Interim
Environmental Monitoring Program:
Vangorda, 2007

Report Prepared for:

Assessment and Abandoned Mines Branch
Energy, Mines and Resources
Government of Yukon
Whitehorse, Yukon

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May 2008

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1.0 INTRODUCTION

1.1 Background

The Faro Mine complex, near Faro, Yukon, includes two mines: the Faro Mine and Mill (Faro site) and Vangorda/Grum Mines (Vangorda site), which are located approximately 12 km apart (Figure 1.1). The complex was formerly owned by the Anvil Range Mining Corporation and produced lead and zinc concentrates to be extracted for lead, zinc, silver, and gold. The Faro site was mined between 1969 and 1992, while the Vangorda site was developed and mined between 1986 and 1998. Milling continued at Faro until April 1998, when all operations were terminated due to poor economic circumstances and projections, and the site went into receivership. Since then, management of the mine property has been under the direction of Deloitte and Touche Inc., acting as the court appointed Interim Receiver. In early 2009, site Care and Maintenance responsibilities will transfer to a contractor acting on behalf of the Yukon Government.

The Yukon government and its consultants, working with the federal government, Selkirk First Nation, and Ross River Dena Council are currently preparing a comprehensive closure plan for the abandoned Faro Mine complex. Before the closure plan can be implemented, it will be subject to regulatory assessment and approval processes. The plan requires regulatory approval in the form of a Water License issued under the *Waters Act* by the Yukon Water Board and will need to be acceptable to relevant government agencies, the First Nations and the public. The assessment process will be carried out through the Yukon Environmental and Socio-Economic Assessment Board under the *Yukon Environmental and Socio-Economic Assessment Act* (YESAA).

Technical studies conducted at the site, which are nearing completion, have indicated that acidification and leaching processes have the potential to result in dramatic increases in metal loadings to surface waters downstream of the Faro Mine complex over the next several to many decades (SRK 2004, 2005). Consequently, the closure process is proceeding to the regulatory and development assessment phases with considerable focus on identifying the mitigation measures required to protect the aquatic ecosystem downstream of the mines. Related to this, Minnow Environmental Inc. was requested to assist in identifying the requirements of a comprehensive, site-wide environmental monitoring program. The new monitoring program will eventually replace requirements listed in the site's current Water License, set to expire February 28, 2009, although the specific process and schedule for implementation will depend on how this can best be accomplished within the overall closure planning process.

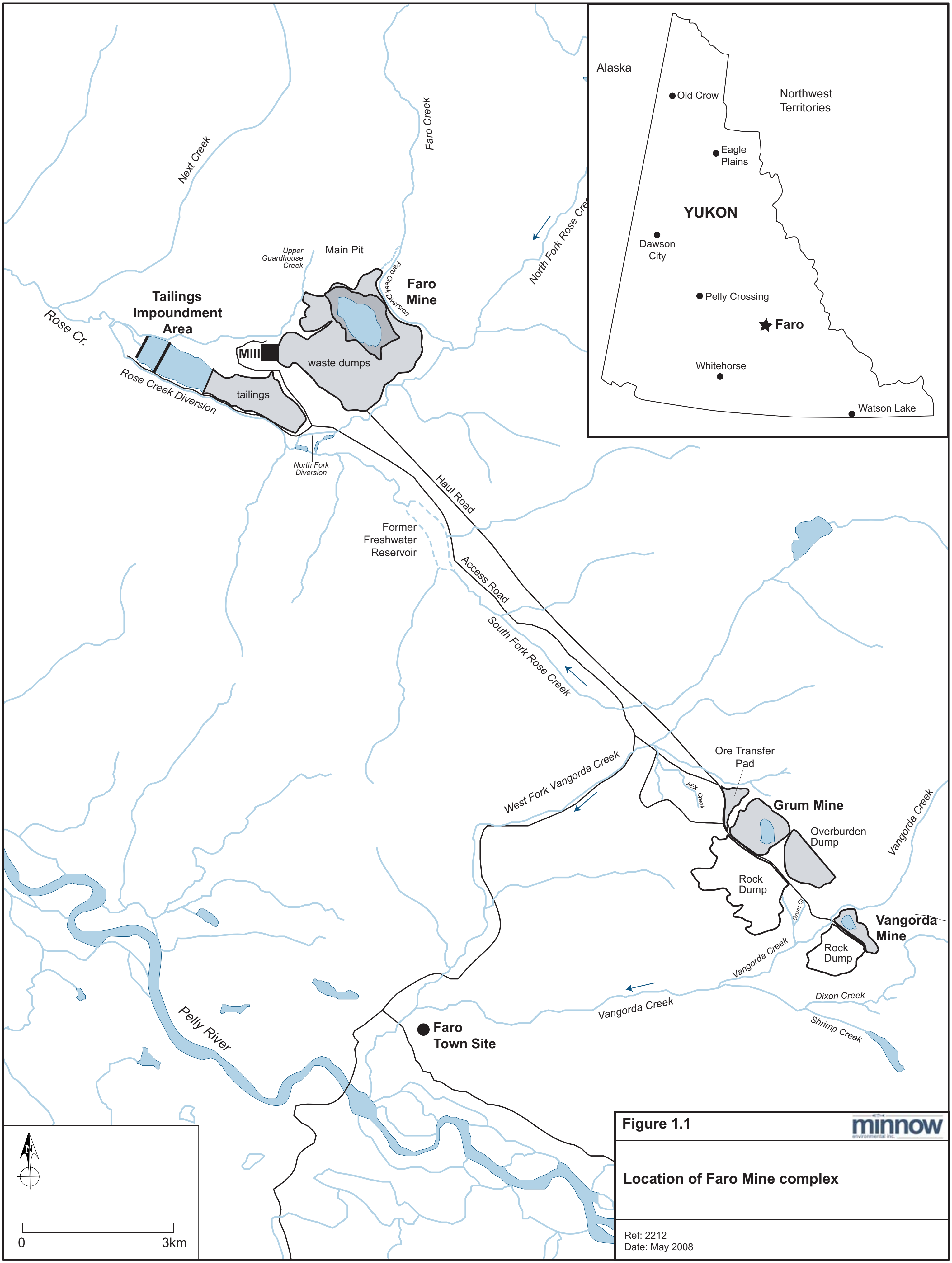


Figure 1.1

Location of Faro Mine complex

Ref: 2212
Date: May 2008

As first steps, Minnow reviewed and re-evaluated the results of previous studies and monitoring (Minnow 2007a) and proposed a general framework for the long-term monitoring program (Minnow 2007b). Key information gaps were identified that need to be addressed in order to optimize the long-term monitoring program design (Minnow 2007b). It was thus proposed that an Interim Aquatic Ecosystem Monitoring Program (IAEMP) be implemented in the short-term in conjunction with monitoring being undertaken at the Vangorda site in 2007 and Rose/Anvil Creeks in 2008 under the current Water License (Minnow 2007b). This report provides a preliminary assessment of the results from the study conducted at the Vangorda site in 2007. A more comprehensive, integrated report will follow after the interim monitoring is completed in the Rose/Anvil Creek system in August 2008.

1.2 Project Objectives

The overall objective of the project was to fill some of the critical data gaps identified by Minnow that will allow for development of the long-term, post-closure monitoring program. The specific objectives for the 2007 study included (for the Vangorda Creek drainage only):

1. Evaluate potential mine-related effects based on water, sediment and benthic invertebrate data.
2. Assess data quality for water samples, including field and laboratory precision and potential differences in results between laboratories.
3. Determine which of artificial substrate samples or Hess sample collection is best able to detect mine-related differences within a control-impact study design framework.
4. Evaluate the relevance of future sediment sample analysis based on characterization of sediment particle sizes, chemistry, and toxicity in a near-field versus reference area.
5. Evaluate the suitability of additional reference areas for potential inclusion in future benthic invertebrate and/or fish surveys.
6. Time permitting, evaluate resident fish communities in terms of the approach and seasonal timing of future surveys that would be most effective in detecting potential future mine-impacts on fish.

The information from this study, when combined with the sampling planned for the Rose/Anvil Creek system in 2008 and the results of parallel sampling programs by Laberge Environmental Services Inc. in 2007 and 2008 (in accordance with requirements of the current Water License), will allow for development of a streamlined program for long-term aquatic ecosystem monitoring at the Faro Mine complex.

1.3 Overview of Current Study and Report Organization

Under the current Water License for the Faro Mine complex, water, sediment and benthic invertebrate samples have been collected by Laberge Environmental Services (LES) in alternate years in the Vangorda and Rose/Anvil Creek systems, respectively (Burns 1991-2007). In these studies, artificial substrates were deployed for five to six weeks in the summer to allow for benthic invertebrate colonization and community assessment in creek areas upstream and downstream of mine drainage. Coincident with retrieval of the artificial substrates, sediment samples were collected for analysis of metal content in the fine fraction (<0.15 mm). Water samples were also collected when artificial substrates were both deployed (mid-July) and retrieved (late August).

Additional samples were collected by Minnow Environmental Inc. at the time of artificial substrate retrieval by LES at the Vangorda site in August 2007 to serve the objectives of this project (Section 1.2). The supplementary sampling included:

- collection of one water sample per area for analysis of various inorganic and conventional parameters as well as a low-level ICP metal scan;
- collection of sediment samples in one mine-exposed area and one reference area for toxicity testing, particle size analysis, and analysis of metals in both the bulk sample and fine fraction;
- collection of resident benthic invertebrate communities using a Hess sampler;
- collection of supporting field water quality data (temperature, dissolved oxygen, conductivity and pH) and habitat observations; and
- exploratory sampling of slimy sculpin.

Methods used for sample collection and for the analysis of samples and data are outlined in Section 2.0. Preliminary study results are presented in Sections 3.0 to 6.0. These results will be augmented and integrated with the results of sampling planned for the Rose Creek system in 2008. Conclusions and recommendations related to the 2007 sampling program are presented in Sections 7.0. References cited throughout this document are listed in Section 8.0.

2.0 METHODS

The sampling described in the sections below was done at the same time as sampling by Laberge Environmental Services (LES) to fulfill monitoring requirements in the Water License (i.e., August 25–29, 2007). This was done to allow direct comparison of different sampling methods and sampling designs being considered for future long-term monitoring. Methods employed in the LES study have been described separately (Burns 2007) and are not repeated herein, except to the extent required to explain data comparisons. Thus, the sections below describe the methods for in-field measurements and sample collection that were in addition to those described by Burns (2007). Sample station locations discussed in this report are shown in Figure 2.1

2.1 Habitat Characterization

Potential mine influence on biological communities is typically determined by comparing communities in mine-exposed areas compared to reference areas. Detection of differences that may be mine-related is enhanced by minimizing the variation attributable to differences in natural habitat factors among areas. Therefore, detailed habitat characterization was undertaken in all study areas to facilitate future selection of reference areas for long-term monitoring.

Water velocity was measured near the bottom (to reflect conditions experienced by benthic invertebrate communities) using a Marsh-McBirney Flo-Mate Model 2000 portable velocity meter. Water depth was measured using a metre stick and stream width was measured using a measuring tape. Velocities and depths were taken at approximately 10 intervals along a transect perpendicular to the flow and recorded on field sheets. Mean values were computed from the recorded data.

Gradient was measured using a clinometer. Stream morphology, substrate type, instream cover, overhead canopy, and aquatic vegetation were visually assessed, identified as appropriate, and categorized (i.e., assigned percentages) based on the judgment of experienced field personnel. All habitat information was documented on standardized habitat assessment forms. Photographs were taken at each sampling area to further support habitat descriptions (Appendix D).

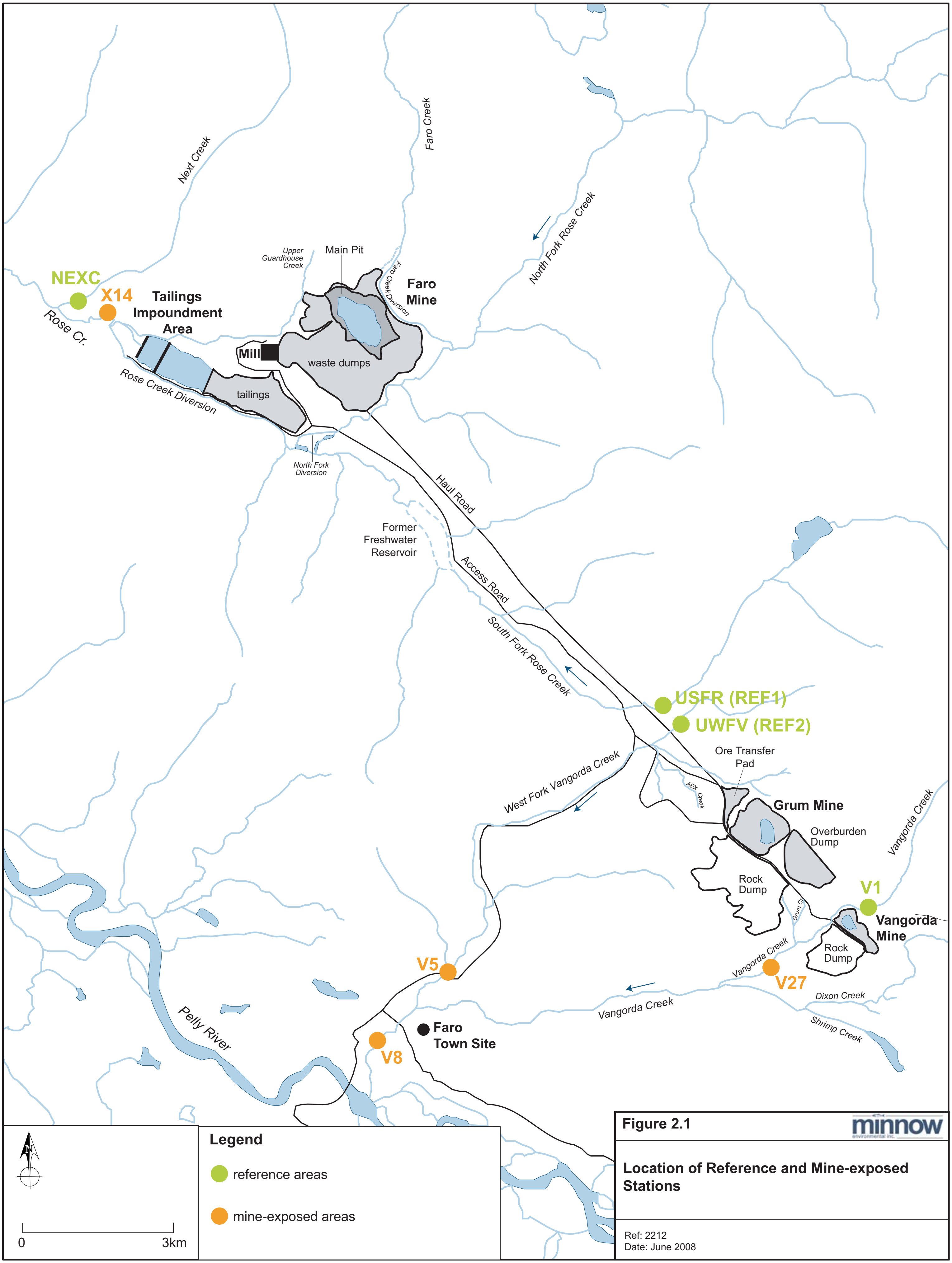


Figure 2.1

Location of Reference and Mine-exposed Stations

2.2 Water Chemistry

Conductivity, pH, dissolved oxygen (DO), and temperature were measured in the field immediately upstream of each benthic invertebrate sampling area (Section 2.4). DO, pH and temperature were measured using a YSI 556 MDS (Multi-parameter Display System) and conductivity was measured using a WTW 3301 meter. Meters were calibrated daily. Probes were placed into the water and allowed to acclimate prior to taking measurements.

Water samples for laboratory analyses were collected directly into appropriate sample bottles supplied by Maxxam Analytics, Burnaby, BC. All water samples were collected immediately upstream of each sampling area and sample bottles were oriented upstream during filling. Sample bottles were rinsed three times with the surface water being sampled prior to final filling. Care was taken to ensure that no headspace was left in the collection bottles, except for samples requiring preservation for which a small headspace was left to accommodate addition of the preservative. All samples were placed in coolers immediately following collection and were later placed in a refrigerator at approximately 4°C until they could be shipped, in coolers with ice packs, to Maxxam Analytics, Burnaby, BC.

Water quality benchmarks were selected to assist in the evaluation of water quality data (Appendix A). CCME (1999) criteria for protection of aquatic life were selected, where available, otherwise alternative water quality criteria or aquatic toxicity values were selected. Observed water concentrations in mine-exposed areas were compared to the applicable benchmarks and to reference area concentrations to identify any parameters present at elevated concentrations. The results were also compared to those reported by LES (Burns 2007) based on samples collected at the same times and locations (e.g., field replicates) and sent to Cantest Ltd., Burnaby, BC.

2.3 Sediment Chemistry

Sediment samples collected by LES under the site Water License are analyzed after they have been dried and passed through a 0.15 mm sieve. While this standardizes the size fraction of particles analyzed for metal content, the results may not be indicative of whole sediment metal concentrations nor of organism exposure. For example, the fine fraction of sediment may represent a small proportion of the whole sediment sample and may be even less representative of the areas sampled if deposits of fines are small and/or rare (Minnow 2007b). To investigate this issue, sediment samples were collected for analysis of particle size distribution and chemistry in both the whole sediment (rocks larger than 2 mm were removed for metals analyses consistent with standard laboratory practise) and in the <0.15 mm fraction.

Sediment samples were collected at V1 and V27 (Figure 2.1). A total of three samples were taken at V27, but the scarcity of fine sediment deposits at V1 allowed for collection of only one sample there. Sediment samples for chemical analyses were collected using a petite ponar grab (15.24 cm x 15.24 cm, 0.023 m^2 total bottom area per grab). Appropriate, suitable, fine patches of substrate (sand, silt and some pea sized gravel) were sought within each reach for sampling. Grabs were deemed acceptable if they showed reasonable penetration and had a visibly intact surface layer. Unacceptable grab samples were discarded. The top 5 cm from several acceptable ponar grabs were composited to fulfill sample volume requirements for all the sediment analyses. Sediment was then mixed to ensure homogeneity and excess water was decanted. A stainless steel spoon was used to separate the sample into three ziplock bags; one for particle size analysis, one for percent moisture and total organic carbon analyses and one for total metals analysis. Details pertaining to the samples (e.g., water depth, substrate characteristics, colour, texture) were recorded on field sheets. Immediately after collection, the sample containers were placed in a cooler on ice, and were later placed in a refrigerator at approximately 4 °C until they could be shipped, in coolers with ice packs, to Maxxam Analytics, Burnaby, BC. Results were reported in units of percent or mg/kg on a dry weight basis.

Federal (CCME 1999) and British Columbia (BCMOE 2006) sediment quality guidelines were used to assess sediment chemistry. Observed sediment concentrations in mine-exposed areas were compared to the applicable guidelines and to reference area concentrations to identify parameters with elevated concentrations.

2.4 Sediment Toxicity

Sediment samples for toxicity testing were collected in the same manner as described above. A stainless steel spoon was used to place the remainder of the homogeneous sediment mixture into pails lined with plastic liners. A minimum volume of 3 L was required for the testing. Immediately after collection, the samples were placed in a cooler on ice, and were later placed in a refrigerator at approximately 4 °C until they could be couriered to Aquatox Testing and Consulting Inc. in Aberfoyle, ON. The samples were tested for potential effects on survival and growth of *Hyallela azteca* over a 14-day exposure period (Environment Canada 1997).

2.5 Benthic Invertebrate Community Assessment

Previous benthic invertebrate community sampling at the Faro Mine complex has chiefly been conducted using artificial substrates deployed for a 5- to 6-week period (Burns 1991-2007). While there are advantages to the use of artificial substrates, sampling of resident benthic communities may be less prone to sampling bias and spatial and temporal variability (Minnow 2007b). Therefore, it was recommended that parallel benthic community surveys be conducted at the Vangorda site in 2007 using both approaches to determine which one will be most cost-effective for long-term monitoring at the Faro Mine complex (Minnow 2007b).

Samples of resident benthic invertebrates were collected using a 0.1 m^2 Hess sampler fitted with a 250 um mesh. Conditions of substrate, depth and water velocity were carefully controlled to optimize habitat comparability among sample stations. Hess samples were taken at stations located as close as possible (while still ensuring comparable habitat/substrate characteristics among stations) to where artificial substrates were deployed by LES (Burns 2007). Five stations were sampled in each area (V1, V27, V5, and V8). One sample was collected at each station and was a composite of three-sub-samples in order to ensure that each sample was representative of average conditions at the station (0.3 m^2 per sample). Each sub-sample was collected by carefully inserting the base of the Hess sampler into the substrate to a depth of approximately 10 cm after which gravel and cobble contained within the sampler was carefully washed while allowing the current to carry dislodged organisms into the mesh collection net. After the area within the sampler was completely washed, any organisms adhering to the mesh, other than that of the collection bag, were rinsed into the bag. At that point, the sampler was moved to the next sub-sampling location and the procedure repeated. After collection of the third sub-sample, all organisms were rinsed to the end of the collection net. To ensure size comparability with samples collected by Burns (2007), the samples were transferred to and re-sieved in a pail with a 300-um mesh bottom. The sample was then rinsed into a labelled two-litre, wide-mouth plastic jar. Internal labels were also used to further ensure correct identification of each sample. Samples were preserved to a level of 10% buffered formalin in ambient water within six hours of collection.

Benthic invertebrate samples were sent to Cordillera Consulting in Summerland, BC, for sorting, enumeration and identification (to lowest practicable level). Although samples collected by LES were initially sent to a different laboratory for analysis (data reported by Burns 2007), the samples were sent to and re-analyzed by Cordillera to allow for direct comparison of sampling methods. As a result, data presented herein for artificial substrates differ somewhat from data reported by Burns (2007) for the same samples.

Commonly used benthic invertebrate community metrics (e.g., Environment Canada 2002) were computed for each station. Organism density (individuals/m^2) was calculated based on the known area sampled. The number of taxa (also known as taxon richness), which is a simple and robust expression of benthic community diversity, included all separate taxa identified to the lowest practicable level, excluding any life stages that could not be conclusively identified as separate taxa. In some instances, for the purposes of data analysis, invertebrate taxa were combined at a generic taxonomic level in order to incorporate abundance associated with indeterminate species and/or standardize taxon levels among stations.

Simpson's indices of diversity ("D") and evenness ("E") were computed from custom MS Excel macros and spreadsheets following the formulae presented by Environment Canada (2002). These indices take into account both the relative abundance of taxa, and the number of taxa, with values ranging from 0 (low diversity or evenness) to 1 (high diversity or evenness). In general, relatively high diversity values reflect moderate abundance of a proportionately high number of taxa, and are often associated with good environmental quality. Low diversity values typically reflect communities with a high abundance of only a few taxa, or simply few taxa, and may indicate an impaired benthic community. Simpson's E measures how well individuals are distributed among the total number of sampled taxa, with low evenness values indicating that benthic communities are dominated by few taxa and generally indicating an impaired biological community.

The Bray-Curtis Index was calculated as described by Environment Canada (2002), taking into account the abundance of each taxon at each station compared to a hypothetical reference station represented by the median value of all reference stations. The Bray-Curtis Index (or "distance co-efficient") describes the difference ("distance") of each station from the hypothetical median reference community, reaching a maximum value of 1 for stations having an entirely different community and a minimum value of 0 for stations having an identical community compared to the median reference community.

The relative abundance (as percent of total organisms) of the most common major taxonomic groups (e.g., Ephemeroptera, Plecoptera, Trichoptera, which are more commonly and collectively referred to as EPT taxa, as well as chironomid midges), was also computed for each of the four study areas on Vangorda Creek. These percentages are not independent variables, because as one group increases in percent abundance, other groups must necessarily decrease. Despite this, such metrics are useful in describing the relative composition of benthic communities in different areas and to enable temporal comparisons of results in future studies of these areas.

Benthic invertebrate community structure was also assessed using a multivariate technique known as correspondence analysis (CA; Thioulouse et al. 1997). CA was used to calculate axes, which can be thought of as new variables summarizing the variation in benthic community data. When depicted in two-dimensional plots, taxa that tend to co-occur will have similar CA axis scores and will plot together, while those that rarely co-occur plot farther apart. Similarly, stations sharing many taxa plot closest to one another, while those with little in common plot farther apart. The greatest variation among either taxa or stations is explained by the first axis, with other axes accounting for progressively less variation. Therefore, this type of multivariate analysis describes not only which stations have distinct benthic communities but also how these benthic communities differ among stations (*i.e.*, which particular taxa differ). CA is influenced by rare species, so those taxa occurring at 10% or fewer stations were eliminated from the analysis. Taxa constituting less than 5% of the total organism abundance were also removed. After screening and data reduction, abundances were log (x+1) transformed. Scores for both stations and taxa were calculated using the ADE-4 package (Thioulouse et al. 1997) and were saved as new summary variables to evaluate the associations of organisms and stations.

Of the metrics that were evaluated, density, number of taxa, Simpson's evenness, and Bray-Curtis distance are emphasized in determining potential mine-related effects at operating mines in Canada (Environment Canada 2002). Therefore, these metrics were referred to as "primary" metrics, while the other metrics, also useful in describing benthic community characteristics (Environment Canada 2002) were referred to as "secondary" metrics.

Benthic invertebrate community metrics were computed for each station and summarized for each area (e.g., mean, standard deviation, standard error, minimum, maximum). Reference-exposure areas differences were tested using multivariate analysis of variance (MANOVA) and analysis of variance (ANOVA), followed by *a priori* user-defined post-hoc tests (Bonferroni). All data were transformed as necessary to satisfy assumptions of normality and homogeneity of variance. In instances where variances could not be homogenized by transformation, contrast tests not requiring this assumption (e.g., Tamhane's) were used. All statistical tests were conducted using SPSS Version 13 software (SPSS Inc. 2006).

2.6 Evaluation of Additional Reference Areas

Historically, benthic community characteristics in Vangorda Creek downstream of the Vangorda site (V27, V5, V8) have been compared to a single upstream area (V1) However, V1 is generally characterized by steeper gradient, more riffle habitat and coarser substrate than found at other Vangorda Creek stations (e.g., V5 and V8), potentially confounding the evaluation of mine-related effects on benthic communities in Vangorda Creek. Also, an evaluation of benthic community data collected between 2000 and 2006 indicated the benthic communities of West Fork Vangorda Creek differ from those on the main stem. Therefore, several reference creeks in the general vicinity of the Vangorda site were investigated with a goal of finding one or more areas with habitat and benthic invertebrate communities comparable to the mine-exposed areas of Vangorda Creek. Of these, three creeks were considered to be most comparable to lower Vangorda Creek (Next Creek, South Fork Rose Creek upstream of the Haul Road, and West Fork Vangorda Creek upstream of the Haul Road). At these areas, the aquatic habitat was characterized in detail and one water sample and one exploratory benthic sample (one 3-sample composite using a Hess sampler) were also collected. The results were compared to reference area V1 and the mine-exposed areas to determine which areas would best serve as reference areas in future benthic invertebrate community assessments at the Vangorda site.

2.7 Fish Surveys

Exploratory backpack electrofishing was opportunistically conducted (i.e., time-permitting) in three areas: Next Creek, Upper South Fork Rose Creek (upstream of the Haul Road) and in Vangorda Creek downstream of V8 (Figure 2.1). Electrofishing was conducted using a Smith-Root POW Type 12A battery powered backpack. No stop nets were used. Sampling effort (electrofisher settings, electrofishing seconds, area sampled) and GPS coordinates were recorded on field sheets following each respective pass. Fish were collected under fish Licence No. 07-52 issued by the Department of Fisheries and Oceans, Whitehorse, Yukon. All captured fish were identified and enumerated prior to their release. The main objective of these fish collections was to confirm the reproductive status (gonad size) of stickleback at this time of year.

3.0 WATER QUALITY ASSESSMENT

3.1 Comparison to Water Quality Benchmarks

All surface waters were well oxygenated at the time of sampling (Table 3.1). Temperatures were in the range of 4 to 8°C at most stations, except the Upper South Fork of Rose Creek which was warmer at 10.1°C. Water pH ranged from 6.5 to 8.5, except at Upper West Fork Vangorda Creek where pH was lower (4.7). As expected, conductivity was higher at mine-exposed stations (135-339 uS/cm) than at reference stations (44-136 uS/cm), reflecting inputs of mine-related dissolved solids (e.g., sulphate and metals). Notably, conductivity was highest at V5 and V8 compared to V27 and the reference stations, indicating a source of dissolved solids to West Fork Vangorda Creek. Indeed, total dissolved solids as well as alkalinity, hardness and total suspended solids were higher at V5 and V8 than at V27 or V1 (Table 3.2).

Concentrations of various analytes measured in water samples were compared to water quality benchmarks, most of which are associated with protection of aquatic life (Appendix A). Concentrations measured in reference samples did not exceed any of the benchmarks (Table 3.2). Benchmarks for cadmium and zinc were only marginally exceeded at V27 and all other substances measured at this station were below levels associated with effects on aquatic life (Table 3.2). Samples collected at V5 and V8 only slightly exceeded the benchmarks for fluoride, sulphate, aluminum, cadmium, iron, and/or selenium (Table 3.2). Overall, the data indicated water quality was relatively good at all stations downstream of the Vangorda site, consistent with the conclusions of a previous evaluation of recent (2004-2006) water quality data (Minnow 2007a).

3.2 Evaluation of Field Duplicate Data

Water samples were collected by LES (Burns 2007) at the same times and locations as those collected by Minnow and then sent to a different laboratory (Cantest, rather than Maxxam). The samples were collected side-by-side, rather than being split aliquots of a single sample and thus can be considered field duplicates. Therefore, in addition to potential spatial differences in water quality, the comparison of results reflected laboratory differences. Differences in reported values from the two sets of analyses were expressed as "relative percent difference" (RPD – see Table 3.3 for calculation) and values greater than 20% were highlighted to indicate the largest differences (Table 3.3).

A high proportion of elevated RPDs were wholly or partially attributable to differences in method detection limits (MDL) between laboratories (highlighted in yellow; Table 3.3).

Table 3.1: Field water quality measurements collected in August 2007, Vangorda Creek, Faro Mine, Yukon.

Area	Station Description	Station ID	Date Measured	pH pH units	DO mg/L	DO %	Conductivity uS/cm	Temperature °C	Wetted Width m	Bankful Width m	Depth m	Velocity m/s	Gradient %
Reference	Upper West Fork Vangorda Creek	REF1	Aug. 25	4.73	10.8	84.0	97	4.7	1.59	2.13	0.100	0.31	5
	Upper South Fork Rose Creek	REF2	Aug. 25	7.08	9.1	81.3	60	10.1	0.16	8.60	0.225	0.37	4.8
	Next Creek	NEX-C1	Aug. 25	7.50	11.4	87.5	136	4.2	6.13	6.50	0.188	0.25	4
	Upper Vangorda Creek	V1-01	Aug. 28	6.85	12.2	98.8	48	6.3	4.43	8.46	0.207	0.11	5
		V1-02	Aug. 28	6.52	12.2	99.0	48	6.5	4.90	7.03	0.138	0.31	8
		V1-03	Aug. 28	6.91	12.1	98.5	49	6.5	5.28	8.11	0.125	0.42	7
		V1-04	Aug. 29	6.56	12.8	99.1	43	4.5	7.01	10.21	0.300	0.06	8
		V1-05	Aug. 29	6.37	13.6	105	44	4.5	4.33	6.74	0.197	0.12	6
Effluent Exposed	Vangorda Creek	V27-01	Aug. 28	7.54	13.4	105	134	5.2	5.06	5.64	0.178	0.19	2
		V27-02	Aug. 28	7.81	12.9	102	140	5.5	4.10	7.80	0.226	0.21	2.5
		V27-03	Aug. 28	7.84	12.7	103	135	5.7	4.49	5.25	0.187	0.12	3.5
		V27-04	Aug. 28	7.87	12.4	103	137	6.3	4.50	5.43	0.238	0.16	3
		V27-05	Aug. 28	8.00	12.3	103	143	7.7	4.59	6.46	0.234	0.13	3
		V5-01	Aug. 29	8.46	14.5	114	329	4.9	2.73	5.19	0.122	0.23	3
		V5-02	Aug. 29	8.47	14.1	110	328	4.9	3.06	5.50	0.128	0.18	3
		V5-03	Aug. 29	8.25	13.5	107	333	5.4	3.55	5.51	0.202	0.22	3
		V5-04	Aug. 29	8.41	13.4	107	336	5.8	3.63	5.43	0.160	0.24	4
		V5-05	Aug. 29	8.48	13.1	106	339	6.2	3.98	6.54	0.106	0.24	3
		V8-01	Aug. 27	8.33	13.2	107	277	6.2	5.75	7.63	0.264	0.18	5
		V8-02	Aug. 27	8.38	13.3	109	280	6.6	4.79	7.80	0.240	0.17	5.5
		V8-03	Aug. 27	8.43	13.1	108	285	7.1	5.60	7.68	0.293	0.09	2.5
		V8-04	Aug. 27	8.46	13.0	109	289	7.8	6.59	10.06	0.229	0.21	2.5
		V8-05	Aug. 27	8.47	12.9	109	291	8.1	3.23	5.95	0.266	0.14	4

(shaded) Dissolved oxygen value is an estimate based on temperature.

Table 3.2: Concentrations of laboratory analytes in water samples collected in August 2007, Faro Mine Complex, Yukon (raw data in Appendix B).

Parameter	Units	Benchmark (see Appendix A)	Reference				Mine Exposed (Vangorda Creek)			
			Upper West Fork Vangorda Creek (REF1) (Sample Date: 8/25/2007)	**Upper South Fork Rose Creek (REF2)** (Sample Date: 8/25/2007)	**Next Creek (NEX-C1)** (Sample Date: 8/26/2007)	**Upper Vangorda Creek (V1)** (Sample Date: 8/28/2007)	**V27** (Sample Date: 8/28/2007)	**V5** (Sample Date: 8/29/2007)	**V8** (Sample Date: 8/27/2007)	**V8Z Field Duplicate** (Sample Date: 8/27/2007)
Alkalinity (Total as CaCO3)	mg/L	12.6 [a]	30.6	21.9	47.4	24.4	52.3	206	134	137
Alkalinity (PP as CaCO3)			< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	3.3	< 0.5	< 0.5
Ammonia - N	"	0.25	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Chloride	"	250	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	2.1	0.8	0.8
Conductivity	uS		75	59	102	71	210	533	396	398
Dissolved solids, total (TDS)	"	500	62	50	78	54	140	354	264	260
Fluoride	"	0.12	0.08	0.07	0.09	0.07	0.08	0.19	0.13	0.13
Hardness	"		35	26.1	49.7	30.8	102	304	214	213
Mercury, total	ug/L	0.026	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05	< 0.05
Nitrate (N)	mg/L	13	< 0.02	< 0.02	< 0.02	< 0.02	0.13	0.03	0.08	0.08
Nitrate plus Nitrite (N)			< 0.02	< 0.02	< 0.02	< 0.02	0.13	0.03	0.08	0.08
Nitrite - N	"	0.06	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005
Organic carbon, dissolved (DOC)	"		3.1	1.9	2.7	1.4	1.8	3.5	2.6	2.5
Organic carbon, total (TOC)	"		3.3	2.7	3.2	2	2.2	3.5	2.6	2.4
Phosphorus, total	mg/L	0.03	< 0.005	0.005	< 0.005	0.01	< 0.005	0.017	0.012	0.008
Sulphate	"	50	4.2	5.5	2.4	8.9	49.3	75.6	65.9	66.5
Suspended solids, total (TSS)	"	29	< 1	< 1	< 1	< 1	< 1	11	3	12
ICP - Metals Scan										
Aluminum	mg/L	0.1	0.0306	0.0263	0.0172	0.0143	0.0184	0.275	0.101	0.107
Antimony	"	0.020	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.00007	0.00015	0.00013	0.00012
Arsenic	"	0.005	0.0001	0.0003	< 0.00001	0.0002	0.0004	0.001	0.0004	0.0005
Barium	"	1	0.0287	0.025	0.0256	0.0257	0.0326	0.078	0.0528	0.0539
Beryllium	"	1.1	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.00005	< 0.00005	< 0.00005	< 0.00005
Bismuth		0.260	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Boron	"		< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008	< 0.008
Cadmium	"	0.00003	0.00001	< 0.00001	0.00001	< 0.00001	0.00005	0.00004	0.00004	0.00004
Calcium	"		10.9	8.82	16.5	10.6	28.3	77.8	52.8	54.9
Chromium	"	0.001	< 0.0002	< 0.0002	< 0.0002	< 0.0002	< 0.0002	0.0008	0.0003	0.0003
Cobalt	"		0.00002	0.00004	< 0.00002	< 0.00002	0.00004	0.00027	0.00014	0.00012
Copper	"	0.002	0.0006	0.0004	0.0006	0.0004	0.0009	0.0014	0.0013	0.0011
Iron	"	0.3	0.031	0.164	0.014	0.027	0.049	0.464	0.177	0.18
Lead	"	0.002	0.00007	0.0001	0.00005	0.00004	0.00052	0.00052	0.00032	0.0003
Total Magnesium (Mg)	"	82	1.94	1.32	2.47	1.45	8.55	28.7	19.7	20
Dissolved Magnesium (Mg)			1.87	1.2	2.32	1.34	8.4	28.2	19.9	20
Total Manganese	"	1.0	0.00106	0.00959	0.00035	0.00076	0.0035	0.0218	0.011	0.011
Molybdenum	"	0.073	0.00014	0.0003	0.00024	0.00023	0.00032	0.00158	0.00081	0.00083
Nickel	"	0.065	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0018	0.0011	0.0011
Potassium	"	53	0.326	0.285	0.522	0.343	0.525	1.15	0.892	0.911
Selenium	"	0.001	< 0.0005	< 0.0005	< 0.0005	< 0.0005	< 0.0005	0.0013	< 0.0005	0.0006
Silver	"	0.0001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001	< 0.00001
Total Sodium (Na)	"	200	1.93	1.92	2.37	2.09	2.54	4.12	3.33	3.48
Dissolved Sodium (Na)			1.73	1.6	2	1.81	2.21	3.78	3.11	3.11
Strontium	"	9.3	0.054	0.0495	0.0661	0.0539	0.104	0.27	0.191	0.203
Thallium	"	0.0008	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005
Tin	"	0.35	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	< 0.00005	0.00006	< 0.00005
Titanium	"	1.83	< 0.0005	0.0008	< 0.0005	< 0.0005	0.0007	0.0083	0.0027	0.0027
Uranium	"	0.005	0.00037	0.00029	0.00029	0.00031	0.00126	0.00405	0.00315	0.00323
Vanadium	"	0.006	< 0.00005	0.00008	0.00006	< 0.00005	< 0.00005	0.00095	0.00033	0.00032
Zinc	"	0.030	0.0021	0.0019	0.0019	0.0027	0.0318	0.0039	0.0091	0.009
Zirconium	"	0.004	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005	< 0.005

[a] Values less than benchmark are considered to be of concern.

(Shaded cell) Indicates sample analytical result was above the selected benchmark.

Table 3.3: Comparison of field duplicate samples collected in Vangorda Creek , August 2007. Relative percent differences (RPD) greater than 20% are shaded. Light shade (yellow) indicates differences due at least in part to differences in method detection limits between laboratories.

Analytes	Units	Benchmark	V1			V5			V8			V8	V8Z [b]		V27		
			Minnow/ Maxxam	LES/ Cantest [a]	RPD (%)	Minnow/ Maxxam	LES/ Cantest	RPD (%)	Minnow/ Maxxam	LES/ Cantest	RPD (%)	Minnow/Maxxam		RPD (%)	Minnow/ Maxxam	LES/ Cantest	RPD (%)
Dissolved Hardness (CaCO3)	mg/L		30.8	28.8	6.7	304	259	16	214	182	16	214	213	0.5	102	91.7	11
Alkalinity (Total as CaCO3)	mg/L	12.6	24.4	27.4	12	206	228	10	134	150	11	134	137	2.2	52.3	56.7	8.1
Dissolved Sulphate (SO4)	mg/L		8.9	8.95	0.6	75.6	82.2	8.4	65.9	70	6.0	65.9	66.5	0.9	49.3	47	4.8
Ammonia (N)	mg/L	0.25	< 0.005	< 0.01	67	< 0.005	< 0.01	67	< 0.005	< 0.01	67	< 0.005	< 0.005	0.0	< 0.005	< 0.01	67
Conductivity	uS/cm		71	72	1.4	533	525	1.5	396	381	3.9	396	398	0.5	210	204	2.9
Total Suspended Solids	mg/L	29	< 1	< 1	0.0	11	10	9.5	3	3	0.0	3	12	120	< 1	< 1	0.0
Dissolved Magnesium (Mg)	mg/L		1.34	1.21	10	28.2	23.4	19	19.9	16.3	20	19.9	20	0.5	8.4	7.2	15
Dissolved Sodium (Na)	mg/L		1.81	1.62	11	3.78	3.15	18	3.11	2.55	20	3.11	3.11	0.0	2.21	1.9	15
Total Aluminum (Al)	ug/L	100	14.3	10	35	275	130	72	101	76	28	101	107	5.8	18.4	14	27
Total Antimony (Sb)	ug/L	20	< 0.05	< 0.2	120	0.15	< 0.2	29	0.13	< 0.2	42	0.13	0.12	8.0	0.07	< 0.2	96
Total Arsenic (As)	ug/L	5	0.2	< 0.2	0.0	1	0.7	35	0.4	0.4	0.0	0.4	0.5	22	0.4	0.3	29
Total Barium (Ba)	ug/L	1000	25.7	21	20	78	62	23	52.8	44	18	52.8	53.9	2.1	32.6	24	30
Total Beryllium (Be)	ug/L	1100	< 0.05	< 0.2	120	< 0.05	< 0.2	120	< 0.05	< 0.2	120	< 0.05	< 0.05	0.0	0.05	< 0.2	120
Total Bismuth (Bi)	ug/L	260	< 0.05	< 0.2	120	< 0.05	< 0.2	120	< 0.05	< 0.2	120	< 0.05	< 0.05	0.0	< 0.05	< 0.2	120
Total Boron (B)	mg/L		< 0.008	< 0.01	22	< 0.008	< 0.01	22	< 0.008	< 0.01	22	< 0.008	< 0.008	0.0	< 0.008	< 0.01	22
Total Cadmium (Cd)	ug/L	0.03	< 0.01	< 0.04	120	0.04	0.06	40	0.04	< 0.04	0.0	0.04	0.04	0.0	0.05	< 0.04	22
Total Calcium (Ca)	mg/L		10.6	9.53	11	77.8	71	9.1	52.8	46.7	12	52.8	54.9	3.9	28.3	24.8	13
Total Chromium (Cr)	ug/L	1	< 0.2	< 0.2	0.0	0.8	0.6	29	0.3	0.3	0.0	0.3	0.3	0.0	< 0.2	< 0.2	0.0
Total Cobalt (Co)	ug/L		< 0.02	< 0.2	164	0.27	0.2	30	0.14	< 0.2	35	0.14	0.12	15	0.04	< 0.2	133
Total Copper (Cu)	ug/L	2	0.4	0.4	0.0	1.4	1.3	7.4	1.3	1.2	8.0	1.3	1.1	17	0.9	0.8	12
Total Iron (Fe)	mg/L	0.3	0.027	0.03	11	0.464	0.33	34	0.177	0.19	7.1	0.177	0.18	1.7	0.049	0.05	2.0
Total Lead (Pb)	ug/L	2	0.04	< 0.2	133	0.52	0.5	3.9	0.32	0.4	22	0.32	0.3	6.5	0.52	0.3	54
Total Magnesium (Mg)	mg/L	82	1.45	1.22	17	28.7	24.7	15	19.7	17.3	13	19.7	20	1.5	8.55	7.15	18
Total Manganese (Mn)	ug/L	1000	0.76	0.8	5.1	21.8	21	3.7	11	13	17	11	11	0.0	3.5	3.1	12
Total Mercury (Hg)	ug/L		< 0.05	< 0.02	86	< 0.05	< 0.02	86	< 0.05	< 0.02	86	< 0.05	< 0.05	0.0	< 0.05	< 0.02	86
Total Molybdenum (Mo)	ug/L	73	0.23	< 0.1	79	1.58	1.3	19	0.81	0.7	15	0.81	0.83	2.4	0.32	0.3	6.5
Total Nickel (Ni)	ug/L	65	< 0.5	0.2	86	1.8	1.9	5.4	1.1	1.3	17	1.1	1.1	0.0	< 0.5	0.5	0.0
Total Phosphorus (P)	mg/L	0.03	0.01	< 0.03	100	0.017	< 0.03	55	0.012	< 0.03	86	0.012	0.008	40	< 0.005	< 0.03	143
Total Potassium (K)	ug/L	53000	343	360	4.8	1150	1080	6.3	892	870	2.5	892	911	2.1	525	500	4.9
Total Selenium (Se)	ug/L	1	< 0.5	< 0.2	86	1.3	0.7	60	< 0.5	< 0.2	86	< 0.5	0.6	18	< 0.5	< 0.2	86
Total Silver (Ag)	ug/L	0.1	< 0.01	< 0.05	133	< 0.01	< 0.05	133	< 0.01	< 0.05	133	< 0.01	< 0.01	0.0	< 0.01	< 0.05	133
Total Sodium (Na)	mg/L	200	2.09	1.59	27	4.12	3.28	23	3.33	2.7	21	3.33	3.48	4.4	2.54	1.94	27
Total Strontium (Sr)	ug/L	9300	53.9	46	16	270	247	8.9	191	182	4.8	191	203	6.1	104	91	13
Total Thallium (Tl)	ug/L	0.8	< 0.05	< 0.02	86	< 0.05	0.02	86	< 0.05	< 0.02	86	< 0.05	< 0.05	0.0	< 0.05	< 0.02	86
Total Tin (Sn)	ug/L	350	< 0.05	< 0.2	120	< 0.05	< 0.2	120	0.06	< 0.2	108	0.06	< 0.05	18	< 0.05	< 0.2	120
Total Titanium (Ti)	ug/L	1830	< 0.5	0.2	86	8.3	7	17	2.7	2.5	7.7	2.7	2.7	0.0	0.7	< 0.2	111
Total Uranium (U)	ug/L	5	0.31	0.3	3.3	4.05	3.8	6.4	3.15	3	4.9	3.15	3.23	2.5	1.26	1.1	14
Total Vanadium (V)	ug/L	6	< 0.05	< 0.2	120	0.95	0.6	45	0.33	0.3	9.5	0.33	0.32	3.1	< 0.05	< 0.2	120
Total Zinc (Zn)	ug/L	30	2.7	< 1	92	3.9	2	64	9.1	7	26	9.1	9	1.1	31.8	20	46
Total Zirconium (Zr)	mg/L	0.004	< 0.005	< 0.002	86	< 0.005	< 0.002	86	< 0.005	< 0.002	86	< 0.005	< 0.005	0.0	< 0.005	< 0.002	86

[a] Reported by Burns (2007)
[b] V8Z - duplicate of sample V8 collected in the field
RPD = Relative percent difference =(|value1 - value2|/mean)*100

While not necessarily indicative of a discrepancy in the reported concentrations, these differences in MDLs can substantially affect any summary statistics performed on the data (e.g., means, standard deviations) and thus affect data interpretation. In most cases where concentrations were reported as <MDL by one or both laboratories, the MDLs reported by Cantest were substantially higher (Table 3.3). Of the analytes detectable by both laboratories, reported concentrations of aluminum, sodium, and zinc consistently differed by more than 20% and results reported by Cantest were usually lower than those reported by Maxxam. This pattern suggests systematic analytical bias at one or other laboratory for those particular analytes. That the observed differences between field duplicate samples were predominantly due to laboratory differences rather than field variability was supported by low RPDs for the single set of field duplicate samples which were both collected by Minnow (at V8) and sent to Maxxam compared to RPDs for the other sets which were divided between laboratories (Table 3.3). Quality control (QC) data reported by Maxxam indicated good precision and accuracy for all analyses (Appendix B), but QC data were not reported for Cantest samples (Appendix B in Burns 2007). Some comparisons for arsenic, barium, cadmium, chromium, cobalt, iron, lead, phosphorus, titanium, and vanadium also yielded RPDs of more than 20%; however, because the associated differences were not systematic and the absolute differences were generally not large, these were not considered to be of concern.

