AQUATIC EFFECTS TECHNOLOGY EVALUATION (AETE) PROGRAM

1997 Field Program
Final Report
Dome Mine Site,
Ontario

AETE Project 4.1.3

September 1998
Revised as of March 1999

1997 FIELD PROGRAM - AETE
DOME MINE

SITE REPORT

Report prepared for:

Aquatic Effects Technology Evaluation (AETE) Program
Canada Centre for Mineral and Energy Technology (CANMET)
Natural Resources Canada
555 Booth Street
Ottawa, Ontario
K1A 0G1

Prepared by:

BEAK INTERNATIONAL INCORPORATED
14 Abacus Road
Brampton, Ontario
L6T 5B7

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DOME MINE

SITE REPORT

BEAK INTERNATIONAL INCORPORATED

PROJECT TEAM:

Site Leader: Dennis Farara
Biostatistics: Donald R. Hart, Alan J. Burt
Field Crew Leader: Jay Dickison
Data Management: Deb McMillan
Toxicology: Julie Schroeder

PROJECT MANAGEMENT TEAM:

Paul McKee, M.Sc., Principal

Dennis Farara, B.Sc., Associate

AQUATIC EFFECTS TECHNOLOGY EVALUATION PROGRAM

Notice to Readers

1997 Field Program

The Aquatic Effects Technology Evaluation (AETE) program was established to review appropriate technologies for assessing the impacts of mine effluents on the aquatic environment. AETE is a cooperative program between the Canadian mining industry, several federal government departments and a number of provincial governments; it is coordinated by the Canada Centre for Mineral and Energy Technology (CANMET). The program is designed to be of direct benefit to the industry, and to government. Through technical evaluations and field evaluations, it will identify cost-effective technologies to meet environmental monitoring requirements. The program includes three main areas: acute and sublethal toxicity testing, biological monitoring in receiving waters, and water and sediment monitoring. The program includes literature-based technical evaluations and a comprehensive three year field program.

The program has the mandate to do a field evaluation of water, sediment and biological monitoring technologies to be used by the mining industry and regulatory agencies in assessing the impacts of mine effluents on the aquatic environment; and to provide guidance and to recommend specific methods or groups of methods that will permit accurate characterization of environmental impacts in the receiving waters in as cost-effective a manner as possible. A pilot field study was conducted in 1995 to fine-tune the study design.

A phased approach has been adopted to complete the field evaluation of selected monitoring methods as follows:

Phase I: 1996- Preliminary surveys at seven candidate mine sites, selection of sites for further work and preparation of study designs for detailed field evaluations.

Phase II: 1997-Detailed field and laboratory studies at selected sites.

Phase III: 1998- Data interpretation and comparative assessment of the monitoring methods: report preparation.

Phases II and III are the focus of this report. The objective of the 1997 Field Program is <u>NOT</u> to determine the extent and magnitude of effects of mining at the sites but rather to test a series of hypotheses under field conditions and evaluate monitoring methods for assessing aquatic effects.

In Phase I, the AETE Technical Committee selected seven candidates mine sites for the 1996 field surveys: Myra Falls, Westmin Resources (British Columbia); Sullivan, Cominco (British Columbia); Lupin, Contwoyto Lake, Echo Bay (Northwest Territories); Dome, Placer Dome Canada (Ontario); Levack/Onaping, Inco and Falconbridge (Ontario); Gaspé Division, Noranda Mining and Exploration Inc. (Québec); Heath Steele Division, Noranda Mining and Exploration Inc. (New-Brunswick).

Study designs were developed for four sites that were deemed to be most suitable for Phase II of the field evaluation of monitoring methods: Myra Falls, Dome, Heath Steele, Lupin. Lupin was subsequently dropped based on additional reconnaissance data collected in 1997. Mattabi Mine, (Ontario) was selected as a substitute site to complete the 1997 field surveys.

A summary of the results and comparisons of tools at all the four mine sites studied in 1997 are provided in a separate document which evaluate the cost-effectiveness of each monitoring tool (AETE Report #4.1.3, *Summary and Cost-effectiveness Evaluation of Aquatic Effects Monitoring Technologies Applied in the 1997 AETE Field Evaluation Program,* Beak International Incorporated and Golder Associates Ltd, September 1998)

For more information on the monitoring techniques, the results from their field application and the final recommendations from the program, please consult the *AETE Synthesis Report*.

Any comments regarding the content of this report should be directed to:

Geneviève Béchard
Manager, Metals and the Environment Program
Mining and Mineral Sciences Laboratories - CANMET
Room 330, 555 Booth Street, Ottawa, Ontario, K1A 0G1
Tel.: (613) 992-2489 Fax: (613) 992-5172
E-mail: gbechard@nrcan.gc.ca

PROGRAMME D'ÉVALUATION DES TECHNIQUES DE MESURE D'IMPACTS EN MILIEU AQUATIQUE

Avis aux lecteurs

Études de terrain - 1997

Le Programme d'évaluation des techniques de mesure d'impacts en milieu aquatique (ÉTIMA) vise à évaluer les différentes méthodes de surveillance des effets des effluents miniers sur les écosystèmes aquatiques. Il est le fruit d'une collaboration entre l'industrie minière du Canada, plusieurs ministères fédéraux et un certain nombre de ministères provinciaux. Sa coordination relève du Centre canadien de la technologie des minéraux et de l'énergie (CANMET). Le programme est conçu pour bénéficier directement aux entreprises minières ainsi qu'aux gouvernements. Par des évaluations techniques et des études de terrain, il permettra d'évaluer et de déterminer, dans une perspective coût-efficacité, les techniques qui permettent de respecter les exigences en matière de surveillance de l'environnement. Le programme comporte les trois grands volets suivants : évaluation de la toxicité aiguë et sublétale, surveillance des effets biologiques des effluents miniers en eaux réceptrices, et surveillance de la qualité de l'eau et des sédiments. Le programme prévoit également la réalisation d'une série d'évaluations techniques fondées sur la littérature et d'évaluation globale sur le terrain.

Le Programme ÉTIMA a pour mandat d'évaluer sur le terrain les techniques de surveillance de la qualité de l'eau et des sédiments et des effets biologiques qui sont susceptibles d'être utilisées par l'industrie minière et les organismes de réglementation aux fins de l'évaluation des impacts des effluents miniers sur les écosystèmes aquatiques; de fournir des conseils et de recommander des méthodes ou des ensembles de méthodes permettant, dans une perspective coût-efficacité, de caractériser de façon précise les effets environnementaux des activités minières en eaux réceptrices. Une étude-pilote réalisée sur le terrain en 1995 a permis d'affiner le plan de l'étude.

L'évaluation sur le terrain des méthodes de surveillance choisies s'est déroulée en trois étapes:

Étape I 1996 - Évaluation préliminaire sur le terrain des sept sites miniers candidats, sélection des sites où se poursuivront les évaluations et préparation des plans d'étude pour les évaluations sur le terrain.

Étape II 1997- Réalisation des travaux en laboratoire et sur le terrain aux sites choisis

Étape III 1998 -Interprétation des données, évaluation comparative des méthodes de surveillance; rédaction du rapport.

Ce rapport vise seulement les résultats de l'étape II et III. L'objectif du projet N'EST PAS de déterminer l'étendue ou l'ampleur des effets des effluents miniers dans les sites. Le projet vise à vérifier une série d'hypothèses sur le terrain et à évaluer et comparer un ensemble choisi de méthodes de surveillance.

À l'étape I, le comité technique ÉTIMA a sélectionné sept sites miniers candidats aux fins des évaluations sur le terrain:Myra Falls, Westmin Resources (Colombie-Britannique); Sullivan, Cominco (Colombie-Britannique); Lupin, lac Contwoyto, Echo Bay (Territoires du Nord-Ouest); Levack/Onaping, Inco et Falconbridge (Ontario); Dome, Placer Dome Mine (Ontario); Division Gaspé, Noranda Mining and Exploration Inc.(Québec); Division Heath Steele Mine, Noranda Mining and Exploration Inc.(Nouveau-Brunswick).

Des plans d'études ont été élaborés pour les quatres sites présentant les caractéristiques les plus appropriées pour les travaux prévus d'évaluation des méthodes de surveillance dans le cadre de l'étape II (Myra Falls, Dome, Heath Steele, Lupin). Toutefois, une étude de reconnaissance supplémentaire au site minier de Lupin a révélé que ce site ne présentait pas les meilleures possibilités. Le site minier de Mattabi (Ontario) a été choisi comme site substitut pour compléter les évaluations de terrain en 1997.

Un résumé des résultats obtenus aux quatre sites miniers en 1997, la comparaison et l'évaluation des techniques dans une perspective coût-efficacité sont présentés dans un autre document (Rapport ÉTIMA #4.1.3, *Summary and Cost-effectiveness Evaluation of Aquatic Effects Monitoring Technologies Applied in the 1997 AETE Field Evaluation Program,* Beak International Incorporated and Golder Associates Ltd, September 1998).

Pour des renseignements sur l'ensemble des outils de surveillance, les résultats de leur application sur le terrain et les recommandations finales du programme, veuillez consulter le *Rapport de synthèse ÉTIMA*.

Les personnes intéressées à faire des commentaires sur le contenu de ce rapport sont invitées à communiquer avec M[me] Geneviève Béchard à l'adresse suivante :

Geneviève Béchard
Gestionnaire, Programme des métaux dans l'environnement
Laboratoires des mines et des sciences minérales - CANMET
Pièce 330, 555, rue Booth, Ottawa (Ontario), K1A 0G1
Tél.: (613) 992-2489 / Fax : (613) 992-5172
Courriel : gbechard@nrcan.gc.ca

EXECUTIVE SUMMARY

The Dome Mine (Ontario) study is one of four field evaluations carried out in 1997 under the Aquatic Effects Technology Evaluation (AETE) Program, a joint government-industry program to evaluate the cost-effectiveness of technologies for the assessment of mining-related impacts in the aquatic environment. The other three mines studied were Myra Falls (British Columbia), Mattabi (Ontario) and Heath Steele (New Brunswick). Results of all four studies are summarized and evaluated in a separate summary report.

The Placer-Dome Dome Mine is large open pit and underground mine located west of Timmins, Ontario. The mine began operations in 1910, and is one of the oldest and largest gold mines in Canada. Effluent from the mine is discharged from a tailings pond after treatment for cyanide using a combination of natural degradation and the Inco SO_2/air process. Effluent is discharged seasonally during the ice-free season to take advantage of natural cyanide degradation. The Inco treatment system was brought on-line for the first time in 1997. Mine effluent is discharged to the South Porcupine River, a relatively small, low-gradient watercourse. Approximately 3 km downstream of the effluent discharge, the South Porcupine joins the North Porcupine, and flows into Porcupine Lake.

A number of older mine workings and wastes occur in the South Porcupine watershed upstream of the Dome discharge, and may represent sources of contaminants through runoff and seepage.

The objectives of the 1997 field program were to test 13 hypotheses formulated under four guiding questions:

1. are contaminants getting into the system (and to what degree and in which compartments)?
2. are contaminants bioavailable?
3. is there a measurable (biological) response? and
4. are contaminants causing the responses?

The hypotheses are more specific questions about the ability or relative ability of different monitoring tools to answer these four general questions about mine effect. The evaluation of tools included: sediment monitoring (sediment toxicity tests); fish monitoring (tissue metallothionein and metal analyses, and population/community indicators), and; integration of tools (relationships between exposure and biological responses and use of effluent sublethal toxicity).

Of the 13 hypotheses, 11 were tested at Dome as outlined in Table 1.1. The two hypotheses not tested at Dome were H5 (fish catch-per-unit-effort) and H6 (fish community). These hypotheses were deleted because of natural habitat and fish community differences among areas.

The sediment quality triad was used as an additional means of evaluating the linkages between sediment toxicity, sediment chemistry and benthic community response (H10 and H11) in the South and North Porcupine Rivers. The triad provides a more holistic means of evaluating the tools.

Study Design

The study design at Dome was based on both lake and river sampling for fish, and river sampling for benthos, sediment chemistry and sediment toxicity. River sampling followed a nearfield-farfield-reference design, with the nearfield in the South Porcupine River after mixing with the effluent, the farfield in the Porcupine River downstream of the South Porcupine-North Porcupine confluence, and the reference area in the South Porcupine River upstream of the effluent source. The farfield area for fish in the river was relocated immediately upstream of the North Porcupine confluence owing to a lack of sentinel species downstream. Lake sampling was carried out for one fish species only in Porcupine Lake (exposure area) and McDonald's Lake (reference area).

Sampling Program

The Dome Mine field survey was completed in late September-early October 1997, and included:

- river water sampling at three nearfield stations, three farfield stations and six reference stations for determination of dissolved (filtered) and total metal concentrations, cyanide and other parameters; and lake water sampling at four locations each in Porcupine Lake and McDonald's Lake. Effluent had not been discharged from Dome since 12 August 1997; thus, water quality conditions at the time of the survey were unlikely to reflect any direct effluent impact;

- surficial sediment sampling in the river at the seven nearfield stations, seven farfield stations and seven reference stations using a petite Ponar. Samples were analyzed for "total" metal concentrations, partial metal concentrations (i.e., the Fe and Mn oxide-bound fraction) and concentrations of acid volatile sulphide (AVS) and simultaneously extracted metals (SEM);

- surficial sediment sampling at the above 21 stations for benthic macroinvertebrate community analysis and for sediment toxicity testing (*Hyalella azteca* - survival and growth, *Chironomus riparius* - survival and growth, *Tubifex tubifex* - survival and growth);

- sampling of yellow perch in McDonald's Lake and Porcupine Lake for analysis of growth, liver weight, gonad weight and fecundity (approximately 20 males and 20 females per lake). Fish were captured mainly by seine in Porcupine Lake and gill net in McDonald's Lake. A subset of 12 fish per lake was analyzed for metallothionein (MT) and metals in muscle (metals only), liver, gill and kidney;

- sampling of pearl dace (20 males, 20 females per site area) from nearfield, farfield and reference river areas for analysis of growth, liver weight, gonad weight and fecundity. Fish were captured mainly in baited minnow traps. Nine pearl dace samples per site were analyzed for MT and metals in viscera. An additional nine pearl dace samples were captured from a second reference area (beaver pond in the South Porcupine River) for MT and metal analysis;

- sampling of caged young-of-the-year yellow perch, captured from a nearby unimpacted lake, after ten days of exposure at each of the two lake areas and three river areas. These fish were analyzed as three-fish composites for visceral MT and metals; and

- testing of chronic effluent toxicity, based on three sampling events. The first event was collected under conditions of treatment using the Inco process, the second was collected without Inco treatment (natural degradation only) and the third was collected under non-discharge conditions in October from the effluent storage pond.

Data Overview

Water Quality

Concentrations of Cu, Co and Ni were consistently greater at nearfield and farfield stations and in Porcupine Lake than in the reference areas, with total Cu consistently exceeding the Canadian Water Quality Guideline (CWQG). This could reflect the presence of residual effluent in the slow-flowing river, or secondary impact from mine-related metals in river sediments. Copper and cobalt concentrations appeared to respond to Dome Mine, while nickel was affected both by Dome and by the North Porcupine River. Arsenic concentrations were elevated above the CWQG at one of the reference areas, apparently reflecting an impact of historic mine waste. Other parameters, including nitrate, sulphate, hardness and total dissolved solids, were also greater in exposure areas than reference areas.

Total and dissolved metal concentrations showed similar spatial patterns. For copper and arsenic, the dissolved fraction represented the majority of the total metal concentration present in the water.

Sediment Chemistry

Sediments in the South Porcupine River system were predominantly silt and clay, with relatively low organic carbon contents.

Total metal concentrations in sediment were greatest in the nearfield and lowest in the reference area for Cu and Ni. Sediment arsenic concentrations were greatest in some of the reference sediment samples, although As levels were more variable in reference sediments than elsewhere. Other metals showed variable spatial patterns that did not appear related to Dome. Concentrations of Cu, Ni and As exceeded their Canadian Interim Sediment Quality Assessment Values (PEL values) at most (Cu, Ni) or all (As) stations.

Partial metal concentrations showed generally similar spatial patterns to those observed for total metals for As, Ni and Cu. The partial metal fractions represented about half of the total metals for As and Ni but only about 1% for copper.

The SEM/AVS ratio in sediments was consistently low (≤ 0.5), suggesting that sediments should be generally not be toxic to benthic organisms.

Sediment Toxicity

Sediments showed possible mine-related toxicity only in the case of *Hyalella* survival, although significant mortality was seen relative to laboratory controls in both *Hyalella* and *Chironomus*. No mine-related sublethal effects were observed.

Benthic Macroinvertebrates

The benthic macroinvertebrate community showed apparent responses in terms of reduced total densities, numbers of taxa and numbers of indicator taxa in the nearfield. The numbers of **E**phemeroptera, **P**lecoptera and **T**richoptera (EPT) taxa and relative abundance of chironomids also separated exposed from reference areas. Impacts in the farfield, however, were generally not evident.

Fish

The most common fish species in the river were brook stickleback, pearl dace, northern redbelly dace and fathead minnow. However, pearl dace could not be captured downstream of the North Porcupine River confluence; accordingly, pearl dace were collected in the South Porcupine River at the nearfield area and approximately 1.5 km downstream, just upstream of the North Porcupine confluence. Pearl dace size, liver weight, gonad weight and fecundity were greatest in exposed fish and lowest in the reference fish. When adjusted for body weight, however, gonad weight and fecundity were lower in exposed dace than in reference dace.

Fish communities in McDonald's Lake and Porcupine Lake differed, with rock bass dominating McDonald's Lake but absent in Porcupine Lake catches. Yellow perch were captured in both lakes, but were difficult to capture in the reference. Yellow perch growth, fecundity, liver weight and gonad weight were similar in exposed and reference fish. However, when adjusted for body weight, exposed perch had lower gonad weights.

Visceral metal levels in pearl dace showed an apparent mine-related effect for Cu, Ag and Se. No visceral metallothionein (MT) response was apparent in dace.

Tissue metal levels in yellow perch varied substantially between lakes and among species. Greater tissue metal concentrations were observed in nearfield perch for liver, kidney and muscle, although the opposite trend was observed in gill (higher metals in reference fish). Tissue MT results were generally inconsistent with a mine-related effect, with greater MT in reference fish gill and kidney, but slightly greater MT in exposed fish liver.

Caged juvenile perch showed no responses in terms of visceral MT or metal concentration. In most cases, metal concentrations decreased and MT concentrations increased in caged fish over the exposure period, indicating that caging of fish may itself affect results.

Effluent Toxicity

Dome effluent was relatively toxic to test species, and produced lethality to *Ceriodaphnia* (all samples) and fathead minnow (two samples). The June sample was the least toxic and the October sample the most toxic. *Ceriodaphnia* and *Lemna* were the most sensitive species (chronic IC25 values $<15\%$ effluent) and fathead minnow was least sensitive.

Hypothesis Testing

Hypothesis testing results are summarized in Table 5.2. Results of testing indicate that some contaminants (metals) are bioavailable, that some biological responses occurred and that contaminants may have caused some of the responses.

Technology Evaluation

Some of the tools evaluated at Dome demonstrated a mine effect while others did not (Table 6.2). Monitoring tools that were effective included most water and sediment chemistry tools (except SEM and AVS), benthic community tools, some of the fish health tools (when adjusted for body weight) and some of the fish tissue metal tools. Tools showing no mine-related effect included MT, fish population/community tools (due to confounding habitat effects) and sediment toxicity as measured by *Chironomus* and *Tubifex*. The ineffectiveness of some monitoring tools may in part be attributed to the fact that effluent had not been discharged for several weeks before the survey, and the other confounding factors (habitat, other contaminant sources) were present.

Of related tools that were effective (e.g., total and dissolved metals in water), difference in effectiveness were relatively small as summarized in Table 6.3. Cost is therefore an important deciding factor in determining cost-effectiveness of these tools, as presented for all four mines studied in 1997 in a separate document "Summary and Cost-Effectiveness Evaluation of Aquatic Effects Monitoring Technologies Applied in the 1997 AETE Field Evaluation Program".

SOMMAIRE

L'étude du site de la mine Dome (Ontario) est l'une des quatre évaluations sur le terrain effectuées en 1997 dans le cadre du Programme d'évaluation des techniques de mesure d'impacts en milieu aquatique (ETIMA), programme conjoint gouvernement-industrie destiné à évaluer le rapport coût-efficacité des technologies d'évaluation des impacts liés aux activités minières dans le milieu aquatique. Les trois autres sites miniers étudiés étaient ceux de Myra Falls (Colombie-Britannique), de Mattabi (Ontario) et de Heath Steele (Nouveau-Brunswick). On présente un résumé et une évaluation des résultats de ces quatre études dans un rapport sommaire distinct.

La mine Dome de Placer-Dome, qui combine une grande mine à ciel ouvert et une mine souterraine, est située à l'ouest de Timmins (Ontario). Ouverte en 1910, elle est l'une des plus anciennes et des plus grandes mines d'or du Canada. Ses effluents s'écoulent d'un bassin de décantation des résidus après un traitement d'élimination du cyanure combinant la dégradation naturelle à un procédé SO_2/air de l'Inco. On déverse les effluents pendant la période sans glace afin de profiter de la dégradation naturelle du cyanure. On a commencé à utiliser le système de traitement Inco en 1997. Les effluents miniers sont déversés dans la rivière South Porcupine, un cours d'eau relativement petit à faible gradient qui se jette, à environ 3 km en aval du point de rejet des effluents, dans la rivière North Porcupine, dont les eaux se déversent dans le lac Porcupine.

Dans le bassin hydrographique de la rivière South Porcupine, en aval du point de rejet des effluents de la mine Dome, divers ouvrages et déchets peuvent constituer des sources de contaminants par écoulement et infiltration.

Les objectifs du programme sur le terrain de 1997 étaient de vérifier 13 hypothèses formulées pour tenter de répondre à quatre questions principales :

1. Est-ce que les contaminants pénètrent dans le réseau aquatique (et dans l'affirmative, dans quelle mesure et dans quels compartiments)?
2. Les contaminants sont-ils biodisponibles?
3. La réponse (biologique) est-elle mesurable?
4. Les contaminants sont-ils la cause de ces réponses?

Ces hypothèses représentent des questions plus spécifiques concernant la capacité (relative) des différents outils de surveillance de répondre à ces quatre questions générales sur les effets des activités minières. L'évaluation des outils prévoyait notamment la surveillance des sédiments (tests de toxicité des sédiments), la surveillance des poissons (dosage de la métallothionéine et des métaux dans les tissus et détermination des indicateurs des populations/communautés) et, enfin, l'intégration des outils (rapports entre l'exposition et les réponses biologiques et utilisation de la toxicité sublétale des effluents).

On a vérifié 11 des 13 hypothèses au site de la mine Dome (voir le tableau 1.1). Les deux hypothèses non vérifiées sur ce site étaient les hypothèses H5 (prises de poissons par unité

d'effort) et H6 (communauté de poissons). On a rayé ces hypothèses de la liste à cause de différences touchant l'habitat naturel et les communautés de poissons d'une zone à l'autre.

On a utilisé les trois paramètres de la qualité des sédiments comme outil supplémentaire pour l'évaluation des liens entre la toxicité des sédiments, la chimie des sédiments et la réponse de la communauté benthique (H10 et H11) dans les rivières South et North Porcupine. Ces trois paramètres donnent une vue plus générale pour l'évaluation des outils.

Plan de l'étude

Au site Dome, le plan de l'étude était basé sur l'échantillonnage des poissons des lacs et des rivières, ainsi que sur l'échantillonnage du benthos des rivières, la chimie des sédiments et la toxicité des sédiments. L'échantillonnage des rivières était basé sur un modèle zone voisine - zone éloignée – zone de référence, la zone voisine étant située après la zone de mélange des effluents dans la rivière South Porcupine, la zone éloignée, en aval du confluent de cette rivière avec la rivière North Porcupine, et la zone de référence, en amont de la source des effluents dans la rivière South Porcupine. Pour les poissons de la rivière, à cause de l'absence d'une espèce sentinelle en aval, on a choisi un autre endroit comme zone lointaine, immédiatement en amont du confluent avec la rivière North Porcupine. Dans le lac Porcupine (zone d'exposition) et dans le lac McDonald's (zone de référence), on n'a échantillonné qu'une seule espèce de poisson..

