for 30 samples/day (most of the dry ice is used at the beginning the day during the initial cooling down of the samplers and alcohol)
-the alcohol we use is Van Waters and Rodgers 2-D Alcohol (denatured methanol)
-keep all interior components of the samplers dry and out of the water
-some of the probes may be new and the threads are "tight", make sure that you can get at least 5 turns of the probe into the sampler otherwise when pounding the sampler in the probe may break at the threads.

If you have any questions please phone me at 604 666-6500
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