In summary, the analyses emphasized large differences between laboratories in reported MDLs, and suggested systematic bias in results for aluminum, sodium, and zinc at one or the other laboratory. These findings should be further investigated as part of the interim monitoring planned for the Rose/Anvil Creek system in 2008 to support the selection of a long-term provider of analytical services.

4.0 SEDIMENT QUALITY ASSESSMENT

4.1 Chemistry

The sediments at V1 and V27 were largely comprised of sand and gravel (Table 4.1), typical of fast-flowing, upper perennial creek habitats (Cowardin et al. 1979). Combined silt and clay fractions represented <2% of the whole sediment samples. Nutrient concentrations were also low (Table 4.1).

Metal concentrations at reference area V1 did not exceed applicable sediment quality guidelines in either the whole sediment (<2 mm) or the fine fraction (<0.15 mm; Table 3.1). Arsenic, lead, and zinc were elevated in samples collected at V27, when compared to both benchmarks and concentrations measured at V1. However, the results also showed that concentrations were approximately three times higher in the fine than whole sediment, as would be expected (Horowitz 1991). Thus, a large proportion of the metals present was associated with fine sediment particles, which represented a small proportion of the total sediment composition.

4.2 Evaluation of Collection Methods

Sediment samples were collected by LES (Burns 2007) at the same time but using different methods and at slightly different locations than those collected by Minnow and thus cannot be considered true field duplicates. Furthermore, the sediment samples were sent to different laboratories for analysis (Minnow samples to Maxxam and LES samples to Cantest). However, the comparison of results (<0.15mm fraction) serves to illustrate the effect of variations in approach on reported sediment chemistry.

As described in Section 2.3, Minnow collected sediment samples by compositing the top 5 cm of submerged sediments from several Ponar grab samples collected at each station. Care was taken to standardize the substrates and habitat of sample stations as much as possible. LES samples were collected from exposed areas on stream banks using a trowel and placed directly into sample jars (little or no compositing) (Burns 2007). As different laboratories were used for analysis of the two sets of results, the cause of higher among-station variability associated with trowel samples (Table 4.2) cannot be conclusively apportioned between laboratory or field sources, but field variability (i.e., spatial variability in sediment concentrations and the variability associated with collection methods) typically greatly exceeds laboratory variability for sediment chemistry data. Lower coefficients of variation for Minnow versus LES samples collected at V27 indicated that better precision is achieved by ensuring each sample is a composite of several grabs

Table 4.1: Comparison of sediment properties in Vangorda Creek relative to sediment quality criteria (raw data in Appendix B).

Parameter	Units	MDL[a]	Sediment Quality Guidelines				V1 (reference)		V27-A		V27-B		V27-C	
			Canadian[b]		British Columbia[c]		Whole [d]	<0.15mm	Whole	<0.15mm	Whole	<0.15mm	Whole	<0.15mm
			ISQG[e]	PEL[f]	ISQG[e]	PEL[f]								
Sampling Date							8/28/2007	8/28/2007	8/28/2007	8/28/2007	8/28/2007	8/28/2007	8/28/2007	8/28/2007
Gravel (>2 mm)	%	0.1					82		48		41		29	
Sand (0.0625-2 mm)	%	0.1					17		51		58		70	
Silt (0.0039-0.0625mm)	%	0.1					0.1		0.3		0.4		0.4	
Clay (<0.0039 mm)	%	0.1					1.0		0.9		1.2		1.1	
Total Organic Carbon (TOC)	%	0.05					0.13		3.7		0.3		0.24	
Nitrite (N)	mg/kg	0.5					<0.5		<0.5		<0.5		<0.5	
Available (KCl) Ammonia (N)	mg/kg	0.5					0.9		0.7		0.8		0.8	
Nitrate plus Nitrite (N)	mg/kg	2					<2		<2		<2		<2	
Available (KCl) Orthophosphate (P)	mg/kg	0.5					4.9		3.6		2.8		3.2	
Aluminum (Al)	mg/kg	50					8,020	16,100	8,180	14,800	8,700	14,300	9,630	13,200
Antimony (Sb)	mg/kg	0.2					0.2	0.3	0.7	2	0.5	2.2	0.8	2
Arsenic (As)	mg/kg	1	5.9	17	5.9	17	6.9	16.2	19.9	48.7	16.8	46	24.7	39.8
Barium (Ba)	mg/kg	0.5					64.3	130	73.5	338	88	265	116	209
Beryllium (Be)	mg/kg	0.2					0.3	0.6	0.2	0.5	0.2	0.5	0.3	0.5
Bismuth (Bi)	mg/kg	2					0.2	0.7	0.1	0.3	0.2	0.3	0.2	0.3
Total Boron (B)	mg/kg	5					<5	<5	<5	<5	<5	<5	<5	<5
Cadmium (Cd)	mg/kg	0.1	0.6	3.5	0.6	3.5	0.35	0.52	0.82	2.47	0.92	2.35	1.05	2.26
Chromium (Cr)	mg/kg	0.5	37.3	90	37.3	90	14	26	25	48	22	43	24	42
Cobalt (Co)	mg/kg	0.5					7.4	17.2	11.2	24.1	11.8	23.4	13.6	23.5
Copper (Cu)	mg/kg	0.5	35.7	197	35.7	197	14.7	28.4	21.7	57.9	21.2	55.2	25.1	52.1
Iron (Fe)	mg/kg	50			21,200	43,766	18,500	34,100	19,200	35,600	20,600	36,900	23,000	32,700
Lead (Pb)	mg/kg	1	35.0	91.3	35	91	10.2	25.2	146	352	123	362	152	313
Manganese (Mn)	mg/kg	1					378	736	830	2,320	941	2,290	1,070	2,290
Total Mercury (Hg)	mg/kg	0.05			0.170	0.486	<0.05	<0.05	0.11	0.27	0.19	0.24	0.09	0.22
Molybdenum (Mo)	mg/kg	0.5					0.4	0.8	0.7	1.9	0.9	1.8	1.2	1.9
Nickel (Ni)	mg/kg	0.5			16	75	16.2	32.7	28.1	55.6	26.8	54.7	30.3	52.5
Phosphorus	mg/kg	20												
Selenium (Se)	mg/kg	0.5			2[i]		<0.5	0.6	0.6	1.3	0.6	1.1	0.6	1.2
Silver (Ag)	mg/kg	0.1					0.09	0.14	0.16	0.68	0.3	0.63	0.29	0.73
Strontium (Sr)	mg/kg	0.5					15.5	21	39.9	58	40.7	48.7	40.3	47.3
Thallium (Tl)	mg/kg	0.05					<0.05	0.06	0.19	0.29	0.13	0.32	0.16	0.29
Tin (Sn)	mg/kg	1					0.3	0.5	0.3	0.4	0.2	0.4	0.3	0.3
Titanium (Ti)	mg/kg	5					116	247	95	176	104	174	133	151
Uranium (U)	mg/kg	0.05					1.59	3.71	0.89	1.93	0.85	1.99	1.04	1.87
Vanadium (V)	mg/kg	0.5					14	25	17	31	18	25	18	24
Zinc (Zn)	mg/kg	3	123	315	123	315	53	108	290	709	338	806	385	733

[a] MDL = method detection limit
[b] CCME (1999)
[c] BCMOE (2006)
[d] Samples for metal analysis were pre-screened to 2 mm to remove large particles that could bias sample results.
[e] Interim sediment quality guideline
[f] Probable effect level
[g] Low effect level
[h] Severe effect level
[i] BCMOE (2006a)

Shading indicates selected benchmark and measured values exceeding benchmark.

Table 4.2: Comparison of sediment samples (<0.15mm fraction) collected in Vangorda Creek in this study versus Burns (2007). Coefficients of variation (CV) greater than 20% are shaded.

Analytes	Units	Criteria[c]	V1					V27							
			Minnow/ Maxxam	LES/Cantest [a]			CV(%) [b]	Minnow/Maxxam			CV(%)	LES/Cantest			CV(%)
Total Aluminum (Al)	mg/kg		16,100	13,000	7,550	13,500	29	14,800	14,300	13,200	5.8	6,320	15,400	11,700	41
Total Antimony (Sb)	mg/kg		0.3	0.6	< 0.1	0.7	69	2	2.2	2	5.6	0.9	1.3	1.5	25
Total Arsenic (As)	mg/kg	17	16.2	27	5.7	23.1	61	48.7	46	39.8	10	25.6	43.6	37.4	26
Total Barium (Ba)	mg/kg		130	193	81	197	42	338	265	209	24	185	198	339	35
Total Beryllium (Be)	mg/kg		0.6	< 1	< 1	< 1	0.0	0.5	0.5	0.5	0.0	< 1	< 1	< 1	0.0
Total Boron (B)	mg/kg		< 5	4	4	4	0.0	< 5	< 5	< 5	0.0	4	4	4	0.0
Total Cadmium (Cd)	mg/kg	3.5	0.52	0.5	0.2	0.4	42	2.47	2.35	2.26	4.5	0.9	1.5	1.6	28
Total Chromium (Cr)	mg/kg	90	26	38	15	39	44	48	43	42	7.3	28	55	41	33
Total Cobalt (Co)	mg/kg		17.2	22	6	22	55	24.1	23.4	23.5	1.6	12	24	20	33
Total Copper (Cu)	mg/kg	197	28.4	52	13	46	57	57.9	55.2	52.1	5.3	32	50	53	25
Total Iron (Fe)	mg/kg	43,766	34,100	32,500	15,100	31,600	37	35,600	36,900	32,700	6.1	17,300	36,000	30,200	34
Total Lead (Pb)	mg/kg	91.3	25.2	90.1	15.6	80.1	65	352	362	313	7.6	229	279	299	13
Total Manganese (Mn)	mg/kg		736	861	361	783	40	2,320	2,290	2,290	0.8	931	2,020	1,950	37
Total Mercury (Hg)	mg/kg	0.486	< 0.05	0.08	0.01	0.07	71	0.27	0.24	0.22	10	0.15	0.2	0.36	46
Total Molybdenum (Mo)	mg/kg		0.8	0.6	0.3	0.7	39	1.9	1.8	1.9	3.1	1	1.5	1.5	22
Total Nickel (Ni)	mg/kg	75	32.7	48	15	50	52	55.6	54.7	52.5	2.9	32	59	47	29
Total Selenium (Se)	mg/kg	2	0.6	0.7	0.3	0.6	39	1.3	1.1	1.2	8.3	0.6	0.6	0.7	9.1
Total Silver (Ag)	mg/kg		0.14	0.2	< 0.1	0.2	35	0.68	0.63	0.73	7.4	0.3	0.5	0.5	27
Total Strontium (Sr)	mg/kg		21	33	25	30	14	58	48.7	47.3	11	21	39	38	31
Total Thallium (Tl)	mg/kg		0.06	0.2	< 0.1	0.2	35	0.29	0.32	0.29	5.8	0.2	0.3	0.3	22
Total Tin (Sn)	mg/kg		0.5	< 5	< 5	< 5	0.0	0.4	0.4	0.3	16	< 5	< 5	< 5	0.0
Total Titanium (Ti)	mg/kg		247	248	173	223	18	176	174	151	8.3	143	142	144	0.7
Total Vanadium (V)	mg/kg		25	32	14	32	40	31	25	24	14	16	30	24	30
Total Zinc (Zn)	mg/kg	315	108	190	56	147	52	709	806	733	6.7	394	632	667	26

[a] LES/Cantest data reported by Burns (2007)
[b] CV = Coefficient of variation = standard deviation/mean * 100
[c] see Table 4.1

(Table 4.2). This also suggests one three-grab composite result provides a reasonable indication of "average" conditions and could be a more cost-effective approach for long-term tracking of conditions than separate analyses of three individual grab samples.

It would be expected that mean values computed from three individual trowel samples would be comparable to the values reported for a 3-grab (Ponar) composite sample. While results for V1 were generally in good agreement, the mean values for triplicate trowel samples collected at V27 were almost always lower than values measured in each of the three composite samples collected at the same location (Table 4.3). The reason for this is unknown, but may relate to trowel samples largely being collected from exposed stream banks whereas composite samples were taken from submerged sediment deposits. To ensure the data are representative of concentrations to which benthic organisms may be exposed, it would be appropriate to collect submerged sediments in future surveys.

4.3 Toxicity

Tests were conducted to determine if there was any sediment toxicity potentially attributable to metal concentrations. No effects on either the survival or growth of *Hyallela azteca* were observed after a 7-day laboratory exposure period to aliquots of the same four whole sediment samples described in Section 4.1 (Appendix B).

Table 4.3: Comparison of sediment concentrations in 3-grab composite samples collected by Minnow to means of three single-grab samples collected by LES.

Analytes	Units	Criteria	V1		V27			
			Concentrations in 3-grab composite (Minnow/Maxxam)	Mean of Triplicate Samples (LES/Cantest)	Concentrations in 3-grab composite samples (Minnow/Maxxam)			Mean of Triplicate Samples (LES/Cantest)
Total Aluminum (Al)	mg/kg		16,100	11,350	14,800	14,300	13,200	11,140
Total Antimony (Sb)	mg/kg		0.3	0.5	2	2.2	2	1.2
Total Arsenic (As)	mg/kg	17	16.2	18.6	48.7	46	39.8	36
Total Barium (Ba)	mg/kg		130	157	338	265	209	241
Total Beryllium (Be)	mg/kg		0.6	< 1	0.5	0.5	0.5	< 1
Total Boron (B)	mg/kg		< 5	4	< 5	< 5	< 5	4
Total Cadmium (Cd)	mg/kg	3.5	0.52	0.4	2.47	2.35	2.26	1
Total Chromium (Cr)	mg/kg	90	26	31	48	43	42	41
Total Cobalt (Co)	mg/kg		17.2	17	24.1	23.4	23.5	19
Total Copper (Cu)	mg/kg	197	28.4	37	57.9	55.2	52.1	45
Total Iron (Fe)	mg/kg	43,766	34,100	26,400	35,600	36,900	32,700	27,833
Total Lead (Pb)	mg/kg	91.3	25.2	61.9	352	362	313	269
Total Manganese (Mn)	mg/kg		736	668	2,320	2,290	2,290	1,634
Total Mercury (Hg)	mg/kg	0.486	< 0.05	0.1	0.27	0.24	0.22	0.2
Total Molybdenum (Mo)	mg/kg		0.8	0.5	1.9	1.8	1.9	1.3
Total Nickel (Ni)	mg/kg	75	32.7	38	55.6	54.7	52.5	46
Total Selenium (Se)	mg/kg	2	0.6	0.5	1.3	1.1	1.2	0.6
Total Silver (Ag)	mg/kg		0.14	0.2	0.68	0.63	0.73	0.4
Total Strontium (Sr)	mg/kg		21	29	58	48.7	47.3	33
Total Thallium (Tl)	mg/kg		0.06	0.2	0.29	0.32	0.29	0.3
Total Tin (Sn)	mg/kg		0.5	< 5	0.4	0.4	0.3	< 5
Total Titanium (Ti)	mg/kg		247	215	176	174	151	143
Total Vanadium (V)	mg/kg		25	26	31	25	24	23
Total Zinc (Zn)	mg/kg	315	108	131	709	806	733	564

[a] Reported by Burns (2007)

[b] CV = Coefficient of variation = standard deviation/mean * 100

5.0 BENTHIC INVERTEBRATE COMMUNITY

The effects of discharge from the Vangorda site on Vangorda Creek were examined using several different sampling designs and sample collection methods. As described in Section 2.5, the evaluation included:

1. Collection of benthic invertebrates at five stations in each of areas V1, V27, V5 and V8 (Figure 2.1) using a Hess sampler.
2. Collection of benthic invertebrates at three new reference stations (Upper West Fork Vangorda Creek, Upper South Fork Rose Creek, Next Creek; Figure 2.1) using a Hess sampler, to examine the suitability of these other areas as candidate reference areas for future studies.
3. Comparison of the Hess sampling results to those associated with artificial substrates (AS; rock baskets) deployed for six weeks in each of the same areas listed in #1 (Burns 2007).
4. Comparison of the effectiveness of three stations per area versus five stations per area in determining effluent exposure effects, and the potential trade-off of decreased sampling precision for lower sampling costs.

These options were assessed in terms of relative sensitivity in detecting area differences as well as cost-effectiveness to support recommendations for the future monitoring design at the Faro Mine complex.

5.1 Hess Samples, Five Stations per Area

In Vangorda Creek, density of benthic invertebrates was significantly greater at V27 and lower at V5, compared to the V1 reference area upstream of the Vangorda site (Figure 5.1a, Appendix Table C.10). At V8, downstream of both V27 and V5, density was not significantly different from V1. The number of benthic taxa per station was similar to reference at the downstream areas V27 and V8, but was significantly higher at V5 (Figure 5.1b). This difference was small and statistical significance was attributable to unusually low variability among V5 stations for this metric (Figure 5.1b). Simpson's Evenness (E) was significantly lower at V8 than at reference area V1, but no other significant differences were found between reference and exposure areas for this metric (Figure 5.1c). All three exposure areas had significantly greater mean B-C distance than did the reference area itself, indicating significant departure from the V1 community at these exposure areas (Figure 5.1d).

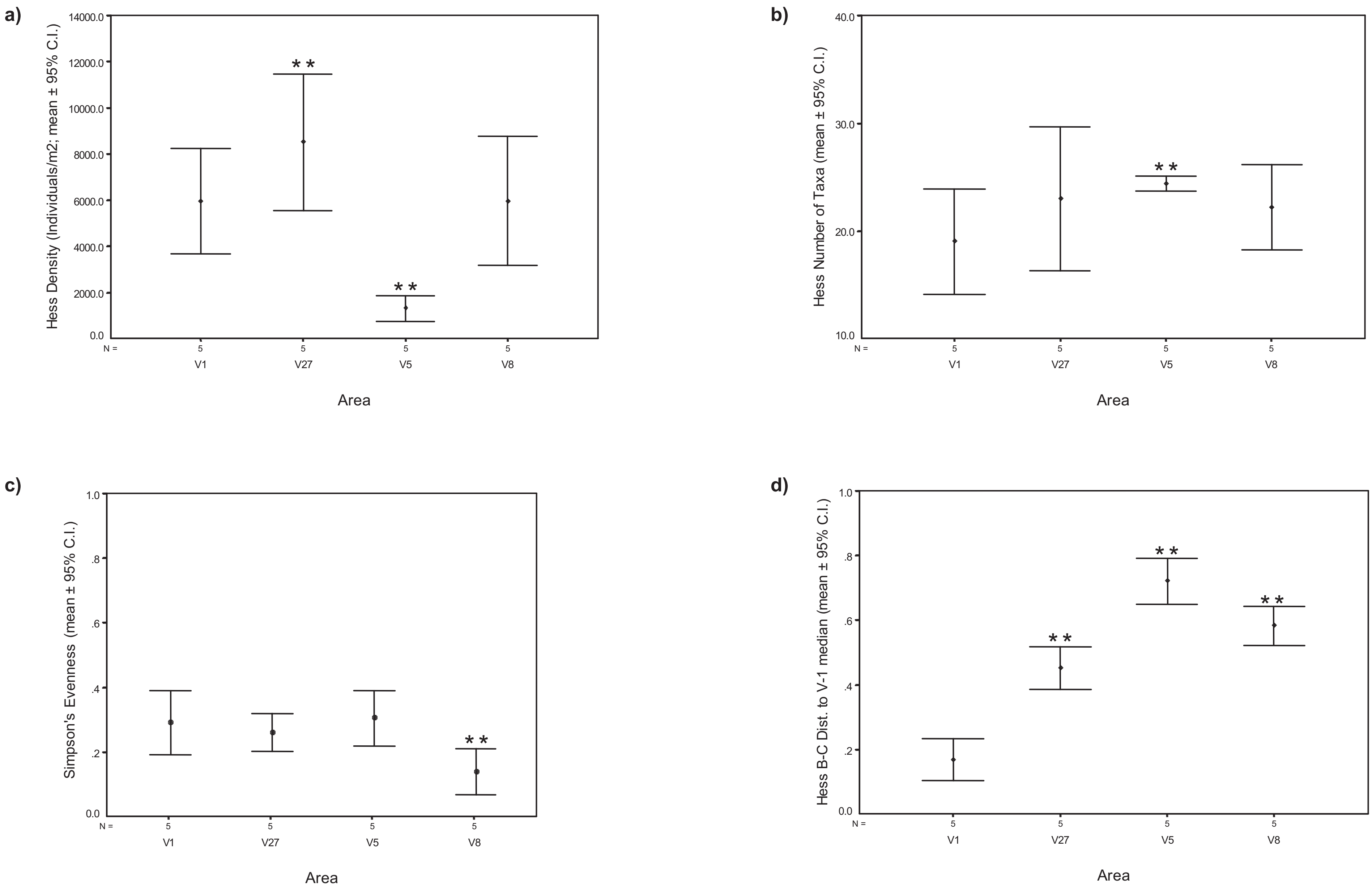


Figure 5.1: Benthic community metrics at Vangorda Creek study areas based on Hess samples: a) density; b) number of taxa; c) Simpson's evenness index; d) Bray-Curtis distance to V1 median. Single versus double asterisks (*) indicate mine-exposed areas that were significantly different from V1 at α = 0.1 versus α = 0.05, respectively.

Correspondence Analysis (CA) explained 56.3% of the total community variance in the first three CA axes (Appendix Table C.7a, Figure 5.2). All three exposure areas differed significantly from V1 in mean CA Axis-1 score (Figure 5.3a). Areas V27 and V8 tended to have higher relative abundance of taxa with high scores on CA-1, including the chironomids *Thiennemannimyia* sp., *Tanytarsus*, and *Synorthocladius*, and simultaneous absence of taxa scoring low on CA-1 such as the cranefly *Gonomyodes*, the chironomid *Diamesa*, and springtails (Collembola) (Appendix Tables C.1 and C.7a). In contrast, the V5 exposure area on West Fork Vangorda Creek had significantly lower CA-1 scores owing to the presence of the same negatively scoring CA-1 taxa (Appendix Tables C.1 and C.7a). Area V5 was clearly separated from all other areas on CA-1 (Figure 5.2a,b), suggesting some fundamental differences in the community at this area, either natural or mine-related.

Significant differences between all three exposure areas and the V1 reference area were also evident on the second CA axis (Figure 5.3b). Area V1 had the lowest CA-2 scores, indicating greater relative abundance of taxa such as the chironomids *Brillia* and *Tanytarsus* (which were also found at V27), and absence of *Hydroptila* caddisflies (found at V8), *Synorthocladius* chironomids (found at V27 and V8), *Chelifera* dance flies (found at all exposure areas), and *Pericoma* moth flies (found at all exposure areas) (Appendix Table C.7a).

Similarities between the communities at V1 and V8 were evident from CA-3 scores (Figure 5.3c), reflecting the presence of taxa such as *Hygrobates* mites as well as the absence of *Tvetenia* midges and the cranefly *Gonomyodes* found at the other areas (Appendix Tables C.1, C.7a). V5 and V27 had significantly lower CA-3 scores than V1 (Figure 5.3c).

Taxa of Ephemeroptera (Mayflies), Plecoptera (stoneflies) and Trichoptera (caddisflies) orders, referred to as EPT taxa, are generally considered to be sensitive to pollution and were found at significantly greater mean percent abundance at area V27, and lower percent abundance at V5 and V8, compared to V1 (Figure 5.4a). Conversely, chironomids occurred at lowest percent abundance at V27, and higher abundance at V8, than at V1 (Figure 5.4b).

Overall, higher organism density and percent EPT, as well as similar number of taxa and Simpson's evenness, at V27 relative to V1 were not indicative of mine-related impact. Natural stream order (upstream/downstream differences as described by Vannote et al. 1980) and/or slight habitat differences likely accounted for the few statistical differences observed between these two areas. The toxic effects of metals on specific taxa in the

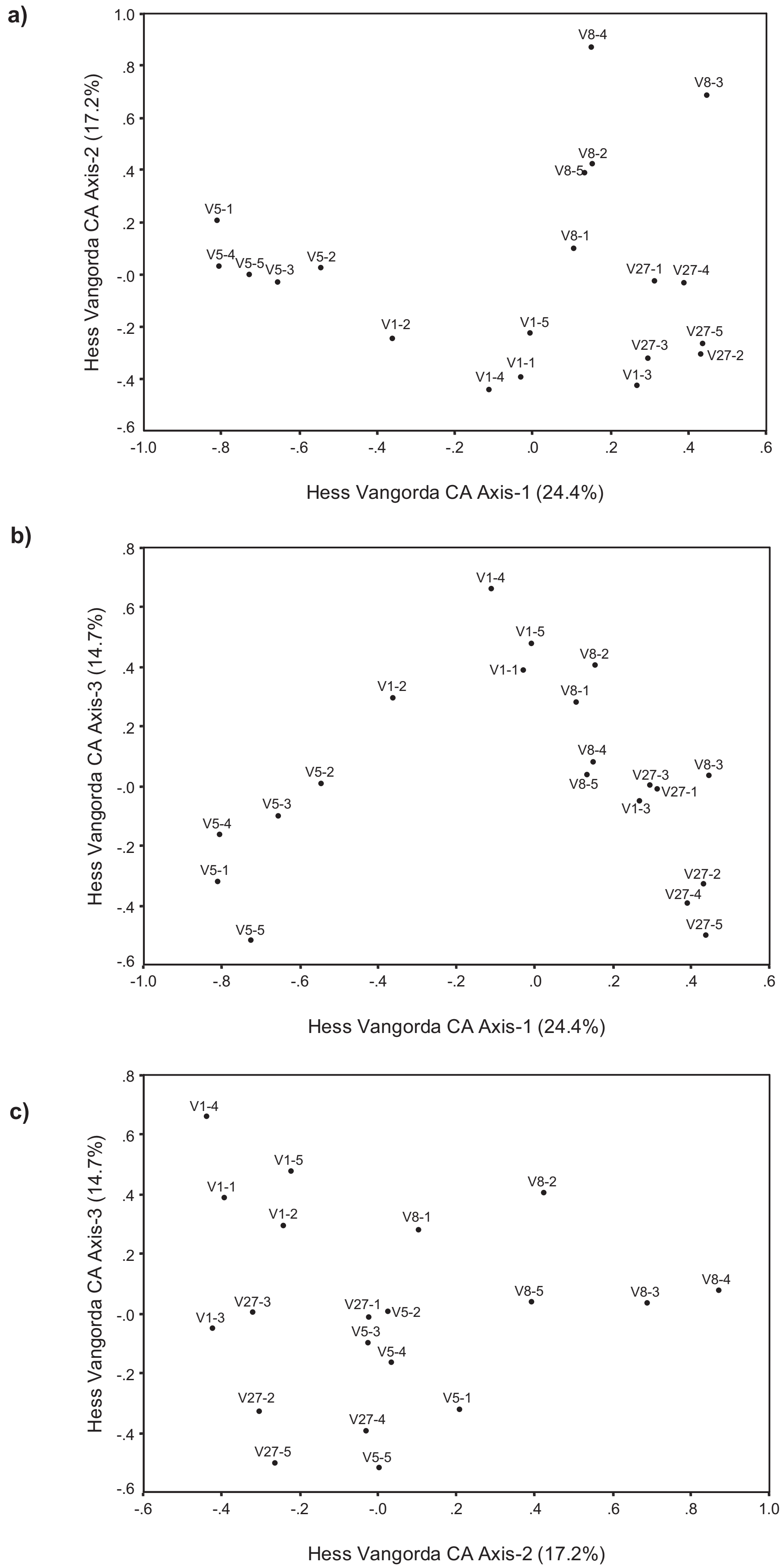


Figure 5.2: Correspondence analysis of benthic invertebrate communities in Vangorda Creek stations based on Hess samples.

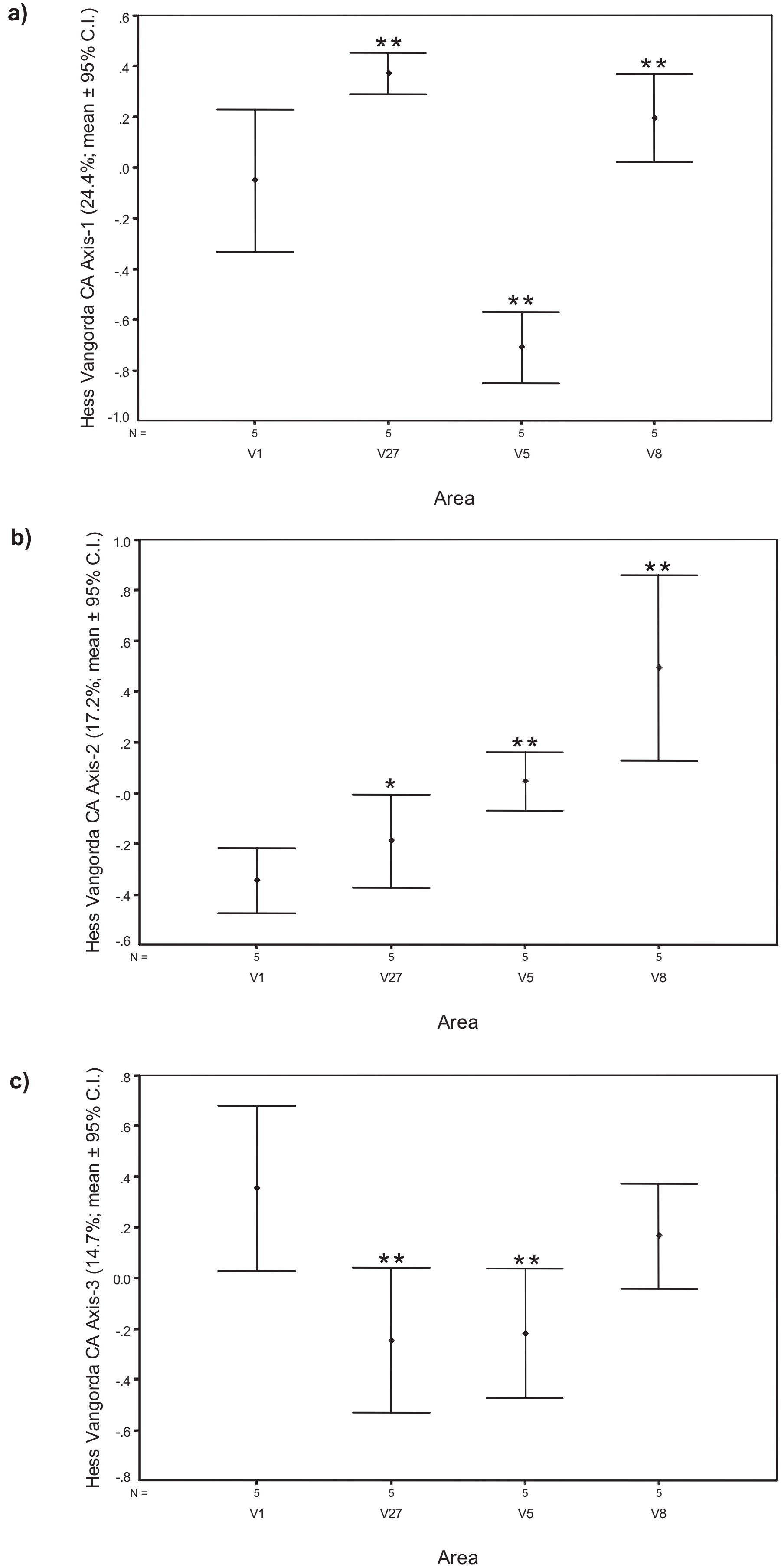
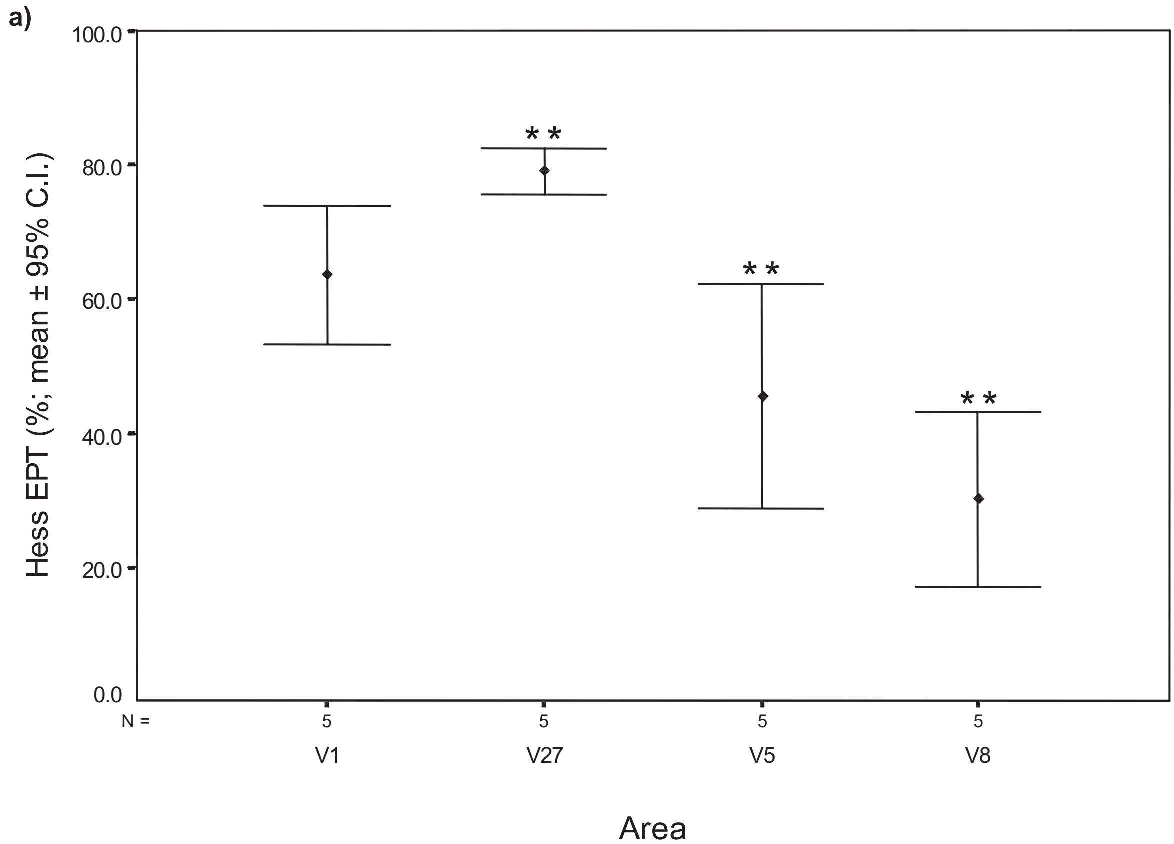


Figure 5.3: Comparison of CA results for benthic invertebrate communities in Vangorda Creek study areas based on Hess samples: a) CA Axis-1; b) CA Axis-2; c) CA Axis-3. Single versus double asterisks (*) indicate mine-exposed areas that were significantly different from V1 at α = 0.1 versus α = 0.05, respectively.



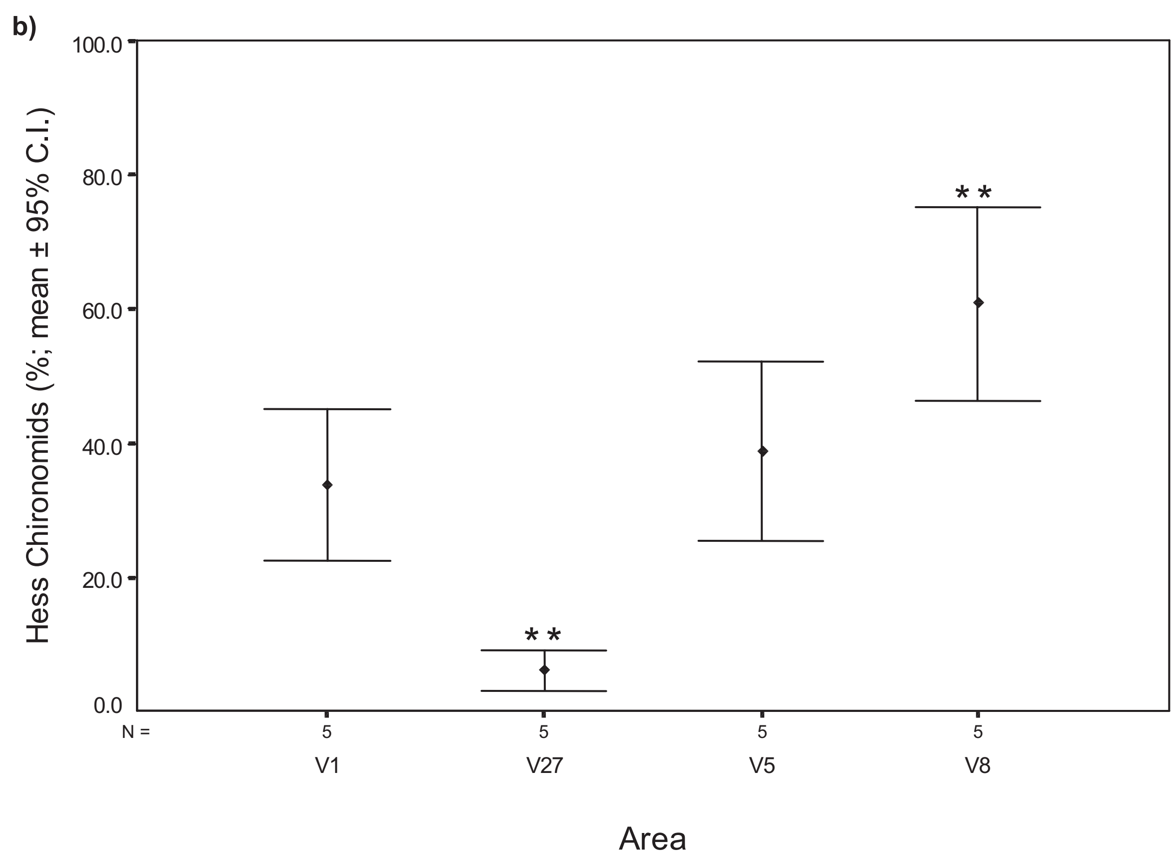


Figure 5.4: Dominant benthic invertebrate taxa at Vangorda Creek study areas based on Hess samples: a) % EPT, and b) % Chironomids. Single versus double asterisks (*) indicate mine-exposed areas that were significantly different from V1 at α = 0.1 versus α = 0.05, respectively.

EPT group has not been well studied. Most of the EPT taxa found at the Vangorda stations are found only in erosional habitats, where they would have little contact with any metal-contaminated sediments. EPT taxa which filter particles from the water, such as the hydropsychid caddisflies, would be more exposed to metal-contaminated suspended sediments, but these taxa occurred commonly at both reference and exposure areas in Vangorda Creek. Many of the chironomid midge taxa important in distinguishing V27 from reference V1 in the Main Fork Vangorda Creek are also characteristic of erosional habitats with little exposure to sediment, and none are known to burrow in fine sediments: *Thiennemannimyia* is a sprawling predator, *Tanytarsus* is a collector-filterer on plants and detritus, *Brillia* lives in tunnels in coarse woody debris, and *Synorthocladius* is a scraping collector-gatherer of periphyton, often on top of rocks (Merritt and Cummins 1984). With the exception of the burrowing cranefly *Gonomyodes*, benthic taxa that distinguished V5 from the other areas are also epibenthic (surface dwelling) species typical of well-oxygenated, flowing creek habitats. These findings are consistent with the dominance of large rocky substrate (gravel, cobble, boulder, bedrock) and paucity of fine sediment deposits in all study areas (Section 4.1 and Appendix D).

5.2 Additional Reference Areas

A single three-sample composite was taken using a Hess sampler in each of three reference areas that were not included in previous routine biological surveys (Figure 2.1):

- UWFV on the upper West Fork Vangorda Creek, upstream of the Haul Road and all influences of the Vangorda site (also called REF1 on field sheets);
- USFR on the upper South Fork of Rose Creek, again upstream of the Haul Road and effects of the Faro Mine complex (also called REF2); and
- NEXC near the mouth of Next Creek, a tributary flowing into Rose Creek downstream of the Faro mine tailings area.

Stations in these three candidate reference areas were compared to stations in the Vangorda Creek study areas (V1, V25, V5, V8), using the same metrics discussed in Section 5.1, to evaluate their potential utility as reference areas for future studies on Rose and/or Vangorda Creeks. Because only one station in each of these areas was sampled, the comparisons are descriptive rather than based on statistical tests.

Although the West Fork of Vangorda Creek is small (Appendix D), and had low water pH (Table 3.1) relative to the other areas sampled, downstream areas V5 and/or V8 showed numerous similarities such as relatively high percent chironomids and CA-1 and CA-2 scores, as well as low organism density, percent EPT, and Simpson's indices compared to stations on the main stem of Vangorda Creek (V1 and V27) (Figures 5.5 and 5.6). Communities at both UWFV and V5 reflected relatively high abundance of the chironomid *Diamesa* and oligochaete worms, and absence of the chironomids *Synorthocladius* and *Thiennemannimyia* sp. (Appendix Table C.1), which were important in distinguishing community differences on CA-1 (Appendix Table C.7b). This suggests that addition of this reference area (UWFV) would benefit future benthic community assessments by assisting in interpretation of data for downstream stations.

Reference areas on South Fork Rose Creek (USFR) and Next Creek (NEXC) showed fairly good habitat comparability (Appendix D), and also fell within the range of benthic invertebrate metrics observed for Vangorda Creek stations (Figures 5.5 and 5.6). The data suggest that these stations may be as suitable as V1 in terms of explaining benthic communities at V27, particularly with respect to number of taxa and %EPT (Figure 5.5). Reference areas V1, USFR and NEXC should be sampled again during the next study conducted in the Rose Creek drainage (tentatively in 2008) to assist in selection of appropriate reference areas for long-term monitoring.