Programme d'échantillonnage

On a terminé les relevés sur le terrain pour le site Dome vers la fin de septembre et le début d'octobre 1997, notamment :

- l'échantillonnage de l'eau de rivière à trois stations de la zone voisine, à trois stations de la zone éloignée et à six stations de la zone de référence pour la détermination des concentrations des métaux dissous (filtrés) et totaux, de cyanure et d'autres paramètres; et l'échantillonnage de l'eau du lac à quatre endroits dans les lacs Porcupine et McDonald's. Comme Dome n'avait pas déversé d'effluents depuis le 12 août 1997, il était peu probable que les conditions de la qualité de l'eau au moment du relevé reflètent un impact direct des effluents;

- l'échantillonnage des sédiments de la surface dans la rivière aux sept stations proches, aux sept stations éloignées et aux sept stations de référence à l'aide d'un échantillonneur « Petite Ponar ». Avec ces échantillons, on a mesuré les concentrations « totales » des métaux, les concentrations partielles de certains métaux (p. ex. la fraction liée aux oxydes de Fe et de Mn), les concentrations des sulfures volatils en milieu acide et celles des métaux extractibles simultanément;

- l'échantillonnage des sédiments en surface aux 21 stations ci-dessus pour l'analyse de la communauté des macroinvertébrés benthiques et pour les essais de toxicité des sédiments (survie et croissance d'*Hyalella azteca*, de *Chironomus riparius* et de *Tubifex tubifex*);

- l'échantillonnage de la perchaude dans les lacs McDonald's et Porcupine pour l'analyse de sa croissance ainsi que pour déterminer le poids du foie, des gonades et la fécondité de cette espèce (environ 20 mâles et 20 femelles par lac). Pour la capture des poissons, on a utilisé surtout une seine dans le lac Porcupine et un filet maillant dans le lac McDonald's. On a utilisé un sous-ensemble de 12 poissons par lac pour doser la métallothionéine (MT) et les métaux des muscles (métaux seulement), du foie, des branchies et des reins;

- l'échantillonnage du mulet perlé (20 mâles, 20 femelles par site) des zones voisine et éloignée, ainsi que de la zone de référence de la rivière pour les analyses de la croissance, du poids du foie, du poids des gonades et de la fécondité. On a capturé la plupart des poissons à l'aide de pièges appâtés avec des ménés. On a dosé la MT et les métaux des viscères de neuf échantillons de mulets perlés par site. On a prélevé neuf échantillons supplémentaires de mulets perlés dans une deuxième zone de référence (étang à castors dans la rivière South Porcupine) pour des dosages de MT et de métaux;

- l'échantillonnage de jeunes de l'année de perchaudes en cage, provenant d'un lac voisin n'ayant pas subi d'impacts de la mine, après dix jours d'exposition dans chacune des deux zones de lac et des trois zones de rivière. On a dosé la MT et les métaux de trois échantillons composés de viscères de ces poissons;

- des tests de toxicité chronique des effluents, basés sur trois échantillonnages. On a recueilli le premier échantillon dans les conditions du traitement avec le procédé Inco, le second sans le traitement Inco (dégradation naturelle seulement) et le troisième en octobre, dans des conditions de non-rejet d'effluents de l'étang de décantation.

Aperçu des données

Qualité de l'eau

De façon générale, les concentrations de Cu, de Co et de Ni des stations proches et éloignées et celles du lac Porcupine étaient supérieures à celles des zones de référence, et la teneur en Cu total dépassait les limites des Recommandations pour la qualité des eaux au Canada (RQEC). Cela peut indiquer la présence d'effluents résiduels dans cette rivière à écoulement lent ou un impact secondaire des métaux des activités minières dans ses sédiments. Il semble que les concentrations de cuivre et de cobalt étaient influencées par la mine Dome, alors que les concentrations de nickel l'étaient tant par la mine que par la rivière North Porcupine. Dans l'une des zones de référence, les concentrations d'arsenic étaient supérieures aux limites des RQEC, ce qui semble être dû à l'impact des rejets de déchets miniers anciens. De plus, les valeurs d'autres paramètres, notamment le nitrate, le sulfate, la dureté et les matières totales dissoutes, étaient également plus élevées dans les zones d'exposition que dans les zones de référence.

On observait des profils semblables de distribution spatiale pour les concentrations de métaux totaux et dissous. Dans le cas du cuivre et de l'arsenic, la fraction dissoute représentait la plus grande partie des concentrations totales de métaux présentes dans l'eau.

Chimie des sédiments

Les sédiments du réseau de la rivière South Porcupine étaient surtout constitués de silt et d'argile, avec des teneurs relativement faibles en carbone organique.

Dans le cas du Cu et du Ni, les concentrations de métaux totaux dans les sédiments étaient les plus élevées dans la zone voisine et les plus faibles dans la zone de référence. Les concentrations d'arsenic dans les sédiments étaient plus élevées dans certains échantillons de sédiments de la zone de référence, même si les teneurs en As étaient plus variables dans les sédiments de cette zone qu'ailleurs. Pour d'autres métaux, on a noté des profils variables de distribution spatiale qui ne semblaient pas liés aux activités de Dome. Les concentrations de Cu, de Ni et d'As dépassaient les valeurs de l'évaluation intérimaire canadienne de la qualité des sédiments (teneurs à effets probables) (Canadian Interim Sediment Quality Assessment Values) pour la plupart des stations (Cu, Ni) ou pour l'ensemble de celles-ci (As).

De façon générale, dans le cas de As, Ni et Cu, les concentrations partielles de métaux présentaient des profils de distribution spatiale semblables à ceux observés pour les métaux totaux. Les fractions métalliques partielles représentaient environ la moitié des métaux totaux dans le cas de As et de Ni, mais seulement environ 1 % dans le cas du cuivre.

Dans les sédiments, le rapport des concentrations des sulfures volatils en milieu acide et de celles des métaux extractibles simultanément était faible (inférieur ou égal à 0,5), ce qui suggère que, de façon générale, les sédiments ne devraient pas être toxiques pour les organismes benthiques.

Toxicité des sédiments

On n'a noté d'effets de toxicité des sédiments pouvant être liés aux activités minières que dans le cas du taux de survie d'*Hyalella*, bien qu'on ait observé une mortalité significative par rapport à des témoins en laboratoire tant pour *Hyalella* que pour *Chironomus*. On n'a pas observé d'effets sublétaux liés aux activités minières.

Macroinvertébrés benthiques

La communauté des macroinvertébrés benthiques semblait réagir par une diminution des densités totales, du nombre de taxons et du nombre de taxons indicateurs dans la zone voisine. Les nombres de taxons *Ephemeroptera*, *Plecoptera* et *Trichoptera* (EPT) et l'abondance relative des chironomidés distinguait également les zones exposées des zones de référence. Cependant, de façon générale, les impacts dans les zones éloignées n'étaient pas évidents.

Poissons

Les espèces de poissons les plus communes dans les rivières étaient l'épinoche à cinq épines, le mulet perlé, le ventre rouge du nord et le tête-de-boule. Toutefois, on n'a pu capturer de mulet perlé en aval du confluent de la rivière North Porcupine et, donc, on en a capturé dans la zone voisine de la rivière South Porcupine et à environ 1,5 km en aval, juste en amont du confluent avec la rivière North Porcupine. Pour le mulet perlé, on a observé les plus fortes valeurs de taille, de poids du foie, de poids des gonades et de fécondité chez les poissons exposés et les plus faibles valeurs chez les poissons de la zone de référence. Toutefois, après des ajustements pour tenir compte du poids corporel, les valeurs du poids des gonades et de la fécondité étaient plus faibles chez les mulets exposés que chez ceux de la zone de référence.

Les communautés de poissons des lacs McDonald's et Porcupine présentaient des différences : alors que le crapet des roches dominait dans le lac McDonald's, il était absent des prises du lac Porcupine. On a capturé des perchaudes dans les deux lacs, mais cette espèce était difficile à capturer dans la zone de référence. Pour la perchaude, les valeurs de la croissance, de la fécondité, du poids du foie et du poids des gonades des poissons exposés étaient semblables à celles des poissons de la zone de référence. Toutefois, après des ajustements pour tenir compte du poids corporel, les poids des gonades des perchaudes exposées étaient plus faibles.

On a observé un effet qui semblait être lié aux activités minières dans les teneurs en métaux (Cu, Ag et Se) des viscères chez le mulet perlé. On n'a observé aucune réponse de la métallothionéine des viscères (MT) chez le mulet.

Chez la perchaude, les teneurs en métaux des tissus présentaient d'importantes variations d'un lac à l'autre et d'une espèce à l'autre. On a observé les plus fortes concentrations de métaux dans les tissus du foie, des reins et des muscles des perchaudes de la zone voisine, même si on observait la tendance opposée dans les branchies (teneurs plus élevées en métaux chez les poissons de la zone de référence). En général, les résultats des dosages de la MT des tissus ne correspondaient pas à un effet lié aux activités minières, étant donné que les valeurs de MT étaient plus élevées dans les branchies et les reins des poissons de la zone de référence, mais légèrement plus élevées dans le foie des poissons exposés.

Pour ce qui est des concentrations de MT ou de métaux des viscères, on n'observait pas de réponse chez les juvéniles de perchaude en cage. Dans la plupart des cas, leurs concentrations de métaux diminuaient et leurs concentrations de MT augmentaient au cours de la période d'exposition, ce qui indique que le fait d'utiliser des poissons en cage peut être un facteur qui influe sur les résultats.

Toxicité des effluents

Les effluents de Dome étaient relativement toxiques pour les espèces testées et ils avaient des effets létaux pour *Ceriodaphnia* (tous les échantillons) et la tête-de-boule (deux échantillons). L'échantillon de juin était le moins toxique et celui d'octobre, le plus toxique. *Ceriodaphnia* et *Lemna* étaient les espèces les plus sensibles [toxicité chronique (CI_{25}) inférieure à 15 % d'effluent], et la tête-de-boule était la moins sensible.

Vérification des hypothèses

Les résultats des vérifications des hypothèses sont résumés au tableau 5.2; ils indiquent que certains contaminants (métaux) sont biodisponibles, qu'on observe certaines réponses biologiques et que les contaminants peuvent être à l'origine de certaines de ces réponses.

Évaluation des techniques

Avec certains des outils évalués chez Dome, on a observé un effet dû aux activités minières, mais pas avec d'autres (tableau 6.2). Les outils de surveillance jugés efficaces étaient notamment la plupart des outils de chimie de l'eau et des sédiments (sauf le rapport des concentrations des sulfures volatils en milieu acide et de celles des métaux extractibles simultanément), les outils d'évaluation de la communauté benthique, certains des outils d'évaluation de la santé des poissons (après des ajustements pour tenir compte du poids corporel) et certains des outils de dosage des métaux dans les tissus des poissons. Les outils qui n'indiquaient pas d'effets dus aux activités minières étaient notamment les outils de dosage de la MT, les outils d'évaluation des populations ou des communautés de poissons (à cause d'effets liés à l'habitat venant brouiller les pistes) et les outils de mesure de la toxicité des sédiments (à l'aide de *Chironomus* et de *Tubifex*). On peut attribuer en partie l'inefficacité de certains outils de surveillance au fait qu'il n'y a pas eu de rejet d'effluents pendant plusieurs semaines avant le relevé, ainsi qu'à d'autres facteurs venant brouiller les indices (habitat, autres sources de contaminants).

On a noté des différences d'efficacité relativement faibles entre les outils efficaces apparentés (p. ex. le dosage des métaux totaux et dissous dans l'eau) (voir le tableau 6.3). Donc, le coût est un facteur important pour déterminer le rapport coût-efficacité de ces outils, comme on l'explique pour les quatre mines à l'étude dans un document distinct de 1997 « Summary and Cost-Effectiveness Evaluation of Aquatic Effects Monitoring Technologies Applied in the 1997 AETE Field Evaluation Program ».

TABLE OF CONTENTS

Page

LIST OF APPENDICES

LIST OF TABLES

Table No.

LIST OF FIGURES

Figure No.

1.0 INTRODUCTION

The Assessment of the Aquatic Effects of Mining in Canada (AQUAMIN), initiated in 1993, evaluated the effectiveness of Canada's *Metal Mining Liquid Effluent Regulations* (MMLER). One of the key recommendations of the 1996 AQUAMIN Final Report is that a revised MMLER include a requirement that metal mines conduct Environmental Effects Monitoring (EEM), to evaluate the effects of mining activity on the aquatic environment, including fish, fish habitat and the use of fisheries resources.

In parallel, the Canada Centre for Mineral and Energy Technology (CANMET) is coordinating a cooperative government-industry program, the Aquatic Effects Technology Evaluation (AETE) program, to review and evaluate technologies for the assessment of mining-related impacts in the aquatic environment. The intention of the AETE program is to evaluate and identify cost-effective technologies to meet environmental monitoring requirements at mines in Canada. The program is focused on evaluation of environmental monitoring tools that may be used for a national mining EEM program, baseline assessments or general impact studies.

The three principal components of the AETE program are lethal and sublethal toxicity testing of water/effluents and sediments, biological monitoring in receiving waters, and water and sediment chemistry assessments. The program includes both literature-based technical evaluations and comparative field programs at candidate sites. The AETE program is presently at the stage of evaluating selected monitoring methods at four case study sites across Canada.

An AETE Pilot Field Study was carried out in the Val d'Or region of Quebec in 1995 to evaluate a large number of environmental monitoring methods and to reduce the list of monitoring technologies for further evaluation at a cross-section of mine sites across Canada (BEAK, 1996). In 1996, a field evaluation program was initiated and involved preliminary sampling at seven candidate mine sites with the objective of identifying a short-list of mines that had suitable conditions for further detailed monitoring and testing of hypotheses related to the AETE program. Preliminary study designs were developed for four sites that were deemed to be most suitable for hypotheses testing in 1997 (EVS *et al.,* 1997). The sites selected were Heath Steele, New Brunswick; Lupin, N.W.T.; Dome Mine, Ontario; and Westmin Resources (now Boliden-Westmin), British Columbia. Lupin was subsequently dropped based on a 1997 reconnaissance survey and replaced with the Mattabi Mines Ltd.

Site in Ontario (BEAK and GOLDER, 1998a). The following report documents the results of the 1997 Field Evaluation at the Dome Mine site in Timmins, Ontario.

The 1996 Field Evaluation Program constituted Phase I of the Field Evaluation Program. The 1997 program consists of Phases II and III of the Program. Phase II includes the review of necessary background information, finalization of a study design and implementation of the field studies. Phase III includes the compilation, interpretation and reporting of results.

1.1 Study Objectives

The overall goal of the AETE Program is to identify cost-effective methods and technologies that are suitable for assessing aquatic environmental effects caused by mining activity. An effect is defined as “a measurable difference in an environmental variable (chemical, physical or biological) between a point downstream (or exposed to mining) in the receiving environment and an adequate reference point (either spatial or temporal)”. Based on this definition, the AETE Technical Committee developed a series of hypotheses to be tested under field conditions at a number of mine sites in Canada. The Committee agreed that specific hypotheses should be articulated in order to clarify the purpose of the program elements. For the formulation of the hypotheses, the definition of an effect was refined by the AETE Committee to distinguish between effects or responses as measured in biological variables as opposed to effects reflected in physical or chemical changes.

The questions used in developing the hypotheses to be tested in the 1997 field evaluation program were:

1. Are contaminants getting into the system (and to what degree, and in which compartments)? This question relates to the presence of elevated concentrations of metals in environmental media (e.g., water, sediments), and requires an understanding of metal dispersal mechanisms, chemical reactions in sediment and water, and aquatic habitat features which influence exposure of biological communities.

2. Are contaminants bioavailable? This question relates to the presence of metals in biota or to indicators of bioaccumulation, such as the induction of metallothionein in fish. Only if contaminants are bioavailable can a biological effect from chemical contaminants occur.

3. Is there a measurable response? Biological responses may occur only if contaminants are entering the environment and occur in bioavailable forms. These responses may occur at various levels of biological organization, including sub-organism levels (e.g., histopathological effects), at the organism level (e.g., as measured in toxicity testing), or at population and community levels (as measured in resident benthic invertebrate and fish communities).

4. Are contaminants causing the responses? This question is difficult to measure in field studies directly, as cause-effect mechanisms are difficult to assess under variable conditions prevailing in nature. However, correlations between measures of exposure, chemical bioavailability and response may be used to develop evidence useful in evaluating this question.

The AETE Technical Committee developed a study framework, using the above questions and the three components (water and sediment monitoring, biological monitoring in receiving waters and toxicity testing). The following eight areas of work were identified to finalize the work plan, develop the hypotheses, prioritize issues and identify field work requirements:

1. Chemical presence;
2. The overlap between communities and chemistry testing to determine whether biological responses are related to a chemical presence (bioavailability of contaminants);
3. Biological response in the laboratory;
4. Biological response in the field;
5. Chemical characteristics of the water and sediments used to predict biological responses in the field (contaminants causing a response);
6. The overlap between biological community responses and bioassay responses to evaluate whether community changes in the field are predicted by bioassay responses;
7. The overlap between chemistry and bioassay responses to evaluate whether chemicals are responsible for bioassay responses; and
8. The overlap between the chemical, the exposure and the effects in the laboratory and the effects in the field.

The core objective, however, is to **test the 13 hypotheses, developed by the AETE Committee, at as many of the four selected mine sites as possible** (Table 1.1). The hypotheses are more specific questions about the ability or relative ability of different monitoring tools to answer the four general questions (above) about mine effects.

These 13 hypotheses can be categorized into:

- ***Sediment Monitoring***: evaluation of sediment toxicity testing tools (test types) as to their relative ability to detect linkages between mine exposure and sediment toxicity (H1);

- ***Biological Monitoring (in Fish)***: evaluation of tissue biomonitoring tools (measurement types) as to their ability to detect linkages between mine exposure and tissue contamination (H2 to H4); and evaluation of population/community biomonitoring tools (measurement types) as to their ability to detect linkages between mine exposure and ecological response (H5 to H8); and

- ***Integration of Tools***: evaluation of various monitoring tools as to their relative ability to detect relationships between specific measures of mine exposure and specific biological response measures, or between sediment toxicity and benthic community response measures (H9 to H12); and evaluation of effluent toxicity testing tools (test types) as to their ability to detect relationships between effluent toxicity and population/community response measures (H13).

Dome Mine was one of the better sites for testing the hypotheses because 11 of the 13 hypotheses were testable (Table 1.1). Due to natural habitat and fish community differences among areas, Hypothesis H5 (catch per unit effort - CPUE) and H6 (fish community), were not tested. For example, during the field survey it was discovered that McDonald's Lake, which was recommended as the reference lake in the original study design (EVS *et al.*, 1997), is the only lake in the Timmins area that has rock bass, introduced by unknown sources. The rock bass population is now well established and they dominate the fish community in McDonald's Lake. Consequently, yellow perch (one of the sentinel species used for the field evaluation) required considerable more effort to capture the requisite number of individuals in the reference lake compared to the exposure

TABLE 1.1: HYPOTHESES TESTED IN 1997. AETE FIELD PROGRAM
(Hypotheses in bold print were tested at Dome)

<u>**Sediment Monitoring**</u> **H1. Sediment Toxicity:** **H:** ***The strength of the relationship between sediment toxicity responses and any exposure indicator is not influenced by the use of different sediment toxicity tests or combinations of toxicity tests.***
<u>**Biological Monitoring - Fish**</u> **H2. Metals in Fish Tissues (bioavailability of metals):** **H:** ***There is no difference in metal concentrations observed in fish liver, kidney, gills, muscle or viscera.***
H3. Metallothionein in Fish Tissues: **H:** ***There is no difference in metallothionein concentration observed in liver, kidney, gills, viscera, muscle.***
H4. Metal vs. Metallothionein in Fish Tissues: **H:** ***The choice of metallothionein concentration vs. metal concentrations in fish tissues does not influence the ability to detect environmental exposure of fish to metals.***
H5. Fish - CPUE: H: *There is no environmental effect in observed CPUE (catch per unit effort) of fish.*
H6. Fish (or Benthic) - Community: **H:** ***There is no environmental effect in observed fish (or benthic) community structure.***
H7: Fish - Growth: **H:** ***There is no environmental effect in observed fish growth.***
H8. Fish - Organ/Fish Size: **H:** ***There is no environmental effect in observed organ size.***
<u>**Integration of Tools**</u> **H9. Relationship between Water Quality and Biological Components:** **H:** ***The strength of the relationship between biological variables and metal chemistry in water is not influenced by the choice of total vs. dissolved analysis of metals concentration.***
H10. Relationship Between Sediment Chemistry and Biological Responses: **H:** ***The strength of the relationship between biological variables and sediment characteristics is not influenced by the analysis of total metals in sediments vs. either metals associated with iron and manganese oxyhydroxides or with acid volatile sulphides.***
H11. Relationship Between Sediment Toxicity and Benthic Invertebrates: **H:** ***The strength of the relationship between sediment toxicity responses and in situ benthic macroinvertebrate community characteristics is not influenced by the use of different sediment toxicity tests, or combinations of toxicity tests.***
H12. Metals or Metallothionein vs. Chemistry (receiving water and sediment): **H:** ***The strength of the relationship between the concentration of metals in the environment (water and sediment chemistry) and metal concentration in fish tissues is not different from the relationship between metal concentration in the environment and metallothionein concentration in fish tissues.***
H13. Chronic Toxicity - Linkage with Fish and Benthos Monitoring Results: H: *The suite of sublethal toxicity tests cannot predict environmental effects to resident fish performance indicators or benthic macroinvertebrate community structure.*

lake where perch is a dominant species in the absence of rock bass. The results from testing of Hypotheses H5 and H6 would have been strongly influenced by factors that were not mine related.

The AETE committee supported the use of caged young-of-the-year yellow perch to assist in the testing of Hypotheses H2, H3 and H4 and it was also desired to evaluate an overall "sediment quality triad" hypothesis, which would provide weight-of-evidence as to whether mine-related contaminants appear to be causing biological responses.

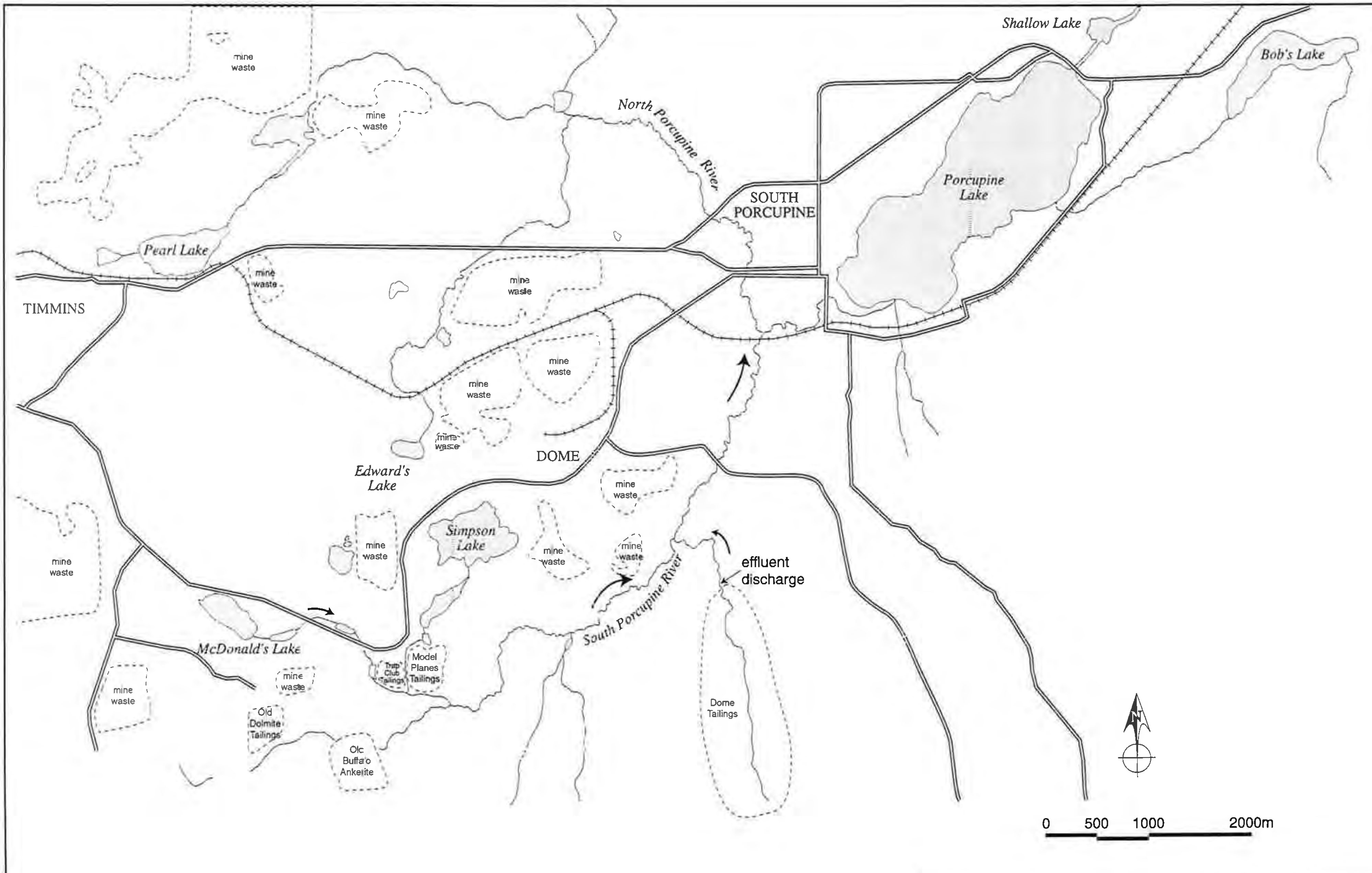
The mine stopped discharging effluent to the receiving environment approximately two months prior to the field survey, therefore, Hypothesis H13 was evaluated qualitatively.

1.2 Site Description

The Dome Mine, located in South Porcupine, just west of Timmins, Ontario (Figure 1.1) is one of the largest underground/open pit gold mines in Canada. The operations which started in 1910 represent one of the oldest and largest mines in Canada. The mine processes approximately 4.2 million tonnes of ore annually, of which 1.3 million tonnes is supplied from the underground operation and the remainder from the open pit.

The South Porcupine River is the receiving environment for mine effluent discharged periodically from Dome's #6 Dam (Figure 1.1). The river is a low-gradient, muddy-bottom stream with dense macrophytes throughout its length. Some sections are almost two metres deep because of a number of beaver dams along the creek. The effluent is fully mixed with receiving water within 500 m of the discharge point, and the North Porcupine River adds substantial additional dilution water approximately 3 km downstream. About 2 km downstream from the confluence of the two branches, the Porcupine River flows into Porcupine Lake. Upstream of the Dome Mine discharge there are several abandoned mines and tailings areas along the South Porcupine River that influence its water quality.