5.3 Artificial Substrate Sample Studies, Vangorda Creek: 5 stations per area.

Artificial substrates (AS) were used to sample the benthic community at the same areas sampled in the Hess survey: V1, V27, V5, and V8 (Burns 2007). Artificial substrates may reduce the effect of natural substrate variability on the benthic community under study if all other habitat factors are standardized, but they may also be biased by preferential colonization of opportunistic taxa and other factors (Minnow 2007b).

Mean abundance of benthic invertebrates on AS was greatest at area V5, and was significantly greater than at area V1 (Figure 5.7), contrary to results of the resident benthic community survey sampled by Hess, which showed lowest densities at that location (Figure 5.7a). AS collected in the other areas had mean invertebrate abundance similar to the V1 reference area. Number of taxa and Simpson's evenness were also statistically similar among areas (Figure 5.7b,c). Mean Bray-Curtis values for exposure areas at V27 and V8 were statistically similar to that of reference area V1, but V5 was slightly higher indicating greater dissimilarity from V1 than the other exposure areas (Figure 5.7d). V5 was also distinguished from other areas based on Hess samples (Figure 5.1a,b,d).

Correspondence Analysis (CA) of the artificial substrate data explained 49.8% of the total community variance in the first three axes (Appendix Tables C.7c). The first CA axis separated the West Fork exposure area V5 from the other Vangorda Creek areas (Figure

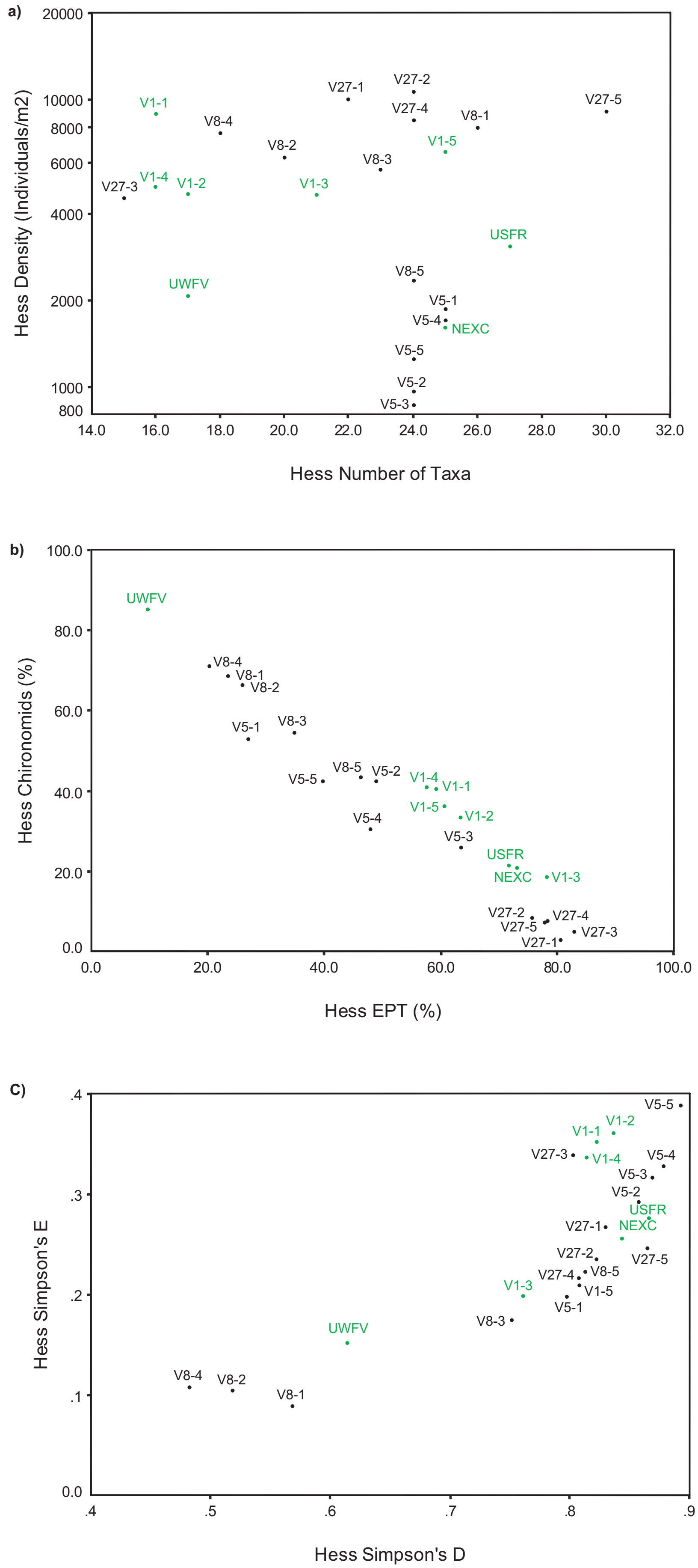


Figure 5.5: Comparison of benthic invertebrate community metrics for candidate reference stations (UWFV, USFR, NEXC; green) compared to reference stations at V1 (also green) and mine-exposed stations at V27, V5 and V8 (black): a) density versus number of taxa; b) % Chironomids versus % EPT and c) Simpson's evenness versus Simpson's diversity.

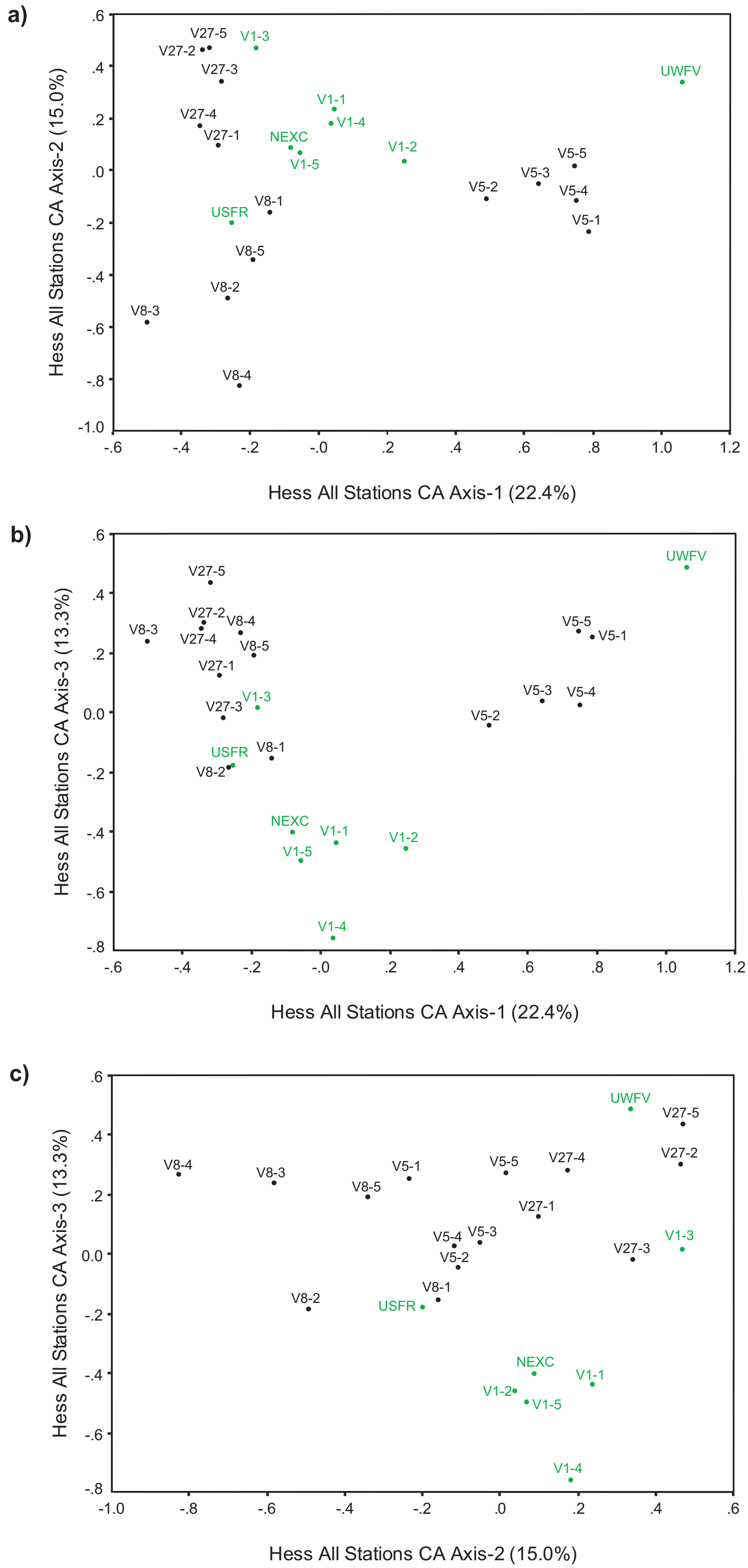


Figure 5.6: Correspondence analysis of benthic invertebrate communities at candidate reference stations (UWFV, USFR, NEXC; green) compared to reference stations at V1 (also green) and mine-exposed stations at V27, V5 and V8 (black).

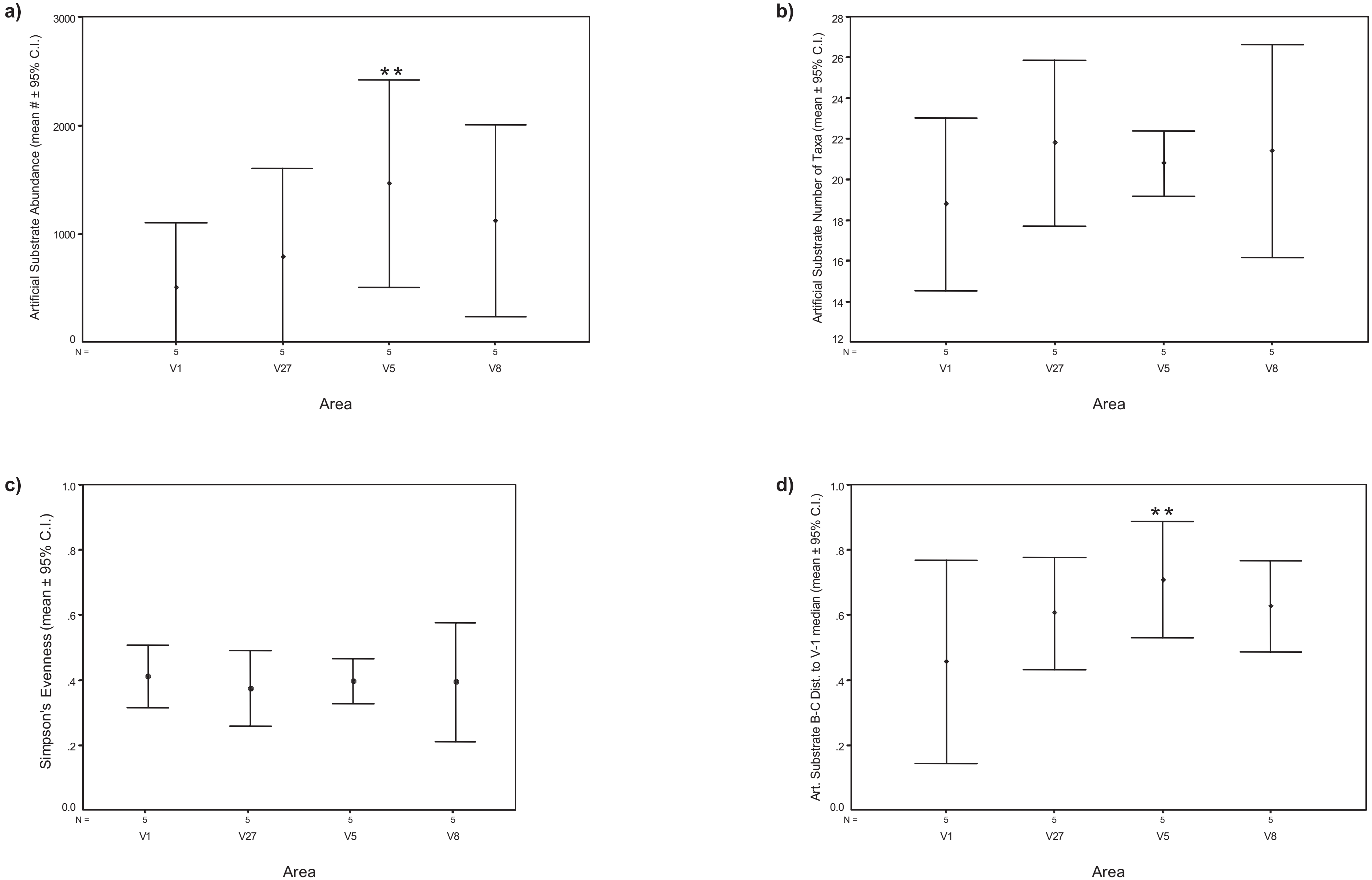


Figure 5.7: Benthic community metrics at Vangorda Creek study areas based on artificial substrate samples: a) density; b) number of taxa; c) Simpson's evenness index; d) Bray-Curtis distance to V1 median. Single versus double asterisks (*) indicate mine-exposed areas that were significantly different from V1 at α = 0.1 versus α = 0.05, respectively.

5.8a,b and 5.9a). The CA-1 scores indicated a trend from dominance by stratiomyid Diptera, *Feltria* mites, and *Dicranota* crane flies (positive scores, typifying V5), to dominance by the mayflies *Ameletus* and *Cinygmula*, and the grazing caddisfly *Glossosoma* (negative scores, typifying V1 and V27). No significant separation of areas occurred on CA Axis-2, where all areas varied quite widely (Figure 5.8a,c and 5.9b). On the third CA axis, exposure area V8 was significantly distinguished from the V1 reference area (Figure 5.9c), based upon the relative dominance by *Aturus* mites (positive scores, typifying V8 stations) or by Stratiomyidae and *Feltria* mites (negative scores, typifying V5 and some V1 stations). The aforementioned taxa, which were important in distinguishing the communities that colonized artificial substrates, were relatively unimportant in distinguishing resident benthic communities sampled by Hess (Section 5.1).

Similar to observations made based on Hess samples, a greater proportion of EPT and lower proportion of chironomids were found in the artificial substrate community at V27 compared to other areas (Figure 5.10). Mean EPT and chironomid proportions on AS at V5 and V8 were similar to V1 mean values.

Although there were some similarities in benthic community patterns described by AS and by Hess samples (Figure 5.11), reference-exposure differences in metrics such as density/abundance, number of taxa, Bray-Curtis distance, and CA scores between exposure areas and V1 were less apparent and rarely statistically significant in magnitude for AS (Appendix Table C.10). Only Percent EPT differed significantly at near-field exposure area V27 relative to reference area V1, with higher values at V27 being contrary to what would be expected if this difference was mine-related. The communities sampled by both AS and Hess suggested the differences may be due to steeper gradient at V27 than V1, although this is contrary to the gradients actually measured in the reaches where samples were taken (i.e., V1 steeper than V27; Appendix Table D.1). The mean CA-1 score for V5 was significantly different from that of V1, and also well separated from V27 and V8 (Figure 5.3a), supporting the previous recommendation for a separate West Fork reference area for future studies (Section 5.2).

Metrics for AS samples within an area tended to be more variable, or less precise (higher coefficient of variation), than the equivalent Hess samples (Table 5.1, Appendix Table Table C.5). This accounted for fewer significant differences being detected using AS data in both 4-group ANOVA (Appendix Table C.9) and comparisons of exposure areas to V1 metrics (Appendix Table C.10). These results support the use of Hess samples over artificial substrates in future studies of Vangorda Creek areas, since lower CVs are more

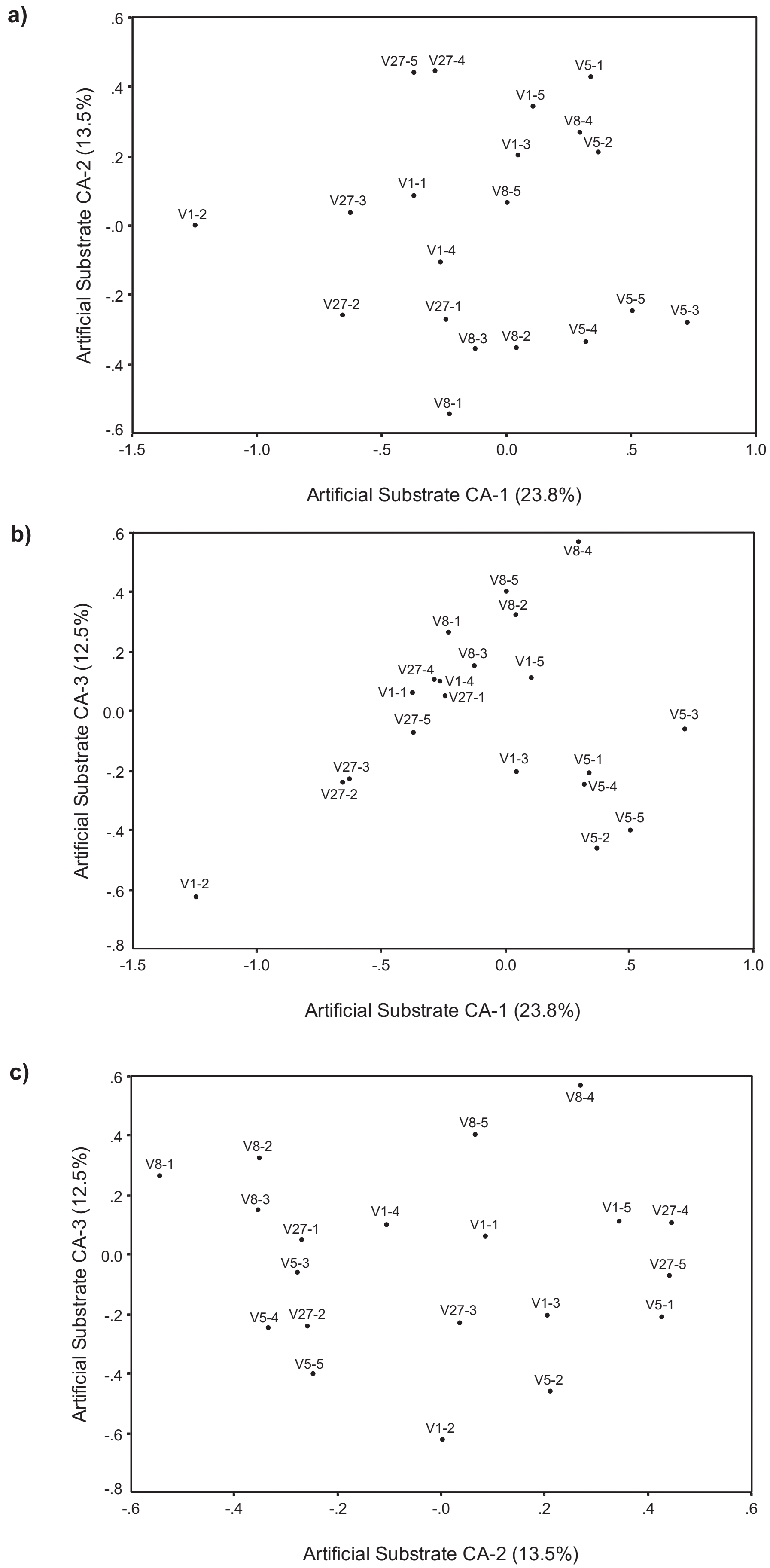


Figure 5.8: Correspondence analysis of benthic invertebrate communities in Vangorda Creek based on artificial substrate samples.

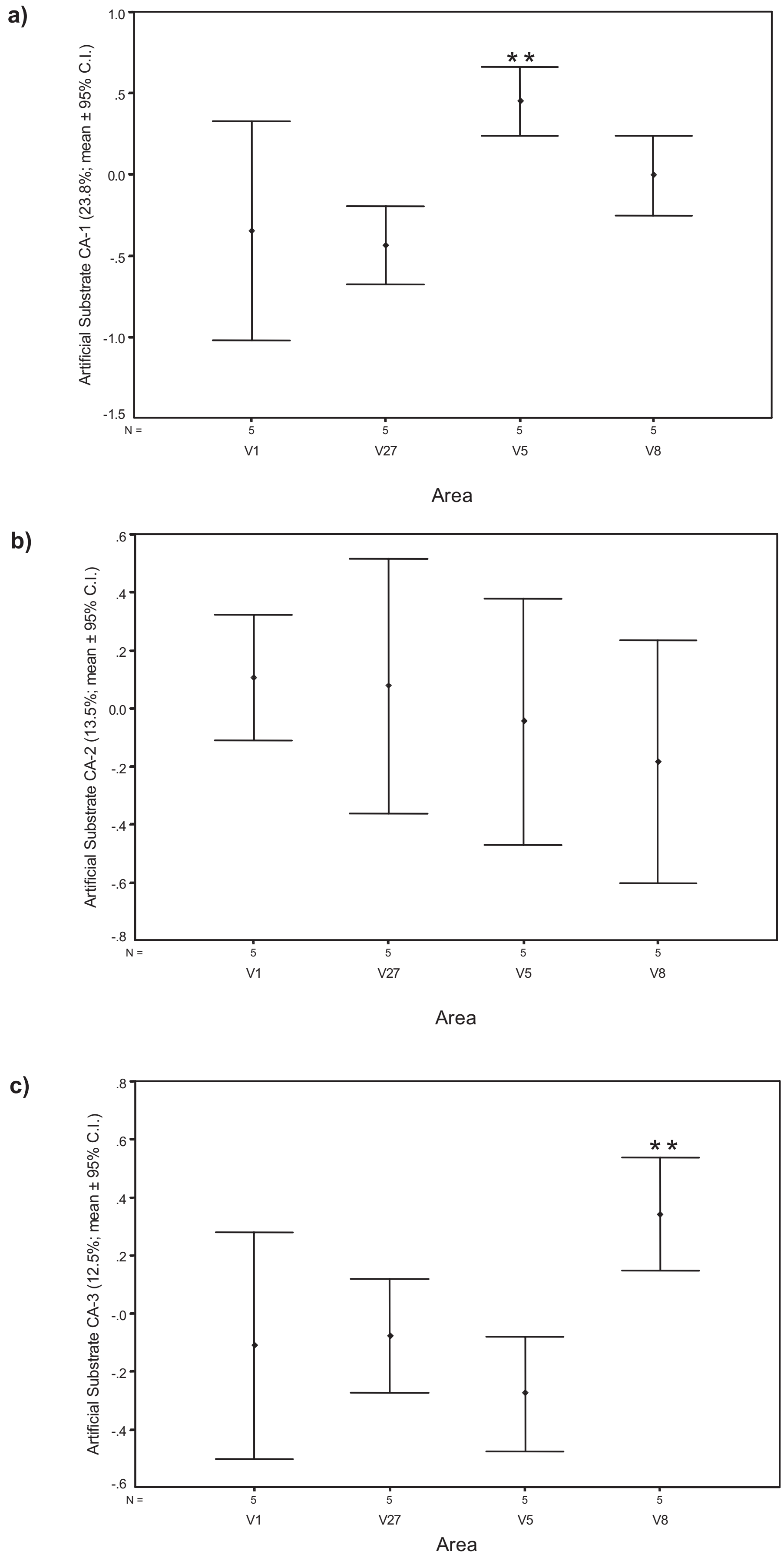


Figure 5.9: Correspondence analysis of benthic invertebrate communities based on artificial substrate samples: a) CA Axis-1; b) CA Axis-2 and c) CA Axis-3. Single versus double asterisks indicate mine-exposed areas that were significantly different from V1 at $\alpha = 0.1$ versus $\alpha = 0.05$, respectively.

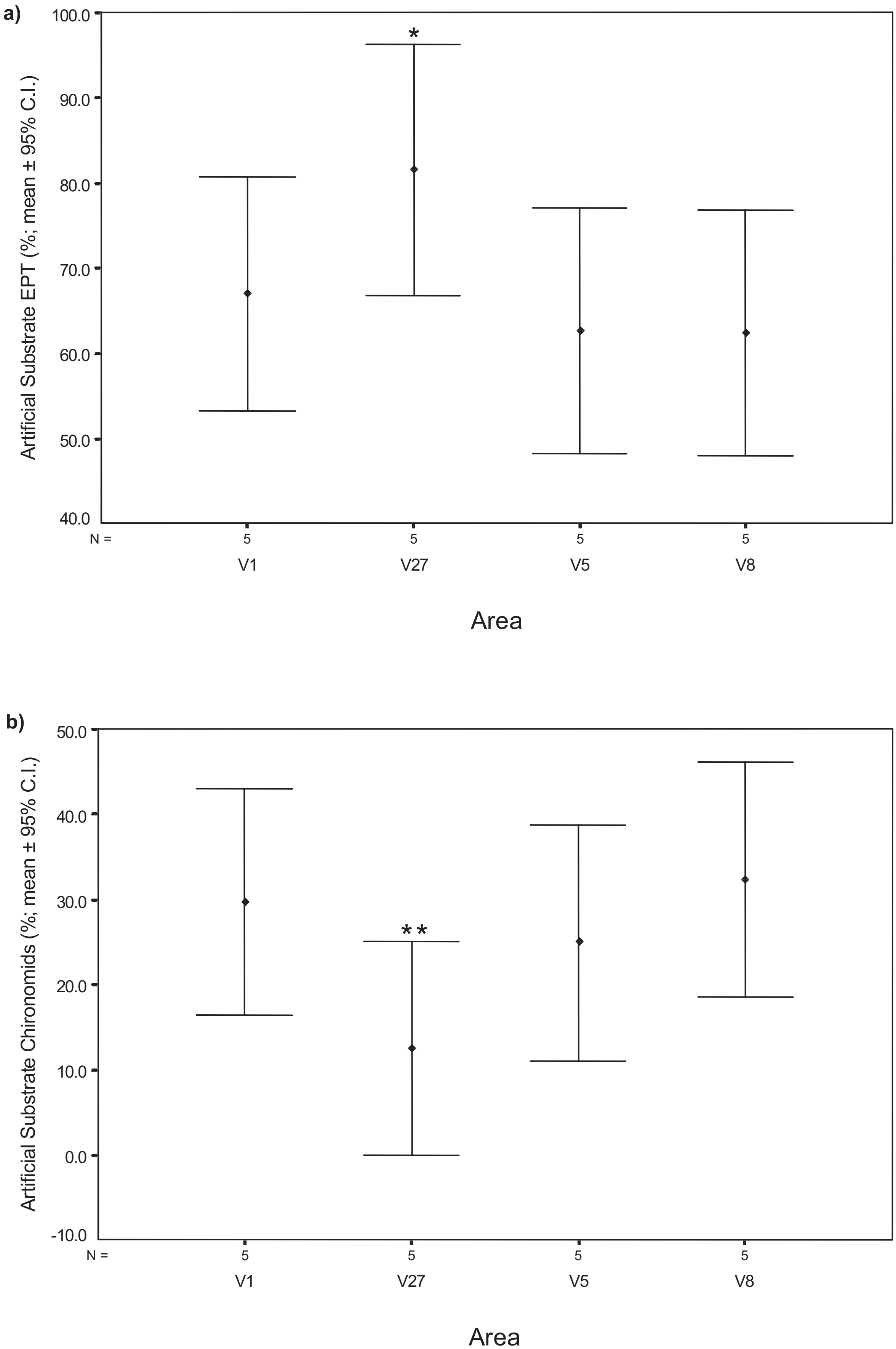


Figure 5.10: Dominant benthic invertebrate taxa at Vangorda Creek study areas based on artificial substrate samples: a) % EPT, and b) % Chironomids. Single versus double asterisks (*) indicate mine-exposed areas that were significantly different from V1 at α = 0.1 versus α = 0.05, respectively.

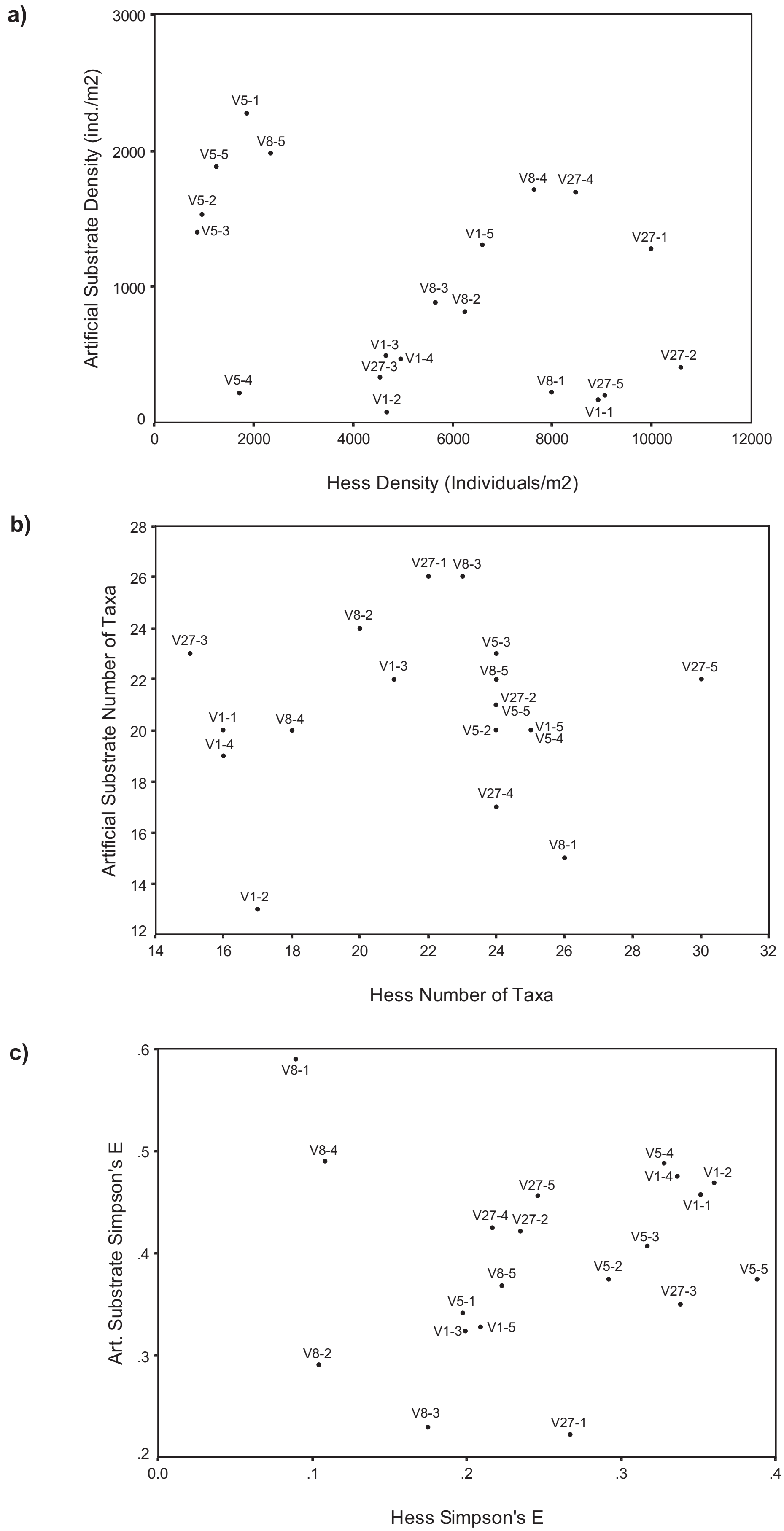


Figure 5.11: Comparison of Hess and artificial substrate samples collected at Vangorda Creek, 2007.

d)

e)

f)

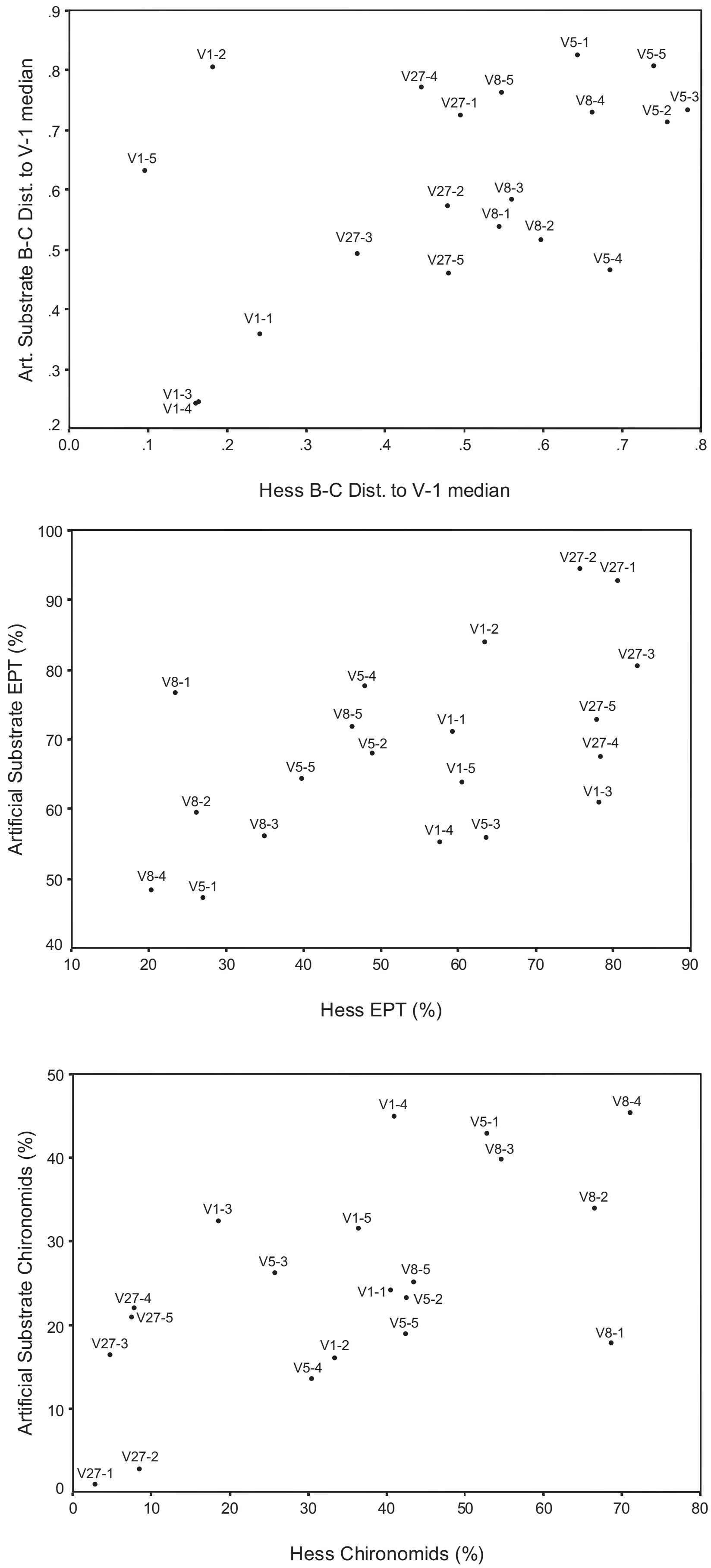


Figure 5.11: Comparison of Hess and artificial substrate samples collected at Vangorda Creek, 2007.

Table 5.1: Coefficients of variation (CV; %) for each benthic community metric based on replicate (5) Hess samples versus artificial substrates (AS) collected in each area. Shaded values represent lowest mean for each comparison.

Metric	Station	Hess	AS
Density (for Hess) or Sample Abundance (for AS)	V1	32	101
	V27	29	88
	V5	35	55
	V8	40	67
	Mean	**34**	**78**
Number of Taxa	V1	22	19
	V27	25	16
	V5	2.4	7
	V8	15	21
	Mean	**16**	**16**
Simpson's E	V1	29	20
	V27	19	26
	V5	24	15
	V8	43	39
	Mean	**29**	**25**
B-C Dist. to V1 median	V1	32	58
	V27	12	24
	V5	8	21
	V8	9	19
	Mean	**15**	**30**
Mean CV for Primary Metrics	**Mean**	**24**	**37**
Simpson's D	V1	4	3
	V27	3	3
	V5	4	2
	V8	25	3
	Mean	**9**	**3**
EPT (%)	V1	14	17
	V27	4	15
	V5	31	19
	V8	37	19
	Mean	**21**	**18**
Chironomids (%)	V1	28	38
	V27	40	84
	V5	29	47
	V8	20	36
	Mean	**29**	**51**
CA Axis 1	V1	467	164
	V27	18	46
	V5	17	40
	V8	75	3697
	Mean	**144**	**987**
CA Axis 2	V1	31	174
	V27	83	478
	V5	200	794
	V8	63	192
	Mean	**94**	**410**
CA Axis 3	V1	78	302
	V27	98	215
	V5	99	61
	V8	105	48
	Mean	**95**	**156**
Mean CV for Secondary Metrics	**Mean**	**59**	**237**
OVERALL CV	**Mean**	**49**	**177**

likely to reveal differences between or among areas, whether owing to natural or mine related changes.

5.4 Optimal Number of Stations per Area

Generally, as the number of stations per area is increased, a smaller magnitude of difference can be detected among areas, making it easier to detect mine-related effects. However, the increase in sensitivity (benefit) must be weighed against the additional effort and expense (cost) of collecting and analyzing additional samples. This issue was examined by comparing statistical results generated using the first three stations from each area compared to those based on all five stations per area. As described in previous sections, standard metrics were computed for all exposure areas and statistically compared to those for reference area V1.

When considering three of the four ("primary") metrics[1] typically used to assess mine-related impacts in national Environmental Effects Monitoring Studies at mines (Environment Canada 2002), as well as several other commonly used ("secondary") metrics, five samples yielded a slightly lower overall coefficient of variation than did three samples whether considering Hess or AS collection methods (Table 5.2). In the case of Hess samples, there was very little difference in the CV for three versus five samples for most metrics (maximum spread of 8% for percent chironomids) and there were no examples where the CV for three stations was substantially smaller than that based on five stations. Larger differences were observed for AS (e.g., maximum difference in CVs of 12% for percent chironomids) and in one case (abundance) the CV was substantially lower when three than when five stations were considered, contrary to what would be expected. Based on the community metrics shown in Table 5.2, three reference-exposure differences were significant with the original five-station analysis of AS data (excluding CA data), and the same three contrasts remained significant when only three stations per area were used ($p<0.1$; Appendix Tables C.10 versus C.11). Reducing Hess samples from five to three reduced the number of significant differences between V1 and exposure areas from 11 to 8, with one of the 8 contrasts being a new result (Number of Taxa, V1 vs. V8; $p<0.1$). Therefore, the data were equivocal with respect to the potential benefit of increasing the number of samples per area in routine monitoring from three to five.

Although a smaller number of stations per area may not always impair the power to test reference-exposure differences in benthic metrics, especially with the less sensitive AS sampling, these results should be interpreted cautiously. With only three stations per

[1] Bray-Curtis results were computed for five samples per area, but not three samples per area.

Table 5.2: Comparison of coefficients of variation (CV; %) for benthic community metrics based on three versus five Hess samples or artificial substrates (AS). Shaded values represent lowest mean CV for each within-method comparison.

Metric	Station	Hess		AS	
		Three Stations	Five Stations	Three Stations	Five Stations
Density (for Hess) or Sample Abundance (for AS)	V1	44	32	96	101
	V27	43	29	84	88
	V5	49	35	29	55
	V8	20	40	61	67
	Mean	**39**	**34**	**68**	**78**
Number of Taxa	V1	16	22	28	19
	V27	25	25	12	16
	V5	2.6	2.4	8.9	7
	V8	14	15	29	21
	Mean	**14**	**16**	**19**	**16**
Simpson's E	V1	32	29	21	20
	V27	20	19	33	26
	V5	25	24	10	15
	V8	40	43	57	39
	Mean	**30**	**29**	**30**	**25**
Mean for Primary Metrics[a]	**Mean**	**28**	**26**	**39**	**39**
Simpson's D	V1	5	4	3	3
	V27	2	3	4	3
	V5	5	4	3	2
	V8	22	25	3	3
	Mean	**8**	**9**	**3**	**3**
EPT (%)	V1	16	14	17	17
	V27	5	4	9	15
	V5	43	31	20	19
	V8	23	37	19	19
	Mean	**22**	**21**	**16**	**18**
Chironomids (%)	V1	39	28	37	38
	V27	58	40	139	84
	V5	37	29	37	47
	V8	13	20	41	36
	Mean	**37**	**29**	**63**	**51**
Mean for Secondary Metrics	**Mean**	**22**	**20**	**28**	**24**
OVERALL	**Mean**	**25**	**23**	**33**	**32**

[a] CV for Bray-Curtis was not computed for three-sample scenario and is thus not shown in comparison.

area, there is probability that a single atypical station will bias the mean for the area, even if this did not occur in the present study. Also, contrast test critical values (p-values for the t-tests) tended to be less significant when using three stations per area Appendix Tables C.10 and C.11). General statistical theory shows that the power of the test will improve with increased sample size when observations are sampled at random from test populations.

Overall, the results were not definitive in indicating that five stations per area would be preferable to three stations, or vice-versa, in long-term benthic invertebrate monitoring. It is suggested that a similar comparison be conducted in 2008 in the Rose Creek drainage to augment the data on which such a decision would be based.

6.0 FISH HEALTH

Minnow (2007) recommended that future monitoring programs include a sentinel species fish survey following methods outlined by Environment Canada (2002) for Environmental Effects Monitoring at operating mines in Canada. Slimy sculpin were identified as an appropriate sentinel species.

Environment Canada (2002, 2005) guidance for sentinel species surveys allows for implementation of either a conventional or non-lethal sampling design (as summarized in Minnow 2007b). If population abundance is adequate to sustain the sacrifice of 40-50 adult fish per area, the conventional design is generally preferred because it tends to provide data that are more readily interpreted with respect to potential effects on reproduction. As it is anticipated that such surveys would be conducted no more frequently than once every 5-10 years (Minnow 2007b), this level of harvesting is likely sustainable at the Faro Mine complex (i.e., production and immigration will likely exceed harvest).

Slimy sculpin that were inspected in late August 2007 had very small ovaries and testes, consistent with spawning having recently occurred (likely in June). Therefore, a conventional sampling design would necessitate fish collection in spring prior to spawning (e.g., in May), rather than in later summer when benthic community sampling is done.

To serve a conventional sampling design (Environment Canada 2002), 20 adult female and 20 adult male sculpin would be targeted in each mine-exposed and reference area. There was insufficient time during the 2007 field program to assess sculpin densities and catchability in detail. Previous fish surveys indicate that approximately 900 seconds of electrofishing augmented by other collection methods (e.g., minnow traps and/or seine nets) over a 1- to 2-d period may yield up to 40-50 sculpin per area (P. Sparling, White Mountain Environmental Consulting, pers. comm., April 2007). Therefore, it appears that the required sample sizes may be obtainable within a reasonable period of time (e.g., approximately one week to collect and measure sculpin in two mine-exposed areas and two to three reference areas). However, sculpin distribution is often patchy, and preferred habitats vary among seasons (P. Sparling, pers. comm.). Therefore, at least one survey should be attempted to confirm that adequate numbers of fish can be found in each targeted mine-exposed and reference area before the sentinel species approach is recommended for long-term monitoring.

7.0 CONCLUSIONS AND RECOMMENDATIONS

The following conclusions can be drawn from the August 2007 Vangorda data. Recommendations for future surveys are indicated in bold, where applicable.

1. Analysis of water samples showed only slight elevations in cadmium and zinc at V27 compared to both Canadian water quality guidelines for protection of aquatic life and reference sample concentrations. Samples collected at V5 and V8 had concentrations of fluoride, sulphate, aluminum, cadmium, iron, and/or selenium that were slightly elevated. Overall, the data indicated water quality was relatively good at all stations downstream of the Vangorda site, consistent with a previous evaluation of routine water quality monitoring data (Minnow 2007a).

2. Differences observed between duplicate sets of samples collected in the field could be due to either spatial variations in water quality or the fact that the samples were sent to two different laboratories (Maxxam and Cantest, both in Burnaby, BC). While good comparability was achieved for most parameters found at detectable levels, the data suggested systematic bias in results for aluminum, sodium, and zinc at one or the other laboratory. In addition, results reported by Maxxam were associated with much lower (better) method detection limits for many analytes than those routinely reported by Cantest for Faro projects. **Potential laboratory bias, particularly in analysis of zinc, should be investigated prior to selecting a long-term provider of analytical services. In addition, it is desirable to ensure the long-term provider offers low-level method detection limits to maximize data usability and interpretability.**

3. Sediment metal concentrations were approximately three times higher in the fine sediment fraction compared to whole sediment, indicating that a large proportion of the metals present were associated with fine sediment particles. However, fine sediments represented a small proportion of the total sediment (e.g., <2% silt and clay). Sediments containing elevated concentrations of arsenic, lead and zinc, collected downstream of the Vangorda site at V27, did not impair the survival or growth of *Hyallela azteca* in 7-day laboratory exposures. **A similar sediment evaluation should be conducted in the Rose Creek drainage in August 2008. Each sample should again be a composite of three submerged sub-samples (e.g, by Ponar) to ensure that the data are representative of average conditions at each sample station.**

4. Benthic invertebrate community assessment based on both Hess samples and artificial substrates indicated negligible mine-related influence in Vangorda Creek at the present time.