Discharge from the #6 Dam is largely seasonal, and at times is treated by an INCO-SO_2/Air cyanide destruction process before release to receiving waters. The operation utilizes gravity settling to produce a clear effluent which is recycled back to the mill for reuse. Excess effluent is treated using best available technology economically achievable



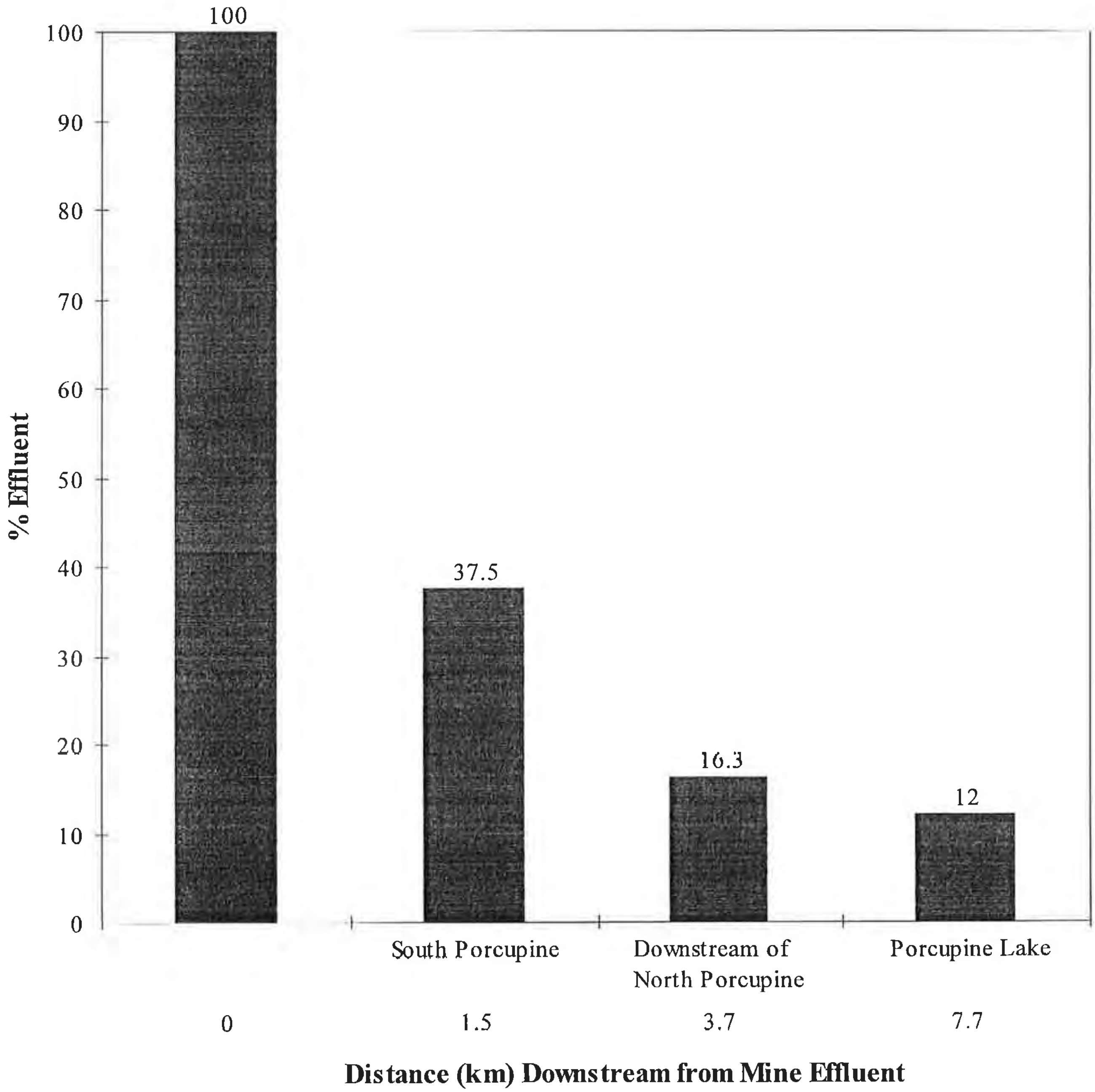
General Site Location of Dome Mine
Porcupine Lake

beak international incorporated	Figure 1.1	May 1998

(BATEA) prior to discharge. The INCO treatment system is only used when cyanide is not broken down naturally.

During the discharge period, estimated effluent exposure in the receiving waters, based on flow estimates provided by Dome, is 37% effluent in the area upstream of the confluence with the North Porcupine River, and 16% from the confluence downstream to Porcupine Lake (Figure 1.2). Little dilution occurs in Porcupine Lake itself, but there may be substantial settling of natural suspended solids from the river and adsorbed contaminants in the lake. It should be noted that suspended solids concentrations in treated mine effluent are generally low, and effluent itself is unlikely to be a significant source of particulate matter.

Owing to the extensive historic mining disturbance in the area, reference areas were not free of mine-related contaminants, but were sited as far as possible from historic tailings within the constraints imposed by the existing hydrology and natural setting. The stream reference area has been influenced by the abandoned Buffalo Ankerite mine, where roughly one million ounces of gold were mined between 1920 and 1950. Approximately 100 m upstream of the stream reference area is the Vedron Gold Inc. site which is actively being explored. In addition, there are a number of other abandoned tailings areas between McDonald's Lake and the Dome Mine discharge (Figure 1.1). The effects of these two operations (primarily from the abandoned Buffalo mine) were evident in the sediment and water chemistry at the stream reference site. McDonald's Lake, located further upstream, is the source of the city's drinking water supply, although there were also historical mining operations in this area as well.



Dome Mine Exposure Gradient

beak international incorporated	Figure 1.2	May 1998

2.0 STUDY DESIGN

2.1 Adjustments to Preliminary Study Design

EVS *et al.* (1997) developed a preliminary study design for sampling at the Dome Mine, based on the data from the 1996 field evaluation. However, refinements were made to this design based on additional findings during the undertaking of the study. The preliminary study design developed by EVS *et al.* (1997) for Dome Mine was reviewed and discussed with the AETE Technical Committee. Recommendations from this review received AETE's approval, and are integral to the final study design outlined in this section. Those recommendations were that:

- because there was very little effluent dilution along the South Porcupine River until the confluence with the North Porcupine River, it was recommended that the original recommendation for a gradient design for Hypotheses H10, H11 and H12 be changed to a Control-Impact (CI) design with two exposure areas in the river and one exposure area in the lake; and
- a recommendation was made that the Dome site provided the opportunity to use caged fish for supporting the testing of Hypotheses H2, H3 and H4.

Based on these recommendations and the preliminary study design (EVS *et al.,* 1997), it was anticipated that all 13 hypotheses could be tested at the Dome Mine site. However, once the field work was underway, additional information was gathered that resulted in changes to the study plan and the number of hypotheses that could be adequately tested.

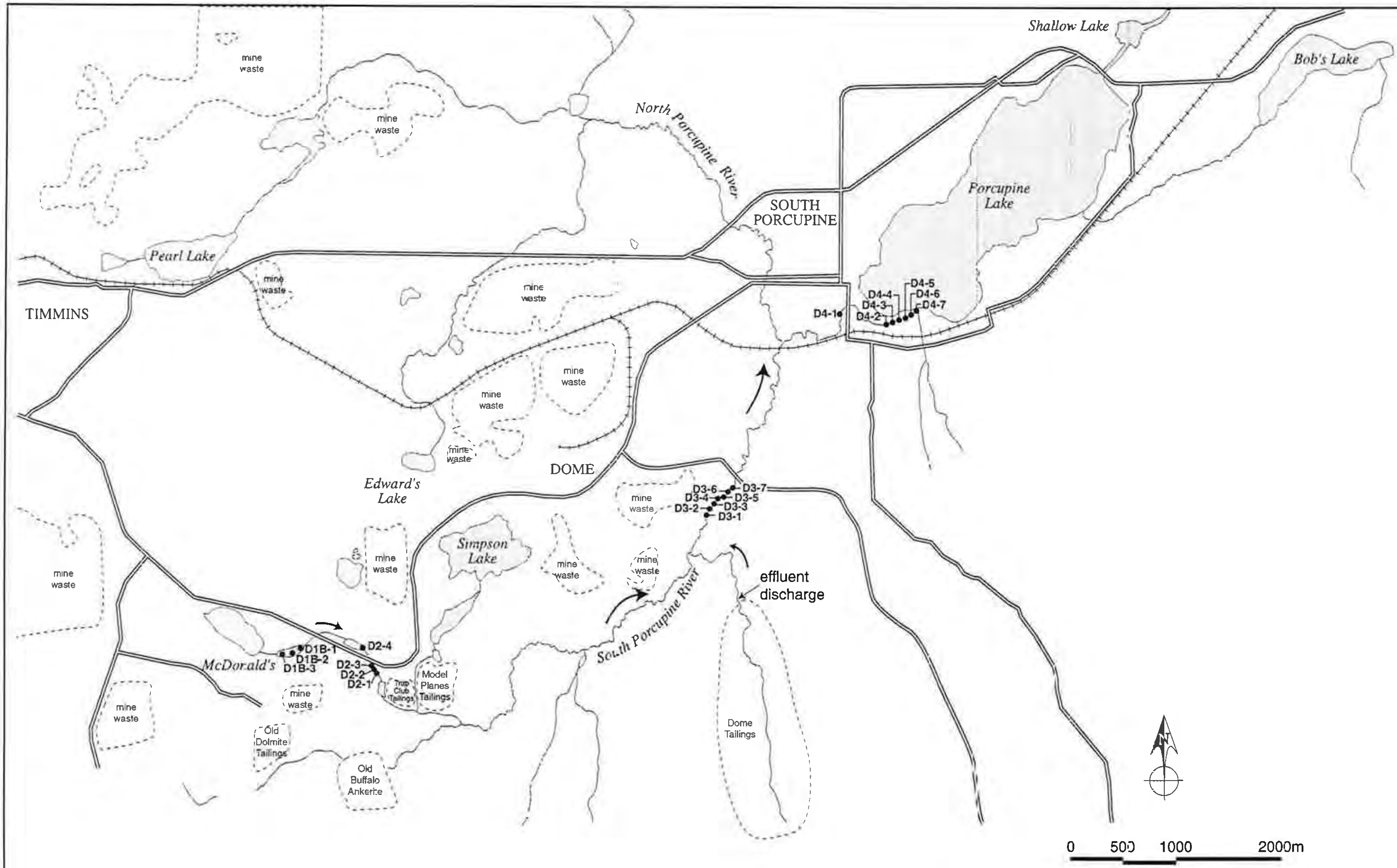
During the field survey it was found that the proposed stream reference area was only approximately 50 m long. This did not provide sufficient area for siting of seven benthos/sediment chemistry reference stations required for the approved study design. The stream, further upstream from this reference area and as far upstream as its source at McDonald's Lake, was overgrown with emergent vegetation which did not provide suitable habitat for sampling. In addition, the reference area was located adjacent to an abandoned mine shaft (Buffalo Ankerite) and approximately 50 m downstream the stream flowed over historical tailings from that mine (Trap Club Tailings). Therefore, reference fish collected in this area would have been exposed to these historical mine tailings.

A small area created by a beaver dam, approximately 100 m downstream of the outlet of McDonald's Lake, provided additional reference habitat that could be sampled. Therefore, three benthic sampling stations were established in this area and pearl dace, the stream sentinel species, were also collected in this location (stations from this area are labelled D1B-1 to 3). At the original reference site three stations were sampled and approximately 75 m upstream, at a road culvert, another station was sampled (these stations are labelled D2-1 to 4; Figure 2.1a).

It was initially recommended that the CPUE and fish community hypotheses could be tested at the Dome site. However, as discussed in Section 1.2, once on-site it was determined that McDonald's Lake had been stocked with rock bass. The rock bass dominated the McDonald's Lake fish community to the extent that yellow perch (the lake sentinel species) were extremely scarce. Local residents living on the lake had indicated that perch were once the most abundant fish species and that currently there were virtually none in the lake because of the rock bass. In contrast, yellow perch are plentiful in the exposure lake (Porcupine Lake) and are easily captured. In the reference lake, considerably more effort was required and all gear types were used (gill nets, electrofishing, minnow traps and seining) to catch the requisite number of perch, while in the exposure lake only seining was required to obtain the requisite number of fish. Consequently, tests of Hypotheses H5 (CPUE) and H6 (fish community) were impractical since any relationships found would have been strongly influenced by the presence of rock bass in the reference lake.

Similarly, changes in habitat from the stream reference area (i.e., shallow, narrow, overgrown stream) to the exposure area (deep beaver ponded areas) made comparison of catch per unit effort by electrofishing between these two areas impractical. Pearl dace were obtained by baited minnow traps. All fish in the reference area D2 (i.e., not including those from the beaver pond - D1B) were captured under road bridges where the fish congregated because of the increased water depth and overhead cover.

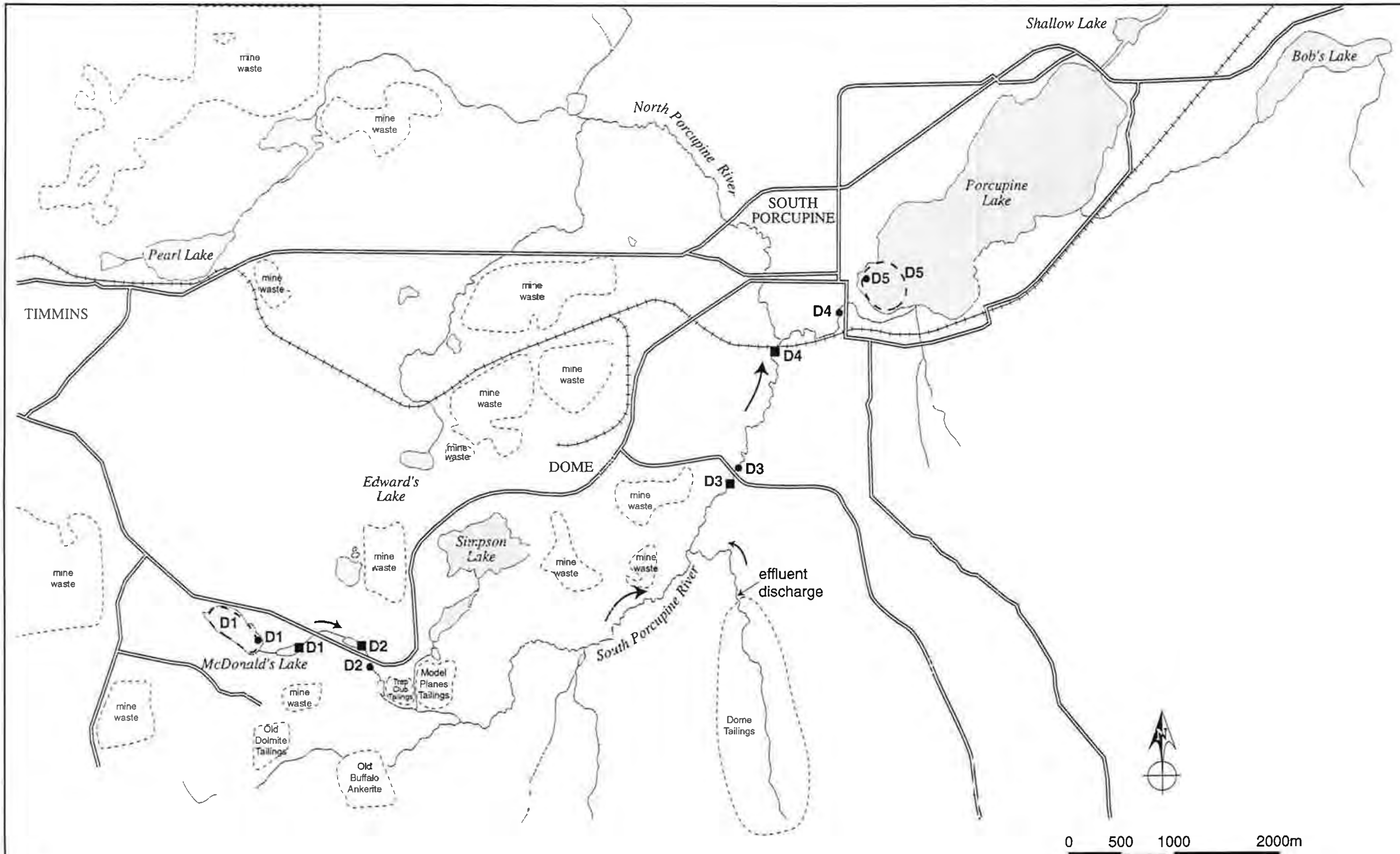
In addition, in the far-field area, downstream of the North Porcupine confluence, no pearl dace could be caught, as far downstream as Porcupine Lake. Consequently, the originally proposed far-field area for pearl dace had to be moved to upstream of a beaver dam, located approximately 200 m upstream of the confluence of the North Porcupine River and for benthos it was located near the inlet to the lake, where habitat conditions were similar to the near-field (Figures 2.1a and 2.1b). Fish collected in the new far-field area (i.e.,



Location of Benthic Sampling Sites at the Dome Mine Site
Canmet Study

beak international incorporated

Figure	June
2.1a	1998



- sampling location for caged yellow perch
- stream sampling location for collection of pearl dace
- lake sampling location for collection of yellow perch

Location of Fish Sample Sites at the Dome Mine Site

Canmet Study

beak international incorporated	Figure 2.1b	June 1998

upstream of the confluence with the North Porcupine) would have been exposed to a similar effluent concentration to fish collected in the near-field because there is very little additional effluent dilution between the two areas. However, this field study did find that there was a change in metal contaminant levels in fish tissues between the two areas (discussed in more detail in Section 4).

Figure 2.1c illustrates locations where water samples were collected for the purposes of hypothesis testing and habitat characterization. Because all biological monitoring stations within each area were in proximity to each other, water samples were generally collected at only three of the stations within each area.

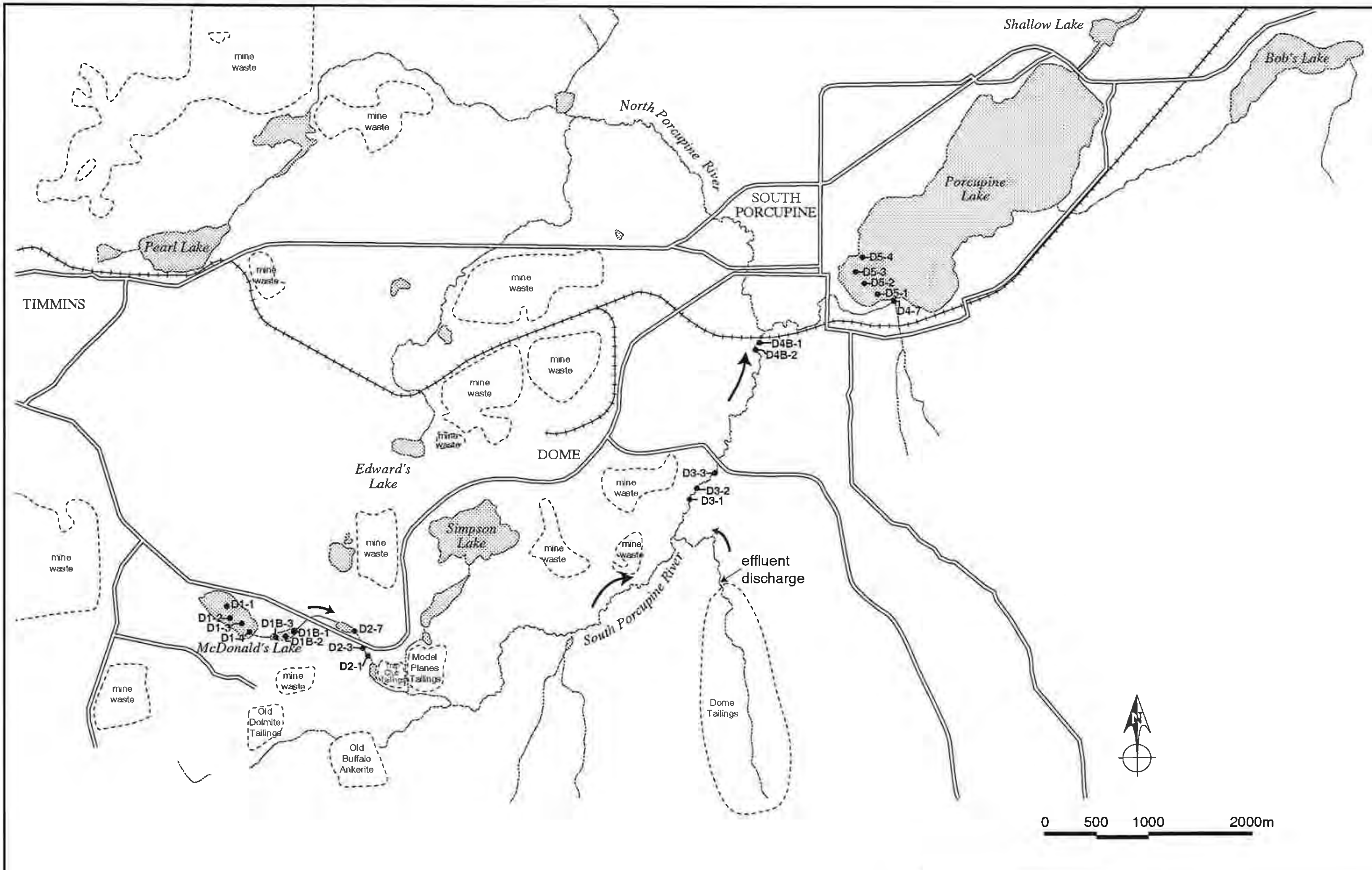
Because of these confounding factors (i.e., road bridges and changes in habitat), the results of testing Hypotheses H5 and H6 with stream fish would have been questionable. However, Hypothesis H6 was tested using benthic invertebrate communities.

2.2 Final Study Design

2.2.1 General Considerations

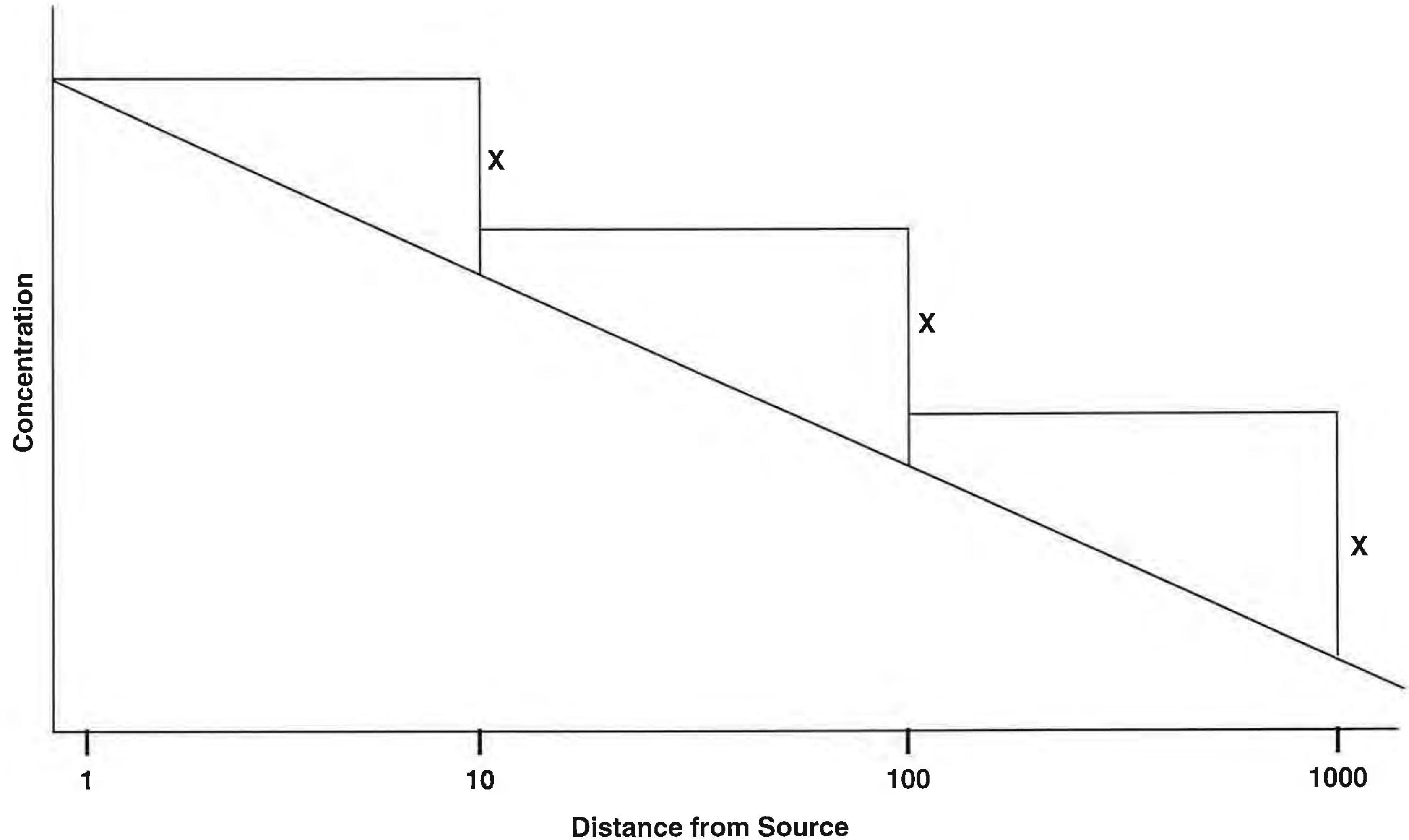
In general, sampling is carried out in relation to a point source discharge in order to permit testing of hypotheses about the environmental effect of the discharge. Sampling is carried out both above and below the source (Control versus Exposed). To the extent possible, it is desirable to space the "below discharge" samples at exponentially increasing distances, because most dilution/mixing models assume exponential decay models. That is, a contaminant will decrease in concentration by a given amount over each order of magnitude increase in distance from the discharge (see Figure 2.2). When monitoring mine discharges, the nature of the receiving environment will often cause this ideal to be impossible to achieve, especially where tributary streams produce a stepwise dilution of effluent, or when dilution occurs rapidly (e.g., a stream discharging into a large lake).

There are many possible field study designs for monitoring of mining discharges and testing of the hypotheses, which can be put into three basic categories (Figure 2.3, Types A, B, C). The difference between the first two (Type A versus Type B or C) is driven by site differences (e.g., stepwise, Type A, versus more continuous dilution patterns, Types B and C), whereas the difference between the Type B and Type C is driven by the biota being sampled. For example, benthos because of their sessile nature, and some forage fish



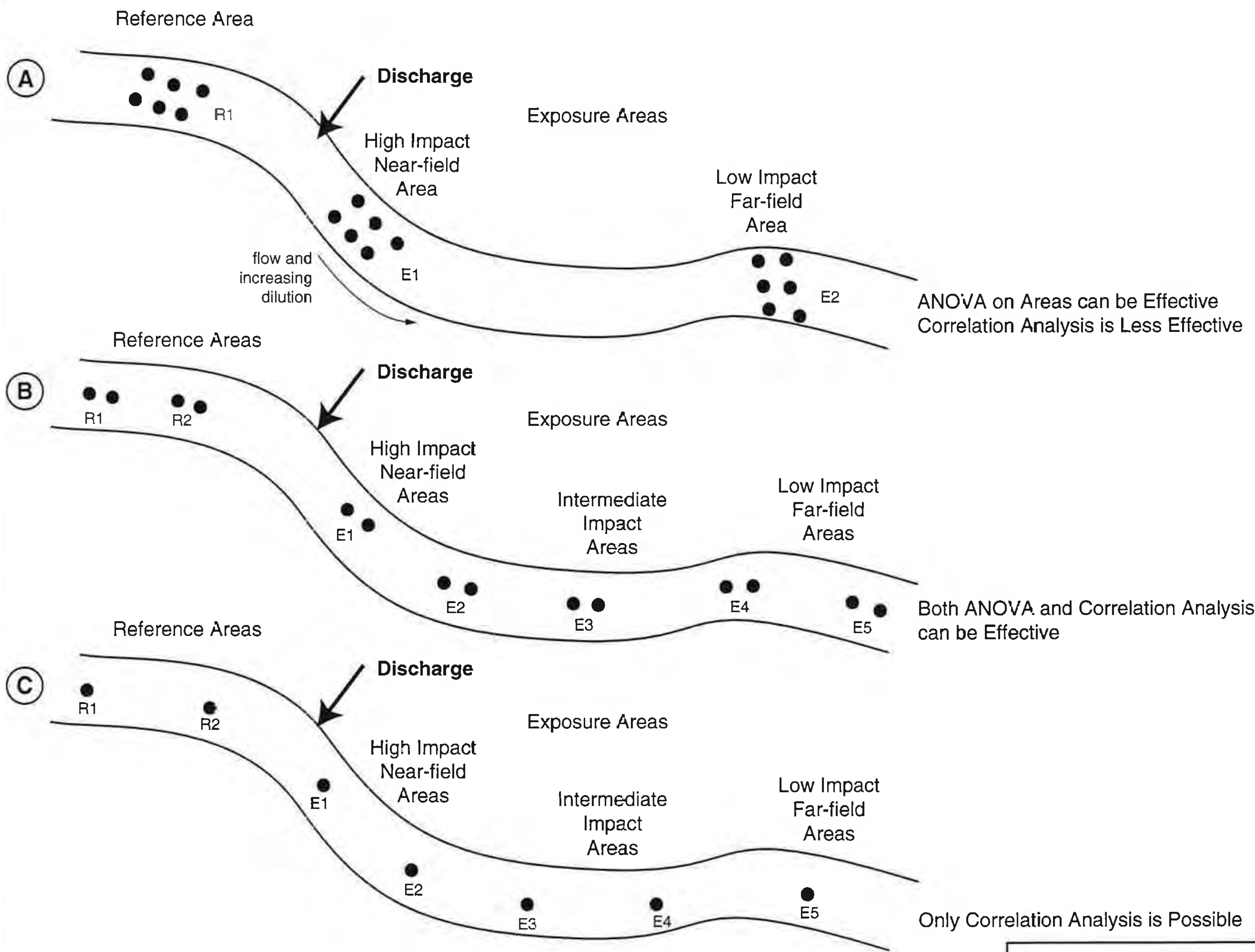
Location of Water Sample Sites at the Dome Mine Site
Canmet Study

beak international incorporated | Figure **2.1c** | June 1998



Idealized Effluent Dilution Model Downstream of a Mine Discharge

beak international incorporated | Figure 2.2 | June 1998



Representative Sampling Designs Downstream of Effluent Discharges (dots represent sampling stations)

beak	beak international incorporated	Figure 2.3	June 1998

because of their limited mobility, allow for replicate sampling in a small area (Type B) with the primary design constraints being hydrology and habitat. For larger more mobile fish, sampling would be carried out over a larger area to ensure the groups of fish are not mixing and are distinct from one another, possibly necessitating a Type C design. Alternatively, a Type A design might be used for large fish, using individual fish rather than stations as replicates.

The ideal situation for testing hypotheses for the 1997 field evaluation is a Type B study design which is a combination of easy-to-sample biota and a site which can be sampled with a gradient design approximating that described above. This provides for:

- a gradient design permitting regression/correlation analysis of the impact pattern along the stream below the discharge, and of possible cause-effect relationships between chemical and biological variables; and
- replication at locations so that testing in an Analysis of Variance (ANOVA) design is possible.

Unfortunately, due to the natural site characteristics at the Dome Mine site which provided little change in effluent dilution along the length of the South Porcupine River, the Type B study design could not be implemented.

The other two types of study design (Types A and C) sacrifice either one or the other of the above two attributes (i.e., a gradient design with replication at each location). For Type A, the nature of the site precludes a gradient design (e.g., Dome Mine). Therefore, replicate samples are taken at an "above"="Control" location, and at a "near field"="High Impact" and at a "far field"="Low Impact" location. This does not allow one to model the pattern of impact below the discharge, but an ANOVA for testing impact-related hypotheses is easily done.

For a Type C study design (i.e., gradient design with no replication), one can model the pattern of impact below the discharge but the only possible hypothesis testing is that associated with simple regression analysis. However, there still needs to be a gradient in contaminant levels for this type of design. This type of study design was not used at any of the mine sites used for the 1997 field evaluation program.

Finally, it is necessary to select an appropriate sampling effort and (apart from the above "basic types of design" considerations) to allocate the effort appropriately to above versus below discharge areas, to locations within areas, and to replicates within locations. For the AETE program, it was determined by the AETE Committee that a total sampling effort per mine site of 20 to 25 field samples was a reasonable trade-off between feasibility and cost and statistical power and robustness (EVS *et al.,* 1997). The following design is based on that total effort allocated to Dome Mine.

2.2.2 Design at Dome Mine

The exposure gradient at Dome Mine is essentially a two-step gradient (refer to Figure 1.2). Because there is a major change in exposure between the reaches above and below the North Porcupine confluence, and probably a less discernible change between there and further downstream to Porcupine Lake, a design with two exposure reaches plus an upstream reference reach was proposed for examination of mine effects in the river using water, sediments, pearl dace and benthic invertebrate communities. The study design for river locations at Dome Mine was the same as Type A in Figure 2.3. The near-field area in the South Porcupine River is exposed to effluent (after complete mixing with receiving water) discharged from Dome's #6 dam which controls flow from an active tailings area. The far-field area for benthos was located below the confluence with the North Porcupine River, where substantial dilution of effluent occurs (Figures 2.1a and 2.1b), whereas the far-field area for fish was located just upstream of the confluence.

Because lake conditions have distinct influences on biological communities, Porcupine Lake fish communities (exposure area) cannot be compared to those in the stream, so a separate lake reference area for fish was established in McDonald's Lake, the upstream source of the South Porcupine River. These two lakes were sampled for adult yellow perch for testing of the fish related hypotheses H2 to H8. No sediment or benthic related hypotheses were tested in the lakes.

Caged young-of-the-year yellow perch were placed in all stream and lake areas (Figure 2.1b).

Sampling Effort in Stream Areas

A sampling effort of 21 stations was divided equally among the three stream areas for the characterization of benthic communities, water and sediment chemistry and toxicity. For benthos, the sample from each station was a composite of five petite-Ponar grabs, whereas sediment chemistry and toxicity samples were subsampled from a composite of the top 3 cm from 15 to 20 petite-Ponar grabs.

Eighteen caged young-of-the-year yellow perch, composited into groups of two, were sampled at all areas. Nine adult pearl dace were collected from one station in the original reference area (D2), one station in the new reference area (upstream of the beaver dam - D1B) at the outlet of McDonald's Lake and from one station in each of the near-field (D3) and far-field (D4) areas.

For the testing of growth and organ size related hypotheses (H7 and H8), 20 male and 20 female adult pearl dace were collected from the original reference area and from the near-field and far-field areas.

The study design for Dome Mine allowed for the collection of sediment for chemical and toxicity testing, as well as for benthic invertebrate community characterization, at each of seven stations within the near-field, far-field and reference areas.

Sampling Effort in Lake Areas

Biological and chemical characteristics of lake areas at Dome Mine were examined separately from river areas. Porcupine Lake, the receiving water body of the diluted effluent carried by the South Porcupine River, was the exposure area. McDonald's Lake, at the source of the South Porcupine River, was the reference area. This CI (Control-Impact) design represents a simplification of design Type A in Figure 2.3. Multiple exposure reaches were not sampled since there was no water chemistry gradient. These lake areas were used for the collection of adult yellow perch (12 adults for tissue: gill, liver, kidney, muscle) for metal and metallothionein analyses and for growth and organ size related hypotheses (20 males and 20 females from each area). Four water chemistry samples were collected in each lake. Twenty-four young-of-the-year yellow perch were also caged in each of these areas (i.e., McDonald's and Porcupine Lakes).

2.2.3 Statistical Power

The statistical power of the study design was evaluated using the Borenstein and Cohen (1988) computer code for power analysis. In the South Porcupine River for sediment-related Hypotheses H1 and H6, the total sampling effort of 21 sampling stations equally distributed among three groups (reference, near field, far field) was sufficient to expect that an effect size (average difference between groups) of two within-group standard deviations could be detected with a power of 0.8 or better (i.e., chance of false-negative conclusion (beta) less than 0.2) using a significance criterion based on a chance of false-positive conclusion (alpha) less than 0.05. A total of 60 fish of a particular gender (H7, H8), distributed equally among three groups, was sufficient to expect that an effect size of one within-group standard deviation could be detected, whereas with a total of 27 fish (H2, H3, H4) distributed equally among three groups, was sufficient to expect that an effect size of two within-group standard deviations could be detected.

In the lake habitat, the total sampling effort of 24 adult yellow perch (for fish related hypotheses) equally distributed among two groups (reference, exposure) was sufficient to expect that an effect size of two within-group standard deviations could be detected with a power of 0.8 or better using an alpha less than 0.05.

The absolute difference indicated by the one or two standard deviations will vary from one monitoring parameter (effect measure) to another.

For H9 to H12, with a total of 21 stations for benthos and sediment toxicity or 27 fish measurements, it should be possible to detect strong chemistry-biology-toxicity correlations (those that exceed $r=0.7$; $power=0.8$).

3.0 FIELD AND LABORATORY PROCEDURES

3.1 Sampling Time and Crew

The Dome field program was completed over the period of 29 September to 11 October 1997. The field crew was led by Jay Dickison (BEAK), with Dennis Farara (BEAK-Project Manager) and Lise Trudel (CANMET-AETE Coordinator) in attendance for a portion of the survey.

Benthic invertebrate, fish, sediment and water samples were collected from a reference and two exposure areas in South Porcupine River and from reference (McDonald's Lake) and exposure (Porcupine Lake) lake areas.

3.2 Sampling Effort and Station Characterization

Three exposure areas and three reference areas were surveyed for various physical, chemical and biological parameters. There were adjustments in the locations of survey areas in comparison to the areas proposed in the original study design (refer to Section 2.1). Table 3.1 summarizes the distributions and types of samples collected at Dome.

For adult yellow perch collections, reference and exposure areas were established in McDonald's and Porcupine Lakes, respectively. Twelve adult perch were targeted for each area for testing of Hypotheses H2 to H4 and 20 individuals of each gender were targeted in each lake for testing of Hypotheses H7 and H8.

The original reference area proposed for pearl dace was in the same location as the benthic invertebrate reference area (EVS *et al.*, 1997). However, approximately 100 m downstream, the river enters an old tailings area. Therefore, fish collected in this area would likely be exposed to the historical metal contamination. An additional reference area was established for pearl dace in the beaver pond at the outlet of McDonald's Lake (refer to Figure 2.1b). The near-field exposure for pearl dace was located 500 m downstream of the discharge in the same area as the benthic invertebrate near-field area. However, the far-field area for pearl dace which was proposed for downstream of the confluence of the North Porcupine river had to be relocated to upstream of this confluence because no pearl dace could be captured anywhere downstream of the confluence (refer to Figure 2.1b). For testing of Hypotheses H3 and H4, nine adult pearl dace were collected

TABLE 3.1: SUMMARY OF SAMPLES OBTAINED AT DOME MINE SITE

Sampling Locations	Type of Sample					
	Chronic Toxicity	Sediment Benthos and Toxicity	Water	Fish for Tissue Analysis	Fish Community	Fish for Measurement
Mine Effluent	3	-	3			
Reference Lake Area	-	-	4	12 Yellow Perch 24 Caged Yellow Perch	1	Yellow Perch - 19 males, 22 females
Exposure Lake	-	-	4	12 Yellow Perch 24 Caged Yellow Perch	1	Yellow Perch - 20 males, 20 females
Reference Stream (2 stations)	-	7	6	18 Pearl Dace 18 Caged Yellow Perch	2	Pearl Dace - 20 males, 37 females
Near-field Stream	-	7	3	9 Pearl Dace 18 Caged Yellow Perch	1	Pearl Dace - 20 males, 29 females
Far-field Stream	-	7	3	9 Pearl Dace 18 Caged Yellow Perch	1	Pearl Dace - 21 males, 30 females
Total Number of Samples	3 [1]	21 [2]	23 [3]	162 [4]	6 [5]	238 [6]

[1] Chronic Toxicity was conducted on final effluent samples collected 24 June 1997, 29 July 1997, and 20 October 1997.
[2] Each benthic sample is a composite of 5 Petite Ponar grabs.
[3] 4 water samples were collected in each of the two lakes and 3 at each of 2 river reference areas and 2 river exposure areas.
[4] Tissues analyzed include kidney, liver, gill and muscle for wild Yellow Perch (lakes only), and viscera for caged Yellow Perch and wild Pearl Dace.
[5] Fish community measurements were made by variable and inconsistent means from location to location due to habitat constraints. Thus, community comparisons (CPUE, BPUE) are not made.
[6] Fish measurements include fork length, weight, liver weight, gonad weight and fecundity.

from each of four areas (D1B, D2, D3, D4). For testing of Hypotheses H7 and H8, 20 pearl dace of each gender were collected from three areas (D2, D3, D4).

For sediment-related hypotheses seven stations were established in stream areas D3 and D4 and the reference stations were divided among two stream areas (i.e., D1B and D2).

General habitat characteristics of the stream areas were low-gradient reaches with very slow flow and muddy substrate with dense macrophyte growth. Field notes for each station are provided in Appendix 2.

3.3 Effluent Chemistry and Toxicity

Toxicity testing was conducted on effluent samples collected from the mine discharge or from the storage pond (20 October 1997 sample). Sixty litres of effluent were collected by Dome Mine personnel on 24 June, 29 July and 20 October 1997 and shipped to Beak International Inc. The first sample, collected on 24 June 1997, was not received by the Saskatchewan Research Council (SRC) within 48 hours, so it was tested using *Ceriodaphnia*, algae and fathead minnows at BEAK. A replacement sample was collected one week later and sent to SRC for duckweed testing. The second and third samples were tested both by BEAK and SRC. All samples were tested using receiving water (McDonald's Lake) as the dilution water.

Dome's new effluent treatment system became operational in June 1997, before the first sampling event. Therefore, the first effluent sample collected on 24 June 1997, represented effluent quality with all Dome treatment processes in place, including the new INCO-SO_2/Air Treatment process for cyanide destruction. For the July sample, the cyanide destruction system was not in use since natural degradation was sufficient to break down the cyanide in the effluent. The mine stopped discharging on 12 August 1997. Therefore, the third sample collected on 20 October was taken from the storage ponds. This sample was of lower quality to the effluent discharged in summer, due to the reduced efficiency of natural degradation under cooler water temperatures and reduced sunlight in October relative to the summer months (R. Connell, Dome Mines, pers. comm., 1997).

Toxicity tests conducted on each sample included:

- the *Ceriodaphnia dubia* 7-day survival and reproduction test (Environment Canada 1992a);
- the fathead minnow (*Pimephales promelas*) 7-day survival and growth test (Environment Canada 1992b);
- the *Selenastrum capricornutum* 3-day algae growth test, (Environment Canada 1992c); and
- the duckweed (L*emna minor*) 7-day growth test (Saskatchewan Research Council, 1995, 1996).

The duckweed test was carried out by the Saskatchewan Research Council, in Saskatoon. The other three tests were completed at BEAK's Brampton, Ontario toxicity testing facility.

Bioassay procedures included use of dilution water collected from the site (McDonald's Lake) or laboratory water adjusted to the hardness of field conditions, depending on acclimation success in site water for *Ceriodaphnia dubia* and *Pimephales promelas*. In addition to the toxicity testing using acclimated organisms, required for this study, a comparative study of chronic toxicity using both site dilution water and hardness adjusted (if required) laboratory water and non-acclimated organisms is presented in a separate document for the three mines where effluent toxicity was measured (BEAK and Golder, 1998b). Results of this comparative study showed that site dilution water and hardness adjusted laboratory water produced comparable results in these tests.

Upon receipt at BEAK's laboratory, a subsample of each effluent and dilution water sample was forwarded to Philip Analytical Services. Samples were processed (filtered as appropriate and preserved) and analyzed for the water chemistry parameters identified in Section 3.4.

3.4 Water Chemistry

Detailed field sampling procedures are outlined in Annex 1 (provided as a separate document) and summarized in this section.

3.4.1 Field

All water chemistry samples were collected on 09 October 1997, under dry weather conditions and without any rainfall during the previous three days. Samples were kept chilled in coolers from the time of collection and were subsequently refrigerated following preparation procedures. All necessary sample preparation was completed on the night of 09 October, including filtration of samples for dissolved metals analyses and all sample preservation. Samples which did not require filtration or preservation were transported by air the night of 09 October and placed in cold storage facilities at BEAK's Brampton Office that same night. The remaining samples were transported in coolers to BEAK's Brampton facility on 11 October.

All supporting measurements for water sampling (dissolved oxygen, temperature, pH, conductivity) were recorded at the time of sampling at the stream sampling locations and on the following day (10 October) at the lake sampling stations. Habitat conditions and station coordinates, measured by Global Positioning System, were recorded on data forms (Appendix 2). Habitat information included stream order, substrate conditions, aquatic plant coverage, in-stream and riparian cover, water depth and general flow conditions (Appendix 2). Because the seven stations within each area were in close proximity to one another and because of the lotic environment, water samples were collected only at three of the stations within an area (one station located at the upper, middle and lower end of the area). Four water samples were collected in each of the lakes.

Samples were collected for laboratory analysis of:

- total and dissolved metals (Al, Sb, As, Ba, Be, Bi, B, Cd, Ca, Cr, Co, Cu, Fe, Pb, Mg, Mn, Hg, Mo, Ni, K, Se, Ag, Sr, Ta, Sn, U, V, B and Zn);
- nutrients (nitrate, nitrite, ammonia, P);
- major ions (including sulphate and ion balance);
- acidity, alkalinity, hardness, specific conductance;
- pH;
- colour;
- dissolved organic and inorganic carbon;
- solids (total suspended and dissolved);

- cyanide (cyanates, free, total and weak acid dissociable); and
- turbidity.

Sample containers, filtration and sample preservation procedures are identified in Annex 1, and include use of high density polyethylene containers confirmed free of measurable metal contamination, ultrapure nitric acid and de-ionized distilled water also confirmed by the lab to be free of measurable metal contamination (for field, trip and filter blanks), and a filtration procedure using polypropylene syringes with 0.45 micron syringe-filters. All sample preparation was carried out in a clean indoor work space.

Quality control/quality assurance procedures followed in the field included collection of hidden sample duplicates, and preparation of trip blanks, field blanks and filter blanks (Appendix 1).

3.4.2 Laboratory

All water samples were forwarded to the analytical laboratory (Philip Analytical Services Corporation, Burlington and Mississauga, Ontario) within 48 hours of collection. Procedures used for laboratory analysis are summarized in Table A3.2, Appendix 3.

Results of QA/QC analyses indicated that there was no notable contamination of the samples during the filtering process for dissolved metals (filter blanks) or in the trip and field blanks (Appendix 1, Table A1.2).

3.5 Sediment Chemistry

Annex 1 (separate report) provides more detail on procedures followed in the field for the collection and handling of sediment samples, which are summarized below.

3.5.1 Field

Sediment samples were collected from seven stations per area following benthic invertebrate sampling using a stainless steel petite-Ponar grab. Sediments were collected from water depths ranging from 30 cm to 1 m. Ten to fifteen grab samples were collected at each station depending on the quantity of material retrieved in each grab. Sediment pH and redox potential were measured from several minimally disturbed sediment grabs in each area before the composite samples were collected.

Upon retrieval of the grab, surface water was allowed to run-off before the Ponar was placed into a plastic tub. The top 2 to 3 cm of sediment was collected using a stainless steel spoon and placed into a 20L bucket with a plastic liner. This procedure was repeated with each grab and new material was thoroughly mixed with the previous material until a total of eight litres of sediment per station had been collected. Subsamples of the homogenized sediment sample were dispensed into appropriate sample containers.

Three different types of sediment samples were collected for analysis from each site:

- a sample for "total" metals analyses, based on a nitric acid/hydrogen peroxide extraction procedure;
- a sample for "partial" metals analyses using a hydroxylamine hydrochloride procedure which is designed to solubilize amorphous Fe and Mn oxyhydroxides, along with their associated trace metals; and
- a sample for analysis of Acid Volatile Sulphide (AVS) and Simultaneously-Extracted Metals (SEM).

In addition, two field duplicate samples were collected for total metals determination using extraction with *aqua regia*, to confirm the comparability of results using *aqua regia* and nitric acid/hydrogen peroxide extractions. Subsamples for partial metal extraction were collected by filling half a 500 mL sample bottle with sediment, which was then topped with a layer of site water. These samples were frozen at the end of the day. Subsamples for AVS/SEM analyses were placed into a 250 mL whirl-pak bag, and then into a 1-L jar once the air had been removed from the bag. The 1-L jar was then filled with sediment so that the whirl-pak bag was surrounded by sediment which prevented exposure to air.

3.5.2 Laboratory

Samples for chemical analysis were forwarded to Philip Analytical Services Corporation. Analyses included metals (listed for water samples), moisture, bulk density, Munsell colour, total organic carbon (TOC), loss-on-ignition (LOI) and grain size. Munsell colour, moisture and bulk density were done by BEAK staff.

Quality control/quality assurance procedures in addition to routine lab QA/QC included collection of hidden duplicate samples for metal analysis. One notable data comparability concern is raised regarding the high metal concentrations reported in the SEM fraction relative to concentrations reported as total metals (Appendix 1). Based on investigation, this appears to be caused by differences in the dry weight/wet weight conversion factors used at the chemistry laboratory. However, the same biases will apply to the AVS values, so that the SEM/AVS ratio should be unaffected by this calculation (i.e., the same bias applies to SEM and AVS in any single sample).

3.6 Sediment Toxicity

Sediment samples for toxicity testing were collected from the same stations. Seven litres of sediment were collected from each of the seven stations located in the near-field, far-field and reference stream areas and were placed in 20-L plastic food-grade buckets with polyethylene bag liners.

Toxicity tests conducted on each sample included: *Hyalella azteca* survival and growth (Environment Canada, 1996 Draft Method); *Chironomus riparius* survival and growth (Environment Canada, 1997 Draft Method); and *Tubifex tubifex* survival and reproduction (ASTM E1384-94A, 1995). *Chironomus* and *Hyalella* tests were conducted at BEAK's toxicity testing laboratory in Dorval, Quebec, whereas the *Tubifex* tests were completed at the National Water Research Institute, Environment Canada, in Burlington, Ontario.

3.7 Benthic Invertebrates

3.7.1 Field

Benthic invertebrate samples were collected from seven stations in each of the reference and exposure areas in the South Porcupine River using a petite-Ponar grab. Five grabs were collected at each station and pooled. Each of the five grab samples was sieved using a 250 μm mesh screen prior to preservation to a minimum level of 10% buffered formalin. All samples were collected by the same field crew member.

3.7.2 Laboratory

All samples were processed jointly by BEAK's Benthic Ecology Laboratory and by Zaranko Environmental Assessment Services (ZEAS), Guelph, Ontario. Both laboratories followed the same laboratory protocols summarized below.

In the laboratory, samples were inspected to insure that they were adequately preserved and correctly labelled. Samples were then stained to improve the sorting recovery.

Prior to detailed sorting, the samples were washed free of formalin in a 250 μm sieve under ventilated conditions. The benthic fauna and associated debris were then elutriated free of any sand and gravel. The remaining sand and gravel fraction was closely inspected for any of the denser organisms, such as Pelecypoda, Gastropoda and Trichoptera with stone cases that may not have all been washed from this fraction. The remaining debris and benthic fauna after elutriation were washed through 500 μm and 250 μm sieves to standardize the size of the debris being sorted and facilitate a minimum of 95% recovery of benthic fauna.

All benthic samples were processed with the aid of stereomicroscopes. A magnification of at least 10X was used for macrobenthos (invertebrates >500 μm) and 20X for meioinvertebrates (invertebrate size >250 to <500 μm). Benthos was sorted from the debris, enumerated into the major taxonomic groups, usually order and family levels and placed in vials for more detailed taxonomic analysis.