5. Benthic invertebrate samples collected from the West Fork of Vangorda Creek (V5) and further downstream at V8 showed some similarities to the community sampled on the West Fork Vangorda Creek upstream of the Haul Road, which has not been sampled in previous benthic community surveys. **This reference area should be included, along with V1 or an alternative area (e.g., Upper South Fork Rose Creek or Next Creek), in future monitoring of benthic invertebrate communities in Vangorda Creek.**

6. Reference benthic invertebrate communities sampled in the South Fork Rose Creek upstream of the Haul Road and in Next Creek showed many similarities to the community sampled at V1 (reference) and V27 (mine-exposed), on Vangorda Creek. **Benthic invertebrates in these reference areas should be compared to communities in the Rose Creek system (tentatively scheduled to be sampled in August 2008) to determine if one or more of these areas should continue to be sampled in the long-term monitoring program.**

7. Although there were some similarities in benthic community patterns described by artificial substrates (AS) and by Hess samples, reference-exposure differences in metrics such as density/abundance, number of taxa, Bray-Curtis distance, and correspondence analysis scores were less apparent and rarely statistically significant for AS compared to Hess samples. **A similar comparative evaluation should be undertaken in the Rose Creek drainage in 2008 to confirm these findings prior to deciding on an approach for long-term monitoring.**

8. The data were not definitive in indicating that five stations per area would be preferable to three stations, or vice-versa, in long-term benthic invertebrate monitoring. **It is suggested that a similar comparison be conducted on Hess samples and artificial substrates collected in the Rose Creek drainage before deciding the appropriate sample sizes per area for long-term monitoring.**

9. **A sentinel species fish survey based on slimy sculpin should be attempted in the spring of 2008 or 2009 to confirm that adequate numbers of fish can be found in key mine-exposed and reference areas and thus determine if type of survey is appropriate for inclusion in the long-term monitoring program at the Faro Mine complex.**

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APPENDIX A

Water Quality Benchmarks

Appendix A: Selection of Benchmarks for Water Quality Evaluation

In all cases where a Canadian water quality guideline (CWQG) exists for a parameter, such a guideline was selected as the benchmark for evaluation of water quality at Faro (Tables A.1 and A.2). In the absence of a CWQG, the most conservative provincial water quality criterion from British Columbia, Saskatchewan, or Ontario was selected, if such value(s) existed. As exception was the uranium guideline from Saskatchewan which is based on more recent information than the Ontario water quality objective for uranium. In the absence of either a Canadian or provincial criterion, a Canadian drinking water quality guideline was selected. For parameters for which no water quality criteria have been developed, alternative benchmarks (provided by Senes) were identified that represent a low- or no- observed effect concentration reported in the scientific literature for a sensitive aquatic species.

Some water quality criteria vary on the basis of water hardness (aluminum, beryllium cadmium, copper, lead, manganese, nickel). In such cases, the criterion corresponding to a hardness of 100 mg/L as $CaCO_3$ was selected. Although some reference and negligibly-influenced surface waters in the vicinity of Faro mine have lower mean water hardness than 100 mg/L, the receiving waters in which elevated metal levels are sometimes found (and are therefore of potential concern) also have elevated water hardness. For example, mean water hardnesses at mine-influenced stations such as X2, X14, R2-R11, V27, and V8 are all >100 mg/L (Minnow 2007). Although hardness values at these stations are occasionally lower, such cases tend to be associated with periods of high precipitation or snowmelt when metal levels also tend to be diluted. A hardness value of 100 mg/L can be considered conservative since water hardnesses of up to 793 mg/L (X-14, Minnow 2007) have been observed in mine-affected areas.

In the case of alkalinity and total suspended solids, the available water quality criteria are expressed as a change relative to background concentrations (Table A.1). In these cases, background values reported by Minnow (2007) were used for development of the screening benchmarks shown in Table A.2. Better estimates of background concentrations near the Faro Mine complex (especially for metals) will likely be available later in 2008 based on analysis of more recent monitoring data associated with lower method detection limits, but such data were not available at the time this document was prepared.

The CWQG for ammonia is expressed on the basis of un-ionized ammonia, which comprises an increasingly larger fraction of the total ammonia present in water as either water pH or temperature increases (or both). Because the temperature and pH of surface waters near Faro rarely rise above 15°C or 8.5, respectively, it is conservative to use as the benchmark the total ammonia concentration corresponding to an un-ionized concentration of 0.019 mg/L (the CWQG) under such conditions (Tables A.1 and A.2).

Although separate CWQGs exist for the two main valence states of chromium, speciation of chromium in water samples is not readily available from commercial laboratories and the lower value of 0.001 mg/L (for hexavalent chromium) is generally applied for data screening purposes.

Except for alkalinity and pH, water concentrations of potential concern are those that are higher than the selected benchmark. In the case of alkalinity and pH, it is values below the benchmark that are of greatest interest at an acid-generating site like Faro.

Table A.1: Benchmarks considered for evaluation of water quality. Shade indicates criterion that was selected for each parameter for application at Faro.

Measurements	Units	Water Quality Criteria: Canadian Water Quality Guideline (for protection of FW aquatic life)[a]	British Columbia (freshwater)[b]	Saskatchewan[z]	Ontario Provincial Water Quality Objective[c]	Canadian Drinking Water Quality Guideline[a]	Alternative Aquatic Effects-Based Benchmarks[p]	Background (Minnow 2007a)
Micellaneous Parameters								
alkalinity	mg/L				no decreases more than 25% of natural concentration			16.8
ammonia - N, total	"	0.24[d]			0.25[d]			0.03
chloride	"					250[k]		
conductivity	uS							292
cyanide, WAD	mg/L	0.005 (free)	0.01		0.005 (free)	0.2		
dissolved solids, total (TDS)	"					500[k]		
fluoride	"	0.120				1.5		
hardness	"							153
mercury, total	ug/L	0.026[e]	0.004-0.02[m]	0.026[e]	0.2 (filtered)	0.001		
nitrate - N	mg/L	13	40		narrative	10		
nitrite - N	"	0.06	0.02		0.06	3.2		
organic carbon, dissolved (DOC)	"							
organic carbon, total (TOC)	"							
pH	pH units	6.5-9.0	6.5 - 9.0		6.5-8.5	6.5-8.5		7.1
phosphorus, total	mg/L				0.03 for rivers[o]			
sulphate	"		50			500[k]		20
suspended solids, total (TSS)	"	no more than 25 mg/L above background						3.65
ICP - Metals Scan								
aluminum	mg/L	0.005 - 0.100[f]	0.05	0.005 - 0.100[f]	0.015 - 0.075[o]	0.1		0.13
antimony	"				0.02[o]	0.006	0.15[q]	
arsenic	"	0.005	0.005	0.005	0.005[o]	0.005 proposed		
barium	"					1.0	5.8[s]	0.087
beryllium	"				0.011 - 1.1[aa]		0.0038[r]	
bismuth							0.26[y]	
boron	"		1.2		0.2[o]	5.000		
cadmium	"	0.000017 or more depending on hardness[g]		0.000017 or more depending on hardness	0.0001 - 0.0005[o]	0.005		
calcium	"						116[s]	43.8
chromium	"	0.001 (for hexavalent form), 0.0089 (for trivalent form)		0.001 (hexavalent form)	0.001 (for hexavalent form), 0.0089 (for trivalent form)	0.05		
cobalt	"		0.004		0.0009			
copper	"	0.002-0.004[h]	0.002-0.008[l]	0.002-0.004[h]	0.001-0.005[o]	1.0[k]		0.002
iron	"	0.3		0.3	0.300	0.3[k]		0.385
lead	"	0.001 - 0.007[i]	0.005-0.011[l]	0.001 - 0.007[i]	0.001 - 0.005[o]	0.010		
magnesium	"						82[s]	11.2
manganese	"		0.7 - 1.9[l]			0.05[k]		0.045
molybdenum	"	0.073	1		0.04[o]			0.0009
nickel	"	0.025 - 0.150[j]		0.025 - 0.150[j]	0.025			
potassium	"						53[s]	1.52
selenium	"	0.001	0.002	0.001	0.100	0.01		
silver	"	0.0001	0.00005/0.0015[n]	0.0001	0.0001			
sodium	"					200[k]	680[s]	3.4
strontium	"						9.3[t]	0.176
thallium	"	0.0008			0.0003[o]			
tin	"						0.35[s]	
titanium	"						1.83[u]	0.0036
uranium	"			0.015	0.005[o]	0.02	0.011[v]	0.0024
vanadium	"				0.006[o]		0.024[w]	
zinc	"	0.030	0.0075-0.090[l]	0.030	0.02[o]	5.0		0.08
zirconium	"				0.004		548[x]	

[a] CCME (Canadian Council of Ministers of the Environment). 1999. Canadian Environmental Quality Guidelines. 1999 (plus updates), Canadian Council of Ministers of the Environment, Winnipeg
[b] BCMOE (British Columbia Ministry of Environment). 2006. British Columbia Approved Water Quality Guidelines (Criteria), 2006 Edition. Updated August 2006. For parameters with both maximum and 30-day average values, the 30-d average is shown.
[c] OMOE (Ontario Ministry of Environment and Energy). 1994. Policies, Guidelines, Provincial Water Quality Objectives of the Ministry of the Environment and Energy (Ontario), July 1994
[d] based on conservative assumption of pH 8.5 and temperature of 15C to achieve un-ionized ammonia of <0.02 mg/L
[e] Inorganic mercury
[f] 0.005 mg/L at pH<6.5, Ca<4 mg/L and DOC<2 mg/L; 0.1 mg/L at pH ≥ 6.5; $[Ca^{2+}]$ ≥ 4 mg/L; DOC ≥ 2 mg/L
[g] CWQG for cadmium = $10^{\{0.86[\log(\text{hardness})] - 3.2\}}$ in ug/L
[h] 0.002 at $[CaCO_3]$ = 0-120 mg/L, 0.003 at $[CaCO_3]$ = 120-180 mg/L, 0.004 at $[CaCO_3]$ > 180 mg/L
[i] 0.001 at $[CaCO_3]$ = 0-60 mg/L, 0.002 at $[CaCO^3]$ = 60-120 mg/L, 0.004 at $[CaCO_3]$ = 120-180 mg/L, 0.007 at $[CaCO_3]$ > 180 mg/L
[j] 0.025 at $[CaCO_3]$ = 0-60 mg/L, 0.065 at $[CaCO^3]$ = 60-120 mg/L, 0.110 at $[CaCO_3]$ = 120-180 mg/L, 0.150 at $[CaCO_3]$ > 180 mg/L
[k] Canadian drinking water quality guideline, aesthetic objective (CCME 1999).
[l] for hardnesses ranging between 25 and 300 mg/L, respectively
[m] depending on proportion present as MeHg
[n] hardnesses of ≤100 mg/L and >100 mg/L, respectively
[o] interim objective
[p] toxicity reference value for most sensitive aquatic receptor (aquatic plants, phytoplankton, benthic invertebrates, zooplankton, fish). From Senes Consultants Limited, Richmond Hill, Ontario.
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[z] Saskatchewan Environment. 2006. Surface Water Quality Objectives. Interim Edition. EPB356. July 2006. 9pp.
[aa] 0.011 for hardness <75 mg/L and 1.1 for hardness >75 mg/L.

Table A.2: Selected benchmarks for evaluation of water quality at Faro Mine, Yukon.

Parameters	Units	Selected Benchmark
Micellaneous Parameters		
alkalinity	mg/L	12.6[a]
ammonia - N, total	"	0.25
chloride	"	250
conductivity	uS	
cyanide, WAD	mg/L	0.005 (free)
dissolved solids, total (TDS)	"	500
fluoride	"	0.12
hardness	"	
nitrate - N	mg/L	13
nitrite - N	"	0.06
organic carbon, dissolved (DOC)	"	
organic carbon, total (TOC)	"	
pH	pH units	6.5-9.0
phosphorus, total	mg/L	0.03
sulphate	"	50
suspended solids, total (TSS)	"	29[b]
Metals		
aluminum	mg/L	0.1
antimony	"	0.020
arsenic	"	0.005
barium	"	1.0
beryllium	"	1.1[c]
bismuth		0.260
boron	"	
cadmium	"	0.00003[c]
calcium	"	
chromium	"	0.001
cobalt	"	
copper	"	0.002[c]
iron	"	0.3
lead	"	0.002[c]
magnesium	"	82.000
manganese	"	1.0[c]
mercury, total	ug/L	0.026
molybdenum	mg/L	0.073
nickel	"	0.065[c]
potassium	"	53
selenium	"	0.001
silver	"	0.0001
sodium	"	200
strontium	"	9.3
thallium	"	0.0008
tin	"	0.35
titanium	"	1.83
uranium	"	0.005
vanadium	"	0.006
zinc	"	0.030
zirconium	"	0.004

[a] Represents a 25% decrease below background level of 16.8 mg/L reported by Minnow (2007a)
[b] Based on an increase of 25 mg/L above background level of 4 mg/L reported by Minnow (2007a)
[c] Based on water hardness of 100 mg/L as $CaCO_3$

APPENDIX B

Water and Sediment Data

Driven by service and Science
www.maxxamanalytics.com

Your P.O. #: BC07-066-FC
Your Project #: 2212
Your C.O.C. #: F82587, F82588

Attention: Patti Orr
Minnow Environmental Inc.
6800 Kitimat Road
Mississauga, ON
CANADA L5N 5M1

Report Date: 2007/09/13

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: A740575
Received: 2007/08/31, 14:20

Sample Matrix: Soil
Samples Received: 8

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Elements by ICPMS (total)	8	2007/09/10	2007/09/10	BRN SOP-00203	Based on EPA 200.8
Moisture	4	N/A	2007/09/11	BRN SOP-00321 R3.0	Ont MOE -E 3139
Ammonia-N (Available) ◊	4	2007/09/10	2007/09/10	BRN SOP-00239	Carter, SSMA 4.2
Nitrate+Nitrite (N) (Available)	4	N/A	2007/09/10	BRN SOP-000233 R1.0	Based on Carter- 4.2
Nitrite (N) (Available) (soil)	4	2007/09/10	2007/09/10	BRN SOP-00233 R1.0	Carter,SSMA 4.2
Available Phosphate	4	2007/09/07	2007/09/07	BRN SOP-00235 R3.0	Carter, SSMA 4.2
Sublet (Inorganics) ◊	4	N/A	2007/09/11		
TOC Soil Subcontract ◊	4	2007/09/12	2007/09/12		

Sample Matrix: Water
Samples Received: 8

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Analytical Method
Alkalinity - Water	8	2007/09/04	2007/09/04	BRN SOP-00264 R2.0	Based on SM2320B
Chloride by Automated Colourimetry	8	N/A	2007/09/11	BRN-SOP 00234 R1.0	Based on EPA 325.2
Carbon (DOC)	8	N/A	2007/09/04	BRN SOP-00224 R3.0	Based on SM-5310C
Conductance - water	8	N/A	2007/09/04	BRN SOP-00264 R2.0	Based on SM-2510B
Fluoride	8	N/A	2007/09/04	BRN SOP-00225 R1.0	Based SM - 4500 F C
Hardness (calculated as CaCO3)	8	N/A	2007/09/11		
Mercury (Total)	8	2007/09/07	2007/09/10	BRN SOP-00205	Based on EPA 245.1
Elements by ICP-AES (dissolved)	8	2007/09/10	2007/09/10	BRN SOP-00201 R1.0	Based on EPA 6010B
Elements by ICPMS (total) ◊	8	N/A	2007/09/12	BRN SOP-00204	Based on EPA 200.8
Elements by ICP-AES (total)	8	N/A	2007/09/10	BRN SOP-00201 R1.0	Based on EPA 6010B
Ammonia (N)	8	N/A	2007/09/12	BRN SOP-00231 R3.0	Based on SM-4500MH3G
Nitrate + Nitrite (N)	8	N/A	2007/09/04	ING233 Rev.4.4	Based on EPA 353.2
Nitrite (N) by CFA	8	N/A	2007/09/04	BRN SOP-00233 R1.0	EPA 353.2
Nitrogen - Nitrate (as N)	8	N/A	2007/09/05		
Sulphate by Automated Colourimetry	8	N/A	2007/09/11	BRN-SOP 00243 R1.0	Based on EPA 375.4
Total Dissolved Solids (Filt. Residue)	8	N/A	2007/09/07	ING443 Rev.5.1	APHA 2540C
Carbon (Total Organic)	8	N/A	2007/09/04	BRN SOP-00224 R3.0	Based on SM-5310C
Total Phosphorus	8	N/A	2007/09/12	BRN SOP-00236 R4.0	SM 4500
Total Suspended Solids	8	N/A	2007/09/12	BRN SOP-00277 R2.0	Based on SM-2540 D

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

(1) This test was performed by Maxxam Bedford(From Burnaby)
(2) SCC/CAEAL

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

ELAINE COUSINS, CS Manager
Email: elaine.cousins@maxxamanalytics.com
Phone# (604) 444-4808 Ext:276

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports.   SCC and CAEAL have approved this reporting process and electronic report format.

Total cover pages: 1

Maxxam Job #: A740575
Report Date: 2007/09/13

Minnow Environmental Inc.
Client Project #: 2212
Site Reference:
Your P.O. #: BC07-066-FC
Sampler Initials: KC

RESULTS OF CHEMICAL ANALYSES OF SOIL

Maxxam ID		G74778	G74779	G74780	G74781		
Sampling Date		2007/08/28	2007/08/28	2007/08/28	2007/08/28		
COC Number		F82588	F82588	F82588	F82588		
	Units	**V27-A (D/S 01)**	**V27-B (03)**	**V27-C (04)**	**V1**	**RDL**	**QC Batch**
CONVENTIONALS							
Nitrite (N)	mg/kg	<0.5	<0.5	<0.5	<0.5	0.5	1836722
Parameter							
Subcontract Parameter	N/A	ATTACHED	ATTACHED	ATTACHED	ATTACHED	N/A	1843048
Nutrients							
Available (KCl) Ammonia (N)	mg/kg	0.7	0.8	0.8	0.9	0.5	1836723
Nitrate plus Nitrite (N)	ug/g	<2	<2	<2	<2	2	1836720
Available (KCl) Orthophosphate (P)	ug/g	3.6	2.8	3.2	4.9	0.5	1834384
Physical Properties							
Moisture	%	7.2	16.7	20.9	15.7	0.3	1836531

RDL = Reportable Detection Limit

Maxxam Job #: A740575
Report Date: 2007/09/13

Minnow Environmental Inc.
Client Project #: 2212
Site Reference:
Your P.O. #: BC07-066-FC
Sampler Initials: KC

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		G74778	G74779	G74780	G74781		
Sampling Date		2007/08/28	2007/08/28	2007/08/28	2007/08/28		
COC Number		F82588	F82588	F82588	F82588		
	Units	**V27-A (D/S 01)**	**V27-B (03)**	**V27-C (04)**	**V1**	**RDL**	**QC Batch**
Total Metals by ICPMS							
Total Aluminum (Al)	mg/kg	8180	8700	9630	8020	100	1837797
Total Antimony (Sb)	mg/kg	0.7	0.5	0.8	0.2	0.1	1837797
Total Arsenic (As)	mg/kg	19.9	16.8	24.7	6.9	0.2	1837797
Total Barium (Ba)	mg/kg	73.5	88.0	116	64.3	0.1	1837797
Total Beryllium (Be)	mg/kg	0.2	0.2	0.3	0.3	0.1	1837797
Total Bismuth (Bi)	mg/kg	0.1	0.2	0.2	0.2	0.1	1837797
Total Boron (B)	mg/kg	<5	<5	<5	<5	5	1837797
Total Cadmium (Cd)	mg/kg	0.82	0.92	1.05	0.35	0.05	1837797
Total Chromium (Cr)	mg/kg	25	22	24	14	1	1837797
Total Cobalt (Co)	mg/kg	11.2	11.8	13.6	7.4	0.3	1837797
Total Copper (Cu)	mg/kg	21.7	21.2	25.1	14.7	0.5	1837797
Total Iron (Fe)	mg/kg	19200	20600	23000	18500	100	1837797
Total Lead (Pb)	mg/kg	146	123	152	10.2	0.1	1837797
Total Manganese (Mn)	mg/kg	830	941	1070	378	0.2	1837797
Total Mercury (Hg)	mg/kg	0.11	0.19	0.09	<0.05	0.05	1837797
Total Molybdenum (Mo)	mg/kg	0.7	0.9	1.2	0.4	0.1	1837797
Total Nickel (Ni)	mg/kg	28.1	26.8	30.3	16.2	0.8	1837797
Total Selenium (Se)	mg/kg	0.6	0.6	0.6	<0.5	0.5	1837797
Total Silver (Ag)	mg/kg	0.16	0.30	0.29	0.09	0.05	1837797
Total Strontium (Sr)	mg/kg	39.9	40.7	40.3	15.5	0.1	1837797
Total Thallium (Tl)	mg/kg	0.19	0.13	0.16	<0.05	0.05	1837797
Total Tin (Sn)	mg/kg	0.3	0.2	0.3	0.3	0.1	1837797
Total Titanium (Ti)	mg/kg	95	104	133	116	1	1837797
Total Uranium (U)	mg/kg	0.89	0.85	1.04	1.59	0.05	1837797
Total Vanadium (V)	mg/kg	17	18	18	14	2	1837797
Total Zinc (Zn)	mg/kg	290	338	385	53	1	1837797

RDL = Reportable Detection Limit

Maxxam Job #: A740575
Report Date: 2007/09/13

Minnow Environmental Inc.
Client Project #: 2212
Site Reference:
Your P.O. #: BC07-066-FC
Sampler Initials: KC

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL)

Maxxam ID		G81718	G81721	G81726	G81727		
Sampling Date		2007/08/28	2007/08/28	2007/08/28	2007/08/28		
COC Number		F82588	F82588	F82588	F82588		
	Units	**V27-A (D/S 01) 0.15MM**	**V27-B (03) 0.15MM**	**V27-C (04) 0.15MM**	**V1 0.15MM**	**RDL**	**QC Batch**
Total Metals by ICPMS							
Total Aluminum (Al)	mg/kg	14800	14300	13200	16100	100	1837797
Total Antimony (Sb)	mg/kg	2.0	2.2	2.0	0.3	0.1	1837797
Total Arsenic (As)	mg/kg	48.7	46.0	39.8	16.2	0.2	1837797
Total Barium (Ba)	mg/kg	338	265	209	130	0.1	1837797
Total Beryllium (Be)	mg/kg	0.5	0.5	0.5	0.6	0.1	1837797
Total Bismuth (Bi)	mg/kg	0.3	0.3	0.3	0.7	0.1	1837797
Total Boron (B)	mg/kg	<5	<5	<5	<5	5	1837797
Total Cadmium (Cd)	mg/kg	2.47	2.35	2.26	0.52	0.05	1837797
Total Chromium (Cr)	mg/kg	48	43	42	26	1	1837797
Total Cobalt (Co)	mg/kg	24.1	23.4	23.5	17.2	0.3	1837797
Total Copper (Cu)	mg/kg	57.9	55.2	52.1	28.4	0.5	1837797
Total Iron (Fe)	mg/kg	35600	36900	32700	34100	100	1837797
Total Lead (Pb)	mg/kg	352	362	313	25.2	0.1	1837797
Total Manganese (Mn)	mg/kg	2320	2290	2290	736	0.2	1837797
Total Mercury (Hg)	mg/kg	0.27	0.24	0.22	<0.05	0.05	1837797
Total Molybdenum (Mo)	mg/kg	1.9	1.8	1.9	0.8	0.1	1837797
Total Nickel (Ni)	mg/kg	55.6	54.7	52.5	32.7	0.8	1837797
Total Selenium (Se)	mg/kg	1.3	1.1	1.2	0.6	0.5	1837797
Total Silver (Ag)	mg/kg	0.68	0.63	0.73	0.14	0.05	1837797
Total Strontium (Sr)	mg/kg	58.0	48.7	47.3	21.0	0.1	1837797
Total Thallium (Tl)	mg/kg	0.29	0.32	0.29	0.06	0.05	1837797
Total Tin (Sn)	mg/kg	0.4	0.4	0.3	0.5	0.1	1837797
Total Titanium (Ti)	mg/kg	176	174	151	247	1	1837797
Total Uranium (U)	mg/kg	1.93	1.99	1.87	3.71	0.05	1837797
Total Vanadium (V)	mg/kg	31	25	24	25	2	1837797
Total Zinc (Zn)	mg/kg	709	806	733	108	1	1837797

RDL = Reportable Detection Limit

Maxxam Job #: A740575
Report Date: 2007/09/13

Minnow Environmental Inc.
Client Project #: 2212
Site Reference:
Your P.O. #: BC07-066-FC
Sampler Initials: KC

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		G74770	G74771	G74772		
Sampling Date		2007/08/25 10:30	2007/08/25 13:30	2007/08/26 08:30		
COC Number		F82587	F82587	F82587		
	Units	**REF1**	**REF2**	**NEXC1**	**RDL**	**QC Batch**

Misc. Inorganics						
Fluoride (F)	mg/L	0.08	0.07	0.09	0.01	1825983
ANIONS						
Nitrite (N)	mg/L	<0.005	<0.005	<0.005	0.005	1826419
Calculated Parameters						
Nitrate (N)	mg/L	<0.02	<0.02	<0.02	0.02	1825502
Misc. Inorganics						
Dissolved Hardness (CaCO3)	mg/L	35.0	26.1	49.7	0.5	1827341
Dissolved Organic Carbon (C)	mg/L	3.1	1.9	2.7	0.5	1826869
Alkalinity (Total as CaCO3)	mg/L	30.6	21.9	47.4	0.5	1826117
Total Organic Carbon (C)	mg/L	3.3	2.7	3.2	0.5	1826798
Alkalinity (PP as CaCO3)	mg/L	<0.5	<0.5	<0.5	0.5	1826117
Anions						
Dissolved Sulphate (SO4)	mg/L	4.2	5.5	2.4	0.5	1838888
Dissolved Chloride (Cl)	mg/L	<0.5	<0.5	<0.5	0.5	1838884
Nutrients						
Ammonia (N)	mg/L	<0.005	<0.005	<0.005	0.005	1841342
Nitrate plus Nitrite (N)	mg/L	<0.02	<0.02	<0.02	0.02	1826416
Total Phosphorus (P)	mg/L	<0.005	<0.005	<0.005	0.005	1838312
Physical Properties						
Conductivity	uS/cm	75	59	102	1	1826116
Physical Properties						
Total Suspended Solids	mg/L	<1	1	<1	1	1838408
Total Dissolved Solids	mg/L	62	50	78	10	1835207

RDL = Reportable Detection Limit

Maxxam Job #: A740575
Report Date: 2007/09/13

Minnow Environmental Inc.
Client Project #: 2212
Site Reference:
Your P.O. #: BC07-066-FC
Sampler Initials: KC

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		G74773	G74774	G74775	G74776		
Sampling Date		2007/08/27 09:30	2007/08/29	2007/08/28	2007/08/28		
COC Number		F82587	F82587	F82587	F82587		
	Units	**V8**	**V5**	**V27**	**V1**	**RDL**	**QC Batch**
Misc. Inorganics							
Fluoride (F)	mg/L	0.13	0.19	0.08	0.07	0.01	1825983
ANIONS							
Nitrite (N)	mg/L	<0.005	<0.005	<0.005	<0.005	0.005	1826419
Calculated Parameters							
Nitrate (N)	mg/L	0.08	0.03	0.13	<0.02	0.02	1825502
Misc. Inorganics							
Dissolved Hardness (CaCO3)	mg/L	214	304	102	30.8	0.5	1827341
Dissolved Organic Carbon (C)	mg/L	2.6	3.5	1.8	1.4	0.5	1826869
Alkalinity (Total as CaCO3)	mg/L	134	206	52.3	24.4	0.5	1826117
Total Organic Carbon (C)	mg/L	2.6	3.5	2.2	2.0	0.5	1826798
Alkalinity (PP as CaCO3)	mg/L	<0.5	3.3	<0.5	<0.5	0.5	1826117
Anions							
Dissolved Sulphate (SO4)	mg/L	65.9	75.6	49.3	8.9	0.5	1838888
Dissolved Chloride (Cl)	mg/L	0.8	2.1	<0.5	<0.5	0.5	1838884
Nutrients							
Ammonia (N)	mg/L	<0.005	<0.005	<0.005	<0.005	0.005	1841342
Nitrate plus Nitrite (N)	mg/L	0.08	0.03	0.13	<0.02	0.02	1826416
Total Phosphorus (P)	mg/L	0.012	0.017	<0.005	0.010	0.005	1838312
Physical Properties							
Conductivity	uS/cm	396	533	210	71	1	1826116
Physical Properties							
Total Suspended Solids	mg/L	3	11	<1	<1	1	1838408
Total Dissolved Solids	mg/L	264	354	140	54	10	1835207

RDL = Reportable Detection Limit

Maxxam Job #: A740575
Report Date: 2007/09/13

Minnow Environmental Inc.
Client Project #: 2212
Site Reference:
Your P.O. #: BC07-066-FC
Sampler Initials: KC

RESULTS OF CHEMICAL ANALYSES OF WATER

Maxxam ID		G74777		
Sampling Date		2007/08/27 09:30		
COC Number		F82587		
	Units	**V8Z**	**RDL**	**QC Batch**
Misc. Inorganics				
Fluoride (F)	mg/L	0.13	0.01	1825983
ANIONS				
Nitrite (N)	mg/L	<0.005	0.005	1826419
Calculated Parameters				
Nitrate (N)	mg/L	0.08	0.02	1825502
Misc. Inorganics				
Dissolved Hardness (CaCO3)	mg/L	213	0.5	1827341
Dissolved Organic Carbon (C)	mg/L	2.5	0.5	1826869
Alkalinity (Total as CaCO3)	mg/L	137	0.5	1826117
Total Organic Carbon (C)	mg/L	2.4	0.5	1826798
Alkalinity (PP as CaCO3)	mg/L	<0.5	0.5	1826117
Anions				
Dissolved Sulphate (SO4)	mg/L	66.5	0.5	1838888
Dissolved Chloride (Cl)	mg/L	0.8	0.5	1838884
Nutrients				
Ammonia (N)	mg/L	<0.005	0.005	1841342
Nitrate plus Nitrite (N)	mg/L	0.08	0.02	1826416
Total Phosphorus (P)	mg/L	0.008	0.005	1838312
Physical Properties				
Conductivity	uS/cm	398	1	1826116
Physical Properties				
Total Suspended Solids	mg/L	12	1	1838408
Total Dissolved Solids	mg/L	260	10	1835207

RDL = Reportable Detection Limit

Maxxam Job #: A740575
Report Date: 2007/09/13

Minnow Environmental Inc.
Client Project #: 2212
Site Reference:
Your P.O. #: BC07-066-FC
Sampler Initials: KC

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		G74770	G74771	G74772		
Sampling Date		2007/08/25 10:30	2007/08/25 13:30	2007/08/26 08:30		
COC Number		F82587	F82587	F82587		
	Units	**REF1**	**REF2**	**NEXC1**	**RDL**	**QC Batch**
Low Level Elements						
Total Mercury (Hg)	ug/L	<0.05	<0.05	<0.05	0.05	1835311
Dissolved Metals by ICP						
Dissolved Magnesium (Mg)	mg/L	1.87	1.20	2.32	0.05	1837760
Dissolved Sodium (Na)	mg/L	1.73	1.60	2.00	0.05	1837760
Total Metals by ICP						
Total Boron (B)	mg/L	<0.008	<0.008	<0.008	0.008	1837752
Total Calcium (Ca)	mg/L	10.9	8.82	16.5	0.05	1837752
Total Iron (Fe)	mg/L	0.031	0.164	0.014	0.005	1837752
Total Magnesium (Mg)	mg/L	1.94	1.32	2.47	0.05	1837752
Total Sodium (Na)	mg/L	1.93	1.92	2.37	0.05	1837752
Total Zirconium (Zr)	mg/L	<0.005	<0.005	<0.005	0.005	1837752
Total Metals by ICPMS						
Total Aluminum (Al)	ug/L	30.6	26.3	17.2	0.2	1837295
Total Antimony (Sb)	ug/L	<0.05	<0.05	<0.05	0.05	1837295
Total Arsenic (As)	ug/L	0.1	0.3	<0.1	0.1	1837295
Total Barium (Ba)	ug/L	28.7	25.0	25.6	0.02	1837295
Total Beryllium (Be)	ug/L	<0.05	<0.05	<0.05	0.05	1837295
Total Bismuth (Bi)	ug/L	<0.05	<0.05	<0.05	0.05	1837295
Total Cadmium (Cd)	ug/L	0.01	<0.01	0.01	0.01	1837295
Total Chromium (Cr)	ug/L	<0.2	<0.2	<0.2	0.2	1837295
Total Cobalt (Co)	ug/L	0.02	0.04	<0.02	0.02	1837295
Total Copper (Cu)	ug/L	0.6	0.4	0.6	0.1	1837295
Total Lead (Pb)	ug/L	0.07	0.10	0.05	0.02	1837295
Total Manganese (Mn)	ug/L	1.06	9.59	0.35	0.02	1837295
Total Molybdenum (Mo)	ug/L	0.14	0.30	0.24	0.02	1837295
Total Nickel (Ni)	ug/L	<0.5	<0.5	<0.5	0.5	1837295
Total Potassium (K)	ug/L	326	285	522	50	1837295
Total Selenium (Se)	ug/L	<0.5	<0.5	<0.5	0.5	1837295
Total Silver (Ag)	ug/L	<0.01	<0.01	<0.01	0.01	1837295
Total Strontium (Sr)	ug/L	54.0	49.5	66.1	0.01	1837295
Total Thallium (Tl)	ug/L	<0.05	<0.05	<0.05	0.05	1837295
Total Tin (Sn)	ug/L	<0.05	<0.05	<0.05	0.05	1837295

RDL = Reportable Detection Limit

Maxxam Job #: A740575
Report Date: 2007/09/13

Minnow Environmental Inc.
Client Project #: 2212
Site Reference:
Your P.O. #: BC07-066-FC
Sampler Initials: KC

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		G74770	G74771	G74772		
Sampling Date		2007/08/25 10:30	2007/08/25 13:30	2007/08/26 08:30		
COC Number		F82587	F82587	F82587		
	Units	**REF1**	**REF2**	**NEXC1**	**RDL**	**QC Batch**
Total Titanium (Ti)	ug/L	<0.5	0.8	<0.5	0.5	1837295
Total Uranium (U)	ug/L	0.37	0.29	0.29	0.01	1837295
Total Vanadium (V)	ug/L	<0.05	0.08	0.06	0.05	1837295
Total Zinc (Zn)	ug/L	2.1	1.9	1.9	0.5	1837295

RDL = Reportable Detection Limit

Maxxam Job #: A740575
Report Date: 2007/09/13

Minnow Environmental Inc.
Client Project #: 2212
Site Reference:
Your P.O. #: BC07-066-FC
Sampler Initials: KC

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		G74773	G74774	G74775	G74776		
Sampling Date		2007/08/27 09:30	2007/08/29	2007/08/28	2007/08/28		
COC Number		F82587	F82587	F82587	F82587		
	Units	**V8**	**V5**	**V27**	**V1**	**RDL**	**QC Batch**
Low Level Elements							
Total Mercury (Hg)	ug/L	<0.05	<0.05	<0.05	<0.05	0.05	1835311
Dissolved Metals by ICP							
Dissolved Magnesium (Mg)	mg/L	19.9	28.2	8.40	1.34	0.05	1837760
Dissolved Sodium (Na)	mg/L	3.11	3.78	2.21	1.81	0.05	1837760
Total Metals by ICP							
Total Boron (B)	mg/L	<0.008	<0.008	<0.008	<0.008	0.008	1837752
Total Calcium (Ca)	mg/L	52.8	77.8	28.3	10.6	0.05	1837752
Total Iron (Fe)	mg/L	0.177	0.464	0.049	0.027	0.005	1837752
Total Magnesium (Mg)	mg/L	19.7	28.7	8.55	1.45	0.05	1837752
Total Sodium (Na)	mg/L	3.33	4.12	2.54	2.09	0.05	1837752
Total Zirconium (Zr)	mg/L	<0.005	<0.005	<0.005	<0.005	0.005	1837752
Total Metals by ICPMS							
Total Aluminum (Al)	ug/L	101	275	18.4	14.3	0.2	1837295
Total Antimony (Sb)	ug/L	0.13	0.15	0.07	<0.05	0.05	1837295
Total Arsenic (As)	ug/L	0.4	1.0	0.4	0.2	0.1	1837295
Total Barium (Ba)	ug/L	52.8	78.0	32.6	25.7	0.02	1837295
Total Beryllium (Be)	ug/L	<0.05	<0.05	0.05	<0.05	0.05	1837295
Total Bismuth (Bi)	ug/L	<0.05	<0.05	<0.05	<0.05	0.05	1837295
Total Cadmium (Cd)	ug/L	0.04	0.04	0.05	<0.01	0.01	1837295
Total Chromium (Cr)	ug/L	0.3	0.8	<0.2	<0.2	0.2	1837295
Total Cobalt (Co)	ug/L	0.14	0.27	0.04	<0.02	0.02	1837295
Total Copper (Cu)	ug/L	1.3	1.4	0.9	0.4	0.1	1837295
Total Lead (Pb)	ug/L	0.32	0.52	0.52	0.04	0.02	1837295
Total Manganese (Mn)	ug/L	11.0	21.8	3.50	0.76	0.02	1837295
Total Molybdenum (Mo)	ug/L	0.81	1.58	0.32	0.23	0.02	1837295
Total Nickel (Ni)	ug/L	1.1	1.8	<0.5	<0.5	0.5	1837295
Total Potassium (K)	ug/L	892	1150	525	343	50	1837295
Total Selenium (Se)	ug/L	<0.5	1.3	<0.5	<0.5	0.5	1837295
Total Silver (Ag)	ug/L	<0.01	<0.01	<0.01	<0.01	0.01	1837295
Total Strontium (Sr)	ug/L	191	270	104	53.9	0.01	1837295
Total Thallium (Tl)	ug/L	<0.05	<0.05	<0.05	<0.05	0.05	1837295
Total Tin (Sn)	ug/L	0.06	<0.05	<0.05	<0.05	0.05	1837295

RDL = Reportable Detection Limit

Maxxam Job #: A740575
Report Date: 2007/09/13

Minnow Environmental Inc.
Client Project #: 2212
Site Reference:
Your P.O. #: BC07-066-FC
Sampler Initials: KC

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		G74773	G74774	G74775	G74776		
Sampling Date		2007/08/27 09:30	2007/08/29	2007/08/28	2007/08/28		
COC Number		F82587	F82587	F82587	F82587		
	Units	**V8**	**V5**	**V27**	**V1**	**RDL**	**QC Batch**
Total Titanium (Ti)	ug/L	2.7	8.3	0.7	<0.5	0.5	1837295
Total Uranium (U)	ug/L	3.15	4.05	1.26	0.31	0.01	1837295
Total Vanadium (V)	ug/L	0.33	0.95	<0.05	<0.05	0.05	1837295
Total Zinc (Zn)	ug/L	9.1	3.9	31.8	2.7	0.5	1837295

RDL = Reportable Detection Limit

Maxxam Job #: A740575
Report Date: 2007/09/13

Minnow Environmental Inc.
Client Project #: 2212
Site Reference:
Your P.O. #: BC07-066-FC
Sampler Initials: KC

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		G74777		
Sampling Date		2007/08/27 09:30		
COC Number		F82587		
	Units	**V8Z**	**RDL**	**QC Batch**
Low Level Elements				
Total Mercury (Hg)	ug/L	<0.05	0.05	1835311
Dissolved Metals by ICP				
Dissolved Magnesium (Mg)	mg/L	20.0	0.05	1837760
Dissolved Sodium (Na)	mg/L	3.11	0.05	1837760
Total Metals by ICP				
Total Boron (B)	mg/L	<0.008	0.008	1837752
Total Calcium (Ca)	mg/L	54.9	0.05	1837752
Total Iron (Fe)	mg/L	0.180	0.005	1837752
Total Magnesium (Mg)	mg/L	20.0	0.05	1837752
Total Sodium (Na)	mg/L	3.48	0.05	1837752
Total Zirconium (Zr)	mg/L	<0.005	0.005	1837752
Total Metals by ICPMS				
Total Aluminum (Al)	ug/L	107	0.2	1837295
Total Antimony (Sb)	ug/L	0.12	0.05	1837295
Total Arsenic (As)	ug/L	0.5	0.1	1837295
Total Barium (Ba)	ug/L	53.9	0.02	1837295
Total Beryllium (Be)	ug/L	<0.05	0.05	1837295
Total Bismuth (Bi)	ug/L	<0.05	0.05	1837295
Total Cadmium (Cd)	ug/L	0.04	0.01	1837295
Total Chromium (Cr)	ug/L	0.3	0.2	1837295
Total Cobalt (Co)	ug/L	0.12	0.02	1837295
Total Copper (Cu)	ug/L	1.1	0.1	1837295
Total Lead (Pb)	ug/L	0.30	0.02	1837295
Total Manganese (Mn)	ug/L	11.0	0.02	1837295
Total Molybdenum (Mo)	ug/L	0.83	0.02	1837295
Total Nickel (Ni)	ug/L	1.1	0.5	1837295
Total Potassium (K)	ug/L	911	50	1837295
Total Selenium (Se)	ug/L	0.6	0.5	1837295
Total Silver (Ag)	ug/L	<0.01	0.01	1837295
Total Strontium (Sr)	ug/L	203	0.01	1837295
Total Thallium (Tl)	ug/L	<0.05	0.05	1837295
Total Tin (Sn)	ug/L	<0.05	0.05	1837295

RDL = Reportable Detection Limit

Maxxam Job #: A740575
Report Date: 2007/09/13

Minnow Environmental Inc.
Client Project #: 2212
Site Reference:
Your P.O. #: BC07-066-FC
Sampler Initials: KC

ELEMENTS BY ATOMIC SPECTROSCOPY (WATER)

Maxxam ID		G74777		
Sampling Date		2007/08/27 09:30		
COC Number		F82587		
	Units	**V8Z**	**RDL**	**QC Batch**
Total Titanium (Ti)	ug/L	2.7	0.5	1837295
Total Uranium (U)	ug/L	3.23	0.01	1837295
Total Vanadium (V)	ug/L	0.32	0.05	1837295
Total Zinc (Zn)	ug/L	9.0	0.5	1837295

RDL = Reportable Detection Limit

Maxxam Job #: A740575
Report Date: 2007/09/13

Minnow Environmental Inc.
Client Project #: 2212
Site Reference:
Your P.O. #: BC07-066-FC
Sampler Initials: KC

General Comments

Sample G81718-01: Metals were analyzed on the fraction passed through 0.15 mm sieve.

Sample G81721-01: Metals were analyzed on the fraction passed through 0.15 mm sieve.

Sample G81726-01: Metals were analyzed on the fraction passed through 0.15 mm sieve.

Sample G81727-01: Metals were analyzed on the fraction passed through 0.15 mm sieve.

ELEMENTS BY ATOMIC SPECTROSCOPY (SOIL) Comments

Sample G81718-01 Elements by ICPMS (total): 0.15mm sieve sample.

Sample G81721-01 Elements by ICPMS (total): 0.15mm sieve sample.

Sample G81726-01 Elements by ICPMS (total): 0.15mm sieve sample.

Sample G81727-01 Elements by ICPMS (total): 0.15mm sieve sample.

Results relate only to the items tested.