Benthic invertebrates were most commonly identified to the lowest practical level, genus or species for most groups. The level to which each group was identified and the taxonomic keys that the identification were based on are provided in Appendix 4.

For meeting the data quality objectives, subsampling error was determined for both density and number of taxa in 10% of the samples that were subsampled. Ten percent of sorted samples were also resorted by an independent taxonomist to ensure 95% recovery of all invertebrates (Appendix 1, Table A1.1).

A voucher collection or reference collection of benthic invertebrate specimens was compiled. This is a collection of representative specimens for each taxon so that there can be continuity in taxonomic identifications if different taxonomists process future samples. The voucher collection will be maintained at BEAK. The BEAK and ZEAS Benthic Ecology Laboratories also maintain master reference collections of all taxa which have been identified by the labs.

The specimens selected for the voucher collection were preserved such that they will remain intact for many years. Chironomids and oligochaetes remain on the initial slides and representatives of each taxon were circled with a permanent marker and labelled. All other species were preserved in 80% ethanol in separately labelled vials. Each vial contains a 3% solution of glycerol to prevent spoilage of the fauna if the vials accidentally dry out.

3.7.3 Chironomid Deformities

In the last decade there has been considerable attention paid towards the use of chironomid mouth-part deformities to monitor contaminant effects. Previous studies have shown that the incidence of chironomid deformities (especially in *Chironomus*) can be associated with contaminated sediments.

For the 1997 study, all mounted chironomid specimens from each site were scored for mandible and mentum abnormalities. These data were not used in the testing of specific hypotheses, but are discussed briefly in Section 4.

3.8 Fish

3.8.1 Sentinel Species

A fish survey was completed in each of the survey areas using a range of methods including angling, back-pack electrofishing, beach seining, minnow traps, and small-mesh gill nets. Both target species (pearl dace, yellow perch) were collected in sufficient numbers. The majority of pearl dace were collected with baited minnow traps and the majority of yellow perch were obtained by seining in Porcupine Lake and gill netting in McDonald's Lake.

The numbers of sentinel fish collected and submitted for metallothionein and metals analyses are as follows:

	Yellow Perch	Pearl Dace
Reference Lake	12	0
Stream Reference D1B (beaver pond)	0	9
Stream Reference D2	0	9
Near-field	0	9
Far-field	0	9
Exposure Lake	12	0

With respect to pearl dace, large fish (typically > 12 cm) were selected for the purpose of metallothionein analyses. These fish were frozen whole using dry ice and kept frozen until sample submission. For each of the stream stations, approximately five to ten additional fish were frozen whole in the event that additional material was required for analysis. These fish are not included in the totals presented in the table above. For yellow perch, fish were retained live for purposes of tissue sampling for metallothionein analysis. The selected tissues (gills, muscle, kidney, and liver) were removed from fish immediately upon their death and frozen on dry ice.

In addition to the fish sampled for metallothionein and metal analyses, 20 males and 20 females were collected in each area for measurements of liver and gonad weights, length, age and fecundity.

3.8.2 Caged Fish

The original intention for the caged fish study was to collect fish (yellow perch and pearl dace, if possible) from McDonald's Lake. Initial fishing efforts at this location failed to produce young-of-the-year or yearling yellow perch or pearl dace. Accordingly, young-of-the-year yellow perch were collected from the Wealthy Lakes, located south west of McDonald's Lake. According to the local Ministry of Natural Resources District Biologist, these lakes are unaffected by mines in the Timmins area. Three groups of these fish were submitted to determine reference metal and metallothionein levels in caged fish prior to exposure. Twenty-four perch were placed in cages at each of the two lake sampling areas and held for ten days. At the three stream locations, 18 perch were placed in cages and held for ten days. Fish cages consisted of 20-L plastic screened buckets, fitted with "snap-on" plastic lids. Approximately one-third of each bucket consisted of screened material, so that once immersed in the river, the river current would flow through the bucket.

All fish survived except for one perch at the station in McDonald's Lake (reference). Composite whole fish samples (three fish per sample) were prepared for each station (i.e., six composites at the lake stations and five composites at the stream locations were analyzed) and were submitted frozen on dry ice for metallothionein and metal analyses.

3.8.3 Fish Measurements

Biological measurements were carried out on sentinel species and caged fish at a laboratory set up on the Dome Mine premises. For all fish, lengths were measured using standard measuring boards (total length, fork length) to the nearest millimetre. Whole body weights were determined to the nearest 0.1 g, whereas organ weights were taken to the nearest 0.001g, using Ohaus balances. Age was determined for a subsample of pearl dace using scales. For the yellow perch all fish were aged using sectioned dorsal spines.

3.8.4 Tissue Metallothionein and Metal Analyses

All analyses of Dome Mine fish tissues were carried out at the Department of Fisheries and Oceans, Freshwater Institute, under the direction of Dr. J. Klaverkamp. Analyses were completed on individual yellow perch tissues or where necessary composites of two or three perch were used. Laboratory procedures used are as documented by J. Klaverkamp (Annex 1).

4.0 DATA OVERVIEW

This section summarizes the major trends for each of the data components (water, sediment, effluent and sediment toxicity, benthos and fish), whereas results of hypotheses testing based on these data are presented in Section 5.2.

4.1 Effluent Chemistry and Toxicity

4.1.1 Effluent Chemistry

Effluent chemistry data for three samples collected on 24 June, 29 July and 20 October 1997 are provided in Table 4.1. Concentrations of chemicals in the mine effluent were compared to the MMLER monthly average discharge limits and grab sample limits. Regulations exist for arsenic, copper, lead, nickel, zinc, pH and total suspended solids.

The October sample collected from the holding pond was the poorest quality and was of lower quality than effluent that was discharged in summer. This reflects the reduced efficiency of natural degradation in the fall relative to summer. It is important to remember that this sample does not represent effluent that was discharged to the South Porcupine River.

Copper was the only element that exceeded the grab sample limit in the October sample. Zinc was slightly higher than the monthly average limit but was well below the grab sample limit. Copper also exceeded the average monthly MMLER limit in the July sample. Total cyanide was at its highest level in the July sample (3.9 mg/L) which represented effluent that was not treated with the new INCO-SO_2 system. The treatment system was operational for the June sample (total cyanide = 0.035 mg/L).

Dissolved metals represented a high percentage of the total metals measured in the effluent samples.

The effluent from Dome Mine has historically remained in compliance with the permit limits specified in its Certificate-of-Approval from the Ontario Ministry of the Environment. Neither of the samples of final effluent collected here during discharge

Table 4.1: Chemical Analyses Conducted on Effluent Samples Collected at Dome Mine Site, 1997.

			MMLER[2]		PDE-1	PDE-1	PDE-2	PDE-2	PDE-3	PDE-3
			Monthly	Grab Sample	(Total)	(Dissolved)	(Total)	(Dissolved)	(Total)	(Dissolved)
Parameter	**Units**	**LOQ[1]**	Mean	Maximum	97/06/24	97/06/24	97/07/29	97/07/29	97/10/20	97/10/20
Acidity(as $CaCO_3$)	mg/L	1	na[3]	na[3]	-[4]	-	-	-	-	nd
Alkalinity(as $CaCO_3$)	mg/L	1	na	na	73	-	83	-	68	-
Aluminum	mg/L	0.01	na	na	0.03	nd	0.42	0.29	1.2	0.788
Ammonia(as N)	mg/L	0.05	na	na	9.51	-	9.26	-	11	-
Antimony	mg/L	0.002	na	na	0.004	0.004	0.007	0.007	0.012	0.0081
Arsenic	mg/L	0.002	0.5	1.0	nd[5]	nd	0.015	0.015	0.049	0.036
Barium	mg/L	0.005	na	na	0.005	0.005	0.009	0.008	0.009	0.007
Beryllium	mg/L	0.005	na	na	nd	nd	nd	nd	nd	nd
Bicarbonate(as $CaCO_3$, calculated)	mg/L	1	na	na	72	-	81	-	65	-
Bismuth	mg/L	0.002	na	na	nd	nd	nd	nd	nd	nd
Boron	mg/L	0.005	na	na	0.192	0.182	0.201	0.194	0.273	0.263
Cadmium	mg/L	0.0005	na	na	nd	nd	nd	nd	nd	nd
Calcium	mg/L	0.1	na	na	75.7	79.6	50.8	52.9	52.4	53.1
Carbonate(as $CaCO_3$, calculated)	mg/L	1	na	na	1	-	2	-	3	-
Chloride	mg/L	1	na	na	77	-	69	-	75	-
Chromium	mg/L	0.002	na	na	nd	nd	nd	0.003	0.0016	0.0011
Cobalt	mg/L	0.001	na	na	0.1	0.097	0.111	0.11	0.17	0.112
Colour	TCU	5	na	na	nd	-	nd	-	nd	-
Conductivity - @25øC	us/cm	1	na	na	1030	-	974	-	1020	-
Copper	mg/L	0.002	0.3	0.6	0.07	0.026	0.387	0.249	1.3	0.78
Cyanates	mg/L	0.5	na	na	9.2	-	3.1	-	3.4	-
Cyanide, Free	mg/L	0.002	na	na	nd!(0.010)	-	1.77	-	1.5	-
Cyanide, Total	mg/L	0.002	na	na	0.035	-	3.91	-	2	-
Cyanide, weak acid dissociable	mg/L	0.002	na	na	0.004	-	0.04	-	1.22	-
Dissolved Inorganic Carbon(as C)	mg/L	0.5	na	na	15.5	-	20.4	-	2.2	-
Dissolved Organic Carbon(DOC)	mg/L	0.5	na	na	4.6	-	4.3	-	3.5	-
Hardness(as $CaCO_3$)	mg/L	0.1	na	na	201	-	150	-	145	-
Iron	mg/L	0.02	na	na	0.03	nd	0.16	nd	0.15	nd
Lead	mg/L	0.0001	0.2	0.4	0.0001	nd	0.0007	nd	nd	nd
Magnesium	mg/L	0.1	na	na	0.4	0.4	4.2	4.3	3	3.1
Manganese	mg/L	0.002	na	na	nd	nd	0.022	0.018	0.018	0.003
Mercury	mg/L	0.0001	na	na	nd	nd	0.0001	0.0001	nd	nd
Molybdenum	mg/L	0.002	na	na	0.025	0.025	0.031	0.029	0.041	0.032
Nickel	mg/L	0.002	0.5	1.0	0.028	0.025	0.294	0.241	0.58	0.361
Nitrate(as N)	mg/L	0.05	na	na	4.11	-	3.74	-	3.5	-
Nitrite(as N)	mg/L	0.01	na	na	0.24	-	0.38	-	0.55	-
Orthophosphate(as P)	mg/L	0.01	na	na	nd	-	0.05	-	nd	-
pH	Units	0.1	6.0[6]	5.0[6]	8.2	-	8.4	-	8.7	-
Phosphorus	mg/L	0.1	na	na	nd	nd	nd	nd	nd	nd
Phosphorus, Total	mg/L	0.01	na	na	0.04	-	nd	-	nd	-
Potassium	mg/L	0.5	na	na	32.5	32.7	32.4	33	38.8	39.5
Reactive Silica(SiO_2)	mg/L	0.5	na	na	1.3	-	2.7	-	1.7	-
Selenium	mg/L	0.002	na	na	nd	nd	0.005	0.005	0.002	0.004
Silver	mg/L	0.0005	na	na	0.0086	0.0081	0.0091	0.0067	0.02	0.011
Sodium	mg/L	0.1	na	na	103	105	101	104	121	122
Strontium	mg/L	0.005	na	na	0.203	0.203	0.201	0.187	0.22	0.2
Sulphate	mg/L	2	na	na	276	-	232	-	274	-
Thallium	mg/L	0.0001	na	na	nd	nd	nd	nd	nd	nd
Tin	mg/L	0.002	na	na	nd	nd	nd	nd	nd	nd
Titanium	mg/L	0.002	na	na	0.005	0.005	0.005	0.003	0.006	0.003
Total Dissolved Solids(Calculated)	mg/L	1	na	na	646	-	576	-	639	-
Total Kjeldahl Nitrogen(as N)	mg/L	0.05	na	na	11	-	10.4	-	2.63	-
Total Suspended Solids	mg/L	5	25.0	50.0	nd	-	6	-	6	-
Turbidity	NTU	0.1	na	na	0.2	-	0.7	-	0.8	-
Uranium	mg/L	0.0001	na	na	nd	nd	nd	nd	nd	nd
Vanadium	mg/L	0.002	na	na	nd	nd	nd	nd	0.002	nd
Zinc	mg/L	0.002	0.5	1.0	nd	nd	0.016	0.003	0.001	nd

[1] LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence
[2] MMLER = *Metal Mining Liquid Effluent Regulations*, Monthly Average Limit (Fisheries Act, 1994)
[3] na = Regulation values not available
[4] - = Not Analyzed
[5] nd = Parameter not detected
[6] pH limits listed are minimum
! = LOQ higher than listed due to dilution ( ) Adjusted LOQ
(shaded) - Denotes values that exceed the Metal Mining Liquid Effluent Regulations (MMLER)

conditions indicated metal concentrations that would be inconsistent with permit requirements.

4.1.2 Effluent Toxicity Data

Detailed effluent toxicity results are provided in Appendix 3 and summarized in Table 4.2 and Figure 4.1.

The Dome Mine effluent was generally highly toxic. The LC50 for *Ceriodaphnia dubia* was as low as 6.25% effluent for the sample collected in October and 15% effluent for the effluent which was being discharged to the environment in July (Table 4.2). Acute lethality of fathead minnow was also noted in two of the samples (July, October). Overall, *Ceriodaphnia dubia* appeared to be the most sensitive to the mine effluent with IC25 values of <6.25 to 8.4 % effluent, although *Lemna minor* was also quite sensitive to the effluent with IC25s ranging from 3.7 to 15% effluent (Table 4.2, Figure 4.1). Fathead minnows were the least sensitive with IC25 values ranging from 46 to 65% effluent. The IC25 results for *Selenastrum* showed the highest variability among samples represented by the large standard error bar in Figure 4.1.

The October sample was the most toxic to all organisms followed by July and then June samples. The June and July samples represented effluent quality that was actually being discharged to the environment. The trends in the toxicity data closely reflected the overall trends in effluent chemistry (Table 4.1).

The toxicity data indicate that a 25:1 effluent dilution in the South Porcupine River (i.e., <4% effluent) would be required to minimize the potential for sublethal effects on aquatic organisms in the creek. Effluent concentrations in the stream generally exceed the sublethal effects level. Effluent concentrations upstream of the confluence of the North Porcupine River are typically around 37% effluent and below the confluence the concentrations are generally about 16% effluent. The toxicity data suggest that the potential exists for effects to occur on biological communities throughout the stream and into Porcupine Lake during the discharge period.

Table 4.2: Results of Effluent Toxicity Tests Conducted on Three Dome Mine Effluent Samples, 1997.
(Expressed as % Effluent. Values in parentheses represent the 95% confidence interval)

Sample	*Ceriodaphnia dubia* (Water Flea)			*Pimephales promelas* (Fathead Minnow)			*Selenastrum capricornutum* (Algae)		*Lemna minor* (Duckweed)	
	LC50	IC25	IC50	LC50	IC25	IC50	IC25	IC50	IC25	IC50
P-E-1 Jun 24-97	57.4 (47.0-70.2)	<6.25 na	32.3 (22.4-36.8)	>100 na	64.5 (44.1-80.4)	>100 na	80.9 (62.7-98.1)	>100 na	14.9* (9.5-23.3)	40.6* (32.7-50.4)
P-E-2 Jul 29-97	15.4 (12.9-18.3)	8.44 (5.49-13.1)	14.8 (11.1-17.5)	79.0** (69.7-91.0)	46.8** (38.2-56.8)	80.9** (71.3-91.6)	27.1 (10.6-33.4)	35.2 (28.8-39.5)	3.7 (1.86-7.37)	12.2 (7.39-20.2)
P-E-3 Oct. 20-97	6.25 (0-12.5)	<6.25 na	<6.25 na	50.9 (43.9-59.1)	>50 na	>50 na	5.64 (3.99-19.9)	27.6 (19.6-35.2)	2.17 (1.72-2.74)	7.8 (6.52-9.34)

Notes:
*Duckweed test conducted on sample collected July 2, 1997.
All tests conducted using McDonald's Lake water as dilution water except where indicated by **.
Fathead minnow data analysed according to Environment Canada amendments (Nov. 1997) - IC values represent growth effects alone.

June sample collected after effluent had been treated by wastewater facility.
July sample: effluent was not treated by wastewater facility (effluent met MISA (Municipal Industrial Strategy for Abatement) requirements without treatment).
October sample collected from holding pond (same level of treatment as July sample) but not discharged to the environment.

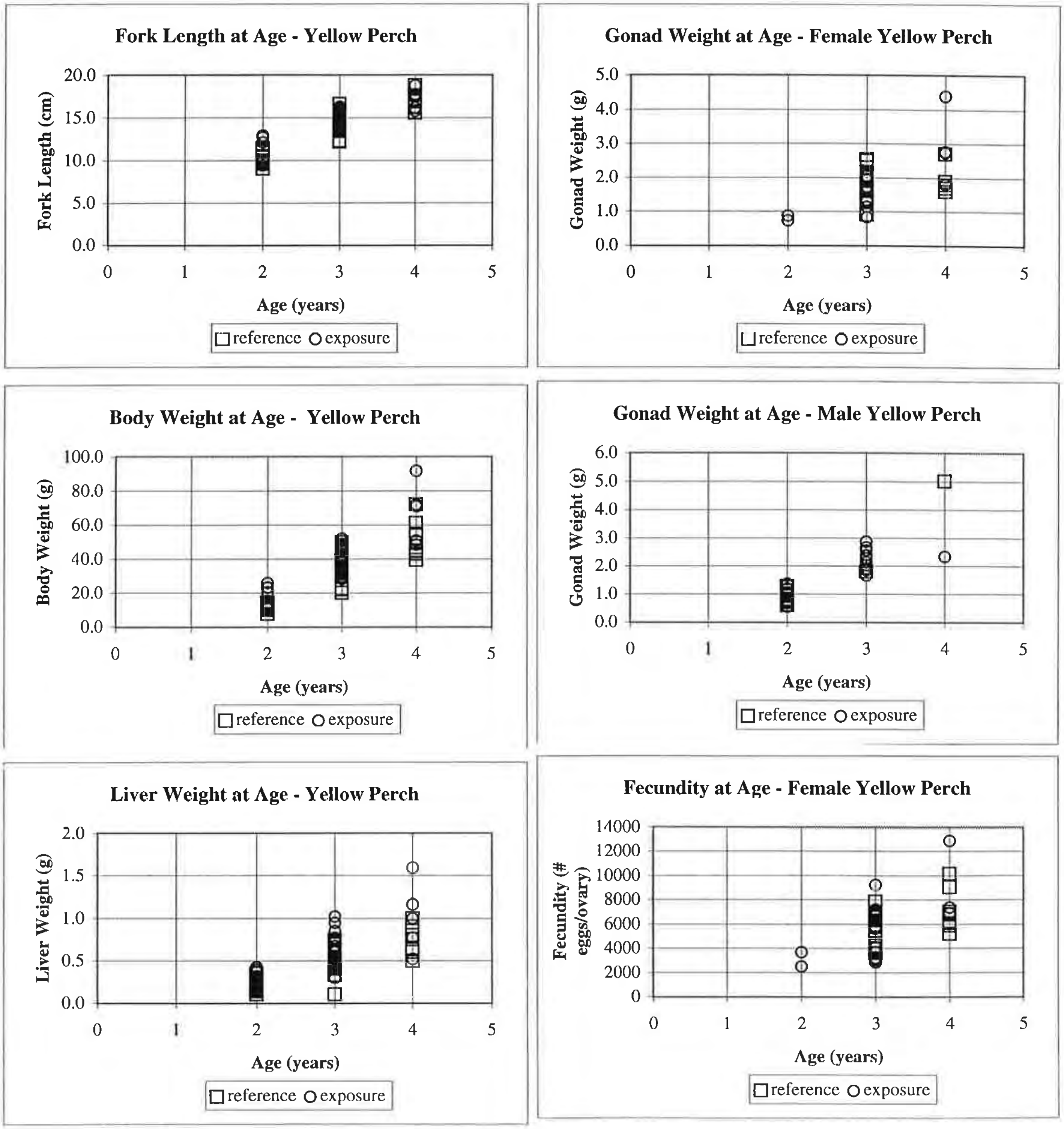
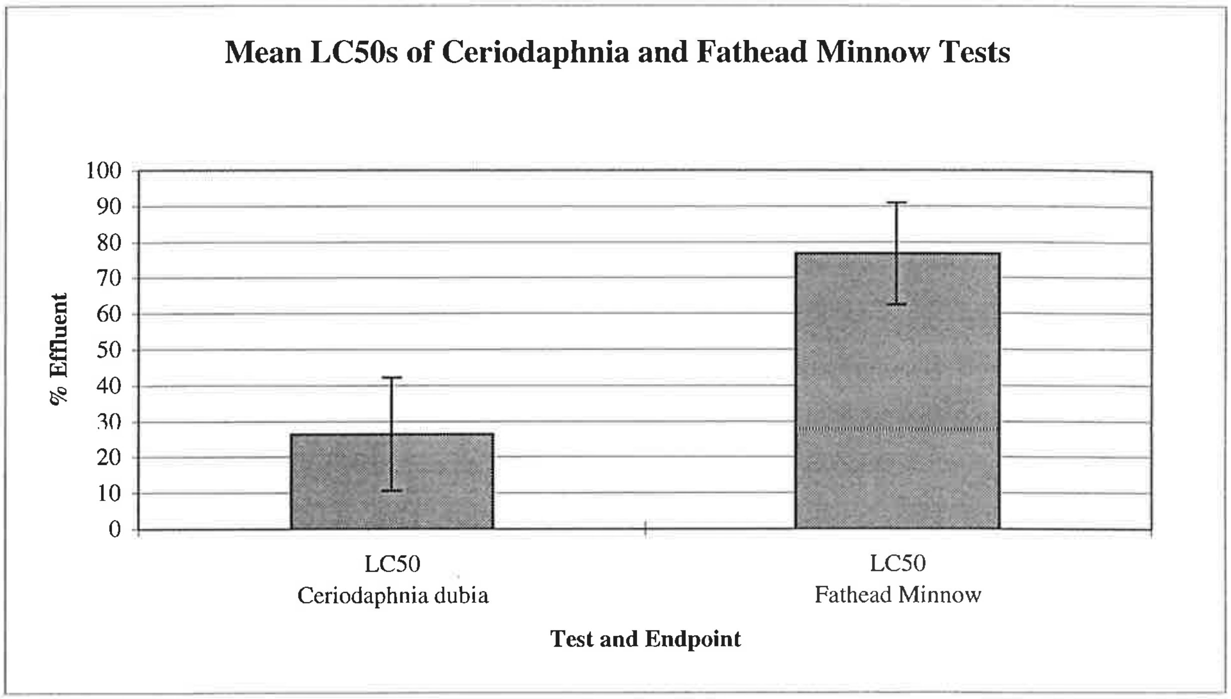


Figure 4.10: Fork Length, Body Weight, Liver Weight, Gonad Weight and Fecundity at Age for Yellow Perch Collected at Dome Mine, October 1997.



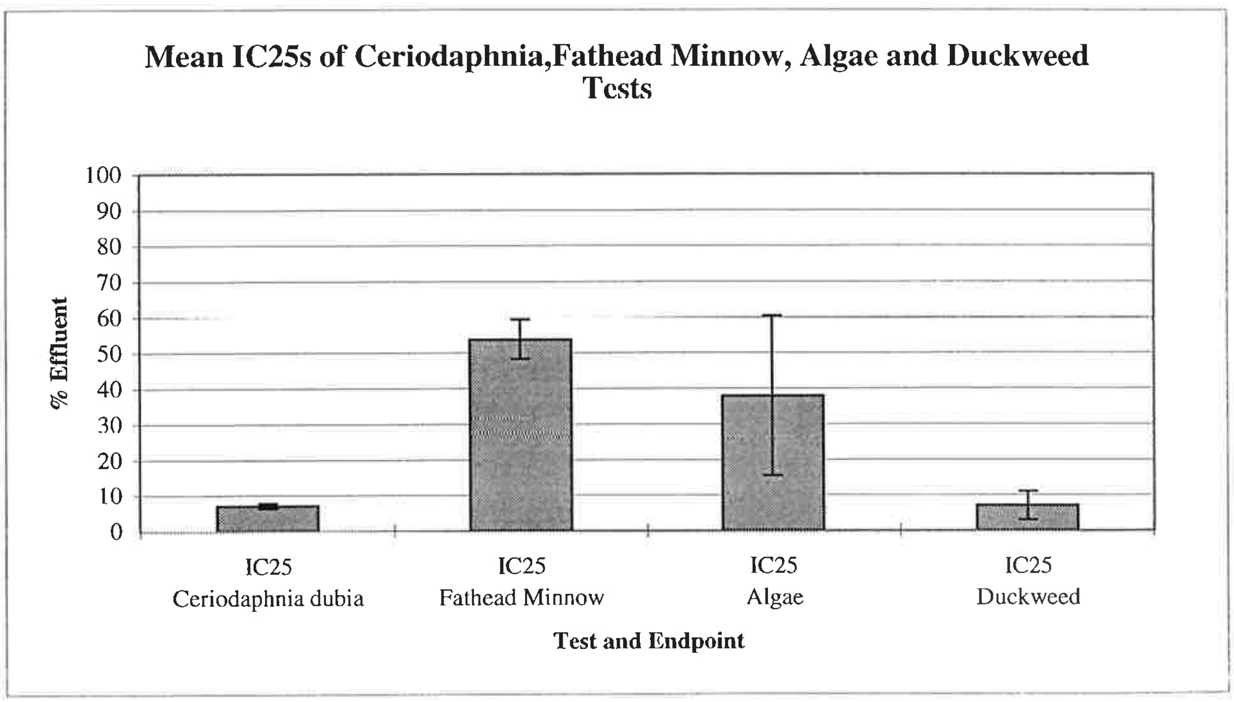


Figure 4.1: Mean Effluent Toxicity Test Results (± 1 S.E.), Based on Four Species Responses to Three Effluent Samples.