Minnow Environmental Inc.
Attention: Patti Orr
Client Project #: 2212
P.O. #: BC07-066-FC
Site Reference:

Quality Assurance Report

Maxxam Job Number: VA740575

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
1825983 WAY	MATRIX SPIKE	Fluoride (F)	2007/09/04		82	%	80 - 120
	SPIKE	Fluoride (F)	2007/09/04		105	%	80 - 120
	BLANK	Fluoride (F)	2007/09/04	<0.01		mg/L	
	RPD	Fluoride (F)	2007/09/04	2.8		%	25
1826116 CK	SPIKE	Conductivity	2007/09/04		101	%	80 - 120
	BLANK	Conductivity	2007/09/04	<1		uS/cm	
	RPD	Conductivity	2007/09/04	0.5		%	25
1826117 CK	MATRIX SPIKE	Alkalinity (Total as CaCO3)	2007/09/04		94	%	80 - 120
	SPIKE	Alkalinity (Total as CaCO3)	2007/09/04		94	%	80 - 120
	BLANK	Alkalinity (Total as CaCO3)	2007/09/04	<0.5		mg/L	
		Alkalinity (PP as CaCO3)	2007/09/04	<0.5		mg/L	
	RPD	Alkalinity (Total as CaCO3)	2007/09/04	0.5		%	25
		Alkalinity (PP as CaCO3)	2007/09/04	NC		%	25
1826416 BB3	MATRIX SPIKE	Nitrate plus Nitrite (N)	2007/09/04		99	%	80 - 120
	SPIKE	Nitrate plus Nitrite (N)	2007/09/04		103	%	80 - 120
	BLANK	Nitrate plus Nitrite (N)	2007/09/04	<0.02		mg/L	
	RPD [G74774-01]	Nitrate plus Nitrite (N)	2007/09/04	NC		%	25
1826419 BB3	MATRIX SPIKE	Nitrite (N)	2007/09/04		102	%	80 - 120
	SPIKE	Nitrite (N)	2007/09/04		103	%	80 - 120
	BLANK	Nitrite (N)	2007/09/04	<0.005		mg/L	
	RPD [G74774-01]	Nitrite (N)	2007/09/04	NC		%	25
1826798 MX	MATRIX SPIKE	Total Organic Carbon (C)	2007/09/04		105	%	80 - 120
	SPIKE	Total Organic Carbon (C)	2007/09/04		105	%	80 - 120
	BLANK	Total Organic Carbon (C)	2007/09/04	<0.5		mg/L	
	RPD	Total Organic Carbon (C)	2007/09/04	NC		%	20
1826869 MX	MATRIX SPIKE	Dissolved Organic Carbon (C)	2007/09/04		102	%	80 - 120
	SPIKE	Dissolved Organic Carbon (C)	2007/09/04		106	%	80 - 120
	BLANK	Dissolved Organic Carbon (C)	2007/09/04	<0.5		mg/L	
	RPD	Dissolved Organic Carbon (C)	2007/09/04	1.3		%	20
1834384 TS1	MATRIX SPIKE [G74780-01]	Available (KCl) Orthophosphate (P)	2007/09/07		90	%	75 - 125
	SPIKE	Available (KCl) Orthophosphate (P)	2007/09/07		109	%	75 - 125
	BLANK	Available (KCl) Orthophosphate (P)	2007/09/07	<5		ug/g	
	RPD [G74780-01]	Available (KCl) Orthophosphate (P)	2007/09/07	8.5		%	25
1835207 FS1	MATRIX SPIKE	Total Dissolved Solids	2007/09/07		96	%	80 - 120
	SPIKE	Total Dissolved Solids	2007/09/07		104	%	80 - 120
	BLANK	Total Dissolved Solids	2007/09/07	<10		mg/L	
	RPD	Total Dissolved Solids	2007/09/07	1.4		%	25
1835311 JT3	MATRIX SPIKE [G74770-01]	Total Mercury (Hg)	2007/09/10		120	%	70 - 130
	QC STANDARD	Total Mercury (Hg)	2007/09/10		112	%	80 - 120
	SPIKE	Total Mercury (Hg)	2007/09/10		88	%	80 - 120
	BLANK	Total Mercury (Hg)	2007/09/10	<0.05		ug/L	
	RPD [G74770-01]	Total Mercury (Hg)	2007/09/10	NC		%	25
1836531 CW3	BLANK	Moisture	2007/09/11	<0.3		%	
	RPD	Moisture	2007/09/11	3.3		%	20
1836720 BB3	MATRIX SPIKE	Nitrate plus Nitrite (N)	2007/09/10		84	%	70 - 130
	SPIKE	Nitrate plus Nitrite (N)	2007/09/10		81	%	70 - 130
	BLANK	Nitrate plus Nitrite (N)	2007/09/10	<2		ug/g	
	RPD	Nitrate plus Nitrite (N)	2007/09/10	NC		%	35
1836722 BB3	MATRIX SPIKE	Nitrite (N)	2007/09/10		83	%	80 - 120
	SPIKE	Nitrite (N)	2007/09/10		91	%	80 - 120
	BLANK	Nitrite (N)	2007/09/10	<0.5		mg/kg	
	RPD	Nitrite (N)	2007/09/10	NC		%	25
1836723 NN	MATRIX SPIKE [G74780-01]	Available (KCl) Ammonia (N)	2007/09/10		88	%	80 - 120

Minnow Environmental Inc.
Attention: Patti Orr
Client Project #: 2212
P.O. #: BC07-066-FC
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Quality Assurance Report (Continued)

Maxxam Job Number: VA740575

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
1836723 NN	SPIKE	Available (KCl) Ammonia (N)	2007/09/10		92	%	80 - 120
	BLANK	Available (KCl) Ammonia (N)	2007/09/10	<0.5		mg/kg	
	RPD [G74780-01]	Available (KCl) Ammonia (N)	2007/09/10	NC		%	25
1837295 AA1	MATRIX SPIKE						
	[G74770-01]	Total Arsenic (As)	2007/09/12		107	%	75 - 125
		Total Cadmium (Cd)	2007/09/12		110	%	75 - 125
		Total Chromium (Cr)	2007/09/12		110	%	75 - 125
		Total Cobalt (Co)	2007/09/12		113	%	75 - 125
		Total Copper (Cu)	2007/09/12		116	%	75 - 125
		Total Lead (Pb)	2007/09/12		117	%	75 - 125
		Total Selenium (Se)	2007/09/12		110	%	75 - 125
		Total Thallium (Tl)	2007/09/12		116	%	75 - 125
		Total Zinc (Zn)	2007/09/12		115	%	75 - 125
	SPIKE	Total Arsenic (As)	2007/09/12		103	%	75 - 125
		Total Cadmium (Cd)	2007/09/12		100	%	75 - 125
		Total Chromium (Cr)	2007/09/12		107	%	75 - 125
		Total Cobalt (Co)	2007/09/12		110	%	75 - 125
		Total Copper (Cu)	2007/09/12		114	%	75 - 125
		Total Lead (Pb)	2007/09/12		112	%	75 - 125
		Total Selenium (Se)	2007/09/12		108	%	75 - 125
		Total Thallium (Tl)	2007/09/12		109	%	75 - 125
		Total Zinc (Zn)	2007/09/12		109	%	75 - 125
	BLANK	Total Aluminum (Al)	2007/09/12	0.3, RDL=0.2		ug/L	
		Total Antimony (Sb)	2007/09/12	<0.05		ug/L	
		Total Arsenic (As)	2007/09/12	<0.1		ug/L	
		Total Barium (Ba)	2007/09/12	<0.02		ug/L	
		Total Beryllium (Be)	2007/09/12	0.07, RDL=0.05		ug/L	
		Total Bismuth (Bi)	2007/09/12	<0.05		ug/L	
		Total Cadmium (Cd)	2007/09/12	<0.01		ug/L	
		Total Chromium (Cr)	2007/09/12	<0.2		ug/L	
		Total Cobalt (Co)	2007/09/12	<0.02		ug/L	
		Total Copper (Cu)	2007/09/12	<0.1		ug/L	
		Total Lead (Pb)	2007/09/12	<0.02		ug/L	
		Total Manganese (Mn)	2007/09/12	<0.02		ug/L	
		Total Molybdenum (Mo)	2007/09/12	<0.02		ug/L	
		Total Nickel (Ni)	2007/09/12	<0.5		ug/L	
		Total Potassium (K)	2007/09/12	<50		ug/L	
		Total Selenium (Se)	2007/09/12	<0.5		ug/L	
		Total Silver (Ag)	2007/09/12	<0.01		ug/L	
		Total Strontium (Sr)	2007/09/12	<0.01		ug/L	
		Total Thallium (Tl)	2007/09/12	<0.05		ug/L	
		Total Tin (Sn)	2007/09/12	<0.05		ug/L	
		Total Titanium (Ti)	2007/09/12	<0.5		ug/L	
		Total Uranium (U)	2007/09/12	<0.01		ug/L	
		Total Vanadium (V)	2007/09/12	<0.05		ug/L	
		Total Zinc (Zn)	2007/09/12	<0.5		ug/L	
	RPD [G74770-01]	Total Aluminum (Al)	2007/09/12	1.1		%	25
		Total Antimony (Sb)	2007/09/12	NC		%	25
		Total Arsenic (As)	2007/09/12	NC		%	25
		Total Barium (Ba)	2007/09/12	2.8		%	25
		Total Beryllium (Be)	2007/09/12	NC		%	25
		Total Bismuth (Bi)	2007/09/12	NC		%	25
		Total Cadmium (Cd)	2007/09/12	NC		%	25
		Total Chromium (Cr)	2007/09/12	NC		%	25
		Total Cobalt (Co)	2007/09/12	NC		%	25

Minnow Environmental Inc.
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Quality Assurance Report (Continued)

Maxxam Job Number: VA740575

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
1837295 AA1	RPD [G74770-01]	Total Copper (Cu)	2007/09/12	6.0		%	25
		Total Lead (Pb)	2007/09/12	NC		%	25
		Total Manganese (Mn)	2007/09/12	1.6		%	25
		Total Molybdenum (Mo)	2007/09/12	7.4		%	25
		Total Nickel (Ni)	2007/09/12	NC		%	25
		Total Potassium (K)	2007/09/12	3.8		%	25
		Total Selenium (Se)	2007/09/12	NC		%	25
		Total Silver (Ag)	2007/09/12	NC		%	25
		Total Strontium (Sr)	2007/09/12	0.2		%	25
		Total Thallium (Tl)	2007/09/12	NC		%	25
		Total Tin (Sn)	2007/09/12	NC		%	25
		Total Titanium (Ti)	2007/09/12	NC		%	25
		Total Uranium (U)	2007/09/12	8.1		%	25
		Total Vanadium (V)	2007/09/12	NC		%	25
		Total Zinc (Zn)	2007/09/12	NC		%	25
1837752 GS2	BLANK	Total Boron (B)	2007/09/10	<0.008		mg/L	
		Total Calcium (Ca)	2007/09/10	<0.05		mg/L	
		Total Iron (Fe)	2007/09/10	<0.005		mg/L	
		Total Magnesium (Mg)	2007/09/10	<0.05		mg/L	
		Total Sodium (Na)	2007/09/10	<0.05		mg/L	
		Total Zirconium (Zr)	2007/09/10	<0.005		mg/L	
	RPD [G74770-01]	Total Boron (B)	2007/09/10	NC		%	25
		Total Calcium (Ca)	2007/09/10	3.1		%	25
		Total Iron (Fe)	2007/09/10	12.3		%	25
		Total Magnesium (Mg)	2007/09/10	0.9		%	25
		Total Sodium (Na)	2007/09/10	2.2		%	25
		Total Zirconium (Zr)	2007/09/10	NC		%	25
1837760 GS2	BLANK	Dissolved Magnesium (Mg)	2007/09/10	<0.05		mg/L	
		Dissolved Sodium (Na)	2007/09/10	<0.05		mg/L	
	RPD	Dissolved Magnesium (Mg)	2007/09/10	0.6		%	25
1837797 DJ	MATRIX SPIKE	Total Arsenic (As)	2007/09/10		113	%	75 - 125
		Total Cadmium (Cd)	2007/09/10		111	%	75 - 125
		Total Chromium (Cr)	2007/09/10		104	%	75 - 125
		Total Cobalt (Co)	2007/09/10		110	%	75 - 125
		Total Copper (Cu)	2007/09/10		113	%	75 - 125
		Total Lead (Pb)	2007/09/10		111	%	75 - 125
		Total Mercury (Hg)	2007/09/10		109	%	75 - 125
		Total Selenium (Se)	2007/09/10		112	%	75 - 125
		Total Thallium (Tl)	2007/09/10		121	%	75 - 125
		Total Zinc (Zn)	2007/09/10		111	%	75 - 125
	SPIKE	Total Arsenic (As)	2007/09/10		112	%	75 - 125
		Total Cadmium (Cd)	2007/09/10		106	%	75 - 125
		Total Chromium (Cr)	2007/09/10		107	%	75 - 125
		Total Cobalt (Co)	2007/09/10		106	%	75 - 125
		Total Copper (Cu)	2007/09/10		112	%	75 - 125
		Total Lead (Pb)	2007/09/10		113	%	75 - 125
		Total Mercury (Hg)	2007/09/10		109	%	75 - 125
		Total Selenium (Se)	2007/09/10		110	%	75 - 125
		Total Thallium (Tl)	2007/09/10		117	%	75 - 125
		Total Zinc (Zn)	2007/09/10		113	%	75 - 125
	BLANK	Total Aluminum (Al)	2007/09/10	<100		mg/kg	
		Total Antimony (Sb)	2007/09/10	<0.1		mg/kg	
		Total Arsenic (As)	2007/09/10	<0.2		mg/kg	
		Total Barium (Ba)	2007/09/10	<0.1		mg/kg	
		Total Beryllium (Be)	2007/09/10	<0.1		mg/kg	

Minnow Environmental Inc.
Attention: Patti Orr
Client Project #: 2212
P.O. #: BC07-066-FC
Site Reference:

Quality Assurance Report (Continued)

Maxxam Job Number: VA740575

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
1837797 DJ	BLANK	Total Bismuth (Bi)	2007/09/10	<0.1		mg/kg	
		Total Boron (B)	2007/09/10	<5		mg/kg	
		Total Cadmium (Cd)	2007/09/10	<0.05		mg/kg	
		Total Chromium (Cr)	2007/09/10	<1		mg/kg	
		Total Cobalt (Co)	2007/09/10	<0.3		mg/kg	
		Total Copper (Cu)	2007/09/10	<0.5		mg/kg	
		Total Iron (Fe)	2007/09/10	<100		mg/kg	
		Total Lead (Pb)	2007/09/10	<0.1		mg/kg	
		Total Manganese (Mn)	2007/09/10	<0.2		mg/kg	
		Total Mercury (Hg)	2007/09/10	<0.05		mg/kg	
		Total Molybdenum (Mo)	2007/09/10	<0.1		mg/kg	
		Total Nickel (Ni)	2007/09/10	<0.8		mg/kg	
		Total Selenium (Se)	2007/09/10	<0.5		mg/kg	
		Total Silver (Ag)	2007/09/10	<0.05		mg/kg	
		Total Strontium (Sr)	2007/09/10	<0.1		mg/kg	
		Total Thallium (Tl)	2007/09/10	<0.05		mg/kg	
		Total Tin (Sn)	2007/09/10	<0.1		mg/kg	
		Total Titanium (Ti)	2007/09/10	<1		mg/kg	
		Total Uranium (U)	2007/09/10	<0.05		mg/kg	
		Total Vanadium (V)	2007/09/10	<2		mg/kg	
		Total Zinc (Zn)	2007/09/10	<1		mg/kg	
	RPD	Total Aluminum (Al)	2007/09/10	2.1		%	35
		Total Antimony (Sb)	2007/09/10	3.7		%	35
		Total Arsenic (As)	2007/09/10	1.2		%	35
		Total Barium (Ba)	2007/09/10	1.3		%	35
		Total Beryllium (Be)	2007/09/10	NC		%	35
		Total Bismuth (Bi)	2007/09/10	NC		%	35
		Total Cadmium (Cd)	2007/09/10	NC		%	35
		Total Chromium (Cr)	2007/09/10	1.1		%	35
		Total Cobalt (Co)	2007/09/10	5.3		%	35
		Total Copper (Cu)	2007/09/10	3.8		%	35
		Total Iron (Fe)	2007/09/10	0.6		%	35
		Total Lead (Pb)	2007/09/10	3.4		%	35
		Total Manganese (Mn)	2007/09/10	0.9		%	35
		Total Mercury (Hg)	2007/09/10	NC		%	35
		Total Molybdenum (Mo)	2007/09/10	4.1		%	35
		Total Nickel (Ni)	2007/09/10	5.7		%	35
		Total Selenium (Se)	2007/09/10	NC		%	35
		Total Silver (Ag)	2007/09/10	NC		%	35
		Total Strontium (Sr)	2007/09/10	0.5		%	35
		Total Thallium (Tl)	2007/09/10	NC		%	35
		Total Tin (Sn)	2007/09/10	NC		%	35
		Total Titanium (Ti)	2007/09/10	4.5		%	35
		Total Vanadium (V)	2007/09/10	1.9		%	35
		Total Zinc (Zn)	2007/09/10	3.2		%	35
1838312 MX	SPIKE	Total Phosphorus (P)	2007/09/12		89	%	80 - 120
	BLANK	Total Phosphorus (P)	2007/09/12	<0.005		mg/L	
	RPD [G74771-01]	Total Phosphorus (P)	2007/09/12	NC		%	25
1838408 FS1	SPIKE	Total Suspended Solids	2007/09/12		102	%	N/A
	BLANK	Total Suspended Solids	2007/09/12	<1		mg/L	
1838884 NN	MATRIX SPIKE	Dissolved Chloride (Cl)	2007/09/11		105	%	80 - 120
	SPIKE	Dissolved Chloride (Cl)	2007/09/11		105	%	80 - 120
	BLANK	Dissolved Chloride (Cl)	2007/09/11	<0.5		mg/L	
	RPD [G74772-01]	Dissolved Chloride (Cl)	2007/09/11	NC		%	20
1838888 NN	MATRIX SPIKE	Dissolved Sulphate (SO4)	2007/09/11		98	%	75 - 125

Minnow Environmental Inc.
Attention: Patti Orr
Client Project #: 2212
P.O. #: BC07-066-FC
Site Reference:

Quality Assurance Report (Continued)

Maxxam Job Number: VA740575

QA/QC Batch Num Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
1838888 NN	SPIKE	Dissolved Sulphate (SO4)	2007/09/11		102	%	80 - 120
	BLANK	Dissolved Sulphate (SO4)	2007/09/11	<0.5		mg/L	
	RPD [G74772-01]	Dissolved Sulphate (SO4)	2007/09/11	NC		%	20
1841342 NN	MATRIX SPIKE	Ammonia (N)	2007/09/12		96	%	80 - 120
	SPIKE	Ammonia (N)	2007/09/12		94	%	80 - 120
	BLANK	Ammonia (N)	2007/09/12	<0.005		mg/L	
	RPD [G74770-01]	Ammonia (N)		TBA		%	25

N/A = Not Applicable
TBA = Result to follow
NC = Non-calculable
RPD = Relative Percent Difference

A740575

Maxxam Analytics Inc

8577 Commerce Court
Burnaby, BC V5A 4N5
www.maxxamanalytics.com

Phone: (604) 444-4808
Fax: (604) 444-4511
Toll Free: 1-800-440-4808

CHAIN-OF-CUSTODY RECORD AND ANALYSIS REQUEST

ANALYSIS REQUEST F 82587

LAB - USE ONLY

COMPANY NAME: MINNOW ENVIRONMENTAL

PH. #: 905-567-8771
E-mail: PORR@minnow-environmental.com
FAX #: 905-567-6805

COMPANY ADDRESS: 6800 KITIMAT RD UNIT 13 MISSISSAUGA, ON

CLIENT PROJECT ID: (#) 2212

NOTE 2 COOLERS

SAMPLER NAME (PRINT): KIM CONNORS

PROJECT MANAGER: PATTI ORR

	FIELD SAMPLE ID	MAXXAM LAB # (Lab Use Only)	MATRIX: GROUND WATER	MATRIX: SURFACE WATER	MATRIX: SOIL	MATRIX: OTHER	# CONTAINERS	SAMPLING: DATE DD/MM/YY	SAMPLING: TIME	HEADSPACE VAPOUR	Alkalinity	Ammonia-N	Chloride	Fluoride	Sulphate	nitrate-N	nitrite-N	TOC	DOC	TDS	TSS	hardness	total phosphorus	total metals	★CHECK MDL SHEETS★		CONDUCTIVITY	
1	Ref 1			✓			6	25/08/07	10:30		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	
2	Ref 2			✓			6	25/08/07	13:30		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	
3	Nex C1			✓			6	26/08/07	08:30		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	
4	V8			✓			6	27/08/07	09:30		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	
5	V5			✓			6	29/08/07			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	
6	V27			✓			6	28/08/07			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	
7	V1			✓			6	28/08/07			✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	
8	V8Z			✓			6	2[illegible]/08/07	09:30		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓			✓	
9																												
10																												
11																												
12																												

TAT (Turnaround Time)

<5 DAY TAT MUST HAVE PRIOR APPROVAL

*some exceptions apply please contact lab

- STANDARD 5 BUSINESS DAYS ☑
- RUSH 3 BUSINESS DAYS ☐
- RUSH 2 BUSINESS DAYS ☐
- URGENT 1 BUSINESS DAY ☐

OTHER BUSINESS DAYS ____

P.O. NUMBER / QUOTE NUMBER: BC07-066-FC

SPECIAL DETECTION LIMITS / CONTAMINANT TYPE: NOTE MDL SHEETS ATTACHED

☐ CCME
☐ CSR
☐ ALBERTA TIER 1
☐ OTHER

LAB USE ONLY

ARRIVAL TEMPERATURE °C: 2, 2, 3

DUE DATE:

LOG IN CHECK:

ACCOUNTING CONTACT:

SPECIAL REPORTING OR BILLING INSTRUCTIONS: Att. Elaine Cousins

JARS USED:

RELINQUISHED BY SAMPLER: Kim Connors	DATE: DD/MM/YY Aug 30/07	TIME: 4:25	RECEIVED BY:
RELINQUISHED BY:	DATE: DD/MM/YY	TIME:	RECEIVED BY:
RELINQUISHED BY:	DATE: DD/MM/YY [illegible]	TIME: 14:20	RECEIVED BY LABORATORY: A.M

CUSTODY RECORD

COCFORM - BC - 06/06

ORIGINAL - MAXXAM   YELLOW - MAXXAM   PINK - CLIENT

Maxxam Analytics Inc

8577 Commerce Court
Burnaby, BC V5A 4N5
www.maxxamanalytics.com

Phone: (604) 444-4808
Fax: (604) 444-4511
Toll Free: 1-800-440-4808

CHAIN-OF-CUSTODY RECORD AND ANALYSIS REQUEST

F 82588

COMPANY NAME: MINNOW ENVIRONMENTAL

PH. #: 905-567-8771
E-mail: PORR@MINNOW-ENVIRONMENTAL.COM
FAX #: 905-567-6805

COMPANY ADDRESS: 6800 KITIMAT RD UNIT 13 MISSISSAUGA, ON

CLIENT PROJECT ID: (#) 2212.

NOTE 2 COOLERS

SAMPLER NAME (PRINT): KIM CONNORS.

PROJECT MANAGER: PATTI ORR.

ANALYSIS REQUEST — LAB USE ONLY

★ REFER TO QUOTE FOR SPECIAL INSTRUCTIONS ★

	FIELD SAMPLE ID	MAXXAM LAB # (Lab Use Only)	MATRIX: GROUND WATER	SURFACE WATER	SOIL / SEDIMENT	OTHER	# CONTAINERS	SAMPLING: DATE DD/MM/YY	TIME	HEADSPACE VAPOUR	PARTICLE SIZE	TOC	TKN	TOTAL PHOSPHORUS	TOTAL MERCURY	TOTAL METALS BULK & BREAKDOWN
1	V27-A (d/s 01)				✓		2	28/08/07			✓	✓	✓	✓	✓	✓
2	V27-B (03)				✓		2	28/08/07			✓	✓	✓	✓	✓	✓
3	V27-C (04)				✓		2	28/08/07			✓	✓	✓	✓	✓	✓
4	V1				✓		2	28/08/07			✓	✓	✓	✓	✓	✓
5																
6																
7																
8																
9																
10																
11																
12																

TAT (Turnaround Time)

<5 DAY TAT MUST HAVE PRIOR APPROVAL

some exceptions apply please contact lab

- STANDARD 5 BUSINESS DAYS ☑
- RUSH 3 BUSINESS DAYS ☐
- RUSH 2 BUSINESS DAYS ☐
- URGENT 1 BUSINESS DAY ☐
- OTHER BUSINESS DAYS ____

P.O. NUMBER / QUOTE NUMBER: BC07-066-FC

SPECIAL DETECTION LIMITS / CONTAMINANT TYPE: SEE ATTACHED MDL's REFER TO SPECIAL INSTRUCTIONS

☐ CCME ☐ CSR ☐ ALBERTA TIER 1 ☐ OTHER

ACCOUNTING CONTACT:

SPECIAL REPORTING OR BILLING INSTRUCTIONS: Attn. Elaine Cousins

JARS USED:

LAB USE ONLY — ARRIVAL TEMPERATURE °C: 2, 2, 3 | DUE DATE: | LOG IN CHECK:

RELINQUISHED BY SAMPLER: Kim Connors	DATE: DD/MM/YY Aug 30/07	TIME: 14:25	RECEIVED BY:
RELINQUISHED BY:	DATE: DD/MM/YY	TIME:	RECEIVED BY:
RELINQUISHED BY:	DATE: DD/MM/YY 31/8/07	TIME: 14:20	RECEIVED BY LABORATORY: A.M

CUSTODY RECORD

COCFORM - BC - 06/06

ORIGINAL - MAXXAM YELLOW - MAXXAM PINK - CLIENT

Your Project #: A740575
Your C.O.C. #: N/A

Attention: Elaine Cousins
Maxxam Analytics Inc
Burnaby to Bedford
8577 Commerce Crt
Burnaby, BC
V5A 4N5

Report Date: 2007/09/10

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: A795627
Received: 2007/09/05, 14:15

Sample Matrix: Soil
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Total Organic Carbon in Soil	4	N/A	2007/09/07	ATL SOP 00044 R2	LECO 203-601-224

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

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MARIE (MCNAIR) MUISE, Project Manager
Email: marie.muise.reports@maxxamanalytics.com
Phone# (902) 420-0203

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CAEAL have approved this reporting process and electronic report format.

Total cover pages: 1

Maxxam Job #: A795627
Report Date: 2007/09/10

Maxxam Analytics Inc
Client Project #: A740575
Project name:
Sampler Initials:

RESULTS OF ANALYSES OF SOIL

Maxxam ID		U46414	U46415	U46416		
Sampling Date		2007/08/28	2007/08/28	2007/08/28		
COC Number		N/A	N/A	N/A		
	Units	**G74778-01R\V27-A(D/S 01)**	**G74779-01R\V27-B(03)**	**G74780-01R\V27-C(04)**	**RDL**	**QC Batch**
Organic Carbon (TOC)	g/kg	3.7	3.0	2.4	0.2	1354494

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

Maxxam ID		U46417		
Sampling Date		2007/08/28		
COC Number		N/A		
	Units	**G74781-01R\V1**	**RDL**	**QC Batch**
Organic Carbon (TOC)	g/kg	1.3	0.2	1354494

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

200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel:902-420-0203 Toll-free:800-565-7227 Fax:902-420-8612 www.maxxamanalytics.com

Maxxam Job #: A795627
Report Date: 2007/09/10

Maxxam Analytics Inc
Client Project #: A740575
Project name:
Sampler Initials:

GENERAL COMMENTS

Results relate only to the items tested.

200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel:902-420-0203 Toll-free:800-565-7227 Fax:902-420-8612 www.maxxamanalytics.com

Maxxam Analytics Inc
Attention: Elaine Cousins
Client Project #: A740575
P.O. #:
Project name:

Quality Assurance Report

Maxxam Job Number: DA795627

QA/QC Batch Num	Init	QC Type	Parameter	Date Analyzed yyyy/mm/dd	Value	Recovery	Units	QC Limits
1354494	BBD	QC STANDARD	Organic Carbon (TOC)	2007/09/07		97	%	75 - 125
		Method Blank	Organic Carbon (TOC)	2007/09/07	ND, RDL=0.2		g/kg	
		RPD	Organic Carbon (TOC)	2007/09/07	2.8		%	35

ND = Not detected
RPD = Relative Percent Difference
QC Standard = Quality Control Standard

200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel:902-420-0203 Toll-free:800-565-7227 Fax:902-420-8612 www.maxxamanalytics.com

Your Project #: A740575
Your C.O.C. #: N/A

Attention: Elaine Cousins
Maxxam Analytics Inc
Burnaby to Bedford
8577 Commerce Crt
Burnaby, BC
V5A 4N5

Report Date: 2007/09/11

CERTIFICATE OF ANALYSIS

MAXXAM JOB #: A795621
Received: 2007/09/05, 14:15

Sample Matrix: Soil
Samples Received: 4

Analyses	Quantity	Date Extracted	Date Analyzed	Laboratory Method	Method Reference
Particle size in solids (pipette&sieve)	4	N/A	2007/09/07	ATL SOP 00012 R2	based on MSAMS-1978

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

Encryption Key

Please direct all questions regarding this Certificate of Analysis to your Project Manager.

MARIE (MCNAIR) MUISE, Project Manager
Email: marie.muise.reports@maxxamanalytics.com
Phone# (902) 420-0203

==
Maxxam has procedures in place to guard against improper use of the electronic signature and have the required "signatories", as per section 5.10.2 of ISO/IEC 17025:2005(E), signing the reports. SCC and CAEAL have approved this reporting process and electronic report format.

Total cover pages: 1

Maxxam Job #: A795621
Report Date: 2007/09/11

Maxxam Analytics Inc
Client Project #: A740575
Project name:
Sampler Initials:

RESULTS OF ANALYSES OF SOIL

Maxxam ID		U46394	U46404	U46405		
Sampling Date		2007/08/28	2007/08/28	2007/08/28		
COC Number		N/A	N/A	N/A		
	Units	**G74778-01R\V27-A(D/S 01)**	**G74779-01R\V27-B(03)**	**G74780-01R\V27-C(04)**	**RDL**	**QC Batch**
< -4 Phi	%	100	100	100	0.1	1353856
< -3 Phi	%	100	100	100	0.1	1353856
< -2 Phi	%	100	100	100	0.1	1353856
< -1 Phi	%	52	59	71	0.1	1353856
< 0 Phi	%	19	34	35	0.1	1353856
< +1 Phi	%	5.2	9.8	13	0.1	1353856
< +2 Phi	%	2.0	2.9	3.8	0.1	1353856
< +3 Phi	%	1.3	1.8	1.9	0.1	1353856
< +4 Phi	%	1.2	1.6	1.5	0.1	1353856
< +5 Phi	%	1.1	1.3	1.4	0.1	1353856
< +6 Phi	%	1.0	1.5	1.1	0.1	1353856
< +7 Phi	%	0.9	1.3	1.2	0.1	1353856
< +8 Phi	%	0.9	1.2	1.1	0.1	1353856
< +9 Phi	%	0.8	1.2	1.0	0.1	1353856
Gravel	%	48	41	29	0.1	1353856
Sand	%	51	58	70	0.1	1353856
Silt	%	0.3	0.4	0.4	0.1	1353856
Clay	%	0.9	1.2	1.1	0.1	1353856

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

200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel:902-420-0203 Toll-free:800-565-7227 Fax:902-420-8612 www.maxxamanalytics.com

Maxxam Job #: A795621
Report Date: 2007/09/11

Maxxam Analytics Inc
Client Project #: A740575
Project name:
Sampler Initials:

RESULTS OF ANALYSES OF SOIL

Maxxam ID		U46406		
Sampling Date		2007/08/28		
COC Number		N/A		
	Units	**G74781-01R\V1**	**RDL**	**QC Batch**
< -4 Phi	%	100	0.1	1353856
< -3 Phi	%	100	0.1	1353856
< -2 Phi	%	100	0.1	1353856
< -1 Phi	%	18	0.1	1353856
< 0 Phi	%	3.5	0.1	1353856
< +1 Phi	%	1.4	0.1	1353856
< +2 Phi	%	1.2	0.1	1353856
< +3 Phi	%	1.2	0.1	1353856
< +4 Phi	%	1.2	0.1	1353856
< +5 Phi	%	1.2	0.1	1353856
< +6 Phi	%	1.2	0.1	1353856
< +7 Phi	%	1.1	0.1	1353856
< +8 Phi	%	1.0	0.1	1353856
< +9 Phi	%	1.1	0.1	1353856
Gravel	%	82	0.1	1353856
Sand	%	17	0.1	1353856
Silt	%	0.1	0.1	1353856
Clay	%	1.0	0.1	1353856

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

200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel:902-420-0203 Toll-free:800-565-7227 Fax:902-420-8612 www.maxxamanalytics.com

Maxxam Job #: A795621
Report Date: 2007/09/11

Maxxam Analytics Inc
Client Project #: A740575
Project name:
Sampler Initials:

GENERAL COMMENTS

Results relate only to the items tested.

200 Bluewater Rd, Suite 105, Bedford, Nova Scotia Canada B4B 1G9 Tel:902-420-0203 Toll-free:800-565-7227 Fax:902-420-8612 www.maxxamanalytics.com

AquaTox Testing & Consulting Inc.
11B Nicholas Beaver Rd.
RR 3
Guelph ON N1H 6H9
Tel: (519) 763-4412 Fax: (519) 763-4419

Hyalella azteca Test Report

Survival and Growth

SAMPLE IDENTIFICATION

Work Order:	211960	Shipped By:	Fed Ex/Rd
Company :	Minnow Environmental Inc. (BMS Corp.)	Date Received :	2007-09-06
Location :	Mississauga ON	Time Received :	14:00
Sampling Method :	Composite	Date Tested :	2007-09-19
Sampled By :	K. Connors	Lab Storage:	4±2 °C
Sample Volume:	1 x 5 L pail		

Test Method : Test for Survival and Growth in Sediment Using the Freshwater Amphipod *Hyalella azteca*. Environment Canada, Conservation and Protection. Ottawa, Ontario. Report EPS 1/RM/33, December, 1997.

SAMPLE SUMMARY

Sample Number	Sample Name	Description	Sample Date	Sample Time	Temp. on Arrival
-	Control	Fine brown organic sediment; no odour.	2006-08-28	11:00	-
19474	V27-A (d/s 01)	Dark brown with rocks, vegetation, mild odour.	2007-08-28	12:00	18.5 °C
19475	V27-B (03)	Dark brown with rocks, no odour.	2007-08-28	12:00	18.5 °C
19476	V27-C (04)	Dark brown with rocks, no odour.	2007-08-28	12:00	18.5 °C
19477	V1	Brown with rocks, no odour.	2007-08-28	15:00	18.5 °C

RESULTS

Survival Data (Treatment Average Survival, %)[1]

Control	V27-A (d/s 01)	V27-B (03)	V27-C (04)	V1
100	100	100	100	100

[1]Based on visual inspection of the data, samples sharing the same line are not significantly different from one another (i.e. they are considered to be homogenous, that is, from the same population) ($\alpha = 0.05$). Data did not meet the assumptions for normality and homogeneity of variance.

Growth Data (Treatment Average Weight, mg)[2]

V27-C (04)	Control	V27-B (03)	V27-A (d/s 01)	V1
0.275	0.297	0.307	0.357	0.410

[2] **Tukey Method of Multiple Comparisons (Toxstat 3.5)[a]:** Samples sharing the same line are not significantly different from one another (i.e. they are considered to be homogenous, that is, from the same population) ($\alpha = 0.05$). All data sets met the assumptions for normality and homogeneity of variance.

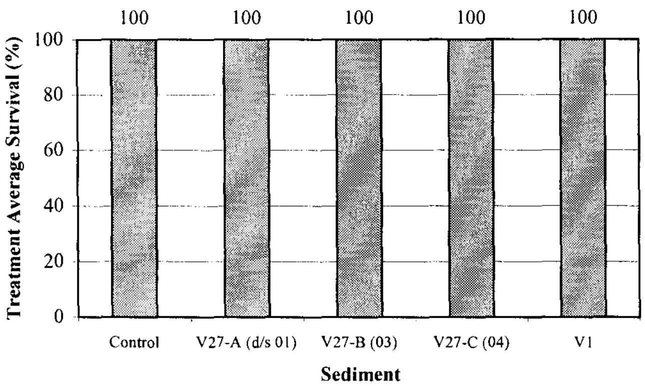
POTASSIUM CHLORIDE REFERENCE TOXICANT DATA

Test Date :	2007-09-07	Historical Mean LC50 :	145 µg/L
Test Duration :	96 hours	Warning Limits (± 2 SD) :	79 - 265
LC50 (95% confidence limits) :	187 µg/L (143 - 244)	Statistical Method :	Probit [b]
Organism Batch :	Ha07-09	Test Conducted By :	KJ/EJ/AS

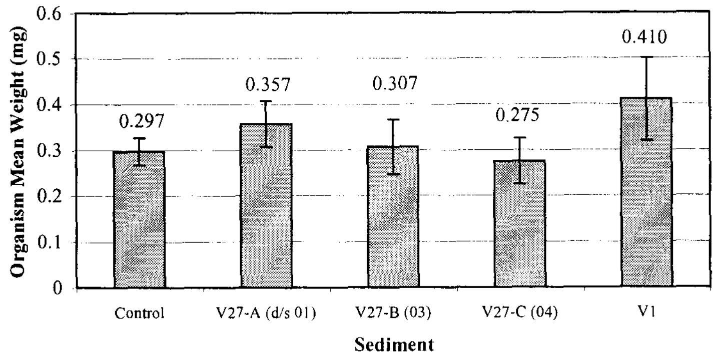
The reference toxicant test was conducted as a water only test, as specified in the test method.

Work Order : 211960

***Hyalella azteca* Survival**



***Hyalella azteca* Growth**



SEDIMENT CHARACTERISTICS

Sample Number	Sample Name	TOC (mg/kg)	Moisture Content (%)	Particle Size (%)			
				Gravel	Sand	Silt	Clay
–	Control	93000	72.0	0.00	42.00	58.00	<2
19474	V27-A (d/s 01)	3700	7.2	48	51	0.3	0.9
19475	V27-B (03)	3000	16.7	41	58	0.4	1.2
19476	V27-C (04)	2400	20.9	29	70	0.4	1.1
19477	V1	1300	15.7	82	17	0.1	1.0

TEST CONDITIONS

Test Organism:	*Hyalella azteca*	Test Vessel:	300 mL pyrex beaker
Organism Batch :	Ha07-09	Sediment Depth:	Approx. 3.5 cm
Source:	In-house culture	Sediment Volume:	100 mL per replicate
Life Stage on Test Day 0 :	2-9 days old	Overlying Water Volume:	175 mL per replicate
Test Type:	Static	Control/Test Water:	Well water (no chemicals added)
Samples per Treatment [c]:	1	Control Sediment:	Long Point, Lake Erie
Number of Replicates:	5	Test Aeration :	Yes (all replicates)
Organisms per Replicate:	10	Test Aeration Rate :	2-3 bubbles per second
Organisms per Treatment:	50	Photoperiod (light/dark) :	16 h / 8 h
Feed Type:	YCT (Batch 07-05)	Light Intensity :	646 - 692 lux
Feeding Rate (per replicate):	~2.7 mg dry solids daily	Test Method Deviations :	None
Test Duration :	14 days		

[c] as disclosed by the client

COMMENTS

The results reported relate only to the sample tested.
All test validity criteria as specified in the test method cited in this report were met.
No organisms exhibiting unusual appearance, behavior, or undergoing unusual treatment were used in the test.

REFERENCES

[a] West, Inc. and D. Gulley. 1996. Toxstat Release 3.5. Western Ecosystems Technology. Cheyenne, WY, U.S.A.

[b] Stephan, C. E. 1977. Methods for calculating an LC50. P. 65-84 In: P.L. Mayer and J. L. Hamelink (eds.), Aquatic Toxicology and Hazard Evaluation. Amer. Soc. Testing and Materials, Philadelphia PA. ASTM STP 634.