4.2 Water Chemistry

Selected water chemistry data for Dome Mine that generally showed mine-related trends are summarized in Table 4.3 (total metals and general chemistry) and Table 4.4 (which compares total versus dissolved metals). Detailed data for all parameters measured are provided in Appendix 3, Table A3.1. QA/QC data associated with water chemistry analyses are provided in Appendix 1, Table A1.2.

4.2.1 South Porcupine River

Concentrations of copper, magnesium, cobalt, nickel and potassium were the only key metals that were consistently elevated at the exposure area stations compared to the concentrations at the reference area stations (Table 4.3). The trends in these metals, as well as in the concentrations of total dissolved solids and sulphate showed that, although the mine was not discharging at the time of the survey, water quality in the exposure areas was still influenced by the mine operation. Some of these parameters could be influenced by other sources between the reference area and the Dome Mine discharge. Copper was the only metal that consistently exceeded the Canadian Water Quality Guideline (CWQG) for the protection of aquatic life (CCREM, 1987) at all of the stream exposure stations.

Arsenic and iron exceeded their respective CWQG at a number of stations in the reference area and showed a reverse trend where concentrations of these metals were higher in the reference area and decreased in the far-field area (Table 4.3, Figure 4.2). The mine also appears to be a source of nitrate to the receiving environment.

4.2.2 McDonald's and Porcupine Lakes

Similar to the results for South Porcupine River, only copper was found to exceed CWQG in all samples collected in the exposure lake (Porcupine Lake). Concentrations of all metals that were measured above method detection limits were higher in Porcupine Lake than in McDonald's Lake (Table 4.3). However, many of these metals appeared to be elevated by sources other than the Dome Mine discharge (e.g., abandoned mines upstream and North Porcupine River) because near-field and far-field concentrations for some metals showed no mine-related trends. Comparing the effluent chemistry data to that of

Table 4.3: Selected Water Chemistry Results at Dome Mine Site, October 1997.

Parameter	Units	LOQ[1]	CWQG[2]	REFERENCE STATIONS (LAKE)				EXPOSURE STATIONS (LAKE)				REFERENCE STATIONS (STREAM)						NEAR-FIELD STATIONS (STREAM)			FAR FIELD STATIONS (STREAM)		
				D1-1	D1-2	D1-3	D1-4	D5-1	D5-2	D5-3	D5-4	D1B-1	D1B-2	D1B-3	D2-1	D2-3	D2-7	D3-1	D3-2	D3-3	D4-7	D4B-1	D4B-2
Total Metals																							
Arsenic	mg/L	0.002	0.05	0.002	0.002	0.002	0.002	0.008	0.008	0.008	0.009	0.017	0.016	0.019	0.076	0.07	0.059	0.015	0.021	0.021	0.005	0.011	0.011
Cadmium	mg/L	0.00005	0.0013/0.0018[3]	nd[8]	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.00005	nd	nd
Cobalt	mg/L	0.0002	na[4]	nd	nd	nd	nd	0.0194	0.0195	0.019	0.0201	0.0004	0.0004	0.0005	0.0018	0.0017	0.0016	0.0149	0.006	0.0059	0.003	0.0054	0.0053
Copper	mg/L	0.0003	0.003/0.004[5]	0.0007	0.001	0.0008	0.0007	0.0094	0.0094	0.0099	0.0103	0.0005	0.0006	0.0005	0.0029	0.0017	0.0028	0.0125	0.0248	0.0198	0.0093	0.0156	0.0103
Iron	mg/L	0.02	0.3	0.06	0.06	0.06	0.07	0.09	0.08	0.1	0.1	0.32	0.28	0.31	0.58	0.5	0.44	0.15	0.15	0.17	0.17	0.11	0.23
Lead	mg/L	0.0001	0.004/0.007[6]	nd	0.0001	nd	nd	0.0001	0.0002	0.0002	0.0002	0.0003	0.0003	0.0004	0.0002	0.0002	0.0001	0.0001	nd	nd	0.0002	nd	nd
Magnesium	mg/L	0.1	na	6.6	6.8	6.9	6.6	16.9	16.5	18.1	19.9	11	11	10.9	18.1	17.5	18	31.9	25	24.6	40.2	42.4	39.7
Nickel	mg/L	0.001	0.110/0.150[7]	0.002	0.002	0.002	0.002	0.023	0.022	0.022	0.023	0.004	0.005	0.005	0.009	0.009	0.009	0.048	0.033	0.03	0.033	0.069	0.066
Potassium	mg/L	0.5	na	0.6	0.6	nd	nd	11.5	11.3	11.1	10.9	0.6	0.7	nd	1.4	1.6	1	29.8	12.2	11.8	12.1	20.2	20.5
Selenium	mg/L	0.002	0.001	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.002	nd	nd	nd	0.002	nd
Silver	mg/L	0.00005	0.0001	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.00011	0.00008	nd	nd	nd
Zinc	mg/L	0.001	0.03	0.001	0.001	0.002	0.001	0.003	0.004	0.003	0.003	0.002	0.002	0.001	0.004	0.003	0.005	0.004	0.003	0.003	0.018	0.008	0.008
General Chemistry																							
Nitrate(as N)	mg/L	0.05	na	nd	nd	nd	nd	0.79	0.79	58.4	65.9	nd	nd	nd	0.09	0.05	nd	8.1	0.83	0.89	3.27	8.06	6.54
Sulphate	mg/L	2	na	8	8	8	8	170	170	182	186	4	4	5	51	54	53	334	146	146	348	389	374
Total Dissolved Solids(Calculated	mg/L	1	na	162	158	153	150	420	415	705	745	210	208	211	343	368	370	829	477	486	781	887	836

[1] LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence

[2] CWQG - Canadian Water Quality Guidelines (CCREM, 1987)

[3] Cadmium Guidline values - 0.0013 mg/L (Hardness 120-180), 0.0018 mg/L (Hardness >180)

[4] na - Guideline values not available

[5] Copper Guideline values - 0.003 mg/L (Hardness 120-180), 0.004mg/L (Hardness >180)

[6] Lead Guideline values - 0.004 mg/L (Hardness 120-180), 0.007 mg/L (Hardness >180)

[7] Nickel Guideline values - 0.110 mg/L (Hardness 120-180), 0.150 mg/L (Hardness >180)

[8] nd = Parameter not detected ! = LOQ higher than listed due to dilution ( ) Adjusted LOQ

- Denotes values that exceed the guideline the receiving environment suggests that the Dome Mine effluent appears to be a major contributor of copper, cobalt, nickel and potassium.

General water quality parameters, such as nitrate, sulphate, conductivity, hardness, TKN and TDS were elevated in the exposure lake compared to values in the reference lake.

4.2.3 Total versus Dissolved Metals

Comparisons of dissolved and total metal concentrations for copper, arsenic, iron and nickel which best represent the trends in water chemistry are provided in Figure 4.2 (also Table 4.4). The concentrations of dissolved metals were rarely higher than the corresponding total metal concentrations. This generally only occurred when the total and dissolved values were virtually identical and the higher value for dissolved metal is likely due to analytical variability. Generally, the dissolved fraction represented a high proportion of the total metal present, except for iron where the dissolved fraction was notably lower than the total iron value (Figure 4.2). Copper was the only metal where the dissolved fraction exceeded the CWQG.

4.3 Sediment Chemistry

Sediment chemistry data, for selected total metals, physical parameters, partial metals and acid volatile sulphide (AVS) and simultaneously extracted metals (SEM) in samples collected from the South Porcupine River are provided in Tables 4.5, 4.6, and 4.7, respectively. The complete data set is provided in Appendix 4, Tables A4.1 to A4.3.

The total metal concentrations (Table 4.5) are compared to the Canadian Interim Sediment Quality Assessment Values (CISQAV) (Environment Canada, 1995). The TEL (threshold effect level) value refers to the concentration below which an adverse effect is likely to rarely occur, whereas the PEL (probable effect level) value refers to the concentration above which one could frequently expect adverse effects (Environment Canada, 1995). All QA/QC data associated with the sediment chemistry analyses are provided in Appendix 1, Tables A1.3 to A1.6.

Table 4.4: Total versus Dissolved Concentrations for Selected Metals in Water Samples Collected at Dome Mine Site, October 1997.

Parameter	Units	LOQ[1]	REFERENCE STATIONS (LAKE)								EXPOSURE STATIONS (LAKE)							
			D1-1 Total	D1-1 Dissolved	D1-2 Total	D1-2 Dissolved	D1-3 Total	D1-3 Dissolved	D1-4 Total	D1-4 Dissolved	D5-1 Total	D5-1 Dissolved	D5-2 Total	D5-2 Dissolved	D5-3 Total	D5-3 Dissolved	D5-4 Total	D5-4 Dissolved
Arsenic	mg/L	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.008	0.008	0.008	0.008	0.008	0.008	0.009	0.008
Cadmium	mg/L	0.00005	nd[2]	nd	nd	0.00007	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Cobalt	mg/L	0.0002	nd	nd	nd	nd	nd	nd	nd	nd	0.0194	0.0187	0.0195	0.0192	0.019	0.0188	0.0201	0.0189
Copper	mg/L	0.0003	0.0007	0.0007	0.001	0.0009	0.0008	0.0007	0.0007	0.001	0.0094	0.0083	0.0094	0.0086	0.0099	0.0083	0.0103	0.0082
Iron	mg/L	0.02	0.06	nd	0.06	nd	0.06	nd	0.07	nd	0.09	nd	0.08	nd	0.1	nd	0.1	nd
Lead	mg/L	0.0001	nd	0.0002	0.0001	0.0002	nd	0.0002	nd	0.0002	0.0001	0.0001	0.0002	0.0001	0.0002	0.0002	0.0002	0.0001
Magnesium	mg/L	0.1	6.6	7.2	6.8	7.4	6.9	7.3	6.6	7.3	16.9	18.7	16.5	18.6	18.1	20.9	19.9	21.4
Nickel	mg/L	0.001	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.023	0.021	0.022	0.021	0.022	0.02	0.023	0.02
Potassium	mg/L	0.5	0.6	nd	0.6	nd	nd	0.5	nd	nd	11.5	11.7	11.3	11.6	11.1	11.5	10.9	12
Selenium	mg/L	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Silver	mg/L	0.00005	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Zinc	mg/L	0.001	0.001	nd	0.001	0.002	0.002	nd	0.001	0.008	0.003	0.002	0.004	0.002	0.003	0.002	0.003	0.002

Parameter	Units	LOQ[1]	REFERENCE STATIONS (CREEK)												NEAR FIELD STATIONS (CREEK)					
			D1B-1 Total	D1B-1 Dissolved	D1B-2 Total	D1B-2 Dissolved	D1B-3 Total	D1B-3 Dissolved	D2-1 Total	D2-1 Dissolved	D2-3 Total	D2-3 Dissolved	D2-7 Total	D2-7 Dissolved	D3-1 Total	D3-1 Dissolved	D3-2 Total	D3-2 Dissolved	D3-3 Total	D3-3 Dissolved
Arsenic	mg/L	0.002	0.017	0.013	0.016	0.013	0.019	0.015	0.076	0.041	0.07	0.043	0.059	0.038	0.015	0.012	0.021	0.018	0.021	0.019
Cadmium	mg/L	0.00005	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd
Cobalt	mg/L	0.0002	0.0004	0.0002	0.0004	0.0003	0.0005	0.0003	0.0018	0.0015	0.0017	0.0015	0.0016	0.0015	0.0149	0.0132	0.006	0.0051	0.0059	0.0053
Copper	mg/L	0.0003	0.0005	0.0003	0.0006	0.0004	0.0005	nd	0.0029	0.0032	0.0017	0.0014	0.0028	0.0026	0.0125	0.0104	0.0248	0.0212	0.0198	0.0172
Iron	mg/L	0.02	0.32	0.04	0.28	0.05	0.31	0.05	0.58	0.09	0.5	0.09	0.44	0.08	0.15	nd	0.15	nd	0.17	nd
Lead	mg/L	0.0001	0.0003	0.0002	0.0003	0.0002	0.0004	0.0002	0.0002	0.0001	0.0002	0.0001	0.0001	0.0002	0.0001	0.0003	nd	0.0002	nd	0.0002
Magnesium	mg/L	0.1	11	11.7	11	11.8	10.9	11.8	18.1	19.5	17.5	18.9	18	19.4	31.9	34.9	25	27	24.6	27.3
Nickel	mg/L	0.001	0.004	0.004	0.005	0.004	0.005	0.004	0.009	0.009	0.009	0.01	0.009	0.01	0.048	0.041	0.033	0.029	0.03	0.026
Potassium	mg/L	0.5	0.6	1.1	0.7	1.3	nd	0.6	1.4	1.4	1.6	0.7	1	1.3	29.8	30.5	12.2	12.5	11.8	12.2
Selenium	mg/L	0.002	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.002	0.002	nd	nd	nd	nd
Silver	mg/L	0.00005	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	nd	0.00011	nd	0.00008	nd
Zinc	mg/L	0.001	0.002	0.001	0.002	0.001	0.001	0.001	0.004	0.004	0.003	0.003	0.005	0.004	0.004	0.003	0.003	0.001	0.003	0.002

Parameter	Units	LOQ[1]	FAR FIELD STATIONS (CREEK)					
			D4-7 Total	D4-7 Dissolved	D4B-1 Total	D4B-1 Dissolved	D4B-2 Total	D4B-2 Dissolved
Arsenic	mg/L	0.002	0.005	0.005	0.011	0.011	0.011	0.009
Cadmium	mg/L	0.00005	0.00005	0.00008	nd	0.00008	nd	nd
Cobalt	mg/L	0.0002	0.003	0.0027	0.0054	0.0048	0.0053	0.0049
Copper	mg/L	0.0003	0.0093	0.0084	0.0156	0.0114	0.0103	0.0091
Iron	mg/L	0.02	0.17	0.02	0.11	nd	0.23	0.02
Lead	mg/L	0.0001	0.0002	0.0002	nd	0.0001	nd	0.0001
Magnesium	mg/L	0.1	40.2	44.3	42.4	45.7	39.7	42.1
Nickel	mg/L	0.001	0.033	0.029	0.069	0.063	0.066	0.063
Potassium	mg/L	0.5	12.1	12.7	20.2	19.9	20.5	20
Selenium	mg/L	0.002	nd	nd	0.002	0.002	nd	nd
Silver	mg/L	0.00005	nd	nd	nd	nd	nd	nd
Zinc	mg/L	0.001	0.018	0.005	0.008	0.01	0.008	0.007

[1] LOQ = Limit of Quantitation = lowest level of the parameter that can be quantified with confidence

[2] nd = Parameter not detected

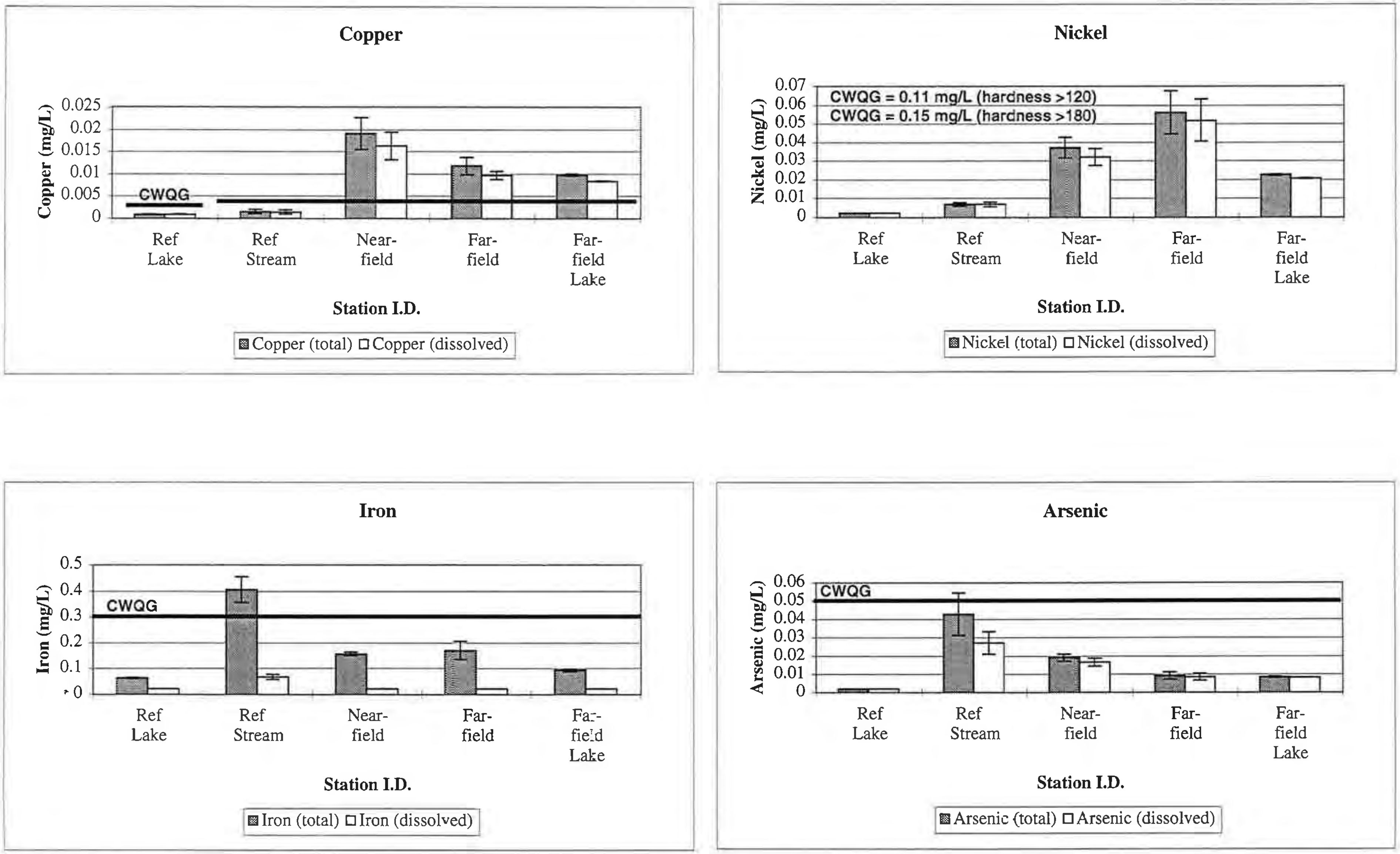


Figure 4.2: Mean Total and Dissolved Metal Concentrations at Reference and Exposure Areas, Dome Mine, October 1997.
Area Means (± 1 S.E.). CWQG = Canadian Water Quality Guideline. Note - CWQG varies for Copper and Nickel in response to water hardness.

4.3.1 Physical Characteristics

The total organic content of the sediments was similar at most stations with values ranging from 2.1 to 3.4% (Table 4.5). The only exceptions were the sediments from the furthest upstream reference stations (Stations D1B-) immediately downstream of McDonald's Lake, where the values ranged from 4.6 to 6.9%. This increase in TOC is likely due to beaver activity. The sediments throughout the study area were predominately fine-grained with generally >60% silt and clay. Silt was the dominant size fraction at most stations. The Eh readings were well into the negative end of the scale suggesting that the sediments were anoxic. This is also supported by the Munsell colour which characterized all sediments as black (Appendix 4).

4.3.2 Total Metal Concentrations

Concentrations of arsenic, copper and nickel exceeded their respective PEL values (Table 4.5). Chromium exceeded the PEL at one reference station and mercury exceeded its PEL at all of the far-field stations, whereas near-field and reference stations had similar mercury levels that were below TEL values. Of these, only copper and nickel followed a trend that appeared to be related to the Dome Mine discharge (waterborne copper and nickel followed the same trend). Concentrations of arsenic and chromium were as high or higher at some of the reference stations compared to the results from near-field stations and mercury was highest in the far-field area, suggesting sources originating in the North Porcupine River.

Concentrations of cobalt, iron, manganese and silver also reflected a mine-related trend with concentrations generally highest in the near-field area and lowest in the reference area. One station in the furthest upstream reference area (Station D1B-1, upstream in the beaver pond) had particularly high concentrations of arsenic, chromium, lead, and nickel. The data for these metals have been confirmed by the analytical lab and the reason for these high levels at this particular station is unknown. There could have been historical tailings in this area from mining activity that took place in the vicinity of McDonald's Lake.

Table 4.5: Selected Sediment Quality Results at Dome Mine Site, October 1997. Metals results represent Total Metal Analyses.

Parameter	Units	MDL[1]	ISQAV[2]		REFERENCE STATIONS (STREAM)							NEAR FIELD EXPOSURE STATIONS (STREAM)							FAR FIELD EXPOSURE STATIONS (STREAM)						
			TEL[3]	PEL[4]	D1B-1	D1B-2	D1B-3	D2-1	D2-2	D2-3	D2-4	D3-1	D3-2	D3-3	D3-4	D3-5	D3-6	D3-7	D4-1	D4-2	D4-3	D4-4	D4-5	D4-6	D4-7
TOC(Solid)	(%)	0.1	na[5]	na	4.6	5.5	6	2.6	2.2	2.9	6.9	2.1	2.2	2.2	2.5	2.5	2.4	2.2	3	3	3.4	3.1	2.4	3	2.7
Arsenic	mg/kg	0.5	5.9	17	1100	77	36	240	210	200	300	180	270	290	280	290	250	290	55	72	59	74	98	80	86
Cadmium	mg/kg	0.05	0.596	3.53	0.24	0.47	0.4	0.36	0.29	0.44	0.52	0.2	0.19	0.23	0.25	0.24	0.24	0.2	0.37	0.6	0.4	0.5	0.5	0.6	0.6
Chromium	mg/kg	0.6	37.3	90	150	29	14	47	40	52	61	59	72	64	56	70	61	68	33	39	50	38	45	44	46
Cobalt	mg/kg	0.2	na	na	33	5.8	4	22	19	20	16	41	44	39	49	45	38	43	23	26	21	30	32	29	33
Copper	mg/kg	0.2	35.7	196.6	58	12	10	290	260	320	140	390	610	660	730	780	700	650	270	310	260	370	560	410	380
Iron	mg/kg	20	na	na	18000	6000	5000	27000	22000	26000	17000	30000	37000	37000	28000	34000	31000	35000	21000	23000	25000	23000	30000	27000	29000
Lead	mg/kg	0.1	35	91.3	59	16	11	18	16	21	18	7.5	8.9	10	12	13	14	12	19	20	15	19	22	22	20
Magnesium	mg/kg	20	na	na	30325	5515	4970	13850	12265	16083	11305	24338	25775	26725	26425	26750	27075	26825	10455	15303	10708	15170	17390	17545	17688
Manganese	mg/kg	1	na	na	420	130	110	830	780	830	290	870	1200	1100	810	870	900	990	500	740	580	690	800	780	830
Mercury	mg/kg	0.04	0.174	0.486	0.11	0.06	0.06	0.15	0.09	0.15	0.12	0.12	0.14	0.12	0.12	0.11	0.11	0.14	0.71	1.2	0.99	1.2	1.4	1.2	1.2
Nickel	mg/kg	0.5	18	35.9	250	32	13	49	43	52	61	220	240	230	260	240	230	220	140	150	110	160	160	150	170
Silver	mg/kg	0.05	na	na	0.21	0.09	0.08	0.45	0.33	0.42	0.17	1.7	1.4	2.4	5.1	3.1	2.7	2.6	0.73	1.1	0.7	1.2	1.5	1.7	1.3
Zinc	mg/kg	1	123.1	314.8	78	50	64	240	190	220	97	65	100	110	64	100	88	94	130	170	150	170	210	190	190
Grain Size Analysis																									
Gravel (>2.0 mm)	%	0.1	na	na	0.6	3.4	2.3	2.4	4.4	9.0	14.1	4.5	11.1	3.6	2.9	2.2	5.0	2.7	3.0	0.7	4.0	2.0	3.9	2.7	4.9
Sand (0.050 mm - 2.0 mm)	%	0.1	na	na	16	15	18	8.6	22	7.7	85.3	12	21	19	11	7.7	7.6	5.1	11	6	4.9	5.1	3.1	5.9	1.9
Silt (0.002-0.050mm)	%	0.1	na	na	55	47	51	51	36	46	0	63	47	56	51	47	56	58	27	41	73	59	44	77	45
Clay (<0.002mm)	%	0.1	na	na	17	18	18	17	20	9.5	0	9.4	7.6	12	15	17	24	26	35	43	10	28	38	7.2	41

[1] MDL - Method Detection Limit - lowest level of the parameter that can be detected with confidence

[2] ISQAV - Canadian Interim Sediment Quality Assessment Values (Freshwater) (Environment Canada, 1995)

[3] ISQAV - Threshold Effect Level (TEL)

[4] ISQAV - Probable Effect Level (PEL)

[5] na - Guideline values no available

(light grey shading) - Denotes values that exceed the Threshold Effect Level (TEL)

(black shading) - Denotes values that exceed the Probable Effect Level (PEL)

Cadmium and zinc exceed their respective TEL values at a number of stations in the far-field area and concentrations were also higher at a number of stations in the reference area compared to levels at stations in the near-field area (Table 4.5).

4.3.3 Partial Metal Concentrations

Partial metal extractions may provide a relative measure of interstitial metal concentrations and may be used to predict sediment toxicity. Consequently, these measurements may provide an indication of the bioavailability of metals and may reflect biological responses better than total metal concentrations.

Of the total metals that exceeded their respective PELs (e.g., arsenic, chromium, copper, mercury and nickel), only partial concentrations of arsenic and nickel exceeded PEL values (Figure 4.3). Decreasing concentrations of partial metals with distance from the mine site were observed for nickel, chromium, cobalt, copper, iron, and molybdenum, whereas no trends were observed for the partial extraction concentrations of the other metals (Table 4.6). Molybdenum was the only metal where a mine-related trend was observed for the partial fraction but not for the total fraction. Only trace amounts of copper were detected in the partial extraction (Figure 4.3).

4.3.4 Acid Volatile Sulphide (AVS) and Simultaneously Extracted Metals (SEM)

In general, SEM/AVS ratios <1 may reflect non-toxic sediment conditions because some of the key metals (e.g., Ni, Pb, Cu, Cd, Zn) which are often associated with sediment toxicity will be in sulphide forms which reduces their bioavailability. However, it is possible that sediments with SEM/AVS ratios <1 will still be toxic due to the presence of other metals (e.g., arsenic, mercury) which are not included in the SEM analysis.

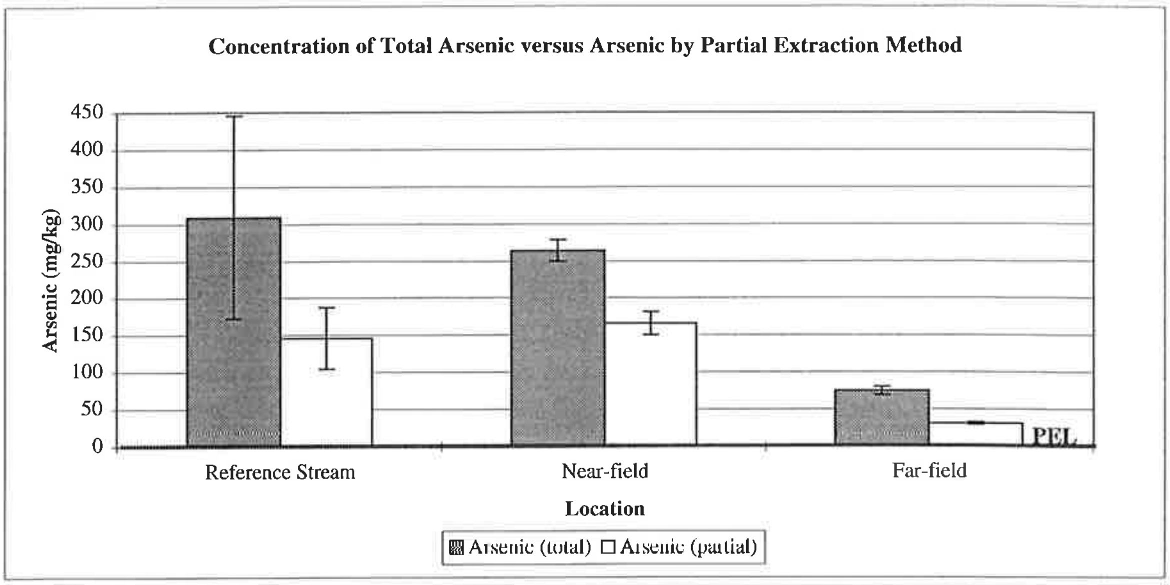
SEM/AVS ratios >1 often reflect sediments that may be toxic because there is insufficient sulphide to react with the bioavailable metals to make them less toxic. Again, SEM/AVS ratios >1 do not always accurately predict that sediments will be toxic because other factors, such as organic material or clay, will also bind metals, thereby reducing their toxicity.

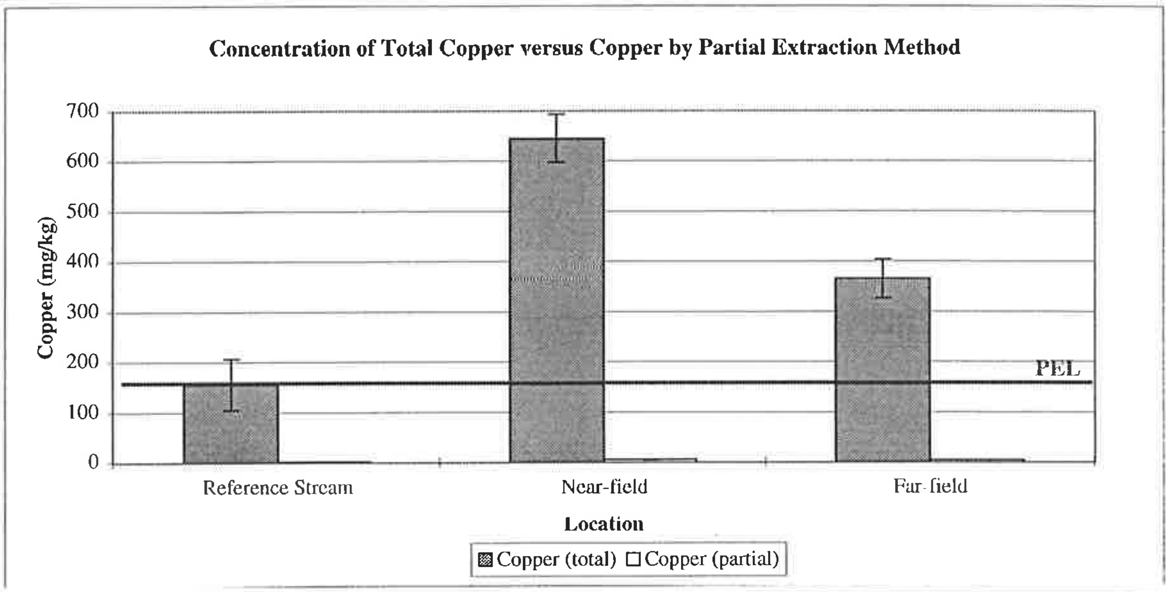
The SEM/AVS ratio was developed to predict acute sediment toxicity and not necessarily for predicting chronic effects, including effects on the benthic community. However, it is

Table 4.6: Selected Sediment Quality Results at Dome Mine Site, October 1997. Metals results based on Partial Extraction.

Component	Units	MDL[1]	REFERENCE STATIONS (STREAM)							NEAR FIELD EXPOSURE STATIONS (STREAM)							FAR FIELD EXPOSURE STATIONS (STREAM)						
			D1B-1	D1B-2	D1B-3	D2-1	D2-2	D2-3	D2-4	D3-1	D3-2	D3-3	D3-4	D3-5	D3-6	D3-7	D4-1	D4-2	D4-3	D4-4	D4-5	D4-6	D4-7
Arsenic	mg/kg	0.5	344	27	10	152	147	167	173	108	137	149	227	209	161	169	29	31	26	30	39	27	35
Cadmium	mg/kg	0.05	0.10	0.14	0.01	0.16	0.15	0.21	0.18	0.13	0.11	0.10	0.12	0.14	0.12	0.11	0.22	0.22	0.17	0.25	0.25	0.21	0.27
Chromium	mg/kg	0.6	10.1	2.6	2.4	4.5	3.9	5.2	2.9	6.3	5.7	5.8	5.9	6.7	5.9	6.5	3.4	4.3	4.2	4.9	5.1	4.0	4.2
Cobalt	mg/kg	0.2	23.1	1.0	0.5	6.0	5.8	5.7	2.7	9.7	7.9	7.6	18.0	10.9	8.3	12.8	5.9	7.8	6.7	8.8	7.9	6.0	8.7
Copper	mg/kg	0.2	0.7	0.1	0.096	2.1	2.1	2.3	0.4	4.2	3.8	4.3	7.5	5.1	3.6	5.6	3.8	3.7	4.1	3.8	3.4	4.2	3.6
Iron	mg/kg	20	6500	1500	860	6600	6100	7300	4900	10000	10000	11000	13000	12000	11000	11000	5500	6800	6100	7400	8600	7200	7600
Lead	mg/kg	0.1	19.2	2.4	0.4	6.9	6.7	8.7	3.0	3.8	4.0	4.1	3.9	5.6	4.8	5.5	5.9	6.9	4.0	7.1	9.4	7.9	8.6
Magnesium	mg/kg	20	15070	2986	4056	6936	6382	7860	5928	15002	14836	16702	14218	15624	16696	17402	4964	7070	3884	7420	8962	8746	9470
Manganese	mg/kg	1	360	104	74	541	609	739	193	615	652	802	683	667	649	665	297	434	319	445	437	413	465
Nickel	mg/kg	0.5	157	6.864	1.7	16	14	19	15	101	96	105	180	128	115	117	61	64	41	78	60	53	73
Silver	mg/kg	0.05	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Zinc	mg/kg	1	49	21	9.8	130	113	161	42	33	52	50	54	69	59	60	70	77	59	99	106	70	92

[1] MDL - Method detection limit - lowest level of the parameter that can be detected with confidence





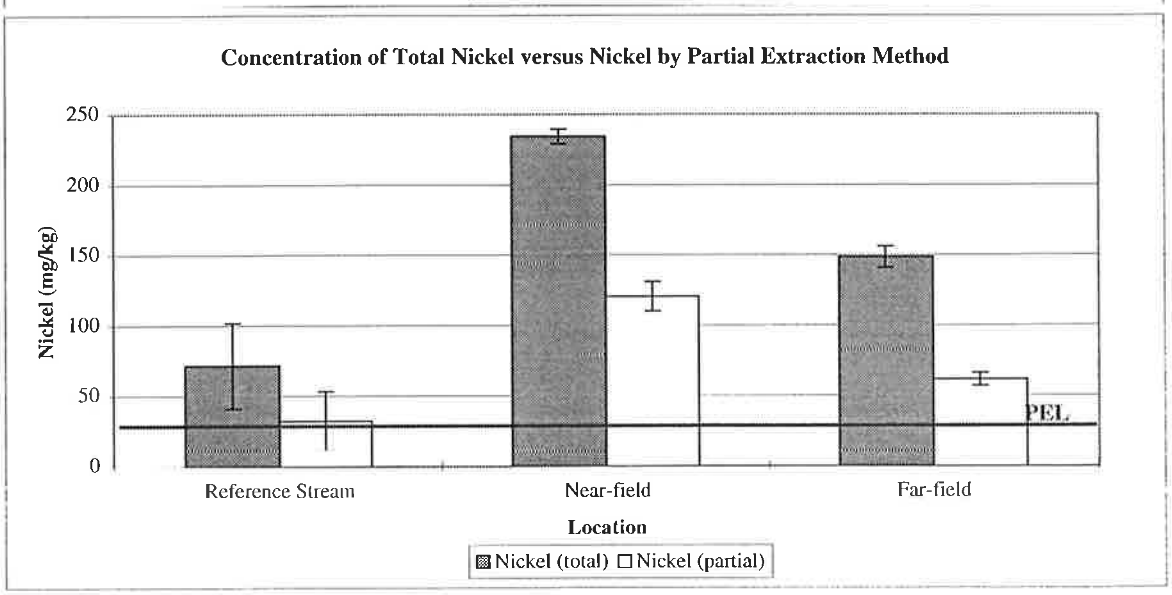


Figure 4.3: Mean Total and Partial Metals Concentrations in Sediments. Dome Mine, October 1997.

Area Means (± 1 S.E.).

not unreasonable to expect that, if sediments are acutely toxic, there would be some change in the benthic community structure that reflects this toxicity. Therefore, there may be a correlation between SEM/AVS ratios >1 and effects observed on benthic communities. This correlation is investigated in this report.

SEM/AVS ratios calculated for sediment samples collected from the near-field, far-field and reference areas are provided in Table 4.7. A comparison of the average ratios among areas is provided in Figure 4.4. Ratios for all stations were less than 0.5 and were lowest in the near-field suggesting that none of the samples would show sediment toxicity (discussed further in the following section). No mine-related trend in the ratios was observed with increasing distance from the mine site (Figure 4.4).

4.3.5 *Aqua Regia* versus Nitric Acid/Hydrogen Peroxide Extraction Methods

Two samples (reference Station D2-1 and near-field Station D3-7) were analysed for total metals after extraction by *aqua regia* to compare with the results of total metals obtained by nitric acid/hydrogen peroxide extraction (Appendix 1, Table A1.6).

For most metals the concentrations from *aqua regia* were generally 15 to 30% lower . The only exception was cadmium which showed higher concentrations for *aqua regia* compared with the nitric acid/hydrogen peroxide extraction. Molybdenum showed the highest variation among the two methods being 87 to 100% lower for *aqua regia* extraction. There were very small differences (< 10%) in copper, iron and zinc concentrations between the two extraction methods.

4.4 Sediment Toxicity

Toxicity tests were conducted on sediment samples collected at all South Porcupine River stations. Sediment toxicity test results for *Chironomus*, *Hyalella* and *Tubifex* are provided in Table 4.8 and area means and standard errors are illustrated in Figure 4.5.

The *Tubifex* test does not appear to be a sensitive measure of acute or sublethal toxicity at the Dome Mine site.

Chironomus survival was significantly lower ($p<0.05$) than the survival in the lab controls at 9 of the 21 stations (Table 4.8). Most of the acute toxicity was noted in the reference area

Table 4.7: Acid Volatile Sulphide (AVS) and Simultaneously Extracted Metals (SEM) Results and Ratios of Sediment Samples from Dome Mine Site, October 1997.

Component	Units	MDL[1]	REFERENCE STATIONS (STREAM)							NEAR FIELD EXPOSURE STATIONS (STREAM)							FAR FIELD EXPOSURE STATIONS (STREAM)						
			D1B-1	D1B-2	D1B-3	D2-1	D2-2	D2-3	D2-4	D3-1	D3-2	D3-3	D3-4	D3-5	D3-6	D3-7	D4-1	D4-2	D4-3	D4-4	D4-5	D4-6	D4-7
Cadmium	umol/g	0.05	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Chromium	umol/g	0.1	0.7	0.1	0.1	0.2	0.3	0.3	0.5	0.3	0.4	0.5	0.4	0.3	0.2	0.3	0.3	0.3	0.2	0.1	0.3	0.2	0.1
Cobalt	umol/g	0.2	0.8	<	<	0.2	0.3	0.2	0.2	0.3	0.3	0.4	0.5	0.2	0.2	0.3	0.3	0.4	0.2	0.2	0.5	0.2	0.2
Copper	umol/g	0.1	<	<	<	2.4	1.9	1.7	1.0	6.1	<	2.7	4.5	<	1.5	4.9	6.2	4.3	3.0	1.9	3.6	1.0	1.7
Iron	umol/g	0.2	533.7	77.6	127.7	346.9	501.0	374.2	530.4	492.4	811.2	1001.6	737.5	523.1	543.9	516.9	520.6	690.8	346.0	283.1	1011.1	440.6	212.5
Lead	umol/g	0.4	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Magnesium	umol/g	3	1103.7	114.7	259.6	328.0	448.1	386.9	574.6	710.9	1194.3	1405.6	953.3	772.7	796.8	719.5	380.0	631.9	198.8	274.1	1115.2	446.3	224.2
Manganese	umol/g	0.1	17.5	3.2	3.5	16.1	27.5	18.0	10.8	19.8	37.7	50.9	28.1	21.5	24.2	21.2	14.8	27.0	9.4	10.4	39.4	17.4	8.4
Nickel	umol/g	0.2	7.4	0.5	0.3	0.6	1.4	0.7	1.7	3.1	3.9	6.5	6.7	2.5	3.3	3.4	3.9	4.2	1.6	1.7	4.3	2.1	1.3
Silver	umol/g	0.1	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<	<
Zinc	umol/g	0.1	2.4	0.9	2.6	4.1	5.5	4.2	3.4	1.1	2.3	3.1	1.7	1.7	1.8	1.6	3.9	5.0	2.1	2.2	7.6	3.0	1.6
Sum of SEM (Cd/Cu/Ni/Pb/Zn)		0.1	9.7	1.4	2.9	7.2	8.9	6.6	6.1	10.3	6.3	12.2	12.9	4.2	6.7	9.9	14.0	13.5	6.8	5.8	15.5	6.2	4.6
AV Sulphide		0.1	142.0	7.9	42.1	74.1	19.0	50.7	227.0	135.0	52.0	42.0	250.0	63.1	174.0	110.0	25.9	186.0	46.2	37.3	94.6	59.7	47.9
SEM/AVS Ratio		0.1	0.07	0.18	0.07	0.10	0.47	0.13	0.03	0.08	0.12	0.29	0.05	0.07	0.04	0.09	0.54	0.07	0.15	0.15	0.16	0.10	0.10

[1] MDL - Method detection limit - lowest level of the parameter that can be detected with confidence

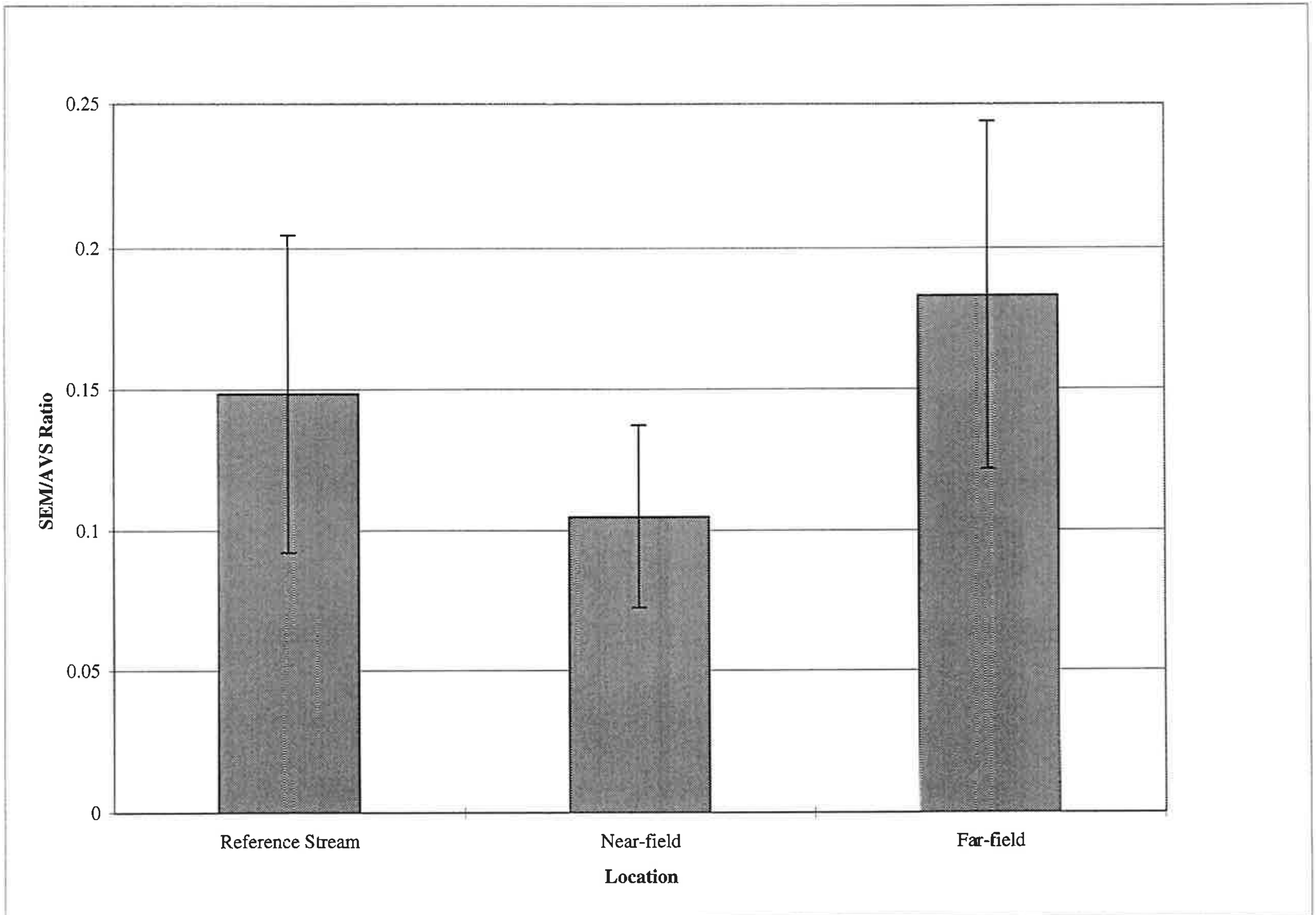


Figure 4.4: Mean SEM/AVS Molar Concentration Ratio by Area (SEM values for Cd, Cu, Ni, Pb and Zn). Dome Mine Area Means (± 1 S.E.)

Table 4.8: Sediment Toxicity Results, Dome Mine, October 1997

Station	*Chironomus riparius*		*Hyalella azteca*		*Tubifex tubifex*	
	Survival ± S.D. (%)	Mean Dry Weight/Organism ± S.D. (mg)	Survival ± S.D. (%)	Mean Dry Weight/Organism ± S.D. (mg)	Survival ± S.D. (%)	Mean Young Produced per Adult
D1B-1-S	48* ± 4	0.73 ± 0.18	24* ± 6	0.11* ± 0.02	100	32.88 ± 5.02
D1B-2-S	52* ± 4	1.06 ±0.12	84 ± 15	0.14* ± 0.03	100	32.50 ± 5.16
D1B-3-S	64* ± 6	0.93 ± 0.17	80 ±7	0.16* ± 0.04	100	34.25 ± 5.34
D2-1-S	58* ± 4	1.00 ± 0.11	68* ± 4	0.29 ±0.07	100	37.50 ± 3.74
D2-2-S	56* ± 6	1.2 ± 0.19	60* ± 10	0.19* ± 0.06	100	25.89 ± 2.36
D2-3-S	64* ± 6	1.09 ± 0.14	64* ± 9	0.19* ± 0.06	100	30.98 ± 2.68
D2-4-S	82 ± 20	0.67* ± 0.12	66* ± 9	0.21 ± 0.05	100	32.05 ± 2.46
D3-1-S	56* ± 6	1.14 ± 0.32	52* ±31	0.10* ± 0.01	100	29.25 ± 5.17
D3-2-S	80 ± 12	0.75 ± 0.19	54* ± 6	0.09* ± 0.05	100	29.65 ± 3.79
D3-3-S	78 ± 4	0.77 ± 0.18	52* ± 4	0.21 ± 0.04	100	25.35 ± 7.35
D3-4-S	86 ± 9	0.78 ± 0.14	14* ± 15	0.14* ± 0.04	100	37.55 ± 5.06
D3-5-S	80 ± 8	0.79 ±0.19	48* ± 13	0.09* ± 0.03	100	16.45 ± 1.19
D3-6-S	80 ±10	0.9 ±0.18	56* ± 6	0.1* ± 0.02	100	26.20 ± 3.61
D3-7-S	78 ±18	1.05 ± 0.21	34* ± 6	0.17* ± 0.03	100	27.95 ± 4.52
D4-1-S	78 ± 4	1.04 ± 0.23	72* ± 11	0.18* ± 0.04	100	38.45 ± 3.71
D4-2-S	70 ±7	1.07 ± 0.17	64* ± 6	0.19* ± 0.02	100	28.81 ± 6.57
D4-3-S	34* ± 6	0.36* ± 0.06	82 ± 8	0.2 ± 0.12	100	36.00 ± 9.27
D4-4-S	68 ±4	0.62* ± 0.07	68 ± 4	0.2* ± 0.03	100	32.70 ± 1.9
D4-5-S	30* ±10	0.41* ± 0.07	42* ± 4	0.14* ± 0.02	100	30.19 ± 5.34
D4-6-S	86 ±13	0.73 ± 0.06	68* ±4	0.2* ± 0.04	100	23.46 ± 1.65
D4-7-S	74 ±6	0.72 ± 0.11	66* ± 6	0.14* ± 0.02	100	31.81 ± 2.07

*: indicates that the growth or survival was significantly less than the growth or survival of the biological control ($p<0.05$ or $p<0.01$ for the Student T test)

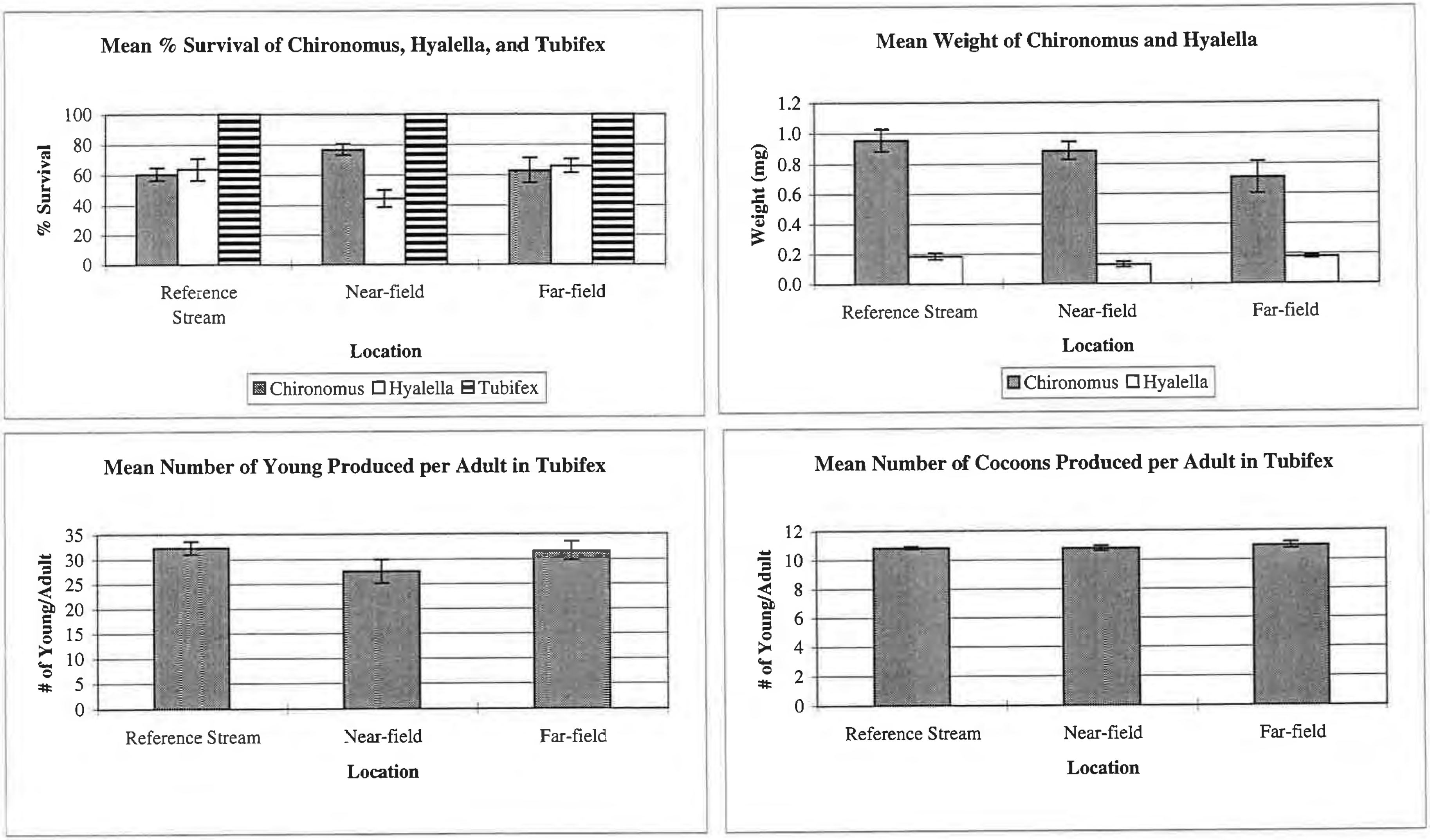


Figure 4.5: Mean Sediment Toxicity Test Results (± 1 S.E.), Dome Mine, October 1997.

stations and consequently the *Chironomus* test did not show a mine-related trend (Figure 4.5).