Date: 2007-10-30
yyyy-mm-dd

Approved by: [signature]
Project Manager

Work Order : 211960

Hyalella azteca Survival Data

Sample	Replicate	Number of Survivors (n=10)	Surviving Organisms (%)	Treatment Average Survival (%)	Standard Deviation	CV (%)
	A	10	100	100	0.0	0.0
	B	10	100			
Control	C	10	100			
	D	10	100			
	E	10	100			
	A	10	100	100	0.0	0.0
	B	10	100			
19474	C	10	100			
V27-A (d/s 01)	D	10	100			
	E	10	100			
	A	10	100	100	0.0	0.0
	B	10	100			
19475	C	10	100			
V27-B (03)	D	10	100			
	E	10	100			
	A	10	100	100	0.0	0.0
	B	10	100			
19476	C	10	100			
V27-C (04)	D	10	100			
	E	10	100			
	A	10	100	100	0.0	0.0
	B	10	100			
19477	C	10	100			
V1	D	10	100			
	E	10	100			

Hyalella azteca Weight Data

Sample	Replicate	Foil Weight (mg)	Dry Weigt of Foil + Organisms (mg)	Number of Organisms Weighed	Mean Dry Weight of Organisms (mg)	Treatment Mean Dry Weight (mg)	Standard Deviation	CV (%)
	A	779.18	782.50	10	0.332	0.297	0.03	8.7
	B	766.05	768.75	10	0.270			
Control	C	770.20	773.26	10	0.306			
	D	766.30	769.03	10	0.273			
	E	783.01	786.07	10	0.306			
	A	772.70	775.83	10	0.313	0.357	0.05	14.5
	B	776.30	779.73	10	0.343			
19474	C	799.58	804.00	10	0.442			
V27-A (d/s 01)	D	770.42	773.64	10	0.322			
	E	774.17	777.83	10	0.366			
	A	769.81	773.27	10	0.346	0.307	0.06	20.4
	B	775.14	777.91	10	0.277			
19475	C	764.58	768.45	10	0.387			
V27-B (03)	D	765.16	768.14	10	0.298			
	E	767.44	769.69	10	0.225			
	A	766.32	768.94	10	0.262	0.275	0.05	18.7
	B	764.93	766.85	10	0.192			
19476	C	789.05	792.02	10	0.297			
V27-C (04)	D	771.49	774.74	10	0.325			
	E	783.93	786.92	10	0.299			
	A	783.17	788.23	10	0.506	0.410	0.09	21.8
	B	780.38	784.62	10	0.424			
19477	C	789.62	793.23	10	0.361			
V1	D	782.02	784.85	10	0.283			
	E	804.57	809.31	10	0.474			

Data Reviewed By: I
Date: 2007 10-26

Hyalella azteca Sediment Test Data

Work Order :	211960
Sample Number :	**Control**
Species:	*Hyalella azteca*
Organism Batch :	Ha07-09
Sediment pH:	7.3
Pore Water pH:	7.9
Pore Water Ammonia (mg/L) :	10.5
Sample Treatment:	Dry sieved (2 mm)
Time Start:	12:45

Test Day	Day	Date	Temp. (°C)	Replicate	D.O. (mg/L)	Test Fed? (Y/N)	Analyst(s)	Conductivity (µmhos)	pH	Hardness (mg/l as $CaCO_3$)	Total Ammonia (mg/L)	Unionized Ammonia (mg/L)
0	Wed	2007-09-19	23.0	Composite	7.8	Y	KJ	509	8.4	260	3.00	0.33
1	Thurs	2007-09-20	24.0	–	–	Y	KJ	–	–	–	–	–
2	Fri	2007-09-21	23.0	A	8.1	Y	KJ	–	–	–	–	–
3	Sat	2007-09-22	24.0	–	–	Y	HR	–	–	–	–	–
4	Sun	2007-09-23	23.0	–	–	Y	HR	–	–	–	–	–
5	Mon	2007-09-24	23.0	B	8.3	Y	EJ	–	–	–	–	–
6	Tues	2007-09-25	23.0	–	–	Y	KJ	–	–	–	–	–
7	Wed	2007-09-26	23.0	C	7.7	Y	KJ	–	–	–	–	–
8	Thurs	2007-09-27	23.0	–	–	Y	KJ	–	–	–	–	–
9	Fri	2007-09-28	23.0	D	7.8	Y	KJ	–	–	–	–	–
10	Sat	2007-09-29	23.0	–	–	Y	JL	–	–	–	–	–
11	Sun	2007-09-30	23.0	–	–	Y	KJ	–	–	–	–	–
12	Mon	2007-10-01	23.0	A	7.6	Y	KJ	–	–	–	–	–
13	Tues	2007-10-02	24.0	–	–	Y	KJ	–	–	–	–	–
14	Wed	2007-10-03	24.0	Composite	7.6	N	KJ	554	8.4	260	0.45	0.05

"–" = not measured

Data Reviewed By: JL
Date: 2007-10-26

Hyalella azteca Sediment Test Data

Work Order : 211960
Sample Number : **19474**
Species: *Hyalella azteca*
Organism Batch : Ha07-09
Sediment pH: 7.1
Pore Water pH: 7.5
Pore Water Ammonia (mg/L) : 0.3
Sample Treatment: Hand homogenized
Time Start: 13:05

Test Day	Day	Date	Temp. (°C)	Replicate	D.O. (mg/L)	Test Fed? (Y/N)	Analyst(s)	Conductivity (µmhos)	pH	Hardness (mg/l as $CaCO_3$)	Total Ammonia (mg/L)	Unionized Ammonia (mg/L)
0	Wed	2007-09-19	23.0	Composite	7.9	Y	KJ	453	8.4	230	0.75	0.08
1	Thurs	2007-09-20	24.0	–	–	Y	KJ	–	–	–	–	–
2	Fri	2007-09-21	23.0	A	7.8	Y	KJ	–	–	–	–	–
3	Sat	2007-09-22	24.0	–	–	Y	HR	–	–	–	–	–
4	Sun	2007-09-23	23.0	–	–	Y	HR	–	–	–	–	–
5	Mon	2007-09-24	23.0	B	8.4	Y	EJ	–	–	–	–	–
6	Tues	2007-09-25	23.0	–	–	Y	KJ	–	–	–	–	–
7	Wed	2007-09-26	23.0	C	7.9	Y	KJ	–	–	–	–	–
8	Thurs	2007-09-27	23.0	–	–	Y	KJ	–	–	–	–	–
9	Fri	2007-09-28	23.0	D	7.6	Y	KJ	–	–	–	–	–
10	Sat	2007-09-29	23.0	–	–	Y	JL	–	–	–	–	–
11	Sun	2007-09-30	23.0	–	–	Y	KJ	–	–	–	–	–
12	Mon	2007-10-01	23.0	A	7.8	Y	KJ	–	–	–	–	–
13	Tues	2007-10-02	24.0	–	–	Y	KJ	–	–	–	–	–
14	Wed	2007-10-03	23.0	Composite	7.8	N	KJ	518	7.8	250	0.30	0.01

"–" = not measured

Data Reviewed By: JC
Date: 2007 10 26

Hyalella azteca Sediment Test Data

Work Order :	211960
Sample Number :	**19475**
Species:	*Hyalella azteca*
Organism Batch :	Ha07-09
Sediment pH:	7.4
Pore Water pH:	7.5
Pore Water Ammonia (mg/L) :	0.0
Sample Treatment:	Hand homogenized
Time Start:	13:00

Test Day	Day	Date	Temp. (°C)	Replicate	D.O. (mg/L)	Test Fed? (Y/N)	Analyst(s)	Conductivity (µmhos)	pH	Hardness (mg/l as $CaCO_3$)	Total Ammonia (mg/L)	Unionized Ammonia (mg/L)
0	Wed	2007-09-19	23.0	Composite	7.8	Y	KJ	454	8.4	210	0.25	0.03
1	Thurs	2007-09-20	24.0	–	–	Y	KJ	–	–	–	–	–
2	Fri	2007-09-21	23.0	A	8.2	Y	KJ	–	–	–	–	–
3	Sat	2007-09-22	24.0	–	–	Y	HR	–	–	–	–	–
4	Sun	2007-09-23	23.0	–	–	Y	HR	–	–	–	–	–
5	Mon	2007-09-24	23.0	B	8.4	Y	EJ	–	–	–	–	–
6	Tues	2007-09-25	23.0	–	–	Y	KJ	–	–	–	–	–
7	Wed	2007-09-26	23.0	C	8.0	Y	KJ	–	–	–	–	–
8	Thurs	2007-09-27	23.0	–	–	Y	KJ	–	–	–	–	–
9	Fri	2007-09-28	23.0	D	7.4	Y	KJ	–	–	–	–	–
10	Sat	2007-09-29	23.0	–	–	Y	JL	–	–	–	–	–
11	Sun	2007-09-30	23.0	–	–	Y	KJ	–	–	–	–	–
12	Mon	2007-10-01	23.0	A	8.0	Y	KJ	–	–	–	–	–
13	Tues	2007-10-02	24.0	–	–	Y	KJ	–	–	–	–	–
14	Wed	2007-10-03	23.0	Composite	7.6	N	KJ	508	8.3	260	0.40	0.04

"–" = not measured

Data Reviewed By: JL
Date 2007-10-26

Hyalella azteca Sediment Test Data

Work Order : 211960
Sample Number : **19476**
Species: *Hyalella azteca*
Organism Batch : Ha07-09
Sediment pH: 7.1
Pore Water pH: 7.5
Pore Water Ammonia (mg/L) : 0.0
Sample Treatment: Hand homogenized
Time Start: 12:55

Test Day	Day	Date	Temp. (°C)	Replicate	D.O. (mg/L)	Test Fed? (Y/N)	Analyst(s)	Conductivity (µmhos)	pH	Hardness (mg/l as $CaCO_3$)	Total Ammonia (mg/L)	Unionized Ammonia (mg/L)
0	Wed	2007-09-19	23.0	Composite	7.8	Y	KJ	418	8.4	220	0.75	0.08
1	Thurs	2007-09-20	24.0	–	–	Y	KJ	–	–	–	–	–
2	Fri	2007-09-21	23.0	A	8.3	Y	KJ	–	–	–	–	–
3	Sat	2007-09-22	24.0	–	–	Y	HR	–	–	–	–	–
4	Sun	2007-09-23	23.0	–	–	Y	HR	–	–	–	–	–
5	Mon	2007-09-24	23.0	B	8.4	Y	EJ	–	–	–	–	–
6	Tues	2007-09-25	23.0	–	–	Y	KJ	–	–	–	–	–
7	Wed	2007-09-26	23.0	C	7.6	Y	KJ	–	–	–	–	–
8	Thurs	2007-09-27	23.0	–	–	Y	KJ	–	–	–	–	–
9	Fri	2007-09-28	23.0	D	7.7	Y	KJ	–	–	–	–	–
10	Sat	2007-09-29	23.0	–	–	Y	JL	–	–	–	–	–
11	Sun	2007-09-30	23.0	–	–	Y	KJ	–	–	–	–	–
12	Mon	2007-10-01	23.0	A	7.9	Y	KJ	–	–	–	–	–
13	Tues	2007-10-02	24.0	–	–	Y	KJ	–	–	–	–	–
14	Wed	2007-10-03	23.0	Composite	7.6	N	KJ	512	8.3	240	<0.05	0.00

"–" = not measured

Data Reviewed By: JL
Date: 2007-10-26

***Hyalella azteca* Sediment Test Data**

Work Order :	211960
Sample Number :	**19477**
Species:	*Hyalella azteca*
Organism Batch :	Ha07-09
Sediment pH:	7.2
Pore Water pH:	7.1
Pore Water Ammonia (mg/L) :	0.0
Sample Treatment:	Hand homogenized
Time Start:	12:50

Test Day	Day	Date	Temp. (°C)	Replicate	D.O. (mg/L)	Test Fed? (Y/N)	Analyst(s)	Conductivity (µmhos)	pH	Hardness (mg/l as $CaCO_3$)	Total Ammonia (mg/L)	Unionized Ammonia (mg/L)
0	Wed	2007-09-19	23.0	Composite	7.8	Y	KJ	446	8.4	210	0.00	0.00
1	Thurs	2007-09-20	24.0	–	–	Y	KJ	–	–	–	–	–
2	Fri	2007-09-21	23.0	A	8.3	Y	KJ	–	–	–	–	–
3	Sat	2007-09-22	24.0	–	–	Y	HR	–	–	–	–	–
4	Sun	2007-09-23	23.0	–	–	Y	HR	–	–	–	–	–
5	Mon	2007-09-24	23.0	B	8.2	Y	EJ	–	–	–	–	–
6	Tues	2007-09-25	23.0	–	–	Y	KJ	–	–	–	–	–
7	Wed	2007-09-26	23.0	C	7.9	Y	KJ	–	–	–	–	–
8	Thurs	2007-09-27	23.0	–	–	Y	KJ	–	–	–	–	–
9	Fri	2007-09-28	23.0	D	4.6	Y	KJ	–	–	–	–	–
10	Sat	2007-09-29	23.0	–	–	Y	JL	–	–	–	–	–
11	Sun	2007-09-30	23.0	–	–	Y	KJ	–	–	–	–	–
12	Mon	2007-10-01	23.0	A	7.5	Y	KJ	–	–	–	–	–
13	Tues	2007-10-02	24.0	–	–	Y	KJ	–	–	–	–	–
14	Wed	2007-10-03	23.0	Composite	7.6	N	KJ	472	8.3	210	1.45	0.13

"–" = not measured

Data Reviewed By: JL
Date: 2007-10-26

Attention: Lesley Novak

CHAIN OF CUSTODY RECORD

Stantec

Stantec Work Order No: 211960

Shipping Address: Stantec Consulting Ltd.
11B Nicholas Beaver Road, RR #3
Guelph, Ontario Canada N1H 6H9

Voice: (519) 763-4412 Fax: (519) 763-4419

P.O. Number: 2212
Field Sampler Name (print): KIM CONNORS
Signature: Kim Connors
Affiliation: Minnow
Sample Storage (prior to shipping): fridge
Custody Relinquished by:
Date/Time Shipped: Sept 4/07

Client: Minnow Environmental
6800 Kitimat Rd
Unit 13, Mississauga ON
Phone: 905-567-8771
Fax: 905-567-6805
Contact: Patti Orr

Date Collected (yyyy-mm-dd)	Time Collected (e.g. 14:30, 24 hr clock)	Sample Name	Stantec Sample Number	Temp. on arrival	Rainbow trout Single Concentration	Daphnia magna Single Concentration	Hyalella azteca 14-d Survival and Growth	Chironomus sp. 10-d Survival and Growth	Selenastrum capricornutum Growth		Other (please specify below)	Grab	Composite	# of Containers and Volume (eg. 2 x 1L, 3 x 10L, etc.)
Aug 28, 07	~12:00	V27-A (dS 01)	19474	8.5			✓					✓	✓	1 x 3L
"	~12:00	V27-B (03)	19475	↓			✓					✓	✓	1 x 3L
"	~12:00	V27-C (04)	19476	↓			✓						✓	1 x 3L
"	~15:00	V1	19477	↓			✓						✓	1 x 3L

shipment complete

For Lab Use Only
Received By: Francine (Stantec)
Date: 2007-09-06
Time: 1400
Storage Location: walk in cooler
Storage Temp.(°C): 4±2°C

Please list any special requests or instructions: Cooler 1 of 2

2007-09-06

APPENDIX C

Benthic Invertebrate Data

Table C.1: Benthic invetebrate abundance as #/m^2 (Hess samper) or # per sample (artificial substrates).

Hess sampler (0.1 m^2) x 3 composites = 0.3 m^2 Data converted to # bugs/m^2	Sample ID:	Upper West Fork Vangorda Creek **REF 1**	Upper South Fork Rose Creek **REF 2**	Next Creek **NEXC 1**	Upper Vangorda Creek **V1-01**	Vangorda Creek **V1-02**	Vangorda Creek **V1-03**	Vangorda Creek **V1-04**	Vangorda Creek **V1-05**	Vangorda Creek **V27-01**	Vangorda Creek **V27-02**	Vangorda Creek **V27-03**	Vangorda Creek **V27-04**
Order: Ephemeroptera		7					3						
Family: Ameletidae													
Ameletus sp.	nymph	40	33	53	107		47	27	27	93	27	13	60
Family: Baetidae													
Baetis sp.	nymph	13	507		187	270	133	60	200	800	800	493	693
Baetis bicaudatus	nymph	53		7	13		3	3					17
Acentrella sp.	nymph												
Family: Heptageniidae	nymph	7	120	500	1683	1393	1683	987	1903	3227	3453	1507	2880
Rhithrogena sp;	nymph				440	7	33	73	20	13	53	93	17
Cinygmula sp.	nymph	7	20	13		7	17		37	13	13		
Epeorus sp.	nymph	7	13	7	143	57	210	230	117	67	80	13	73
Family: Ephemerellidae	nymph		653	33	80	163	13	27	123		67	13	
Drunella coloradensis	nymph				3	3	3	7	10				
Drunella doddsi	nymph		60							27	13		10
Order: Plecoptera	nymph (juv./dam.)		7	13			387	133	7	400			
Family: Chloroperlidae	nymph	20		107	80	53	23	10	7		80	160	227
Sweltsa sp.	nymph	7	20	53	140	10	50	20	93	40			57
Suwallia sp.	nymph				680	70	127	27	133	93	173	147	17
Alloperla fraterna	nymph			80	37			103		93	67		53
Paraperla sp.	nymph				10			13					
Family: Perlodidae	nymph		73	7									
Megarcys sp.	nymph				7	3		7	3				3
Skwala sp.	nymph												
Family: Nemouridae													
Zapada sp.	nymph		527	27	320	270	53	403	297	720	1013	200	910
Zapada haysi/orogenensis	nymph	7	7	20	160	40	97	90	120	40	67	13	17
Zapada columbiana	nymph				10	10	57	40	37	53	27	13	33
Zapada cinctipes	nymph		27				3						
Family: Taeniopterygidae													
Taenionema sp	nymph												
Family: Capniidae	nymph	27	20	47	1097	430	560	437	623	907	853	680	680
Family: Leuctridae	nymph		7	20		53	37		20	293	173	40	77
Order: Trichoptera	adult												
Order: Trichoptera	pupa	7	60										
Order: Trichoptera	larvae (juv.)								13	240		133	240
Family: Hydropsychidae	larvae		20	7						107	93		27
Arctopsyche sp.	larvae												
Parapsyche sp.	larvae		13	13	43	7	27	20	20	40	13		3
Hydropsyche sp.	larvae								3				
Family: Rhyacophilidae													
Rhyacophila sp.	larvae			160	23	3	13	77	30	133	120	80	50
Family: Hydroptilidae													
Hydroptila sp.	larvae												
Family: Glossosomatidae													
Glossosoma sp.	larvae		20			107	53	43	107	640	667	160	483
Family: Limnephilidae				7					27		147		
Ecclisomyia sp;	larvae												
Order: Coleoptera													
Family: Elmidae	adult												3
Order: Diptera	adult	33	20	7	27	3		3					
Order: Diptera	larvae										13		
Order: Diptera	pupa												
Order: Diptera UID A	larvae												
Order: Diptera UID B	larvae												
Family : Chironomidae	pupa				103		13						320
Subfamily : Chironominae	larvae												
Micropsectra sp.	larvae									13		53	
Neostempellina sp.	larvae		127										
Pseudochironomus sp.	larvae		73										
Tanytarsus sp.	larvae	7					13				27		
Subfamily : Orthocladiinae	larvae			67	1333		200		333		493	120	160
Acricotopus sp.	larvae												
Brillia sp.	larvae						47				13		
Chaetocladius sp.	larvae								13	67	13		
Corynoneura sp.	larvae		13	20									
Cricotopus/Orthocladius sp. A	larvae		113	33	780	860	430	1400	1467	187	160	40	33
Cricotopus/Orthocladius sp. B	larvae												
Eukiefferiella sp.	larvae	633	153	107	1360	427	133	450	463	13	80		
Parorthocladius sp.	larvae										13		
Rheocricotopus sp.	larvae		133										
Synorthocladius sp.	larvae		27										27
Thiennemaniella sp.	larvae		7										
Tvetenia sp.	larvae			73							93		80
Subfamily : Diamesinae	larvae												
Diamesa sp.	larvae	1100											
Pagastia sp.	larvae			33	27	267	27	167	113				

Table C.1: Benthic invetebrate abundance as #/m^2 (Hess samper) or # per sample (artificial substrates).

Hess sampler (0.1 m^2) x 3 composites = 0.3 m^2 Data converted to # bugs/m^2	Sample ID:	Upper West Fork Vangorda Creek **REF 1**	Upper South Fork Rose Creek **REF 2**	Next Creek **NEXC 1**	Upper Vangorda Creek **V1-01**	Vangorda Creek **V1-02**	Vangorda Creek **V1-03**	Vangorda Creek **V1-04**	Vangorda Creek **V1-05**	Vangorda Creek **V27-01**	Vangorda Creek **V27-02**	Vangorda Creek **V27-03**	Vangorda Creek **V27-04**
Pseudodiamesa sp.	larvae	7											
Subfamily : Tanypodinae	larvae												
Thiennemannimyia Group	larvae		13										27
Family: Syriphidae	larvae												
Family: Psychodidae													
Pericoma sp.	larvae	7								13			
Family: Empididae													
Chelifera/Metachela	larvae	13	20							67	53		7
Oreogeton sp.	larvae				3		7		3	1440	1573	533	1003
Clinocera sp.	larvae												
Family: Tipulidae													
Dicranota sp.	larvae		20	20		53			17				3
Rhabdomastix sp.	larvae												
Hesperoconopa sp;	larvae												
Gonomyodes sp.	larvae												
Family: Simuliidae	pupa	20			13		3		7				7
Simulium sp.	larvae												
Prosimulium sp.	larvae	7											27
Order: Lepidoptera	larvae												
Order: Hemiptera												13	
Order: Collembola													
Phylum: Annelida													
Phylum: Nematoda		7	67	13	27		3		3	40	13		
Class: Oligochaeta		40	7	7		53							3
Class: Turbellaria													
Class: Hirudinea													
Class: Ostracoda		7											
Phylum: Mollusca													
Class: Gastropoda													
Order: Prostigmata	juvenile	7											
Order: Prostigmata	deutonymph			7			27			13			
Order: Prostigmata	adult						3	27					
Family: Aturidae													
Aturus	adult		40	13			80			67	13		107
Family: Hygrobatidae													
Hygrobates	adult			7				27	40				
Family: Lebertidae													
Lebertia	adult		13	13					13	13			
Family: Sperchontidae													
Sperchon	adult		47	13			30	27	40	13	13	13	30
Family: Feltriidae													
Feltria	adult					53			93				
Family: Hydryphantidae													
Wandesia	adult												
Family: Torrenticolidae													
Torrenticola	adult			7									
TOTAL SUBSAMPLE		2090	3100	1614	8936	4672	4648	4938	6582	9985	10569	4530	8464

Table C.1: Benthic invetebrate abundance as #/m^2 (Hess samper) or # per sample (artificial substrates).

Hess sampler (0.1 m^2) x 3 composites = 0.3 m^2 Data converted to # bugs/m^2	Sample ID:	Vangorda Creek **V27-05**	Vangorda Creek **V5-01**	Vangorda Creek **V5-02**	Vangorda Creek **V5-03**	Vangorda Creek **V5-04**	Vangorda Creek **V5-05**	Vangorda Creek **V8-01**	Vangorda Creek **V8-02**	Vangorda Creek **V8-03**	Vangorda Creek **V8-04**	Vangorda Creek **V8-05**
Order: Ephemeroptera												
Family: Ameletidae												
Ameletus sp.	nymph	83						13				
Family: Baetidae												
Baetis sp.	nymph	1040	13	7	20	60	7	93		80	80	53
Baetis bicaudatus	nymph		3									
Acentrella sp.	nymph											7
Family: Heptageniidae	nymph	2267	23	23	37	33	27	280	147	173	187	173
Rhithrogena sp;	nymph	20	3	3	3			27	13	13		13
Cinygmula sp.	nymph	7				3						13
Epeorus sp.	nymph	90	10	47	47	37	113	27	13		27	27
Family: Ephemerellidae	nymph	53							27			
Drunella coloradensis	nymph											
Drunella doddsi	nymph	80						27		13		13
Order: Plecoptera	nymph (juv./dam.)		113	33	53	73	53	520	560	453	267	120
Family: Chloroperlidae	nymph	10		23	10	20	10	13	27	13		
Sweltsa sp.	nymph	17		7			7			13	27	7
Suwallia sp.	nymph	147	3	47	47	27	43		13	67		
Alloperla fraterna	nymph	3						13		27		
Paraperla sp.	nymph											
Family: Perlodidae	nymph											
Megarcys sp.	nymph			10	3	3						
Skwala sp.	nymph							13				
Family: Nemouridae												
Zapada sp.	nymph	1133		17		13	3	13	13	187	240	60
Zapada haysi/orogenensis	nymph	37	17	20	17	20	20	53			27	47
Zapada columbiana	nymph	60	3	3		3		13			27	13
Zapada cinctipes	nymph		7	3		7		40	80		27	7
Family: Taeniopterygidae												
Taenionema sp	nymph											87
Family: Capniidae	nymph	677	127	97	167	270	87	493	480	400	187	233
Family: Leuctridae	nymph	40		37		7	10	13	53	293	53	20
Order: Trichoptera	adult	3										
Order: Trichoptera	pupa				3							
Order: Trichoptera	larvae (juv.)	27	60	10	27	73	10	27	13	13		27
Family: Hydropsychidae	larvae	137	20	7		27	13	27	13	27		33
Arctopsyche sp.	larvae											
Parapsyche sp.	larvae	47		3		7	7		13		27	7
Hydropsyche sp.	larvae											
Family: Rhyacophilidae												
Rhyacophila sp.	larvae	97	73	40	57	57	57	93	93	133	187	93
Family: Hydroptilidae												
Hydroptila sp.	larvae							13	27	40	187	7
Family: Glossosomatidae												
Glossosoma sp.	larvae	827	10	23	53	77	27	27				
Family: Limnephilidae		133	13	7				27				20
Ecclisomyia sp;	larvae		3						40	27		
Order: Coleoptera												
Family: Elmidae	adult											
Order: Diptera	adult	30	3	10	23	47	7				27	7
Order: Diptera	larvae						7		13			13
Order: Diptera	pupa											
Order: Diptera UID A	larvae			3								
Order: Diptera UID B	larvae				3	13						
Family : Chironomidae	pupa	53		20	13	40	33					
Subfamily : Chironominae	larvae											
Micropsectra sp.	larvae											
Neostempellina sp.	larvae											
Pseudochironomus sp.	larvae											
Tanytarsus sp.	larvae	30										
Subfamily : Orthocladiinae	larvae	303	73				37			80		
Acricotopus sp.	larvae	27										
Brillia sp.	larvae	113										
Chaetocladius sp.	larvae	3		3								120
Corynoneura sp.	larvae							13				
Cricotopus/Orthocladius sp. A	larvae	7	670	297	163	333	243	5000	4067	2533	5387	880
Cricotopus/Orthocladius sp. B	larvae									387		
Eukiefferiella sp.	larvae		153	43	20	47	127	427	80			13
Parorthocladius sp.	larvae											
Rheocricotopus sp.	larvae											
Synorthocladius sp.	larvae									67	27	
Thiennemaniella sp.	larvae											
Tvetenia sp.	larvae	133					47					
Subfamily : Diamesinae	larvae											
Diamesa sp.	larvae		67	30	17	57	33					
Pagastia sp.	larvae		17	13	7	40	7	40				

Table C.1: Benthic invetebrate abundance as #/m^2 (Hess samper) or # per sample (artificial substrates).

Hess sampler (0.1 m^2) x 3 composites = 0.3 m^2 Data converted to # bugs/m^2	Sample ID:	Vangorda Creek **V27-05**	Vangorda Creek **V5-01**	Vangorda Creek **V5-02**	Vangorda Creek **V5-03**	Vangorda Creek **V5-04**	Vangorda Creek **V5-05**	Vangorda Creek **V8-01**	Vangorda Creek **V8-02**	Vangorda Creek **V8-03**	Vangorda Creek **V8-04**	Vangorda Creek **V8-05**
Pseudodiamesa sp.	larvae											
Subfamily : Tanypodinae	larvae											
Thiennemannimyia Group	larvae	3								13		
Family: Syriphidae	larvae		7									
Family: Psychodidae												
Pericoma sp.	larvae	7	20		7	10	3				27	7
Family: Empididae												
Chelifera/Metachela	larvae	3	30	10	3	3	3	53	13	107	160	60
Oreogeton sp.	larvae	923	3		3			13		67		7
Clinocera sp.	larvae				7							
Family: Tipulidae												
Dicranota sp.	larvae	27	10			7	7		27		27	7
Rhabdomastix sp.	larvae						3		13			
Hesperoconopa sp;	larvae	27				20						
Gonomyodes sp.	larvae		13			3	13					
Family: Simuliidae	pupa	53	7	3	3		27	40				
Simulium sp.	larvae											
Prosimulium sp.	larvae											
Order: Lepidoptera	larvae											
Order: Hemiptera					3							
Order: Collembola			7	3	7	7	10					
Phylum: Annelida												
Phylum: Nematoda		30		7	3	10	10	227	67	120	187	33
Class: Oligochaeta			193	23	7	273	127					7
Class: Turbellaria									13	27		
Class: Hirudinea												
Class: Ostracoda												
Phylum: Mollusca												
Class: Gastropoda						7						
Order: Prostigmata	juvenile								13			
Order: Prostigmata	deutonymph	80	7								27	7
Order: Prostigmata	adult									13		13
Family: Aturidae												
Aturus	adult	107	13				13	53	227	120	107	53
Family: Hygrobatidae												
Hygrobates	adult								13			
Family: Lebertidae												
Lebertia	adult							13		13		
Family: Sperchontidae												
Sperchon	adult	27	27	7	3	17		160	67	120	80	33
Family: Feltriidae												
Feltria	adult	27	40	27	43					13	53	
Family: Hydryphantidae												
Wandesia	adult	27										
Family: Torrenticolidae												
Torrenticola	adult							80				
TOTAL SUBSAMPLE		9075	1861	966	879	1751	1251	7984	6238	5652	7659	2340

Table C.2: Benthic invertebrate subsample values.

Project: Minnow Environmental Inc.
Collected: August 2007
Analysis by: Cordillera Consulting
Summerland,BC VoH 1Z6
250-494-7553
Taxonomist : Sue Salter
suesalter@shaw.ca
www.cordilleraconsulting.com

		Hess														
		REF 1	REF 2	NEXC 1	V8-01	V8-02	V8-03	V8-04	V8-05	V27-01	V27-02	V27-03	V27-04		V27-05	
													coarse whole	fine 1/8	coarse whole	fine 1/8
	Split %:	1/2	1/2	1/2	1/4	1/4	1/4	1/8	1/2	1/4	1/4	1/4				
Order: Ephemeroptera		1														
Family: Ameletidae																
Ameletus sp.	nymph	6	5	8	1					7	2	1	2	2	1	3
Family: Baetidae																
Baetis sp.	nymph	2	76		7		6	3	8	60	60	37		26	8	38
Baetis bicaudatus	nymph	8		1									5			
Acentrella sp.	nymph								1							
Family: Heptageniidae	nymph	1	18	75	21	11	13	7	26	242	259	113	8	107		85
Rhithrogena sp;	nymph				2	1	1		2	1	4	7	5		6	
Cinygmula sp.	nymph	1	3	2					2	1	1				2	
Epeorus sp.	nymph	1	2	1	2	1		1	4	5	6	1	22		27	
Family: Ephemerellidae	nymph		98	5		2					5	1				2
Drunella coloradensis	nymph															
Drunella doddsi	nymph		9		2		1		2	2	1		3			3
Order: Plecoptera	nymph (juv./dam.)		1	2	39	42	34	10	18	30						
Family: Chloroperlidae	nymph	3		16	1	2	1				6	12	4	8	3	
Sweltsa sp.	nymph	1	3	8			1	1	1	3			1	2	5	
Suwallia sp.	nymph					1	5			7	13	11	5		4	5
Alloperla fraterna	nymph			12	1		2			7	5		8	1	1	
Paraperla sp.	nymph															
Family: Perlodidae	nymph		11	1												
Megarcys sp.	nymph												1			
Skwala sp.	nymph				1											
Family: Nemouridae																
Zapada sp.	nymph		79	4	1	1	14	9	9	54	76	15	1	34	4	42
Zapada haysi/orogenensis	nymph	1	1	3	4			1	7	3	5	1	5		11	
Zapada columbiana	nymph				1			1	2	4	2	1	10		10	1
Zapada cinctipes	nymph		4		3	6		1	1							
Family: Taeniopterygidae																
Taenionema sp	nymph								13							
Family: Capniidae	nymph	4	3	7	37	36	30	7	35	68	64	51	4	25	3	25
Family: Leuctridae	nymph		1	3	1	4	22	2	3	22	13	3	7	2	4	1
Order: Trichoptera	adult														1	
Order: Trichoptera	pupa	1	9													
Order: Trichoptera	larvae (juv.)				2	1	1		4	18		10		9		1
Family: Hydropsychidae	larvae		3	1	2	1	2		5	8	7			1	1	5
Arctopsyche sp.	larvae															
Parapsyche sp.	larvae		2	2		1		1	1	3	1		1		14	
Hydropsyche sp.	larvae															
Family: Rhyacophilidae																
Rhyacophila sp.	larvae			24	7	7	10	7	14	10	9	6	15		21	1
Family: Hydroptilidae																
Hydroptila sp.	larvae				1	2	3	7	1							
Family: Glossosomatidae																
Glossosoma sp.	larvae		3		2					48	50	12	1	18		31
Family: Limnephilidae				1	2				3		11					5
Ecclisomyia sp;	larvae					3	2									
Order: Coleoptera																
Family: Elmidae	adult												1			
Order: Diptera	adult	5	3	1				1	1						1	1
Order: Diptera	larvae					1			2		1					
Order: Diptera	pupa															
Order: Diptera UID A	larvae															
Order: Diptera UID B	larvae															
Family : Chironomidae	pupa													12		2
Subfamily : Chironominae	larvae															
Micropsectra sp.	larvae									1		4				
Neostempellina sp.	larvae		19													
Pseudochironomus sp.	larvae		11													
Tanytarsus sp.	larvae	1									2				1	1
Subfamily : Orthocladiinae	larvae			10			6				37	9		6	3	11
Acricotopus sp.	larvae															1
Brillia sp.	larvae										1				2	4
Chaetocladius sp.	larvae								18	5	1				1	
Corynoneura sp.	larvae		2	3	1											
Cricotopus/Orthocladius sp. A	larvae		17	5	375	305	190	202	132	14	12	3	2	1	2	
Cricotopus/Orthocladius sp. B	larvae						29									
Eukiefferiella sp.	larvae	95	23	16	32	6			2	1	6					
Parorthocladius sp.	larvae										1					
Rheocricotopus sp.	larvae		20													
Synorthocladius sp.	larvae		4				5	1						1		
Thiennemaniella sp.	larvae		1													
Tvetenia sp.	larvae			11							7			3		5
Subfamily : Diamesinae	larvae															
Diamesa sp.	larvae	165														
Pagastia sp.	larvae			5	3											
Pseudodiamesa sp.	larvae	1														
Subfamily : Tanypodinae	larvae															
Thiennemannimyia Group	larvae		2				1							1	1	
Family: Syriphidae	larvae															
Family: Psychodidae																
Pericoma sp.	larvae	1						1	1	1					2	
Family: Empididae																
Chelifera/Metachela	larvae	2	3		4	1	8	6	9	5	4		2		1	
Oreogeton sp.	larvae				1		5		1	108	118	40	53	31	53	28
Clinocera sp.	larvae															
Family: Tipulidae																
Dicranota sp.	larvae		3	3		2		1	1				1			1
Rhabdomastix sp.	larvae					1										
Hesperoconopa sp;	larvae															1
Gonomyodes sp.	larvae															
Family: Simuliidae	pupa	3			3								2			2
Simulium sp.	larvae															
Prosimulium sp.	larvae	1												1		
Order: Lepidoptera	larvae															
Order: Hemiptera												1				
Order: Collembola																
Phylum: Annelida																
Phylum: Nematoda		1	10	2	17	5	9	7	5	3	1				1	1
Class: Oligochaeta		6	1	1					1				1			
Class: Turbellaria						1	2									
Class: Hirudinea																
Class: Ostracoda		1														
Phylum: Mollusca																
Class: Gastropoda																
Order: Prostigmata	juvenile	1				1										
Order: Prostigmata	deutonymph			1				1	1	1						3
Order: Prostigmata	adult						1		2							
Family: Aturidae																
Aturus	adult		6	2	4	17	9	4	8	5	1			4		4
Family: Hygrobatidae																
Hygrobates	adult			1		1										
Family: Lebertidae																
Lebertia	adult		2	2	1		1			1						
Family: Sperchontidae																
Sperchon	adult		7	2	12	5	9	3	5	1	1	1	1	1		1
Family: Feltriidae																
Feltria	adult						1	2								1
Family: Hydryphantidae																
Wandesia	adult															1
Family: Torrenticolidae																
Torrenticola	adult			1	6											
TOTAL SUBSAMPLE		**313**	**465**	**242**	**599**	**468**	**424**	**287**	**351**	**749**	**793**	**340**	**171**	**296**	**194**	**316**
Number of taxa		**25**	**36**	**35**	**34**	**29**	**31**	**25**	**37**	**33**	**35**	**22**	**27**	**22**	**29**	**32**

Table C.2: Benthic invertebrate subsample values.

Project: Minnow Environmental Inc.
Collected: August 2007
Analysis by: Cordillera Consulting
Summerland,BC VoH 1Z6
250-494-7553
Taxonomist : Sue Salter
suesalter@shaw.ca
www.cordilleraconsulting.com

		Hess							Hess													
		V1-01			V1-02		V1-03		V1-04		V1-05		V5-01		V5-02		V5-03		V5-04		V5-05	
		4mm	2mm	300µm	coarse	fine	coarse	fine	coarse	fine	coarse	fine	coarse	fine	coarse	fine	coarse	fine	coarse	fine	coarse	fine
	Split %:	whole	1/4	1/8	whole	1/16	whole	1/4	whole	1/8	whole	1/4	whole	1/2	whole	whole	whole	whole	whole	1/2	whole	1/2
Order: Ephemeroptera							1															
Family: Ameletidae																						
Ameletus sp.	nymph			4			2	3		1	4	1										
Family: Baetidae																						
Baetis sp.	nymph			7	1	5	4	9	2	2		15		2		2		6		9		1
Baetis bicaudatus	nymph		1				1		1				1									
Acentrella sp.	nymph																					
Family: Heptageniidae	nymph	1		63	2	26	25	120	8	36	39	133	3	2		7		11		5		4
Rhithrogena sp;	nymph		1	16	2		6	1	14	1	6		1			1		1				
Cinygmula sp.	nymph				2		5				11								1			
Epeorus sp.	nymph	7	9		17		55	2	69		35		3		14		14		11		34	
Family: Ephemerellidae	nymph			3	1	3		1		1	1	9										
Drunella coloradensis	nymph	1			1		1		2		3											
Drunella doddsi	nymph																					
Order: Plecoptera	nymph (juv./dam.)							29		5	2			17		10		16		11	2	7
Family: Chloroperlidae	nymph			3		1	3	1	3		2					7		3		3	3	
Sweltsa sp.	nymph	2	2	4	3		11	1	6		28					2					2	
Suwallia sp.	nymph		11	20	21		38			1	24	4	1		6	8	9	5		4	5	4
Alloperla fraterna	nymph	11							31													
Paraperla sp.	nymph	3							4													
Family: Perlodidae	nymph																					
Megarcys sp.	nymph	2			1				2		1				3		1		1			
Skwala sp.	nymph																					
Family: Nemouridae																						
Zapada sp.	nymph			12	1	5	8	2	1	15	5	21				5				2	1	
Zapada haysi/orogenensis	nymph	16	8		12		25	1	27		36		5		6		3	2	4	1	4	1
Zapada columbiana	nymph	3			3		13	1	12		11		1		1				1			
Zapada cinctipes	nymph						1						2			1				1		
Family: Taeniopterygidae																						
Taenionema sp	nymph																					
Family: Capniidae	nymph	1		41	1	8	16	38	3	16	11	44	2	18		29		50	1	40	2	12
Family: Leuctridae	nymph					1	3	2			2	1				11				1	3	
Order: Trichoptera	adult																					
Order: Trichoptera	pupa																1					
Order: Trichoptera	larvae (juv.)											1		9		3		8		11	1	1
Family: Hydropsychidae	larvae													3		2				4		2
Arctopsyche sp.	larvae																					
Parapsyche sp.	larvae	9	1		2		8		6		6				1				2		2	
Hydropsyche sp.	larvae										1											
Family: Rhyacophilidae																						
Rhyacophila sp.	larvae	3	1		1		4		7	2	9		12	5	4	8	5	12	5	6	13	2
Family: Hydroptilidae																						
Hydroptila sp.	larvae																					
Family: Glossosomatidae																						
Glossosoma sp.	larvae					2		4	5	1	4	7	1	1		7	1	15	1	11		4
Family: Limnephilidae												2		2	1	1						
Ecclisomyia sp;	larvae												1									
Order: Coleoptera																						
Family: Elmidae	adult																					
Order: Diptera	adult			1	1				1				1			3	2	5	4	5		1
Order: Diptera	larvae																					1
Order: Diptera	pupa																					
Order: Diptera UID A	larvae															1						
Order: Diptera UID B	larvae																	1		2		
Family : Chironomidae	pupa	3	1	3			4								1	5		4		6	2	4
Subfamily : Chironominae	larvae																					
Micropsectra sp.	larvae																					
Neostempellina sp.	larvae																					
Pseudochironomus sp.	larvae																					
Tanytarsus sp.	larvae							1														
Subfamily : Orthocladiinae	larvae			50				15				25		11							1	5
Acricotopus sp.	larvae																					
Brillia sp.	larvae						2	3														
Chaetocladius sp.	larvae											1				1						
Corynoneura sp.	larvae																					
Cricotopus/Orthocladius sp. A	larvae	2		29	2	16	9	30	28	49	48	98	23	89	4	85	1	48	4	48	5	34
Cricotopus/Orthocladius sp. B	larvae																					
Eukiefferiella sp.	larvae			51		8		10	7	16	19	30		23		13		6		7	4	17
Parorthocladius sp.	larvae																					
Rheocricotopus sp.	larvae																					
Synorthocladius sp.	larvae																					
Thiennemaniella sp.	larvae																					
Tvetenia sp.	larvae																					7
Subfamily : Diamesinae	larvae																					
Diamesa sp.	larvae													10		9		5	1	8		5
Pagastia sp.	larvae		2			5	4	1	2	6	10	6	1	2		4		2		6		1
Pseudodiamesa sp.	larvae																					
Subfamily : Tanypodinae	larvae																					
Thiennemannimyia Group	larvae																					
Family: Syriphidae	larvae													1 (?)								
Family: Psychodidae																						
Pericoma sp.	larvae													3				2	1	1	1	
Family: Empididae																						
Chelifera/Metachela	larvae												1	4	2	1		1	1		1	
Oreogeton sp.	larvae	1					2				1		1				1					
Clinocera sp.	larvae																1	1				
Family: Tipulidae																						
Dicranota sp.	larvae					1					1	1	1	1						1		1
Rhabdomastix sp.	larvae																				1	
Hesperoconopa sp;	larvae																			3		
Gonomyodes sp.	larvae													2					1		4	
Family: Simuliidae	pupa		1				1				2			1	1		1				4	2
Simulium sp.	larvae																					
Prosimulium sp.	larvae																					
Order: Lepidoptera	larvae																					
Order: Hemiptera																		1				
Order: Collembola														1		1		2		1	1	1
Phylum: Annelida																						
Phylum: Nematoda				1			1				1					2		1	1	1	1	1
Class: Oligochaeta						1							2	28	3	4		2	4	39	6	16
Class: Turbellaria																						
Class: Hirudinea																						
Class: Ostracoda																						
Phylum: Mollusca																						
Class: Gastropoda																			2			
Order: Prostigmata	juvenile																					
Order: Prostigmata	deutonymph							2						1								
Order: Prostigmata	adult						1			1												
Family: Aturidae																						
Aturus	adult							6						2								2
Family: Hygrobatidae																						
Hygrobates	adult									1		3										
Family: Lebertidae																						
Lebertia	adult											1										
Family: Sperchontidae																						
Sperchon	adult						1	2		1		3		4		2		1	1	2		
Family: Feltriidae																						
Feltria	adult					1						7		6		8		13				
Family: Hydryphantidae																						
Wandesia	adult																					
Family: Torrenticolidae																						
Torrenticola	adult																					
TOTAL SUBSAMPLE		**65**	**38**	**308**	**74**	**83**	**255**	**285**	**241**	**155**	**323**	**413**	**63**	**247**	**47**	**243**	**40**	**224**	**47**	**239**	**103**	**136**
Number of taxa		**15**	**11**	**16**	**18**	**14**	**29**	**24**	**22**	**17**	**28**	**21**	**19**	**25**	**13**	**30**	**12**	**27**	**19**	**28**	**24**	**25**

Table C.2: Benthic invertebrate subsample values.

Project: Minnow Environmental Inc.
Collected: August 2007
Analysis by: Cordillera Consulting
Summerland,BC VoH 1Z6
250-494-7553
Taxonomist : Sue Salter
suesalter@shaw.ca
www.cordilleraconsulting.com

		Artificial Substrate																				
		V1-A	V1-E			V5-A			V5-B			V27-E		V27-D			V8-E			V8-D		
		all	4mm	2mm	300µm	4mm	2mm	300µm	4mm	2mm	300µm	coarse	fine	4mm	2mm	300µm	4mm	2mm	300µm	4mm	2mm	300µm
	Split %:	whole	whole	whole	1/8	1/4	1/2	1/8	1/4	1/2	1/8	whole	whole	whole	whole	1/8	1/4	1/2	1/4	1/4	1/2	1/8
Order: Ephemeroptera																						
Family: Ameletidae																						
Ameletus sp.	nymph									1		1	3						1			
Family: Baetidae																						
Baetis sp.	nymph	8		8	45						3		9	2		46			24		1	2
Baetis bicaudatus	nymph	1																				
Acentrella sp.	nymph																					
Family: Heptageniidae	nymph	16			4			1			8	2	3		2	16		1	12		1	5
Rhithrogena sp;	nymph	9		4									1		3			1	1			
Cinygmula sp.	nymph						1						2	1	1							
Epeorus sp.	nymph	20		29	2		3			4				4	10			3			1	
Family: Ephemerellidae	nymph							3											1			
Drunella coloradensis	nymph	1																				
Drunella doddsi	nymph	1											1									
Order: Plecoptera	nymph (juv./dam.)	6			5			23			27		1	1		8		9	67			34
Family: Chloroperlidae	nymph																					
Sweltsa sp.	nymph	1											1									
Suwallia sp.	nymph									3												
Alloperla fraterna	nymph																					
Paraperla sp.	nymph																					
Family: Perlodidae	nymph																		2			
Megarcys sp.	nymph		4											2	1							
Skwala sp.	nymph																					
Family: Nemouridae																						
Zapada sp.	nymph	15		1	19	1		51		2	15	2	38	2		40		3	56			16
Zapada haysi/orogenensis	nymph	12		38	2	2	33	2	1	55	4	3	16	5	32	4	6	32	24	5	31	2
Zapada columbiana	nymph	7		23	4	1			1	5		3	7	2	10	1		10	7	1	5	
Zapada cinctipes	nymph			2			3						1				1	7	13		5	4
Family: Taeniopterygidae		1																				
Taenionema sp	nymph				2		1				1											
Family: Capniidae	nymph	3			3		1	12		1	27		2					3	18			7
Family: Leuctridae	nymph										1											
Order: Trichoptera	adult																					
Order: Trichoptera	pupa																					
Order: Trichoptera	larvae (juv.)	11											7			5						
Family: Hydropsychidae	larvae			1	1			7		1	4	1	17		1	5	1	1	54		1	11
Arctopsyche sp.	larvae																					
Parapsyche sp.	larvae	1	5	3					3	2		1	2	5			2	1		1	1	
Hydropsyche sp.	larvae																					
Family: Rhyacophilidae																						
Rhyacophila sp.	larvae	2	7	12		10	40	7	10	32	6	7	3	7	11	2	3	17	17	2	9	3
Family: Hydroptilidae																						
Hydroptila sp.	larvae																					1
Family: Glossosomatidae																						
Glossosoma sp.	larvae	3											12			3			1			
Family: Limnephilidae				2				1					4									
Ecclisomyia sp;	larvae									1												
Order: Coleoptera																						
Family: Elmidae	adult																					
Order: Diptera	adult																					
Order: Diptera	larvae									2												
Order: Diptera	pupa				1																	
Order: Diptera UID A	larvae																					
Order: Diptera UID B	larvae																					
Family : Chironomidae	pupa	7	13	3	7	1	1	8			4		3	2	2	4		2	2	2		3
Subfamily : Chironominae	larvae																					
Micropsectra sp.	larvae																					
Neostempellina sp.	larvae																					
Pseudochironomus sp.	larvae																					
Tanytarsus sp.	larvae																	1				
Subfamily : Orthocladiinae	larvae	6		6	11			18									4	5	71			19
Acricotopus sp.	larvae																					
Brillia sp.	larvae	2		5	3			23			7		9			8	1	2	13	1	5	12
Chaetocladius sp.	larvae																					
Corynoneura sp.	larvae																				1	
Cricotopus/Orthocladius sp. A	larvae	17		8	15			40		1	17	1	13						28	2	4	32
Cricotopus/Orthocladius sp. B	larvae																					
Eukiefferiella sp.	larvae	7			7			31				1	7			28						17
Parorthocladius sp.	larvae																					
Rheocricotopus sp.	larvae																					
Synorthocladius sp.	larvae										6											
Thiennemaniella sp.	larvae																					
Tvetenia sp.	larvae							1					8									
Subfamily : Diamesinae	larvae																					
Diamesa sp.	larvae	1																				
Pagastia sp.	larvae				4					1	10	1				6				1	1	8
Pseudodiamesa sp.	larvae																					
Subfamily : Tanypodinae	larvae																					
Thiennemannimyia Group	larvae																					
Family: Syriphidae	larvae																					
Family: Psychodidae																						
Pericoma sp.	larvae				1		1	1		1	3								1			
Family: Empididae					1																	
Chelifera/Metachela	larvae							1											1			2
Oreogeton sp.	larvae												4	1	1	2						
Clinocera sp.	larvae															1						
Family: Tipulidae																						
Dicranota sp.	larvae																					1
Rhabdomastix sp.	larvae																					
Hesperoconopa sp;	larvae	1																				
Gonomyodes sp.	larvae																					
Family: Simuliidae	pupa			1			3		1	1	1		1					1			1	
Simulium sp.	larvae			3	3			12											1		1	
Prosimulium sp.	larvae							3			6		5		1	17			7			2
Order: Lepidoptera	larvae													1								
Order: Hemiptera																						
Order: Collembola																						
Phylum: Annelida																						
Phylum: Nematoda																						
Class: Oligochaeta								3								1						
Class: Turbellaria																						
Class: Hirudinea																						
Class: Ostracoda																						
Phylum: Mollusca																						
Class: Gastropoda																						
Order: Prostigmata	juvenile																					
Order: Prostigmata	deutonymph																					
Order: Prostigmata	adult	1																				
Family: Aturidae																						
Aturus	adult	1														1			4			7
Family: Hygrobatidae																						
Hygrobates	adult	1																				
Family: Lebertidae																						
Lebertia	adult																					
Family: Sperchontidae																						
Sperchon	adult	4			1								3						1			1
Family: Feltriidae																						
Feltria	adult							7			5											
Family: Hydryphantidae																						
Wandesia	adult																					
Family: Torrenticolidae																						
Torrenticola	adult																					
TOTAL SUBSAMPLE		**166**	**29**	**149**	**141**	**15**	**87**	**255**	**16**	**113**	**155**	**23**	**183**	**35**	**75**	**198**	**18**	**99**	**427**	**15**	**68**	**189**
Number of taxa		**29**	**4**	**17**	**21**	**5**	**10**	**21**	**5**	**16**	**19**	**11**	**28**	**13**	**12**	**19**	**7**	**17**	**25**	**8**	**15**	**21**

Table C.3: Number of taxa, after proportional attribution of some taxa, and collapse to higher level of others. Used for BC dist., CA, Simpsons indices.

a) Hess samples:

	countif	Sample ID:	UWFV	USFR	NEXC	V1-1	V1-2	V1-3	V1-4	V1-5	V27-1	V27-2	V27-3	V27-4	V27-5	V5-1	V5-2	V5-3	V5-4	V5-5	V8-1	V8-2	V8-3	V8-4	V8-5
Ameletus sp.	13		42	33	53	107	0	47	27	27	93	27	13	60	83	0	0	0	0	0	13	0	0	0	0
Baetis bicaudatus + Baetis sp.	22		69	507	7	200	270	136	63	200	800	800	493	710	1040	16	7	20	60	7	93	0	80	80	53
Acentrella sp.	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7
Family Heptageniidae (including identified Rhithrogena sp. Cinygmula sp. Epeorus sp.)	23		22	153	520	2266	1464	1946	1290	2077	3320	3599	1613	2970	2384	36	73	87	73	140	334	173	186	214	226
Family Ephemerellidae (including identified Drunella coloradensis, D. doddsi)	16		0	713	33	83	166	16	34	133	27	80	13	10	133	0	0	0	0	0	27	27	13	0	13
Family Chloroperlidae (including identified Sweltsa sp., Suwallia sp., Alloperla fratema, Paraperla sp.)	23		27	20	248	947	133	256	191	234	260	320	307	354	177	4	86	67	55	74	37	58	157	35	8
Family Perlodidae (including identified Megarcys sp., Skwala sp.)	11		0	75	7	7	3	0	8	3	0	0	0	3	0	0	11	4	3	0	19	0	0	0	0
Zapada spp. (including identified Z. columbiana, Z. cinctipes, Z. haysi/orogenesis	23		7	621	49	490	320	268	588	456	936	1107	226	960	1230	38	48	20	50	28	171	135	245	421	153
Taenionema sp	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	105
Family: Capniidae	23		27	20	49	1097	430	715	482	626	1044	853	680	680	677	180	108	197	314	107	710	699	525	245	280
Family: Leuctridae	18		0	7	21	0	53	47	0	20	337	173	40	77	40	0	41	0	8	12	19	77	384	70	24
Family Hydropsychidae (including identified Parapsyche sp., Hydropsyche sp.)	20		0	33	20	43	7	27	20	24	177	106	0	39	188	27	11	0	44	22	30	28	28	27	46
Rhyacophila sp.	21		0	0	160	23	3	13	77	32	161	120	109	65	99	97	44	68	74	62	105	99	140	187	106
Hydroptila sp.	5		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	29	42	187	8
Glossosoma sp.	16		0	20	0	0	107	53	43	114	772	667	217	627	845	13	26	63	100	29	30	0	0	0	0
Family: Limnephilidae (including identified Ecclisomyia sp.)	10		0	0	7	0	0	0	0	29	0	147	0	0	136	21	8	0	0	0	30	43	28	0	23
Family: Elmidae	1	adult	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0
Order: Diptera UID A	1	larvae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0
Order: Diptera UID B	2	larvae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	13	0	0	0	0	0	0
Micropsectra sp.	2	larvae	0	0	0	0	0	0	0	0	13	0	53	0	0	0	0	0	0	0	0	0	0	0	0
Neostempellina sp.	1	larvae	0	127	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pseudochironomus sp.	1	larvae	0	73	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tanytarsus sp.	4	larvae	7	0	0	0	0	13	0	0	0	27	0	0	30	0	0	0	0	0	0	0	0	0	0
Acricotopus sp.	1		0	0	0	0	0	0	0	0	0	0	0	0	41	0	0	0	0	0	0	0	0	0	0
Brillia sp.	3		0	0	0	0	0	59	0	0	0	20	0	0	171	0	0	0	0	0	0	0	0	0	0
Chaetocladius sp.	6		0	0	0	0	0	0	0	15	67	20	0	0	5	0	3	0	0	0	0	0	0	0	120
Corynoneura sp.	3		0	13	24	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	0	0
Cricotopus/Orthocladius sp. A	22		0	113	40	1079	860	536	1400	1682	187	251	70	51	11	725	297	163	333	263	5000	4067	2599	5387	880
Cricotopus/Orthocladius sp. B	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	397	0	0
Eukiefferiella sp.	18		633	153	131	1882	427	166	450	531	13	126	0	0	0	165	43	20	47	137	427	80	0	0	13
Parorthocladius sp.	1		0	0	0	0	0	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	0	0
Rheocricotopus sp.	1		0	133	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Synorthocladius sp.	4		0	27	0	0	0	0	0	0	0	0	0	41	0	0	0	0	0	0	0	0	69	27	0
Thiennemaniella sp.	1		0	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tvetenia sp.	5		0	0	89	0	0	0	0	0	0	146	0	123	202	0	0	0	0	51	0	0	0	0	0
Diamesa sp.	6	larvae	1100	0	0	0	0	0	0	0	0	0	0	0	0	67	30	17	57	33	0	0	0	0	0
Pagastia sp.	12	larvae	0	0	33	27	267	27	167	113	0	0	0	0	0	17	13	7	40	7	40	0	0	0	0
Pseudodiamesa sp.	1	larvae	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Thiennemannimyia Group	4	larvae	0	13	0	0	0	0	0	0	0	0	0	27	3	0	0	0	0	0	0	0	13	0	0
Family: Syriphidae	1	larvae	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0	0	0
Pericoma sp.	9	larvae	7	0	0	0	0	0	0	0	13	0	0	0	7	20	0	7	10	3	0	0	0	27	7
Chelifera/Metachela	16	larvae	13	20	0	0	0	0	0	0	67	53	0	7	3	30	10	3	3	3	53	13	107	160	60
Oreogeton sp.	13	larvae	0	0	0	3	0	7	0	3	1440	1573	533	1003	923	3	0	3	0	0	13	0	67	0	7
Clinocera sp.	1	larvae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0	0
Dicranota sp.	12	larvae	0	20	20	0	53	0	0	17	0	0	0	3	27	10	0	0	7	7	0	27	0	27	7
Rhabdomastix sp.	2	larvae	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	13	0	0	0
Hesperoconopa sp;	2	larvae	0	0	0	0	0	0	0	0	0	0	0	0	27	0	0	0	20	0	0	0	0	0	0
Gonomyodes sp.	3	larvae	0	0	0	0	0	0	0	0	0	0	0	0	0	13	0	0	3	13	0	0	0	0	0
Family Simuliidae (including identified Prosimulium sp.)	11		27	0	0	13	0	3	0	7	0	0	0	34	53	7	3	3	0	27	40	0	0	0	0
Order: Hemiptera	2		0	0	0	0	0	0	0	0	0	0	13	0	0	0	0	3	0	0	0	0	0	0	0
Order: Collembola	5		0	0	0	0	0	0	0	0	0	0	0	0	0	7	3	7	7	10	0	0	0	0	0
Phylum: Nematoda	18		7	67	13	27	0	3	0	3	40	13	0	0	30	0	7	3	10	10	227	67	120	187	33
Class: Oligochaeta	11		40	7	7	0	53	0	0	0	0	0	0	3	0	193	23	7	273	127	0	0	0	0	7
Class: Turbellaria	2		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	27	0	0
Class: Ostracoda	1		7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Class: Gastropoda	1		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7	0	0	0	0	0	0
Aturus	14		0	40	15	0	0	97	0	0	75	13	0	107	139	14	0	0	0	13	53	236	126	118	63
Hygrobates	4		0	0	8	0	0	0	36	40	0	0	0	0	0	0	0	0	0	0	0	14	0	0	0
Lebertia	6		0	13	15	0	0	0	0	13	15	0	0	0	0	0	0	0	0	0	13	0	14	0	0
Sperchon	19		0	47	15	0	0	36	36	40	15	13	13	30	35	29	7	3	17	0	160	70	126	88	39
Feltria	8		0	0	0	0	53	0	0	93	0	0	0	0	35	43	27	43	0	0	0	0	14	58	0
Wandesia	1		0	0	0	0	0	0	0	0	0	0	0	0	35	0	0	0	0	0	0	0	0	0	0
Torrenticola	2		0	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	80	0	0	0	0
Order Prostigmata (including juveniles, deutonymphs, adults)	1		7																						
Number of Taxa after collapse, attribution			17	27	25	16	17	21	16	25	22	24	15	24	30	25	24	24	25	24	26	20	23	18	24

b) Artificial Substrate samples:

	Sample ID:		V1-A	V1-B	V1-C	V1-D	V1-E	V27-A	V27-B	V27-C	V27-D	V27-E	V5-A	V5-B	V5-C	V5-D	V5-E	V8-A	V8-B	V8-C	V8-D	V8-E
Ameletus sp.	nymph		0	22	0	3	0	0	0	1	0	4	0	2	0	0	0	0	0	1	0	4
Baetis sp.	nymph		9	1	16	25	368	24	36	41	370	9	0	24	0	4	32	2	16	7	18	96
Rhithrogena sp;	nymph		14	7	12	19	7	89	10	10	24	3	0	0	0	0	0	19	12	8	0	31
Cinygmula sp.	nymph		0	18	0	9	0	55	91	85	16	5	4	0	0	0	0	13	4	9	0	0
Epeorus sp.	nymph		31	7	37	43	74	82	34	8	110	0	12	72	18	25	23	15	22	34	44	31
Ephemerellidae (Drunella doddsi, D. coloradensis, D. spinifera, Serratella tibialis, unid. Ephemerellidae)			2	3	0	6	0	3	9	3	0	1	24	0	0	0	0	0	4	6	0	4
Family: Chloroperlidae	nymph	combine	1	1	8	0	0	5	1	1	0	1	0	8	0	3	75	1	0	1	0	0
Family: Perlodidae	nymph	combine	0	0	19	7	5	3	3	1	3	0	0	0	2	5	2	0	4	3	0	12
Zapada haysi/orogenensis	nymph		25	3	144	75	145	448	39	45	369	45	599	366	207	44	205	49	223	133	324	474
Zapada columbiana	nymph		14	0	23	15	148	18	3	5	107	24	27	35	83	8	14	7	24	16	46	124
Zapada cinctipes	nymph		0	0	0	0	5	0	0	0	0	2	40	0	8	0	0	0	0	0	139	180
Taenionema sp	nymph		1	0	0	7	18	167	10	4	0	0	3	11	62	20	12	27	52	132	0	0
Family: Capniidae	nymph		3	4	17	27	27	25	10	4	0	2	127	308	201	13	414	2	18	40	101	114
Family: Leuctridae	nymph		0	0	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	0	0	0
Family: Hydropsychidae (include Arctopsyche, Parapsyche, Hydropsyche)	larvae	combine	3	0	16	20	17	124	38	19	64	24	56	50	24	13	90	16	61	67	96	232
Rhyacophila sp.	larvae		6	0	4	3	19	135	30	10	47	11	176	152	177	36	339	22	46	34	50	114
Hydroptila sp.	larvae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	8	0
Glossosoma sp.	larvae		9	2	4	0	0	5	63	30	33	14	0	0	0	0	0	0	0	0	0	4
Family: Limnephilidae (includes Ecclisomyia)		combine	0	0	0	0	2	4	0	0	0	5	8	2	0	0	0	0	0	1	0	0
Oligophleboides sp.	larvae		0	0	0	0	0	0	10	2	0	0	0	0	0	2	0	0	0	3	0	0
Order: Coleoptera	adult		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Tanytarsus sp.	larvae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2
Brillia sp.	larvae		2	0	28	38	42	2	1	3	64	9	219	56	35	2	0	0	42	19	110	60
Chaetocladius sp.	larvae		0	0	0	94	0	0	3	0	0	0	0	0	236	8	241	28	167	288	152	310
Corynoneura sp.	larvae		0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0
Cricotopus/Orthocladius sp. A	larvae		21	6	66	41	184	2	1	29	0	14	381	138	72	6	32	9	45	32	272	112
Eukiefferiella sp.	larvae		9	3	32	6	81	7	6	21	224	8	295	0	24	14	82	0	10	6	136	0
Synorthocladius sp.	larvae		0	0	0	0	0	0	0	0	0	0	0	48	0	0	0	0	0	0	0	0
Tvetenia sp.	larvae		0	0	0	0	0	0	0	0	0	8	10	0	0	0	0	0	0	0	0	0
Diamesa sp.	larvae		1	0	0	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pagastia sp.	larvae		0	0	5	6	32	0	0	2	48	1	0	82	0	0	0	0	0	0	70	0
Pseudodiamesa sp.	larvae		0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pericoma sp.	larvae		0	0	8	0	8	2	0	0	0	0	10	26	136	6	176	0	2	1	0	4
Family: Empididae		combine	0	0	0	0	8	2	4	2	26	4	8	0	16	0	32	0	2	0	16	4
Dicranota sp.	larvae		0	0	0	0	0	1	0	0	0	0	0	0	24	2	2	0	1	0	8	0
Hesperoconopa sp;	larvae		1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Limnophila sp.	larvae		0	0	0	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0
Tipula sp.	larvae		0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0
Family Simuliidae (includes pupae and Simulium and Prosimulium larvae)			0	0	8	0	28	33	8	7	137	6	126	62	8	4	68	4	17	17	20	34
Family : Stratiomyiidae	larvae		0	0	0	0	0	0	0	0	0	0	0	2	1	0	1	0	0	0	0	0
Order: Collembola			0	0	0	0	0	3	0	0	0	0	0	0	16	0	0	0	3	0	0	0
Class: Oligochaeta		combine	0	0	0	0	0	0	0	0	8	0	24	0	2	0	0	0	0	1	0	0
Class: Ostracoda			0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0
Class : Arachnida			0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0
Order : Mesostigmata			0	0	0	0	0	0	0	0	0	0	0	0	24	0	0	0	0	0	0	0
Aturus	adult		1	0	0	0	0	36	0	0	8	0	0	0	0	0	0	9	24	11	56	16
Hygrobates	adult		1	0	8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lebertia	adult		0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0
Sperchon	adult		4	0	4	0	8	3	0	0	0	3	0	0	0	2	0	0	3	7	8	4
Feltria	adult		0	0	4	0	0	0	0	0	0	0	56	40	24	6	32	0	0	0	0	0
		new nind	158	78	466	447	1226	1278	411	335	1657	203	2204	1496	1401	223	1876	223	803	877	1676	1966
		new arntaxa	20	13	22	19	20	26	21	23	17	22	20	20	23	20	21	15	24	26	20	22

Table C.4: Benthic metrics for Hess and artificial substrate sampling stations, Vangorda Creek, 2007.

Station	Area	Area	Hess Density (Individuals/m2)	Hess Number of Taxa	Hess Ephemeroptera (%)	Hess Plecoptera (%)	Hess Trichoptera (%)	Hess EPT (%)	Hess Chironomids (%)	Hess Simpson's D	Hess Simpson's E	Hess Simpsons E (Krebs)	Hess B-C Dist. to V-1 median	Hess Vangorda CA Axis-1 (24.4%)	Hess Vangorda CA Axis-2 (17.2%)	Hess Vangorda CA Axis-3 (14.7%)	Hess All Stations CA Axis-1 (22.4%)	Hess All Stations CA Axis-2 (15.0%)	Hess All Stations CA Axis-3 (13.3%)	Hess Reference Stations CA Axis-1 (36.6%)
UWFV	UWFV	UWFV Ref. Alternate	2057.0	17	6.5100	2.9700	0.3400	9.8200	84.9300	0.6139	0.1524	0.6523	0.8288	.	.	.	1.0582	0.3365	0.4849	-1.0485
USFR	USFR	USFR Ref. Alternate	3080.0	27	45.6500	22.3400	3.6700	71.6600	21.4000	0.8658	0.2760	0.8991	0.6881	.	.	.	-0.2553	-0.1998	-0.1772	0.0044
NEXC	NEXC	NEXC Ref. Alternate	1607.0	25	38.1500	23.2700	11.6400	73.0600	20.7200	0.8431	0.2549	0.8782	0.6540	.	.	.	-0.0817	0.0883	-0.4013	0.0746
V1-1	V1	V1 Reference	8909.0	16	29.8100	28.5200	0.7400	59.0800	40.4400	0.8220	0.3512	0.8768	0.2413	-0.0324	-0.3920	0.3887	0.0436	0.2355	-0.4374	-0.3470
V1-2	V1	V1 Reference	4669.0	17	40.6900	20.1100	2.5100	63.3100	33.2800	0.8365	0.3597	0.8888	0.1811	-0.3638	-0.2437	0.2924	0.2480	0.0379	-0.4594	0.3978
V1-3	V1	V1 Reference	4648.0	21	46.1500	29.9900	2.0000	78.1400	18.5700	0.7604	0.1987	0.7984	0.1602	0.2650	-0.4238	-0.0478	-0.1847	0.4679	0.0149	-0.0543
V1-4	V1	V1 Reference	4935.0	16	28.6500	26.0000	2.8400	57.4900	40.8700	0.8141	0.3362	0.8683	0.1626	-0.1136	-0.4392	0.6588	0.0341	0.1798	-0.7592	0.1256
V1-5	V1	V1 Reference	6582.0	25	37.0300	20.3600	3.0400	60.4200	36.3000	0.8083	0.2087	0.8420	0.0964	-0.0092	-0.2252	0.4789	-0.0563	0.0673	-0.4989	0.2097
V27-1	V27	V27 Exposure NF	9985.0	22	42.4600	26.4300	11.6200	80.5100	2.8000	0.8297	0.2669	0.8692	0.4943	0.3128	-0.0238	-0.0094	-0.2929	0.0975	0.1278	.
V27-2	V27	V27 Exposure NF	10569.0	24	42.6300	23.2100	9.8400	75.6800	8.4400	0.8223	0.2345	0.8581	0.4781	0.4297	-0.3042	-0.3288	-0.3393	0.4630	0.3013	.
V27-3	V27	V27 Exposure NF	4530.0	15	47.0600	27.6600	8.2300	82.9600	4.7000	0.8028	0.3380	0.8601	0.3643	0.2948	-0.3204	0.0045	-0.2827	0.3395	-0.0183	.
V27-4	V27	V27 Exposure NF	8464.0	24	44.3100	24.5000	9.4900	78.3000	7.6400	0.8075	0.2164	0.8426	0.4451	0.3885	-0.0303	-0.3931	-0.3462	0.1727	0.2813	.
V27-5	V27	V27 Exposure NF	9042.0	30	40.2600	23.4900	14.0200	77.7700	7.4300	0.8643	0.2457	0.8942	0.4799	0.4348	-0.2650	-0.4990	-0.3192	0.4689	0.4348	.
V5-1	V5	V5 Exposure FF	1858.0	25	2.8000	14.5300	9.6300	26.9600	52.7400	0.7972	0.1973	0.8304	0.6435	-0.8108	0.2074	-0.3201	0.7855	-0.2347	0.2520	.
V5-2	V5	V5 Exposure FF	956.0	24	8.3700	31.0700	9.4100	48.8500	42.4700	0.8572	0.2918	0.8945	0.7562	-0.5451	0.0260	0.0071	0.4869	-0.1107	-0.0430	.
V5-3	V5	V5 Exposure FF	856.0	24	12.5000	34.7000	16.3600	63.5500	25.7000	0.8682	0.3163	0.9060	0.7835	-0.6568	-0.0259	-0.0986	0.6402	-0.0540	0.0380	.
V5-4	V5	V5 Exposure FF	1704.0	25	7.8100	26.0000	14.1400	47.9500	30.3400	0.8778	0.3273	0.9144	0.6852	-0.8069	0.0326	-0.1618	0.7491	-0.1178	0.0232	.
V5-5	V5	V5 Exposure FF	1244.0	24	11.8200	18.7300	9.1600	39.7100	42.3600	0.8925	0.3876	0.9313	0.7397	-0.7270	0.0008	-0.5179	0.7447	0.0151	0.2731	.
V8-1	V8	V8 Exposure FFF	7984.0	26	5.8500	14.8300	2.6800	23.3600	68.6400	0.5683	0.0891	0.5910	0.5443	0.1051	0.1020	0.2800	-0.1449	-0.1600	-0.1537	.
V8-2	V8	V8 Exposure FFF	6238.0	20	3.2100	19.6500	3.1900	26.0500	66.4800	0.5178	0.1037	0.5450	0.5972	0.1513	0.4242	0.4054	-0.2676	-0.4912	-0.1831	.
V8-3	V8	V8 Exposure FFF	5652.0	23	4.9400	25.7100	4.2500	34.8900	54.4900	0.7510	0.1746	0.7851	0.5601	0.4451	0.6858	0.0342	-0.5034	-0.5830	0.2376	.
V8-4	V8	V8 Exposure FFF	7632.0	18	3.8500	11.2000	5.2500	20.3100	70.9400	0.4824	0.1073	0.5107	0.6625	0.1488	0.8690	0.0780	-0.2330	-0.8253	0.2669	.
V8-5	V8	V8 Exposure FFF	2333.0	24	12.8200	25.4600	8.0200	46.2900	43.4200	0.8127	0.2224	0.8480	0.5475	0.1322	0.3891	0.0388	-0.1941	-0.3409	0.1908	.

Table C.4: Benthic metrics for Hess and artificial substrate sampling stations, Vangorda Creek, 2007.

Station	Area	Area	Hess Reference Stations CA Axis-2 (19.3%)	Hess Reference Stations CA Axis-3 (17.8%)	Artificial Substrate Abundance (ind./m2)	Artificial Substrate Number of Taxa	Artificial Substrate Ephemeroptera (%)	Artificial Substrate Plecoptera (%)	Artificial Substrate Trichoptera (%)	Artificial Substrate EPT (%)	Artificial Substrate Chironomids (%)	Art. Substrate Simpson's D	Art. Substrate Simpson's E	Art. Substrate Simpson's E (Krebs)	Art. Substrate B-C Dist. to V-1 median	Artificial Substrate CA-1 (23.8%)	Artificial Substrate CA-2 (13.5%)	Artificial Substrate CA-3 (12.5%)	Artificial Substrate CA-4 (9.9%)	Artificial Substrate CA-5 (8.7%)
UWFV	UWFV	UWFV Ref. Alternate	0.3270	-0.1413	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
USFR	USFR	USFR Ref. Alternate	-0.4010	-0.4375	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
NEXC	NEXC	NEXC Ref. Alternate	-0.2826	0.1137	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
V1-1	V1	V1 Reference	-0.0114	0.0659	166.0	20	33.7349	27.1084	10.2410	71.0843	24.0964	0.8906	0.4570	0.9375	0.3582	-0.3730	0.0850	0.0610	-0.1560	-0.1810
V1-2	V1	V1 Reference	0.3305	-0.2463	81.0	13	71.6049	9.8765	2.4691	83.9506	16.0494	0.8359	0.4687	0.9056	0.8054	-1.2490	0.0010	-0.6230	1.2350	-0.1970
V1-3	V1	V1 Reference	0.0496	0.1139	494.0	22	13.1579	42.9150	4.8583	60.9312	32.3887	0.8594	0.3233	0.9003	0.2426	0.0430	0.2040	-0.2030	-0.2210	-0.3760
V1-4	V1	V1 Reference	-0.1330	0.3560	467.0	19	22.4839	27.8373	4.9251	55.2463	44.7537	0.8893	0.4756	0.9387	0.2443	-0.2620	-0.1060	0.1030	0.2550	-0.2580
V1-5	V1	V1 Reference	0.1904	0.0528	1306.0	20	34.3798	26.6462	2.9096	63.9357	31.4701	0.8470	0.3268	0.8916	0.6317	0.1050	0.3430	0.1140	-0.1680	-0.2270
V27-1	V27	V27 Exposure NF	.	.	1279.0	26	19.7811	51.9937	20.9539	92.7287	0.8600	0.8265	0.2216	0.8595	0.7250	-0.2430	-0.2710	0.0480	-0.1810	0.1420
V27-2	V27	V27 Exposure NF	.	.	411.0	21	43.7956	16.3017	34.3066	94.4039	2.6764	0.8868	0.4205	0.9311	0.5724	-0.6570	-0.2590	-0.2390	-0.3110	0.2910
V27-3	V27	V27 Exposure NF	.	.	335.0	23	44.1791	18.2090	18.2090	80.5970	16.4179	0.8760	0.3507	0.9158	0.4940	-0.6280	0.0350	-0.2290	-0.1540	0.1140
V27-4	V27	V27 Exposure NF	.	.	1693.0	17	30.6556	28.2930	8.5056	67.4542	21.9728	0.8614	0.4243	0.9152	0.7718	-0.2870	0.4440	0.1080	-0.4270	0.1670
V27-5	V27	V27 Exposure NF	.	.	206.0	22	10.6796	35.9223	26.2136	72.8155	20.8738	0.9001	0.4551	0.9430	0.4610	-0.3720	0.4400	-0.0730	0.1780	0.0800
V5-1	V5	V5 Exposure FF	.	.	2274.0	20	1.7590	35.0044	10.5541	47.3175	42.8320	0.8534	0.3410	0.8983	0.8238	0.3360	0.4260	-0.2100	0.2230	0.5830
V5-2	V5	V5 Exposure FF	.	.	1532.0	20	6.3969	48.3029	13.3159	68.0157	23.2376	0.8664	0.3743	0.9120	0.7129	0.3680	0.2100	-0.4620	0.0050	-0.3730
V5-3	V5	V5 Exposure FF	.	.	1401.0	23	1.2848	40.1856	14.3469	55.8173	26.1956	0.8931	0.4066	0.9337	0.7331	0.7220	-0.2800	-0.0600	0.1690	0.2830
V5-4	V5	V5 Exposure FF	.	.	223.0	20	13.0045	41.7040	22.8700	77.5785	13.4529	0.8974	0.4874	0.9446	0.4667	0.3150	-0.3350	-0.2460	-0.1760	-0.1120
V5-5	V5	V5 Exposure FF	.	.	1876.0	21	2.9318	38.5394	22.8678	64.3390	18.9232	0.8727	0.3742	0.9164	0.8058	0.5040	-0.2470	-0.4010	-0.0720	-0.1390
V8-1	V8	V8 Exposure FFF	.	.	226.0	15	21.6814	38.0531	16.8142	76.5487	17.6991	0.8870	0.5898	0.9503	0.5386	-0.2300	-0.5450	0.2650	-0.0420	-0.0450
V8-2	V8	V8 Exposure FFF	.	.	818.0	24	7.0905	39.2421	13.0807	59.4132	33.9853	0.8564	0.2902	0.8936	0.5166	0.0370	-0.3530	0.3240	0.0060	0.0380
V8-3	V8	V8 Exposure FFF	.	.	883.0	26	7.2480	36.8063	12.0045	56.0589	39.7508	0.8324	0.2294	0.8657	0.5831	-0.1270	-0.3550	0.1520	0.0490	0.0370
V8-4	V8	V8 Exposure FFF	.	.	1708.0	20	3.6300	35.7143	9.0164	48.3607	45.3162	0.8978	0.4893	0.9451	0.7286	0.2920	0.2680	0.5700	0.0910	-0.0920
V8-5	V8	V8 Exposure FFF	.	.	1978.0	22	8.3923	45.7027	17.6946	71.7897	25.0758	0.8765	0.3679	0.9182	0.7631	0.0000	0.0640	0.4000	0.2860	-0.0890

Table C.5: Descriptive statistics of benthic metrics at Faro Vangorda Creek study areas.

Variable	Area	n	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	Unbiased CV (%)	Average CV (%) for Sample Method
						Lower Bound	Upper Bound				
Hess Density (Individuals/m2)	V1	5	5948.600	1838.579	822.237	3665.703	8231.497	4648.000	8909.000	32.5	
	V27	5	8518.000	2373.833	1061.610	5570.497	11465.503	4530.000	10569.000	29.3	
	V5	5	1323.600	444.523	198.797	771.652	1875.548	856.000	1858.000	35.3	
	V8	5	5967.800	2248.285	1005.463	3176.186	8759.414	2333.000	7984.000	39.6	
Hess Number of Taxa	V1	5	19.000	3.937	1.761	14.110	23.890	16.000	25.000	21.8	
	V27	5	23.000	5.385	2.408	16.310	29.690	15.000	30.000	24.6	
	V5	5	24.400	0.548	0.245	23.720	25.080	24.000	25.000	2.4	
	V8	5	22.200	3.194	1.428	18.230	26.170	18.000	26.000	15.1	
Hess EPT (%)	V1	5	63.687	8.358	3.738	53.310	74.065	57.490	78.140	13.8	
	V27	5	79.044	2.781	1.244	75.590	82.497	75.680	82.960	3.7	
	V5	5	45.404	13.417	6.000	28.745	62.064	26.960	63.550	31.0	
	V8	5	30.180	10.521	4.705	17.116	43.244	20.310	46.290	36.6	
Hess Chironomids (%)	V1	5	33.892	9.119	4.078	22.569	45.215	18.570	40.870	28.3	
	V27	5	6.204	2.366	1.058	3.266	9.142	2.800	8.440	40.0	
	V5	5	38.724	10.767	4.815	25.354	52.093	25.700	52.740	29.2	
	V8	5	60.794	11.600	5.188	46.390	75.198	43.420	70.940	20.0	
Hess Simpson's D	V1	5	0.808	0.029	0.013	0.773	0.844	0.760	0.836	3.7	
	V27	5	0.825	0.024	0.011	0.795	0.856	0.803	0.864	3.1	
	V5	5	0.859	0.037	0.016	0.813	0.904	0.797	0.893	4.5	
	V8	5	0.626	0.147	0.066	0.444	0.809	0.482	0.813	24.6	
Hess Simpson's E	V1	5	0.291	0.080	0.036	0.191	0.390	0.199	0.360	28.9	
	V27	5	0.260	0.047	0.021	0.202	0.319	0.216	0.338	19.0	
	V5	5	0.304	0.069	0.031	0.218	0.390	0.197	0.388	23.9	
	V8	5	0.139	0.057	0.025	0.069	0.210	0.089	0.222	42.9	
Hess B-C Dist. to V-1 median	V1	5	0.168	0.052	0.023	0.104	0.233	0.096	0.241	32.4	
	V27	5	0.452	0.052	0.023	0.387	0.517	0.364	0.494	12.2	
	V5	5	0.722	0.057	0.025	0.651	0.792	0.643	0.784	8.2	
	V8	5	0.582	0.049	0.022	0.521	0.644	0.544	0.662	8.9	
Hess Vangorda CA Axis-1 (24.4%)	V1	5	-0.051	0.226	0.101	-0.331	0.229	-0.364	0.265	466.7	
	V27	5	0.372	0.065	0.029	0.291	0.453	0.295	0.435	18.4	
	V5	5	-0.709	0.112	0.050	-0.848	-0.571	-0.811	-0.545	16.5	
	V8	5	0.196	0.140	0.063	0.022	0.371	0.105	0.445	74.9	
Hess Vangorda CA Axis-2 (17.2%)	V1	5	-0.345	0.102	0.046	-0.472	-0.218	-0.439	-0.225	31.2	
	V27	5	-0.189	0.149	0.067	-0.374	-0.004	-0.320	-0.024	82.9	
	V5	5	0.048	0.092	0.041	-0.066	0.162	-0.026	0.207	200.4	
	V8	5	0.494	0.295	0.132	0.128	0.860	0.102	0.869	62.6	
Hess Vangorda CA Axis-3 (14.7%)	V1	5	0.354	0.262	0.117	0.029	0.680	-0.048	0.659	77.7	
	V27	5	-0.245	0.230	0.103	-0.530	0.040	-0.499	0.004	98.4	
	V5	5	-0.218	0.205	0.092	-0.473	0.037	-0.518	0.007	98.7	
	V8	5	0.167	0.167	0.075	-0.040	0.375	0.034	0.405	104.8	48.72

Table C.5: Descriptive statistics of benthic metrics at Faro Vangorda Creek study areas.

Variable	Area	n	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum	Unbiased CV (%)	Average CV (%) for Sample Method
						Lower Bound	Upper Bound				
Artificial Substrate Abundance	V1	5	502.800	484.210	216.546	-98.427	1104.027	81.000	1306.000	101.1	
	V27	5	784.800	660.704	295.476	-35.572	1605.172	206.000	1693.000	88.4	
	V5	5	1461.200	770.467	344.563	504.539	2417.861	223.000	2274.000	55.4	
	V8	5	1122.600	712.124	318.472	238.381	2006.819	226.000	1978.000	66.6	
Artificial Substrate Number of Taxa	V1	5	18.800	3.421	1.530	14.550	23.050	13.000	22.000	19.1	
	V27	5	21.800	3.271	1.463	17.740	25.860	17.000	26.000	15.8	
	V5	5	20.800	1.304	0.583	19.180	22.420	20.000	23.000	6.6	
	V8	5	21.400	4.219	1.887	16.160	26.640	15.000	26.000	20.7	
Artificial Substrate EPT (%)	V1	5	67.030	11.050	4.942	53.310	80.749	55.246	83.951	17.3	
	V27	5	81.600	11.896	5.320	66.829	96.371	67.454	94.404	15.3	
	V5	5	62.614	11.579	5.178	48.237	76.990	47.318	77.578	19.4	
	V8	5	62.434	11.560	5.170	48.080	76.788	48.361	76.549	19.4	
Artificial Substrate Chironomids (%)	V1	5	29.752	10.662	4.768	16.513	42.990	16.049	44.754	37.6	
	V27	5	12.560	10.089	4.512	0.033	25.088	0.860	21.973	84.3	
	V5	5	24.928	11.099	4.964	11.147	38.710	13.453	42.832	46.8	
	V8	5	32.365	11.103	4.966	18.579	46.152	17.699	45.316	36.0	
Art. Substrate Simpson's D	V1	5	0.864	0.025	0.011	0.834	0.895	0.836	0.891	3.0	
	V27	5	0.870	0.028	0.013	0.835	0.905	0.826	0.900	3.4	
	V5	5	0.877	0.018	0.008	0.854	0.900	0.853	0.897	2.2	
	V8	5	0.870	0.026	0.012	0.838	0.902	0.832	0.898	3.1	
Art. Substrate Simpson's E	V1	5	0.410	0.078	0.035	0.313	0.507	0.323	0.476	20.0	
	V27	5	0.374	0.094	0.042	0.258	0.491	0.222	0.455	26.2	
	V5	5	0.397	0.056	0.025	0.327	0.466	0.341	0.487	14.8	
	V8	5	0.393	0.147	0.066	0.211	0.575	0.229	0.590	39.1	
Art. Substrate B-C Dist. to V-1 median	V1	5	0.456	0.251	0.112	0.144	0.769	0.243	0.805	57.8	
	V27	5	0.605	0.138	0.062	0.433	0.776	0.461	0.772	24.0	
	V5	5	0.708	0.143	0.064	0.531	0.886	0.467	0.824	21.2	
	V8	5	0.626	0.113	0.050	0.486	0.766	0.517	0.763	18.9	
Artificial Substrate CA-1 (23.8%)	V1	5	-0.347	0.543	0.243	-1.021	0.327	-1.249	0.105	164.1	
	V27	5	-0.437	0.193	0.086	-0.677	-0.198	-0.657	-0.243	46.4	
	V5	5	0.449	0.169	0.076	0.239	0.659	0.315	0.722	39.6	
	V8	5	-0.006	0.197	0.088	-0.250	0.239	-0.230	0.292	3697.0	
Artificial Substrate CA-2 (13.5%)	V1	5	0.105	0.175	0.078	-0.112	0.322	-0.106	0.343	174.1	
	V27	5	0.078	0.354	0.158	-0.362	0.518	-0.271	0.444	478.2	
	V5	5	-0.045	0.342	0.153	-0.469	0.379	-0.335	0.426	793.7	
	V8	5	-0.184	0.337	0.151	-0.602	0.234	-0.545	0.268	192.0	
Artificial Substrate CA-3 (12.5%)	V1	5	-0.110	0.315	0.141	-0.501	0.281	-0.623	0.114	301.7	
	V27	5	-0.077	0.157	0.070	-0.273	0.119	-0.239	0.108	214.8	
	V5	5	-0.276	0.160	0.071	-0.474	-0.077	-0.462	-0.060	60.8	
	V8	5	0.342	0.156	0.070	0.148	0.536	0.152	0.570	48.0	177.35

Table C.6a:
Correspondence Analysis of Benthic Abundances for Hess samples at Vangorda Creek study areas.

	CA Axis-1	CA Axis-2	CA Axis-3	CA Axis-4
Eigenvalue	0.1782	0.1258	0.1075	0.0621
Variance Explained (%)	24.380	17.210	14.700	8.490
Cumulative Variance (%)	24.380	41.590	56.290	64.790

Table C.6b:
Correspondence Analysis of Benthic Abundances for Hess samples at Faro study areas on Pelly River drainage, 2007.

	CA Axis-1	CA Axis-2	CA Axis-3	CA Axis-4
Eigenvalue	0.1739	0.1162	0.1033	0.0653
Variance Explained (%)	22.380	14.960	13.300	8.400
Cumulative Variance (%)	22.380	37.330	50.630	59.030

Table C.6c:
Correspondence Analysis of Benthic Abundances for Artificial Substrate samples at Vangorda Creek study areas.

	CA Axis-1	CA Axis-2	CA Axis-3	CA Axis-4
Eigenvalue	0.1611	0.0914	0.0850	0.0669
Variance Explained (%)	23.780	13.490	12.540	9.880
Cumulative Variance (%)	23.780	37.270	49.810	59.690

Table C.7a: Scores for benthic taxa from CA of Hess samples at Vangorda Creek study areas (V1, V27, V5, V8).

Taxon	Hess Sampler CA Axis-1 (24.4%)	Hess Sampler CA Axis-2 (17.2%)	Hess Sampler CA Axis-3 (14.7%)	Hess Sampler CA Axis-4 (8.5%)
Ameletus sp.	0.507	-0.664	0.100	-0.174
Baetis bicaudatus + Baetis sp.	0.113	-0.164	-0.019	-0.153
Family Heptageniidae (including identified Rhithrogena sp. Cinygmula sp. Epeorus sp.)	0.055	-0.139	0.075	-0.073
Family Ephemerellidae (including identified Drunella coloradensis, D. doddsi)	0.350	-0.329	0.326	0.060
Family Chloroperlidae (including identified Sweltsa sp., Suwallia sp., Alloperla fratema, Paraperla sp.)	0.011	-0.150	0.082	-0.149
Family Perlodidae (including identified Megarcys sp., Skwala sp.)	-0.497	-0.347	0.582	-0.431
Zapada spp. (including identified Z. columbiana, Z. cinctipes, Z. haysi/orogenesis	0.077	-0.052	0.080	-0.054
Family: Capniidae	-0.026	-0.033	0.078	-0.046
Family: Leuctridae	0.262	0.181	-0.061	-0.013
Family Hydropsychidae (including identified Parapsyche sp., Hydropsyche sp.)	0.035	0.037	-0.029	0.126
Rhyacophila sp.	-0.058	0.116	-0.010	-0.023
Hydroptila sp.	0.485	1.578	0.487	0.206
Glossosoma sp.	-0.059	-0.415	-0.213	-0.160
Family: Limnephilidae (including identified Ecclisomyia sp.)	0.250	0.228	-0.068	0.613
Tanytarsus sp.	0.913	-0.912	-0.952	0.957
Brillia sp.	0.893	-0.923	-0.936	0.927
Chaetocladius sp.	0.427	-0.033	-0.065	0.775
Cricotopus/Orthocladius sp. A	-0.128	0.127	0.211	0.011
Eukiefferiella sp.	-0.399	-0.293	0.352	0.169
Synorthocladius sp.	0.803	1.418	-0.288	-1.324
Tvetenia sp.	0.429	-0.454	-1.317	-0.075
Diamesa sp.	-1.703	0.159	-0.689	-0.023
Pagastia sp.	-0.673	-0.452	0.518	-0.083
Thiennemannimyia Group	0.989	0.514	-0.792	-1.404
Pericoma sp.	-0.532	0.555	-0.482	0.260
Chelifera/Metachela	0.085	0.655	-0.153	0.142
Oreogeton sp.	0.640	-0.218	-0.423	-0.235
Dicranota sp.	-0.295	0.329	-0.017	0.292
Gonomyodes sp.	-1.840	0.252	-1.115	0.202
Family Simuliidae (including identified Prosimulium sp.)	-0.186	-0.270	-0.348	-0.192
Order: Collembola	-1.708	0.136	-0.742	-0.069
Phylum: Nematoda	0.145	0.455	0.094	0.211
Class: Oligochaeta	-1.338	0.109	-0.492	-0.043
Aturus	0.391	0.458	-0.223	0.196
Hygrobates	-0.009	-0.363	1.599	0.350
Lebertia	0.510	0.381	0.589	-0.213
Sperchon	0.144	0.246	0.110	0.052
Feltria	-0.438	0.305	0.041	-0.049

Table C.7b: Scores for benthic taxa from CA of Hess samples including new reference areas (UWFV, USFR, NEXC).

Taxon	All Hess Stations CA Axis-1 (22.4%)	All Hess Stations CA Axis-2 (15.0%)	All Hess Stations CA Axis-3 (13.3%)	All Hess Stations CA Axis-4 (8.4%)
Ameletus sp.	-0.212	0.603	-0.153	-0.307
Baetis bicaudatus + Baetis sp.	-0.047	0.163	0.025	-0.159
Family Heptageniidae (including identified Rhithrogena sp. Cinygmula sp. Epeorus sp.)	-0.049	0.113	-0.101	-0.012
Family Ephemerellidae (including identified Drunella coloradensis, D. doddsi)	-0.396	0.188	-0.383	-0.094
Family Chloroperlidae (including identified Sweltsa sp., Suwallia sp., Alloperla fratema, Paraperla sp.)	0.016	0.126	-0.113	-0.063
Family Perlodidae (including identified Megarcys sp., Skwala sp.)	0.159	-0.054	-0.744	-0.603
Zapada spp. (including identified Z. columbiana, Z. cinctipes, Z. haysi/orogenesis	-0.096	0.021	-0.075	-0.037
Family: Capniidae	0.030	0.012	-0.050	0.046
Family: Leuctridae	-0.306	-0.112	0.122	0.068
Family Hydropsychidae (including identified Parapsyche sp., Hydropsyche sp.)	-0.096	-0.044	0.000	0.067
Rhyacophila sp.	0.004	-0.109	0.014	0.161
Hydroptila sp.	-0.670	-1.585	0.299	0.383
Glossosoma sp.	0.043	0.396	0.033	-0.051
Family: Limnephilidae (including identified Ecclisomyia sp.)	-0.275	-0.119	0.180	0.604
Tanytarsus sp.	-0.107	1.299	0.960	0.382
Brillia sp.	-0.670	1.370	0.815	0.700
Chaetocladius sp.	-0.432	0.169	0.292	0.877
Cricotopus/Orthocladius sp. A	0.024	-0.222	-0.170	0.101
Eukiefferiella sp.	0.413	0.126	-0.359	0.007
Synorthocladius sp.	-0.828	-1.049	0.501	-1.350
Tvetenia sp.	-0.253	0.758	0.586	-0.161
Diamesa sp.	1.900	0.047	0.678	-0.245
Pagastia sp.	0.517	0.139	-0.791	0.113
Thiennemannimyia Group	-0.863	-0.247	0.529	-1.564
Pericoma sp.	0.697	-0.363	0.709	0.243
Chelifera/Metachela	-0.027	-0.490	0.458	0.012
Oreogeton sp.	-0.576	0.461	0.490	-0.033
Dicranota sp.	0.085	-0.361	-0.123	0.084
Gonomyodes sp.	1.827	-0.327	0.662	0.144
Family Simuliidae (including identified Prosimulium sp.)	0.490	0.381	0.327	-0.267
Order: Collembola	1.671	-0.282	0.387	0.097
Phylum: Nematoda	-0.133	-0.365	0.117	0.013
Class: Oligochaeta	1.200	-0.128	0.195	-0.207
Aturus	-0.413	-0.297	0.339	0.038
Hygrobates	-0.193	-0.054	-1.522	0.561
Lebertia	-0.534	-0.333	-0.445	-0.422
Sperchon	-0.225	-0.245	-0.015	0.058
Feltria	0.347	-0.419	0.015	0.260

Table C.7c: Scores for benthic taxa from CA of artificial substrate samples at Vangorda Creek study areas (V1, V27, V5, V8).

Taxon	Artificial Substrate CA-1 (23.8%)	Artificial Substrate CA-2 (13.5%)	Artificial Substrate CA-3 (12.5%)	Artificial Substrate CA-4 (9.9%)
Ameletus sp.	-1.217	0.219	-0.619	1.854
Baetis sp.	-0.268	0.145	0.049	-0.247
Rhithrogena sp;	-0.701	-0.153	0.146	-0.010
Cinygmula sp.	-1.029	-0.257	-0.233	0.116
Epeorus sp.	-0.116	-0.060	-0.025	-0.066
Ephemerellidae (Drunella doddsi, D. coloradensis, D. spinifera, Serratella tibialis, unid. Ephemerellidae)	-0.635	-0.092	-0.123	0.471
Family: Chloroperlidae	0.059	-0.307	-0.794	-0.197
Family: Perlodidae	-0.064	-0.178	0.045	-0.234
Zapada haysi/orogenensis	-0.009	0.015	0.002	-0.025
Zapada columbiana	0.069	0.123	0.109	-0.078
Zapada cinctipes	0.522	0.659	0.739	0.615
Taenionema sp	0.057	-0.633	-0.055	-0.155
Family: Capniidae	0.213	-0.077	-0.130	0.187
Family: Hydropsychidae (include Arctopsyche, Parapsyche, Hydropsyche)	-0.007	-0.039	0.062	-0.082
Rhyacophila sp.	0.138	-0.084	-0.041	-0.087
Glossosoma sp.	-1.065	0.288	-0.269	-0.360
Family: Limnephilidae (includes Ecclisomyia)	0.041	0.635	-0.321	0.165
Oligophleboides sp.	-0.876	-0.795	-0.509	-0.672
Brillia sp.	0.137	0.325	0.172	0.058
Chaetocladius sp.	0.309	-0.632	0.440	0.276
Cricotopus/Orthocladius sp. A	0.089	0.107	-0.009	0.235
Eukiefferiella sp.	0.002	0.243	-0.086	-0.107
Pagastia sp.	0.085	0.842	0.118	-0.320
Pericoma sp.	0.823	-0.152	-0.504	0.016
Family: Empididae	0.208	0.265	0.067	-0.142
Dicranota sp.	1.030	-0.509	0.232	0.150
Family Simuliidae (includes pupae and Simulium and Prosimulium larvae)	0.114	0.132	-0.047	-0.164
Family : Stratiomyiidae	1.257	-0.180	-1.142	0.112
Order: Collembola	0.782	-0.980	0.213	0.162
Class: Oligochaeta	0.400	0.823	-0.190	0.000
Aturus	-0.153	-0.302	0.950	-0.086
Sperchon	-0.057	0.110	0.493	-0.094
Feltria	1.035	0.076	-0.945	0.110

Table C.8: Multivariate analysis of variance (MANOVA) of benthic metrics from Hess and artificial substrate samples collected at Vangorda Creek areas, 2007.

Effect		Value	F	Hypothesis df	Error df	p-value	Observed Power
Intercept	Pillai's Trace	1	66784.48	16	1	0.003000	1.000000
	Wilks' Lambda	0	66784.48	16	1	0.003000	1.000000
	Hotelling's Trace	1068552	66784.48	16	1	0.003000	1.000000
	Roy's Largest Root	1068552	66784.48	16	1	0.003000	1.000000
AREA	Pillai's Trace	2.95	11.172	48	9	0.000000	1.000000
	Wilks' Lambda	0	51.851	48	3.768	0.001000	1.000000
	Hotelling's Trace	.	.	48	.	.	.
	Roy's Largest Root	148448.1	27834.02	16	3	0.000000	1.000000

Table C.9: Benthic Metrics from Hess and Artificial Substrate samples - ANOVA results, Vangorda Creek, 20007.

Source: Area	Dependent Variable	Mean Square	F (ANOVA)	p-value	Observed Power
	Hess Density (Individuals/m2)	44926797.9333	12.5953	0.000176	0.9979
	Hess Number of Taxa	26.1833	1.9042	0.169622	0.3998
	Hess EPT (%)	2268.2760	24.6339	0.000003	1.0000
	Hess Chironomids (%)	2515.9451	29.6642	0.000001	1.0000
	Hess Simpson's D	0.0544	8.9478	0.001032	0.9797
	Hess Simpson's E	0.0282	6.7590	0.003725	0.9305
	Hess B-C Dist. to V-1 median	0.2779	100.2708	0.000000	1.0000
	Hess Vangorda CA Axis-1 (24.4%)	1.1227	51.4445	0.000000	1.0000
	Hess Vangorda CA Axis-2 (17.2%)	0.6681	20.8981	0.000009	1.0000
	Hess Vangorda CA Axis-3 (14.7%)	0.4339	9.0614	0.000971	0.9810
	Artificial Substrate Abundance	861867.6500	1.9458	0.162926	0.4078
	Artificial Substrate Number of Taxa	8.8667	0.8465	0.488476	0.1929
	Artificial Substrate EPT (%)	408.6436	3.0764	0.057557	0.6058
	Artificial Substrate Chironomids (%)	385.9055	3.3416	0.045792	0.6454
	Art. Substrate Simpson's D	0.0001	0.2035	0.892459	0.0801
	Art. Substrate Simpson's E	0.0011	0.1106	0.952624	0.0659
	Art. Substrate B-C Dist. to V-1 median	0.0551	1.9094	0.168782	0.4008
	Artificial Substrate CA-1 (23.8%)	0.8073	8.0859	0.001671	0.9666
	Artificial Substrate CA-2 (13.5%)	0.0877	0.9077	0.459195	0.2046
	Artificial Substrate CA-3 (12.5%)	0.3458	7.9540	0.001803	0.9640

Table C.10: Summary of ANOVA, and user-defined contrasts of selected sampling areas at Faro Vangorda Creek sampling areas.

	1-way ANOVA						Contrast Statistics		
Dependent Variable	p-value	Power	Contrast Type[a]	(I) Area	(J) Area	Value of Contrast (J-I)	Standard Error	t-statistic	p-value[b]
Hess Density (Individuals/m2)			Assume equal variances	V1 Reference	V27 Exposure	2569.400	1194.481	2.151	0.047
	0.00018	0.99786		V1 Reference	V5 Exposure	-4625.000	1194.481	-3.872	0.001
				V1 Reference	V8 Exposure	19.200	1194.481	0.016	0.987
Hess Number of Taxa			Assume equal variances	V1 Reference	V27 Exposure	4.000	2.345	1.706	0.107
	0.16962	0.39979		V1 Reference	V5 Exposure	5.400	2.345	2.303	0.035
				V1 Reference	V8 Exposure	3.200	2.345	1.364	0.191
Hess EPT (%)			Assume equal variances	V1 Reference	V27 Exposure	15.356	6.069	2.530	0.022
	0.00000	1.00000		V1 Reference	V5 Exposure	-18.283	6.069	-3.013	0.008
				V1 Reference	V8 Exposure	-33.507	6.069	-5.521	0.000
Hess Chironomids (%)			Assume equal variances	V1 Reference	V27 Exposure	-27.688	5.825	-4.754	0.000
	0.00000	1.00000		V1 Reference	V5 Exposure	4.832	5.825	0.830	0.419
				V1 Reference	V8 Exposure	26.902	5.825	4.619	0.000
Hess Simpson's D			Does not assume equal variances	V1 Reference	V27 Exposure	0.017	0.017	1.012	0.342
	0.00103	0.97967		V1 Reference	V5 Exposure	0.050	0.021	2.414	0.044
				V1 Reference	V8 Exposure	-0.182	0.067	-2.719	0.049
Hess Simpson's E			Assume equal variances	V1 Reference	V27 Exposure	-0.031	0.041	-0.749	0.465
	0.00373	0.93053		V1 Reference	V5 Exposure	0.013	0.041	0.322	0.752
				V1 Reference	V8 Exposure	-0.151	0.041	-3.708	0.002
Hess B-C Dist. to V-1 median			Assume equal variances	V1 Reference	V27 Exposure	0.284	0.033	8.530	0.000
	0.00000	1.00000		V1 Reference	V5 Exposure	0.553	0.033	16.617	0.000
				V1 Reference	V8 Exposure	0.414	0.033	12.434	0.000
Hess Vangorda CA Axis-1 (24.4%)			Assume equal variances	V1 Reference	V27 Exposure	0.423	0.093	4.526	0.000
	0.00000	1.00000		V1 Reference	V5 Exposure	-0.659	0.093	-7.049	0.000
				V1 Reference	V8 Exposure	0.247	0.093	2.646	0.018
Hess Vangorda CA Axis-2 (17.2%)			Does not assume equal variances	V1 Reference	V27 Exposure	0.156	0.081	1.930	0.094
	0.00001	0.99999		V1 Reference	V5 Exposure	0.393	0.062	6.386	0.000
				V1 Reference	V8 Exposure	0.839	0.139	6.015	0.002
Hess Vangorda CA Axis-3 (14.7%)			Assume equal variances	V1 Reference	V27 Exposure	-0.599	0.138	-4.331	0.001
	0.00097	0.98098		V1 Reference	V5 Exposure	-0.572	0.138	-4.136	0.001
				V1 Reference	V8 Exposure	-0.187	0.138	-1.351	0.196
Artificial Substrate Abundance			Assume equal variances	V1 Reference	V27 Exposure	282.000	420.919	0.670	0.512
	0.16293	0.40778		V1 Reference	V5 Exposure	958.400	420.919	2.277	0.037
				V1 Reference	V8 Exposure	619.800	420.919	1.472	0.160
Artificial Substrate Number of Taxa			Assume equal variances	V1 Reference	V27 Exposure	3.000	2.047	1.466	0.162
	0.48848	0.19291		V1 Reference	V5 Exposure	2.000	2.047	0.977	0.343
				V1 Reference	V8 Exposure	2.600	2.047	1.270	0.222
Artificial Substrate EPT (%)			Assume equal variances	V1 Reference	V27 Exposure	14.570	7.289	1.999	0.063
	0.05756	0.60576		V1 Reference	V5 Exposure	-4.416	7.289	-0.606	0.553
				V1 Reference	V8 Exposure	-4.595	7.289	-0.630	0.537
Artificial Substrate Chironomids (%)			Assume equal variances	V1 Reference	V27 Exposure	-17.191	6.797	-2.529	0.022
	0.04579	0.64543		V1 Reference	V5 Exposure	-4.823	6.797	-0.710	0.488
				V1 Reference	V8 Exposure	2.614	6.797	0.385	0.706
Art. Substrate Simpson's D			Assume equal variances	V1 Reference	V27 Exposure	0.006	0.016	0.366	0.719
	0.89246	0.08012		V1 Reference	V5 Exposure	0.012	0.016	0.780	0.447
				V1 Reference	V8 Exposure	0.006	0.016	0.357	0.726
Art. Substrate Simpson's E			Assume equal variances	V1 Reference	V27 Exposure	-0.036	0.063	-0.571	0.576
	0.95262	0.06595		V1 Reference	V5 Exposure	-0.014	0.063	-0.216	0.831
				V1 Reference	V8 Exposure	-0.017	0.063	-0.270	0.790
Art. Substrate B-C Dist. to V-1 median			Assume equal variances	V1 Reference	V27 Exposure	0.148	0.107	1.381	0.186
	0.16878	0.40077		V1 Reference	V5 Exposure	0.252	0.107	2.345	0.032
				V1 Reference	V8 Exposure	0.170	0.107	1.578	0.134
Artificial Substrate CA-1 (23.8%)			Assume equal variances	V1 Reference	V27 Exposure	-0.090	0.200	-0.451	0.658
	0.00167	0.96657		V1 Reference	V5 Exposure	0.796	0.200	3.984	0.001
				V1 Reference	V8 Exposure	0.342	0.200	1.709	0.107
Artificial Substrate CA-2 (13.5%)			Assume equal variances	V1 Reference	V27 Exposure	-0.028	0.197	-0.140	0.890
	0.45920	0.20459		V1 Reference	V5 Exposure	-0.151	0.197	-0.766	0.455
				V1 Reference	V8 Exposure	-0.290	0.197	-1.473	0.160
Artificial Substrate CA-3 (12.5%)			Assume equal variances	V1 Reference	V27 Exposure	0.033	0.132	0.247	0.808
	0.00180	0.96398		V1 Reference	V5 Exposure	-0.166	0.132	-1.260	0.226
				V1 Reference	V8 Exposure	0.452	0.132	3.426	0.003

(shaded) significant at p = 0.1

[a] Contrast test used is dependent upon results of Levene's Test for homogeneity of variances.

[b] User-defined contrasts are *a priori* tests with each test p = 0.10

Table C.11: Contrast tests using 3 stations per area, Vangorda Creek, 2007.

		Contrast	(I) Area	(J) Area	Value of Contrast	Std. Error	t	df	p-value
Hess Density (Individuals/m2)	Does not assume equal variances	V1 vs. V27	V1 Reference	V27 Exposure	2286.0000	2388.6510	0.9570	3.68	0.397
		V1 vs. V5	V1 Reference	V5 Exposure	-4852.0000	1452.2353	-3.3410	2.20	0.069
		V1 vs. V8	V1 Reference	V8 Exposure	549.3333	1580.5115	0.3480	2.92	0.752
Hess Number of Taxa	Assume equal variances	V1 vs. V27	V1 Reference	V27 Exposure	2.3300	2.5390	0.9190	8.00	0.385
		V1 vs. V5	V1 Reference	V5 Exposure	6.3300	2.5390	2.4950	8.00	0.037
		V1 vs. V8	V1 Reference	V8 Exposure	5.0000	2.5390	1.9700	8.00	0.084
Hess EPT (%)	Assume equal variances	V1 vs. V27	V1 Reference	V27 Exposure	12.8750	9.0303	1.4260	8.00	0.192
		V1 vs. V5	V1 Reference	V5 Exposure	-20.3874	9.0303	-2.2580	8.00	0.054
		V1 vs. V8	V1 Reference	V8 Exposure	-38.7426	9.0303	-4.2900	8.00	0.003
Hess Chironomids (%)	Assume equal variances	V1 vs. V27	V1 Reference	V27 Exposure	-25.4489	7.9270	-3.2100	8.00	0.012
		V1 vs. V5	V1 Reference	V5 Exposure	9.5406	7.9270	1.2040	8.00	0.263
		V1 vs. V8	V1 Reference	V8 Exposure	32.4394	7.9270	4.0920	8.00	0.003
Hess Simpson's D	Does not assume equal variances	V1 vs. V27	V1 Reference	V27 Exposure	0.0120	0.0247	0.4850	2.47	0.667
		V1 vs. V5	V1 Reference	V5 Exposure	0.0346	0.0321	1.0770	3.99	0.342
		V1 vs. V8	V1 Reference	V8 Exposure	-0.1939	0.0746	-2.6000	2.43	0.100
Hess Simpson's E	Assume equal variances	V1 vs. V27	V1 Reference	V27 Exposure	-0.0234	0.0533	-0.4390	8.00	0.673
		V1 vs. V5	V1 Reference	V5 Exposure	-0.0348	0.0533	-0.6520	8.00	0.532
		V1 vs. V8	V1 Reference	V8 Exposure	-0.1807	0.0533	-3.3910	8.00	0.009
Artificial Substrate Abundance	Assume equal variances	V1 vs. V27	V1 Reference	V27 Exposure	428.0000	335.4891	1.2760	8.00	0.238
		V1 vs. V5	V1 Reference	V5 Exposure	1488.6670	335.4891	4.4370	8.00	0.002
		V1 vs. V8	V1 Reference	V8 Exposure	395.3330	335.4891	1.1780	8.00	0.273
Artificial Substrate Number of Taxa	Assume equal variances	V1 vs. V27	V1 Reference	V27 Exposure	5.0000	3.3170	1.5080	8.00	0.170
		V1 vs. V5	V1 Reference	V5 Exposure	2.6700	3.3170	0.8040	8.00	0.445
		V1 vs. V8	V1 Reference	V8 Exposure	3.3300	3.3170	1.0050	8.00	0.344
Artificial Substrate EPT (%)	Assume equal variances	V1 vs. V27	V1 Reference	V27 Exposure	17.2545	8.3555	2.0650	8.00	0.073
		V1 vs. V5	V1 Reference	V5 Exposure	-14.9386	8.3555	-1.7880	8.00	0.112
		V1 vs. V8	V1 Reference	V8 Exposure	-7.9818	8.3555	-0.9550	8.00	0.367
Artificial Substrate Chironomids (%)	Assume equal variances	V1 vs. V27	V1 Reference	V27 Exposure	-17.5267	7.9737	-2.1980	8.00	0.059
		V1 vs. V5	V1 Reference	V5 Exposure	6.5769	7.9737	0.8250	8.00	0.433
		V1 vs. V8	V1 Reference	V8 Exposure	6.3003	7.9737	0.7900	8.00	0.452
Art. Substrate Simpson's D	Assume equal variances	V1 vs. V27	V1 Reference	V27 Exposure	0.0011	0.0222	0.0500	8.00	0.961
		V1 vs. V5	V1 Reference	V5 Exposure	0.0090	0.0222	0.4060	8.00	0.696
		V1 vs. V8	V1 Reference	V8 Exposure	-0.0034	0.0222	-0.1530	8.00	0.882
Art. Substrate Simpson's E	Does not assume equal variances	V1 vs. V27	V1 Reference	V27 Exposure	-0.0854	0.0746	-1.1440	3.82	0.319
		V1 vs. V5	V1 Reference	V5 Exposure	-0.0424	0.0504	-0.8420	2.64	0.469
		V1 vs. V8	V1 Reference	V8 Exposure	-0.0466	0.1208	-0.3860	2.68	0.728

Report of Benthic Invertebrate Analysis – Van Gorda (Faro) Mine Yukon, for Minnow Environmental
Analysis by Cordillera Consulting, March 31 2008

Methods

In November of 2007, 31 samples were received from Faro, Yukon. In the raw samples, the organic and inorganic matter was separated by elutriation. The inorganic elutriate was examined under low power to check for missed trichopterans, molluscs or any other heavy organisms. The remaining sample was sieved in a 300 µ to remove preservative and clay particles. Each sample was evaluated for total numbers and need for subsampling. The following samples Ref 1, Ref. 2, Nexc 1, V8-01, V8-02, V8-03, V8-04, V8-05, V27-01, V27-02, V27-03, were relatively uniform in the size of detrital material and further fractionation was not needed. The subsampling method used for these samples was by area (Caton Tray) and not less than one quarter of the sample was sorted (exception being V8-04). A minimum number of 300 was used for the subsampling criteria.

The balance of the samples was fractioned into either 2 or 3 size fractions depending on the quantity of large organic detrital material. The sieves used were 4 mm, 2 mm and 300 µ. In most cases the whole of the course and very course fraction was sorted and the fine portion was subsampled with 300 organisms as a minimum number. The exceptions to this was V5-01, V5-02, V5-03, V5-05, V27-E, V27-D, V1-A where the fractions were all sorted in their entirety. Another exception was in V1-E, V5-A, V5-B, V8-E and V8-D where the quantity of the course and very course fraction was very large and the invertebrates too few to sort through 100 %. In these cases a minimum number of 300 organisms was the target for the whole sample.

Invertebrates were divided into orders or classes and stored in individual vials in 80% ethanol.

Following the sorting process the invertebrates were identified to the lowest practical level. The following texts were used in the identifications:

Clifford, Hugh F. 1991. Aquatic Invertebrates of Alberta. University of Alberta Press Edmonton, Alberta.

Epler, John. 2001 The Larval Chironomids of North and South Carolina. http://home.earthlink.net/~johnepler/

Epler, John. Identification Manual for the Water Beetles of Florida. http://home.earthlink.net/~johnepler/

Epler, John. Identification Manual for the Aquatic and Semi-aquatic Heteroptera of Florida. http://home.earthlink.net/~johnepler/

Jacobus, Luke and Pat Randolph. 2005. Northwest Ephemeroptera Nymphs. Manual from Northwest Biological Assessment Working Group. Moscow Idaho 2005. Not Published.

Kathman,R.D., R.O. Brinkhurst. 1999. Guide to the Freshwater Oligochaetes of North America. Aquatic Resources Center, College Grove, Tennessee.

Larson, D.J., Y. Alarie, R.E. Roughly.2005. Predaceous Diving Beetles (Coleoptera: Dytiscidae) of the Neararctic Region. NRC-CNRC Research Press. Ottawa.

Mackie, G. Sphaeriidae of North America http://www.collegeofidaho.edu/campus/community/museum/CorbiculaceaOfNorthAmerica-GLMackie/Sphaeriidae/SphaeriidaeIndex.htm

Merritt, R.W., K.W. Cummins and M. Berg. (eds.). 2008. An introduction to the aquatic insects of North America, 4th. Kendall/Hunt, Dubuque, IA.

Needham, James, M. May, M. Westfall Jr. 2000. Dragonflies of North America. Scientific Publishers. Gainsville FL.

Westfall, Minter J. Jr. and May, Michael L. 1996. Damselflies of North America. Scientific Publishers, Gainesville, FL.

Needham, K. 1996. An Identification Guide to the Nymphal Mayflies of British Columbia. Publication #046 Resource Inventory Committee, Government of British Columbia.

Oliver, Donald R. and Mary E. Roussel. 1983. The Insects and Arachnids of Canada Part 11. The Genera of larval midges of Canada. Biosystematics Research Institute. Ottawa, Ontario. Research Branch, Agriculture Canada. Publication 1746.

Proctor, H. The 'Top 18' Water Mite Families in Alberta. Zoology 351.

Stewart, Kenneth W. and Bill Stark. 2002. The Nymphs of North American Stonefly Genera (Plecoptera). The Caddis Press. Columbus Ohio.

Stewart, Kenneth W. and Mark W. Oswood. 2006. The Stoneflies of Alaska and Western Canada. The Caddis Press.Columbus Ohio. 43221-0039.

Wiggins, Glenn B. 1998. Larvae of the North American Caddisfly Genera (Tricoptera) 2nd ed. University of Toronto Press. Toronto Ontario.

QA/QC

Sorting Efficiency

As the project was being sorted every ten samples was resorted by the lab manager to evaluate sorting efficiency. All resorted samples (4 were resorted) achieved > 95% sorting efficiency.

Taxonomic Efficiency

Four samples have been selected to send to another taxonomist to evaluate taxonomic efficiency. Report Pending.

Report of QA/QC Analysis of 12 Samples from Laberge Environmental Services By Cordillera Consulting, March 2008

As requested by Minnow Environmental 12 benthic samples analyzed by another laboratory were received by Cordillera Consulting in January 2008. Contained in the shipment were:

- 12 vials of sorted invertebrates
- 12 one litre Nalgene bottles labelled V1B, V1C, V1D, V5C, V5D, V5E, V8A, V8B, V8C, V27A, V27B and V27C containing the original detritus from which the invertebrates in the vials were sorted
- 6 containers of unsorted fines labelled V1C unsorted 3/4s, V5C unsorted 7/8, V5D unsorted ½, V5E unsorted 16/16ths, V8B unsorted 9/16ths and V27A unsorted 3/4s. One container was broken in transit from the previous laboratory and it was labelled V1D unsorted 3/4s. It was discarded.

Cordillera Consulting contacted the previous laboratory and found the methods for analysis to be as follows:

- The samples were elutriated and sieved using 180 µ and 1 mm sieves.
- The whole of the course portion was sorted, identified and enumerated.
- The fine portion was subsampled in 7 out of 12 samples to portions between 1/16th and one half.
- The fine and course fractions of the sorted invertebrates were stored together in one vial
- The fine and course portions of the sorted debris were stored together in one vial

Two issues emerged as problems right away in the QA/QC process.

1. Minnow Environmental had requested that the finest sieve size be 300µ. However an 180µ sieve was used by the previous lab. There will be higher numbers of very small organisms accounted for in the data as a result.
2. The subsampled fine fraction and whole course fraction of the sorted invertebrates and the sorted debris being stored together makes it impossible to accurately perform a quality control analysis on each portion. No records were kept by the previous lab indicating how many organisms were found in the fractions. Only those sites which have not had subsampling can be analysed for sorting efficiency and taxonomic efficiency accurately.

Sorting Efficiency

Three samples were randomly chosen to resort, V8-B, V8-A and V27-C.

	Original Sorted Numbers	Cordillera Consulting Resort	% Efficiency
V8-B	~2000 ? X 0.3125* = 625	62	~90%
V8-A	262	39	85.10%
V27-C	409	31	92.40%

* 0.3125 is the subsampled portion the sorted 'fine'numbers were multiplied by to get the totals. Cordillera Consulting estimated that 75 organisms were found in the course portion and 625 were found in the 5/16ths of the fine portion.

Sorting efficiency was found to be acceptable in V8-B and V27-C but not acceptable in V8-A. (EEM Guidelines Chapter 5, page 5-109) Organisms found in V8-A were added back to the original numbers.

Taxonomic Efficiency

The invertebrates in V8-A, V8-B and V27-C were reidentified by Sue Salter at Cordillera Consulting.

The absolute total numbers in the three samples number differed by 15.9% in V27-C, 12.9% in V8-A and approximately 26.4% in V8-B.
The % disagreements including both disagreement in numbers and disagreements in taxa identifications was 47% in V27-C, 57.6 % in V8-A and 73.9% in V8-B. V8-B is likely falsely high due to the very rough estimate in total numbers due to subsampling. The acceptable disagreement level of 10% however is very much exceeded and all twelve of these samples need to be re-identified and re-counted.

The errors range from

- **minor** i.e. placing immature larvae at the genus level instead of family or order, not using up to date nomenclature and reference texts
- **major** misidentification of common taxa with unambiguous characteristics (Parapsyche sp., Taeniopterygidae), miscounts of greater than 10%.

Others taxonomic errors suggest the taxonomist has not taken specialized training currently available within the taxonomic community and has not maintained a current collection of reference texts.

The following disagreements in taxa and numbers were recorded:

V27-C

	V27-C	Re ID	Disagreement	Comments
PHYLUM ARTHROPODA				
Class Insecta				
Order Ephemeroptera				
Family Siphlonuridae				
Ameletus sp	1	1		Ameletus is now in the Family Ameletidae
Family Baetidae				
Baetis sp	62	41	21	numbers disagreement
Family Heptageniidae		62		I can see the rationale for putting the immature Heptageniids into Cinymula sp. and I accept this designation. I differ only in the number of Epeorus sp.
Cinygmula sp	95	34		
Epeorus sp	4	3	1	
Rhithrogena sp	4	4		
Family Ephemereliidae				
Drunella doddsi	3	3		
Order Plecoptera juvenile		5		
Family Capniidae		4		It is very difficult to identify even mature Capniids and these Capniids are immature
Capnia sp	7		7	

Family Perlodidae				
Megarcys sp	1	1		
Sweltsa sp group	1			
Family Nemouridae				
Zapada sp	87	46	41	disagreement in numbers
Podmosta sp	4		4	I think the previous lab has misidentified Taeniopterygidae as Podmosta sp.
Family Chloroperlidae				
Sweltsa group		1		Sweltsa sp. belongs in the family Chloroperlidae not Perlodidae
Family Taeniopterygidae		4		Likely mistaken for Podmosta sp.
Order Trichoptera				
Trichoptera Unid J	3	2	1	2 of the Trichoptera Unid J were identified as Oligophlebodes sp.
Trichoptera P				
Family Uenoidae				
Oligophlebodes sp.		2	2	
Family Hydropsychidae juvenile		17	4	
Arctopsyche sp	22		22	Parapsyche sp. has been misidentified as Arctopsyche sp. throughout this project
Parapsyche sp.		1		
Family Glossosomatidae				
Glossosoma sp	29	29		
Family Rhyacophilidae				I did not identify Rhyacophilidae to the species level, and I don't disagree with the identifications; I only disagree with the number found. Rhyacophila acropedes is no longer a valid name. R. brunnea is now used.
Rhyacophila sp.		10	6	
Rhyacophila acropedes or vao				
Rhyacophila angelita				
Rhyacophila hyalinata	4			
Order Diptera				
Family Chironomidae				
Chironomidae P	9	9		
Chironomidae L	48			
Sub Family Orthocladinae				
Brillia sp		3	3	these taxa were found but not recorded by previous lab
Cricotopus sp	3			
Cricotopus/Orthocladius sp.		29	26	It is recommended in current keys that most Cricotopus sp. be referred to as Cricotopus/Orthocladius sp. unless there is pupal association. There is also a disagreement in number
Eukiefferiella sp	8	21	13	numbers disagreement.
Family Diamesinae				
Diamesa sp	2		2	misidentification
Pagastia sp.		2		
Family Empididae				
Weidemannia sp	3		3	misidentification
Oreogeton sp.		2		
Family Psychodidae				

Pericoma sp				
Family Simulidae		7		
Prosimulium L	3		4	
Order Hydracarina				
Lebertia sp.		1	1	misidentification
Sperchon sp	1		1	
Unioncola sp	2		2	misidentification
Total per sample	**409**	**344**	**164**	47.6 % disagreement

V8-A

	V8a	Resort	Disagreement	Comments
PHYLUM ARTHROPODA				
Class Insecta				
Order Ephemeroptera				
Family Siphlonuridae				
Ameletus sp				Ameletus is now in the Family Ameletidae
Family Baetidae				
Baetis sp	3	2	1	
Family Heptageniidae		10		I can see the rationale for putting the immature Heptageniids into Cinymula sp. and I accept this designation. I differ only in the number of Rhithrogena sp. sp.
Cinygmula sp	21	10		
Epeorus sp	12	12		
Rhithrogena sp	16	15	1	
Order Plecoptera				It is very difficult to identify mature Capniids and these Capniids are immature
Family Capniidae		2		
Capnia sp	2		2	
Family Chloroperlidae				
Sweltsa sp group	1	1		
Family Nemouridae				
Zapada sp	73	56	27	disagreement in numbers
Podmosta sp				disagreement in numbers and identification
Family Taeniopterygidae		27		
Order Trichoptera				
Family Hydropsychidae juvenile		13		Parapsyche sp. has been misidentified as Arctopsyche throughout this project
Arctopsyche sp	19		19	
Parapsyche sp.		3		
Family Rhyacophilidae		22	34	disagreement in numbers
Rhyacophila acropedes or vao	44			
Rhyacophila angelita	1			

Rhyacophila hyalinata	11			
Order Diptera				
Family Chironomidae				
Chironomidae P	4	3	1	
Chironomidae L	3		4	
Sub Family Orthocladinae				
Cardiocladius sp	1			
Chaetocladius sp.		29	29	misidentification
Cricotopus sp	16			
Cricotopus/Orthocladius sp.		9		
Eukiefferiella sp	23		23	misidentification
Thienemanniella sp	1		1	misidentification
Family Simulidae				
Simulium sp L	3	4		
Order Hydracarina				
Unioncola sp	7			
Aturus sp.		9	9	misidentification
Total per sample	**262**	**228**	**151**	**57.6 % disagreement**

V8-B

Please note V8-B was a sub-sampled site and the actual numbers for the previous lab are only a very rough estimate because the records of the original numbers were never kept. The numbers in the disagreement column here are not reliable.

	V8-B	V8-B x 5/16	Re ID	Disagreement	Comments
PHYLUM ARTHROPODA					
Class Insecta					
Order Ephemeroptera					
Family Baetidae					
Baetis sp	157	49	16	33	disagreement in numbers
Family Heptageniidae juvenile or dam.			10		
Cinygmula sp	26	8	3		I can see the rationale for putting the immature Heptageniids into Cinymula sp. and I accept this designation. I differ only in the number of Epeorus sp.
Epeorus sp	9	3	16		
Rhithrogena sp	1		9		
Family Ephemereliidae					
Drunella doddsi	3	1	2	1	disagreement in numbers
Drunella grandis	1			1	disagreement in numbers
Drunella spinifera sp.			1	1	disagreement in identification
Serratella tibialis			1	1	disagreement in

					identification
Ephemerella flavilinea	28	9			
Order Plecoptera juvenile			75	75	these juvenile larvae cannot be distinguished to genus or family level
Family Capniidae juvenile			14		It is very difficult to identify mature Capniids and these Capniids are immature; disagreement in number also
Capnia sp	51	16		16	
Family Perlodidae					
Megarcys sp	4	1	3	2	disagreement in number
Family Nemouridae					
Zapada sp	398	124	189		I think the previous lab has misidentified Taeniopterygidae as Podmosta sp.
Podmosta sp	298	93		46	
Family Taeniopterygidae juvenile			40		disagreement in total numbers including immatures
Order Trichoptera					
Trichoptera Unid J	3	1	1		
Family Hydropsychidae Juvenile			47		Parapsyche sp. has been missidentified as Arctopsyche throughout this project; juvenile larvae cannot be identified to genus; disagreement in numbers also
Arctopsyche sp	138	43		17	
Parapsyche			13		
Family Rhyacophilidae					
Rhyacophila sp.			46	27	disagreement in numbers
Rhyacophila acropedes or vao	41	13			
Rhyacophila angelita					
Rhyacophila hyalinata	21	7			
Order Diptera					
Diptera Unid A	1		1		
Diptera Unid L	4	1	1		
Family Chironomidae				51	disagreement in total numbers of Chironomidae
Chironomidae P	27	8	14		
Chironomidae L	250	78			
Sub Family Orthocladinae					
Brillia sp	47	15	42		
Cardiocladius sp	11	3	0		disagreement in identification
Chaetocladius sp.			167		
Cricotopus sp	151	47			
Cricotopus/Orthocladius sp.			45		
Eukiefferiella sp	174	54	10		

Family Diamesinae					
Diamesa sp	23	7	0		diagreement in identification
Family Empididae					
Chelifera sp	4	1	2	2	disagreement in numbers
Family Psychodidae					
Pericoma sp	4	1	2	2	disagreement in numbers
Family Simulidae P			4		
Prosimulium L	16	5	0	16	disagreement in numbers and identification
Prosimulium sp P					
Simulium sp L	18	6	13	5	
Simulium sp P	4	1			
Family Tipulidae					
Dicranota sp	3	1	1	2	disagreement in numbers
Order Collembola			3	12	disagreement in numbers
Isotomurus sp	7	2			
Podura sp	8	3		8	disagreement with identification
Class Arachnida					
Order Aranaea	3	1			
Order Hydracarina					
Hydracarina Unid J	6	2		6	disagreement in numbers and identification
Sperchon sp	7	2	3	4	
Aturus sp.			24	24	
Unioncola sp	115	36	0	115	
Class Ostracoda					
Cypria sp	3	1	1	2	disagreement with numbers
PHYLUM NEMATODA	10	3	0	10	disagreement with numbers
Total per sample	**2075**	**648**	**819**	**479**	73.9 % disagreement

Report on the re-Identification of 12 Vangorda Samples

The first three samples examined in the QA/QC were left unchanged.

Of the remaining 9 samples, the sites which had not had subsampling applied were sieved through 300µ and 210µ sieves. The number of organisms in the 210µ fraction were recorded and preserved but the individuals were not identified. The organisms in the 300µ fraction were all reidentified and the results recorded and sent to the client.

The sites which did have subsampling applied were sieved through 1 mm, 300µ and 210µ sieves. The 210µ fraction was counted and preserved and the other 2 fractions were identified and counted and preserved separately. The results were recorded and sent to the client.

The table below is a record of total numbers from the previous labs identifications, the current identifications and the number of organisms in the 210µ fraction.

	V1b	V1c	V1d	V5c	V5d	V5e	V8b	V8c	V8a	V27a	V27b	V27c
Subsample	all	1/4	1/4	1/8	1/2	1/16	5/16	all	all	1/4	all	all
Previous #s	147	1348	1423	2770	747	3962	2075	1048	262	1502	427	409
Current #s	81	494	467	1401	225	1877	819	885	226	1280	411	335
# in 210µ fraction	9	127	87	65	75	57		71		38	42	

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APPENDIX D

Habitat Descriptions and Photographs

Table D.1: Habitat summary for Vangorda Creek sampling areas, Faro Mine, August 2007.

Characteristics		Reference				Effluent-Exposed (Vangorda Creek)		
		Upper West Fork Vangorda Creek (Ref-1)	Upper South Fork Rose Creek (Ref-2)	Next Creek (Nex-C1)	Upper Vangorda Creek (V1)	V27	V5	V8
Average Length of Reach Assessd (m)		50	10	50	7.8 (4.5 - 13.0)	11.2 (9 - 14)	9.6 (8.0 - 10)	15
Bottom Flow Velocity (m/s)	Mean	0.31 (0.12 - 0.65)	0.37 (0.08 - 0.80)	0.25 (0.03 - 0.72)	0.22 (0.12 - 0.42)	0.16 (0.12 - 0.21)	0.22 (0.18 - 0.24)	0.13 (0.09 - 0.18)
	Maximum	0.65	0.8	0.72	0.5 (0.32 - 0.72)	0.45 (0.36 - 0.62)	0.53 (0.44 - 0.66)	0.38 (0.26 - 0.74)
Depth (m)	Mean	0.10	0.23 (0.050 - 0.390)	0.19 (0.130 - 0.260)	0.17 (0.01 - 0.48)	0.21 (0.08 - 0.40)	0.14 (0.03 - 0.35)	0.26 (0.08 - 0.40)
	Maximum	0.25	0.45	0.35	0.37 (0.19 - 0.50)	0.40 (0.34 - 0.46)	0.30 (0.24 - 0.37)	0.39 (0.35 - 0.43)
Width (m)	Wetted	1.6 (4.43 - 1.8))	7.7 (4.5 - 11)	6.1 (4.5 - 9.0)	4.7 (4.3 - 5.3)	4.5 (4.1 - 5.1)	3.4 (2.7 - 4.0)	5.19 (3.23 - 6.59)
	Bankfull	2.1 (1.61 - 2.52)	8.6 (6.0 - 11)	6.5 (5.0 - 9.0)	7.4 (6.7 - 8.5)	6.1 (5.3 - 7.8)	5.6 (5.2 - 6.5)	7.8 (6.0 - 10.1)
Gradient	%	4.8	4.8	4	6.8	2.8	3.2	3.9
Water Appearance		clear; colourless	clear; colourless	clear; colourless	clear	clear	slightly turbid/cloudy	mostly clear; slightly turbid light brown
General Morphology	%pool	0	30	0	<5 (0 - 10)	0	<5 (0 - 5)	0
	%riffle	100	70	100	85 (25 - 100)	60 (30 - 100)	65 (50 - 80)	30 (20 - 50)
	%run	0	0	0	25 (0 - 70)	40 (0 - 80)	35 (15 - 50)	70 (50 - 80)
Bank Condition		mostly stable	Stable/No Bank Erosion	Stable/No Bank Erosion	Stable/No Bank Erosion	Stable/No Bank Erosion	Stable/No Bank Erosion	moderately stable
Substrate (% areal coverage)	%bedrock	0	0	0	<5 (0 - 5)	0	0	0
	%boulder	25	55	10	50 (20-65)	30 (15 - 50)	30 (20-45)	40 (20 - 60)
	%cobble	40	30	55	45 (30 - 75)	55 (40 - 65)	15 (5 - 25)	45 (30 - 60)
	%gravel	20	15	35	<10 (5 - 25)	15 (10 - 20)	45 (30- 50)	10 (10 - 15)
	%sand&finer	15		0	0	<5	10 (5 - 20)	5 (<1 - <15)
Instream Cover (%total Surface)	undercut banks	0	0	0	0	<5	5 (0 - <10)	<5 (0 - 5)
	boulder	10	70	< 5	20 (10 - 20)	15 (10 - 30)	10 (5 - 15)	15 (10 - 20)
	woody debris	0	< 5	< 5	5 (5 - 75)	0	7.5 (<5-10)	5 (0 - 10)
	deep pool	<5	30	5	<5 (0 - 10)	0	0	<5 (0 - 10)
	macrophytes	0	0	0	0	0	0	0
Av. Residual (Refuge) Pool Depth (m)		0.1	0.25	0.1	< 0.2	< 0.2	< 0.1	< 0.2
Overhead Canopy (%Surface)	Dense	0	0	0	0	0	0	0
	Partially Open	0	10	60	15 (0 - 25)	15 (5 - 25)	85 (75 - 90)	30 (5 - 45)
	Open	100	90	40	85 (75 - 100)	85 (75 - 95)	15 (0 - 25)	70 (35 - 95)
Riparian Vegetation Types	descending dominance	willow, scattered black poplar, cinqfoil, some dwarf birch	willow, scattered poplar, then spruce	spruce, willow, black poplar	willow , moss, spruce, dwarf birch, berry shrubs, cinqfoil, rip-rap	willow, grasses, alder, moss, cinqfoil, equisetum, spruce	alder, willow, moss, equisetum, highbush cranberry, poplar, grass	alder, willow , grasses, poplar, forbs, berry shrubs, spruce, moss
Aquatic Vegetation (% areal coverage)	Emergent	0	0	0	0	0	0	0
	Submergent	0	0	0	0	0	0	0
	Floating	0	0	0	0	0	0	0
	Attached Algae	< 5	< 5	< 1	<10	0	0	0
Surrounding Land Use		U/S of old gravel pit haul road	Haul Road ~30m D/S of site	old gravel pit haul road	U/S mine road; forest	none; mature forest	forest	bridges/road crossings
Evidence of Anthropogenic Disturbance		modified channel, likely to ensure flow to culvert	none	culverts, pushed around substrate	rip-rap & metal culverts	none	none	bridges/road crossings
General Comments/Notes		Stream channel much smaller & shallower than Vangorda but substrate is comparable, in spots, to lower Vangorda. First sample taken 22m U/S of culvert, with next 2 samples taken U/S of that.	Assessed a very small portion of the stream, afterwhich the gradient was steeper with larger boulders. Mayflies noted when shocking. Conductivity will not calibrate, used Hanna meter instead. Site is more a pool/step kind of habitat with an increasing gradient that becomes a canyon type environment.	Sampled D/S of culverts. Loosely compacted substrate. U/S of road has alot of moss, channel narrows to < 9m. Small woody debris and some overhanging willow. LWD up on banks indicating Hgh water mark/flow.	Most sites have some orange fuzzy moss on rocks	Some sites in valley with access down steep hills	Lots of fines and small gravel making Hess sampling difficult	

[a] Numbers provided represent mean values with numbers in parenthesis representing the corresponding range for each respective description.

[b] Morphology type based on Rosgen (1994) classification. B= moderately entrenched, moderate-gradient, riffle-dominated channel with infrequently spaced pools, very stable plan and profile, stable banks; C= low-gradient, meandering, alluvial riffle-pool, channels with point-bars, broad, well-defined floodplains E= low-gradient, meandering, riffle/pool stream with low width:depth ratio and little deposition, very efficient and stable, high meander width ratio; G= entrenched, "gully" step-pool channel, on moderate gradients, with low width:depth ratio

Reference Area V1, Upper Vangorda Creek

a) V1-02

b) V1-04

Area V27, Vangorda Creek

a) V27-02

b) V27-03

Area V8, Vangorda Creek

a) V8-04

b) V8-03

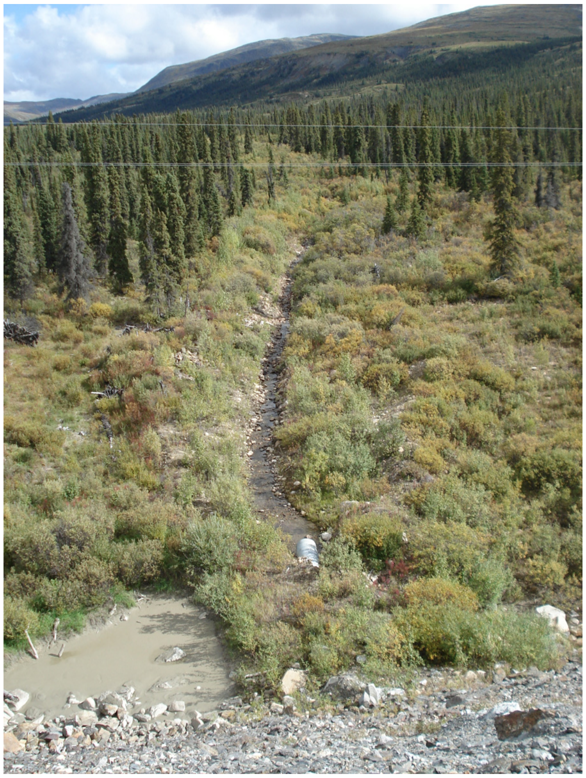
Area V5, West Fork Vangorda Creek

a) V5-01

b) V5-02

Area REF1, Upper West Fork Vangorda Creek

a) view from Haul Road



b) REF1 sampling area

Area REF2, Upper South Fork Rose Creek

a) view from Haul Road

b) REF2 sampling area

Reference Area Next Creek

a) NEXC-1

b) NEXC-2