Hyalella survival was significantly lower ($p<0.05$) than in the lab controls at 17 of the 21 stations. Mean percent survival of *Hyalella* was lowest in the near-field area, whereas the far-field results were similar to those for the reference area. The *Hyalella* results are consistent with a mine-related trend.

Mean *Hyalella* and *Chironomus* growth showed very little variation among areas and showed no obvious trend with increased distance from the mine.

Only the *Hyalella* test using survival as the endpoint measure reflected a mine-related trend in toxicity (Figure 4.5). It appears as though *Chironomus* and *Hyalella* are responding to different contaminants. These results are supported by the benthic invertebrate community data (presented in the following section) where there was no trend in *Chironomus* abundance in relation to the mine discharge, whereas *Hyalella azteca* was absent at all stations in the near-field area.

Plots of the SEM/AVS ratios versus toxicity endpoints showed no relationships (Figure 4.6). All SEM/AVS ratios were well below 1, despite acute sediment toxicity at a number of sites. At the Dome Mine, the SEM/AVS ratio was not a good predictor of sediment toxicity. The reason for this may be that the toxicity is a result of other elements, such as arsenic, which are not accounted for in the SEM/AVS ratio.

Sediment toxicity also did not appear related to the sum of molar cadmium, copper, lead and zinc (partial extractions) expressed as a fraction of the molar concentration of iron in the partial extractions (Figure 4.7).

4.5 Benthic Invertebrates

Benthic invertebrate data are provided in Appendix 5. All associated QA/QC data are provided in Appendix 1, Table A1.1.

Mean benthic invertebrate density and number of taxa were substantially lower in the near field, whereas values in the far field were higher than those of the reference area (Figure 4.8, Table 4.9). Indicator taxa, such as *Hyalella azteca* (the same species used in toxicity

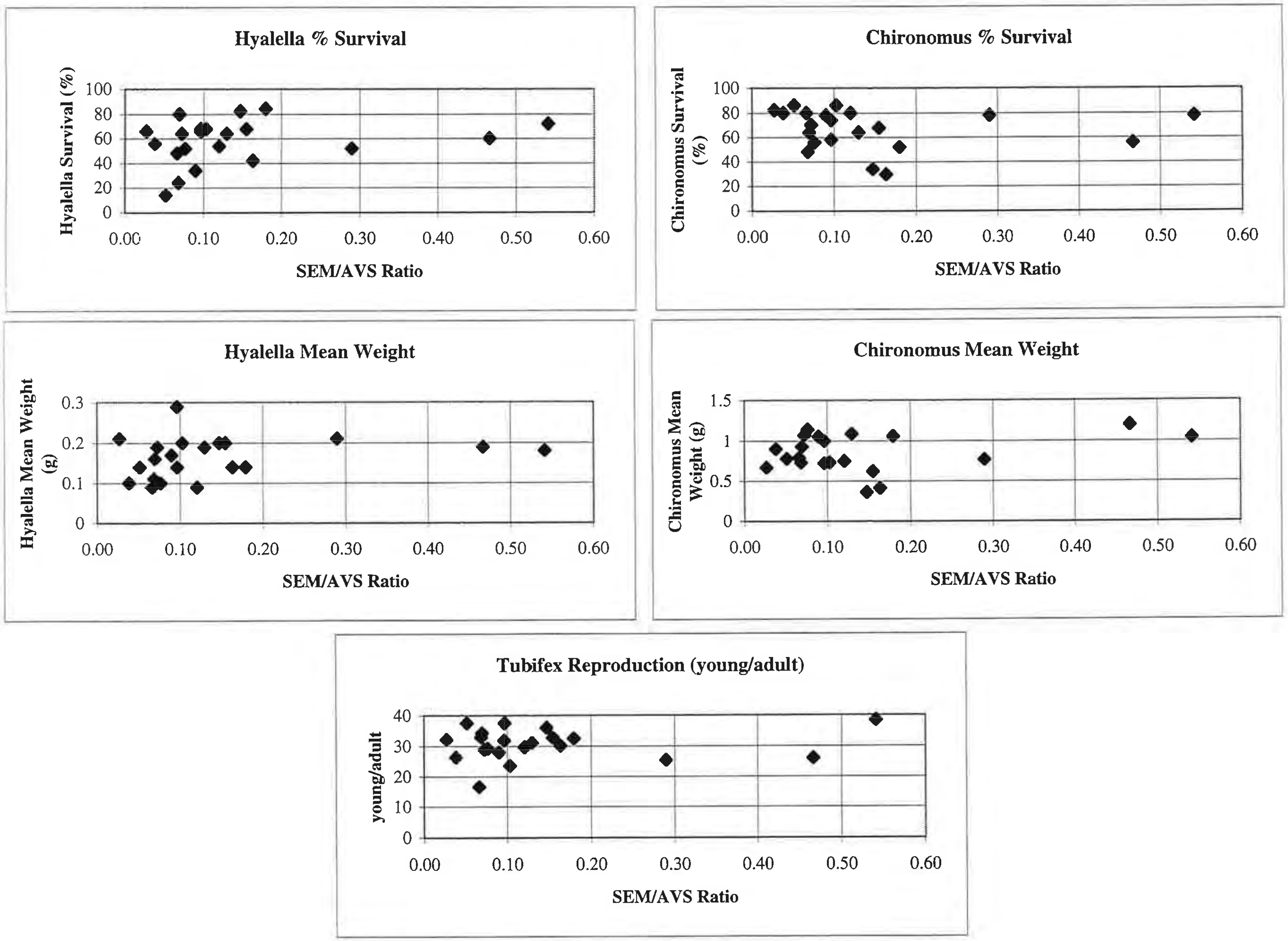


Figure 4.6: Sediment Toxicity versus Ratio of Simultaneously Extracted Metals (Cd+Cu+Ni+Pb+Zn)/Acid Volatile Sulphide. Dome Mine, October 1997.

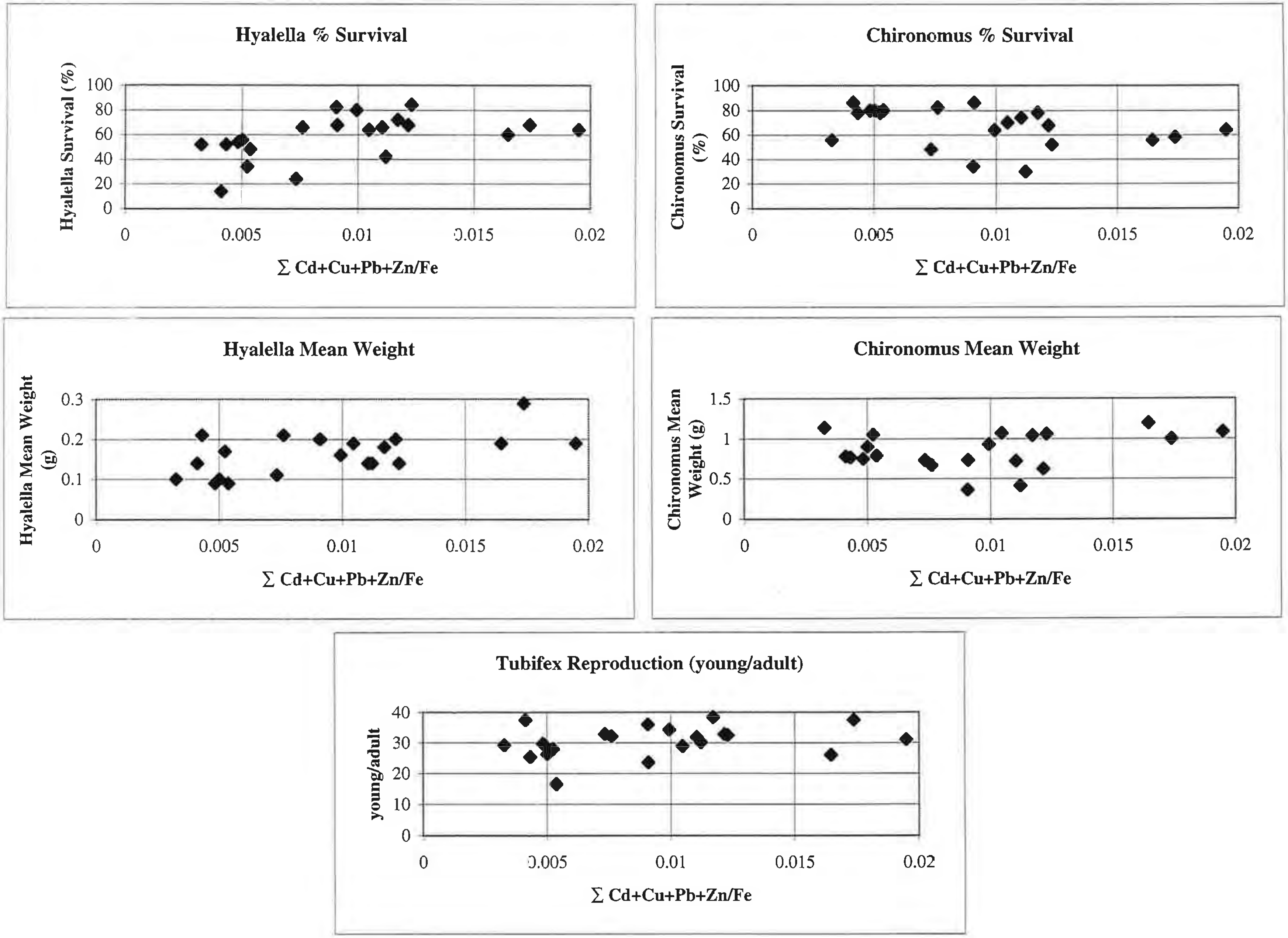


Figure 4.7: Sediment Toxicity versus Ratio of Molar Concentrations of Cd, Cu, Pb and Zn/Iron in Partial Extractions. Dome Mine, October 1997.

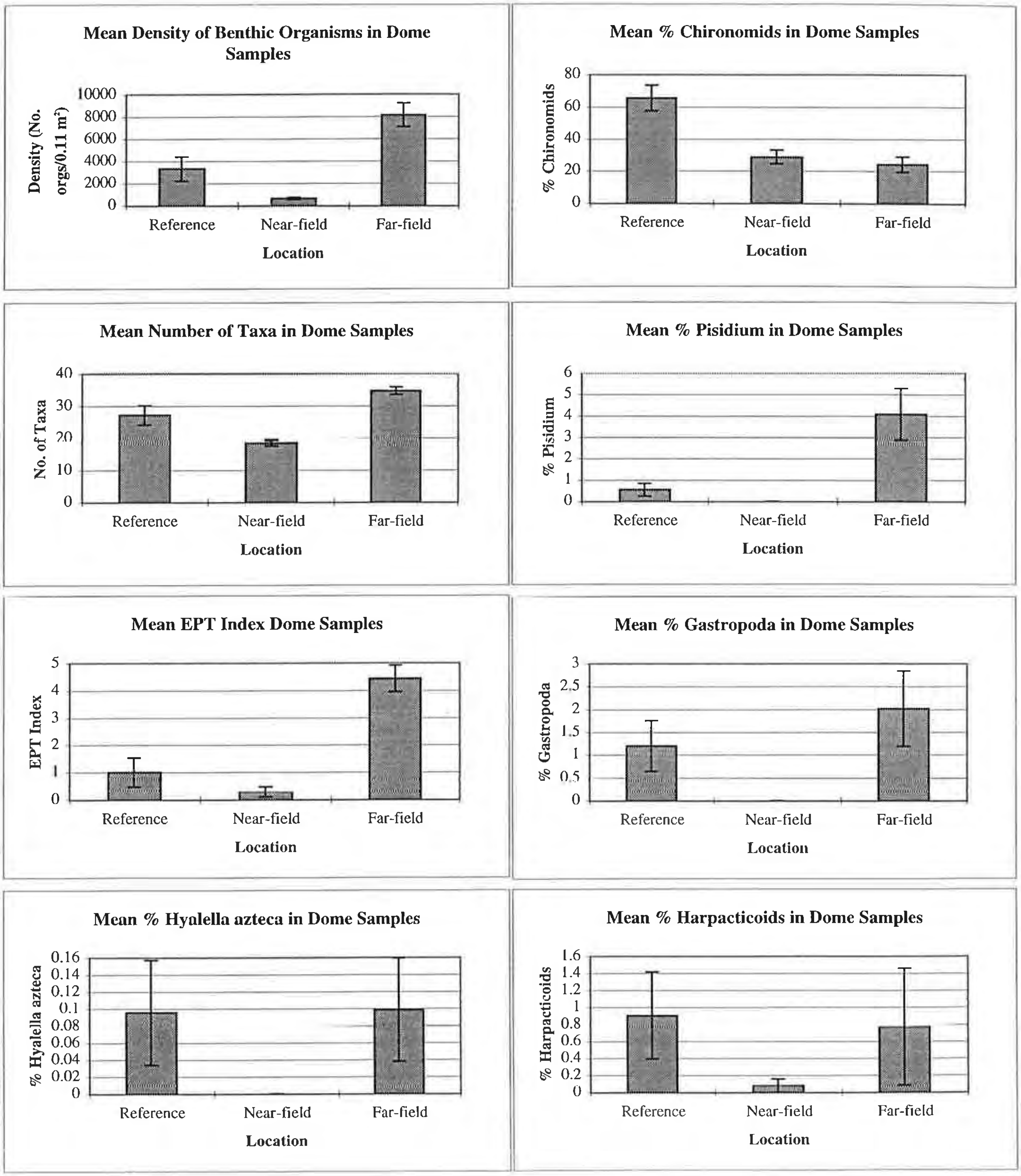


Figure 4.8: Mean Values for Selected Benthic Indices at Dome Mine, October 1997
Area Means (± 1 S.E.)

Table 4.9: Benthic Community Indices for Dome Mine Site, October 1997.

Station	Total Density (no./0.11 m²)	Number of Taxa	EPT Index	*Hyalella azteca* (%)	Chironomids (%)	Pisidium (%)	Gastropoda (%)	Harpacticoids (%)
D1B-1	1124	20	0	0	95.0	0	0	0
D1B-2	697	17	0	0	73.5	0	0	3.4
D1B-3	728	20	0	0	81.3	2.2	0	2.2
D2-1	2379	30	0	0.34	55.5	0	2.7	0
D2-2	4658	37	3	0	33.1	0.34	2.9	0
D2-3	5116	35	3	0.33	48.0	0.63	2.7	0.16
D2-4	8431	31	1	0	71.4	0.66	0.09	0.57
D3-1	892	15	0	0	17.5	0	0	0
D3-2	724	20	1	0	16.0	0	0	0.55
D3-3	444	18	0	0	42.3	0	0	0
D3-4	865	19	0	0	32.4	0	0	0
D3-5	664	22	1	0	27.7	0	0	0
D3-6	330	15	0	0	43.6	0	0	0
D3-7	628	20	0	0	21.7	0	0	0
D4-1	11775	32	4	0	28.7	0.54	2.6	0
D4-2	4288	34	5	0	19.0	6.0	6.7	4.9
D4-3	7644	41	7	0.42	50.1	0.63	1.3	0.42
D4-4	6694	34	4	0.06	22.3	2.9	1.6	0
D4-5	7553	37	4	0.21	17.8	4.0	0.32	0
D4-6	7042	32	4	0	16.0	9.8	1.0	0
D4-7	11922	33	3	0	15.3	4.7	0.60	0.08

tests), the clam *Pisidium,* mayflies and gastropods (snails are particularly sensitive to copper) all showed a clear mine-related trend where they were present in the reference and far-field areas and absent in the near-field area (Figure 4.8). Other indicator taxa, such as *Tanytarsus,* Hydracarina and Harpacticoida also showed a mine-related trend where numbers were lowest in the near-field area. *Chironomus,* the same genera used in the sediment toxicity tests, showed no mine-related trend. EPT (Ephemeroptera-Plecoptera-Trichoptera) index values and percent chironomids also separated reference from exposure communities.

Chironomid Deformities

There were no trends in chironomid mentum and mandible deformities between reference and exposure areas (Appendix 5, Table A5.2). The occurrence of deformities was low in all areas, even at the near-field stations where sediment contamination was quite high. This is not surprising since metals are not generally considered to be genotoxicants.

4.6 Fish

4.6.1 Fish Catches

South Porcupine River

The habitats in the near-field and far-field areas were not conducive to back-pack electrofishing. The reference area was easy to electrofish because of the shallow water, however, most of the fish in this area congregated under the road bridges which provided deeper water and overhead cover. In the near field and far field, the stream was too deep for effective back-pack electrofishing. For example, in the near field, 587 seconds of electrofishing time only yielded two adult pearl dace, compared to three minnow traps set in the same area that resulted in 90 adult pearl dace in 24 hours.

The most common species throughout the South Porcupine River was brook stickleback (although they were not effectively captured by minnow trap) followed by pearl dace, northern redbelly dace and fathead minnow. A few white sucker and mottled sculpin were captured during electrofishing and with minnow traps in the far-field area.

In general, pearl dace were slightly more abundant (higher catch per unit effort, minnow trap) in the near-field area, and scarcest in the far-field area, upstream of the confluence with the North Porcupine River when compared to fish catches in the reference area (Table 4.10). Pearl dace were absent downstream of the confluence with the North Porcupine River. Pearl dace tended to be slightly younger but larger and with larger livers and gonads in exposed areas than in the reference area (Table 4.10a).

McDonald's and Porcupine Lakes

Rock bass was the most abundant species in McDonald's Lake, whereas yellow perch and spottail shiner were most common in Porcupine Lake. Other species captured in McDonald's Lake were smallmouth bass, yellow perch, white sucker, pearl dace, northern pike and mottled sculpin. In Porcupine Lake northern pike, walleye and brook stickleback were also captured.

Because of the dominance of rock bass in the reference lake, catch-per-unit-effort for yellow perch was six times lower compared to the exposure lake (Table 4.10, seine net). All gear types were deployed in McDonald's Lake in order to catch the requisite number of yellow perch. Gear restrictions were placed on fishing in Porcupine Lake by the Ministry of Natural Resources (MNR), whereby gillnets could only be used if yellow perch could not be captured by angling or seining.

4.6.2 Yellow Perch and Pearl Dace Growth and Reproduction Parameters

Data on ages for all of the yellow perch and selected pearl dace are provided in Appendix 6. Adult yellow perch ranged in age from 2 to 4 years and pearl dace were 1 and 2 years old. Age was found to be a significant covariate for yellow perch measurements but not for pearl dace.

The growth (length, weight) and reproduction (gonad weight, fecundity) data for yellow perch and pearl dace are provided in Table A6.7, Appendix 6.

Mean pearl dace weight and length were highest in the near-field area and lowest in the reference area (Figure 4.9). The same trend was seen for mean liver and gonad weights for both male and female pearl dace. Mean pearl dace fecundity was lowest in the reference area and highest in the far-field area (Figure 4.9).

TABLE 4.10: FISH CAPTURE DATA

	Species	Total Catch	CPUE
McDONALD'S LAKE (REFERENCE)			(fish/hr)
Minnow Traps	Yellow perch	24	0.03
	Rock bass	24	0.03
	Smallmouth bass	2	0.003
			(1,000 ft/hr)
Gillnets	Rock bass	263	6.26
	Yellow perch	21	0.5
	White sucker	7	0.2
	Smallmouth bass	6	0.1
	Pike	1	0.02
			(fish/min)
Electrofishing	Rock bass	21	0.6
			(fish/m^2)
Seine Netting	Yellow perch	268	0.01
	Rock bass	110	0.006
	Pearl dace	13	0.0006
	Smallmouth bass	9	0.0005
	Mottled sculpin	3	0.0002
	White sucker	1	0.00005
PORCUPINE LAKE (EXPOSURE)			(fish/min)
Electrofishing	Yellow perch	8	0.18
			(fish/m^2)
Seine Netting	Yellow perch	2,799	0.06
	Spottail shiners	975	0.02
	Pike	6	0.0001
	Walleye	3	0.00006
	Brook stickleback	1	0.00002
SOUTH PORCUPINE RIVER			
Reference			(fish/hr)
Minnow Traps	Pearl dace	279	1.2
	Brook stickleback	9	0.04
	Northern redbelly dace	9	0.04
	Fathead minnows	3	0.01
			(fish/min)
Electrofishing	Brook stickleback	75	6
	Pearl dace	30	2.4
	Fathead minnows	14	1.1
	Northern redbelly dace	7	0.6
NEAR-FIELD AREA			(fish/hr)
Minnow Traps	Pearl dace	154	1.4
	Brook stickleback	4	0.04
	Northern redbelly	1	0.01
			(fish/min)
Electrofishing	Brook stickleback	130	13.3
	Pearl dace	15	1.5
	Northern redbelly dace	5	0.5
PROPOSED FAR-FIELD AREA			(fish/hr)
Minnow Traps	Yellow perch	3	0.008
	Mottled sculpin	2	0.005
	White sucker	1	0.003
			(fish/min)
Electrofishing	Yellow perch	1	0.04
	White sucker	1	0.04
NEW FAR-FIELD AREA			(fish/hr)
Minnow Traps	Pearl dace	84	0.39
	Northern redbelly dace	10	0.05

Table 4.10a: Summary of Biological Characteristics of Yellow Perch and Pearl Dace, Dome Mine (values are mean ± 1 S.E.)

Yellow Perch Biological Measurement	Reference Area (McDonald's Lake)		Exposure Area (Porcupine Lake)	
	Females	Males	Females	Males
Sample Size [1]	22	19	20	20
Mean Age (yrs)	3 ± 0.1	2 ± 0.1	3 ± 0.1	3 ± 0.1
Mean Fork Length (cm)	15.6 ± 0.27	10.8 ± 0.49	15.3 ± 0.37	13.8 ± 0.43
Mean Total Length (cm)	16.4 ± 0.29	11.5 ± 0.50	16.1 ± 0.39	14.6 ± 0.46
Mean Weight (g)	40.0 ± 2.19	15.7 ± 3.24	44.7 ± 3.90	34.1 ± 2.65
Mean Gonad Weight (g)	1.8 ± 0.13	1.2 ± 0.23	1.7 ± 0.19	1.9 ± 0.15
Mean Liver Weight (g)	0.61 ± 0.037	0.26 ± 0.038	0.72 ± 0.069	0.50 ± 0.038
Mean Fecundity (eggs/female)	5842 ± 456.3	not applicable	5776 ± 583.9	not applicable

Pearl Dace Biological Measurement	South Porcupine River Reference Areas		Near-field		Far-field	
	Females	Males	Females	Males	Females	Males
Sample Size	37	20	29	20	30	21
Mean Age (yrs)	1.1 ± 0.09	1.4 ± 0.24	1.0	1.2 ± 0.17	1.5 ± 0.16	1.6 ± 0.24
Mean Fork Length (cm)	9.2 ± 0.22	7.8 ± 0.12	10.1 ± 0.28	9.3 ± 0.13	9.6 ± 0.23	8.2 ± 0.35
Mean Total Length (cm)	8.8 ± 0.16	8.3 ± 0.11	10.2 ± 0.21	10.1 ± 0.16	9.8 ± 0.27	8.7 ± 0.37
Mean Weight (g)	8.0 ± 0.64	4.6 ± 0.22	10.6 ± 0.87	8.1 ± 0.35	9.8 ± 0.74	5.6 ± 0.73
Mean Gonad Weight (g)	0.47 ± 0.047	0.07 ± 0.007	0.80 ± 0.097	0.14 ± 0.011	0.71 ± 0.089	0.10 ± 0.018
Mean Liver Weight (g)	0.14 ± 0.013	0.11 ± 0.006	0.24 ± 0.021	0.18 ± 0.011	0.20 ± 0.020	0.11 ± 0.021
Mean Fecundity (eggs/female)	1110 ± 102.7	not applicable	1521 ± 120.3	not applicable	1903 ± 138.4	not applicable

[1] Sample size represents the total catch. All measurements (where possible) were taken on the first 20 fish (approximately), while only fork length and weight were measured on the other fish.

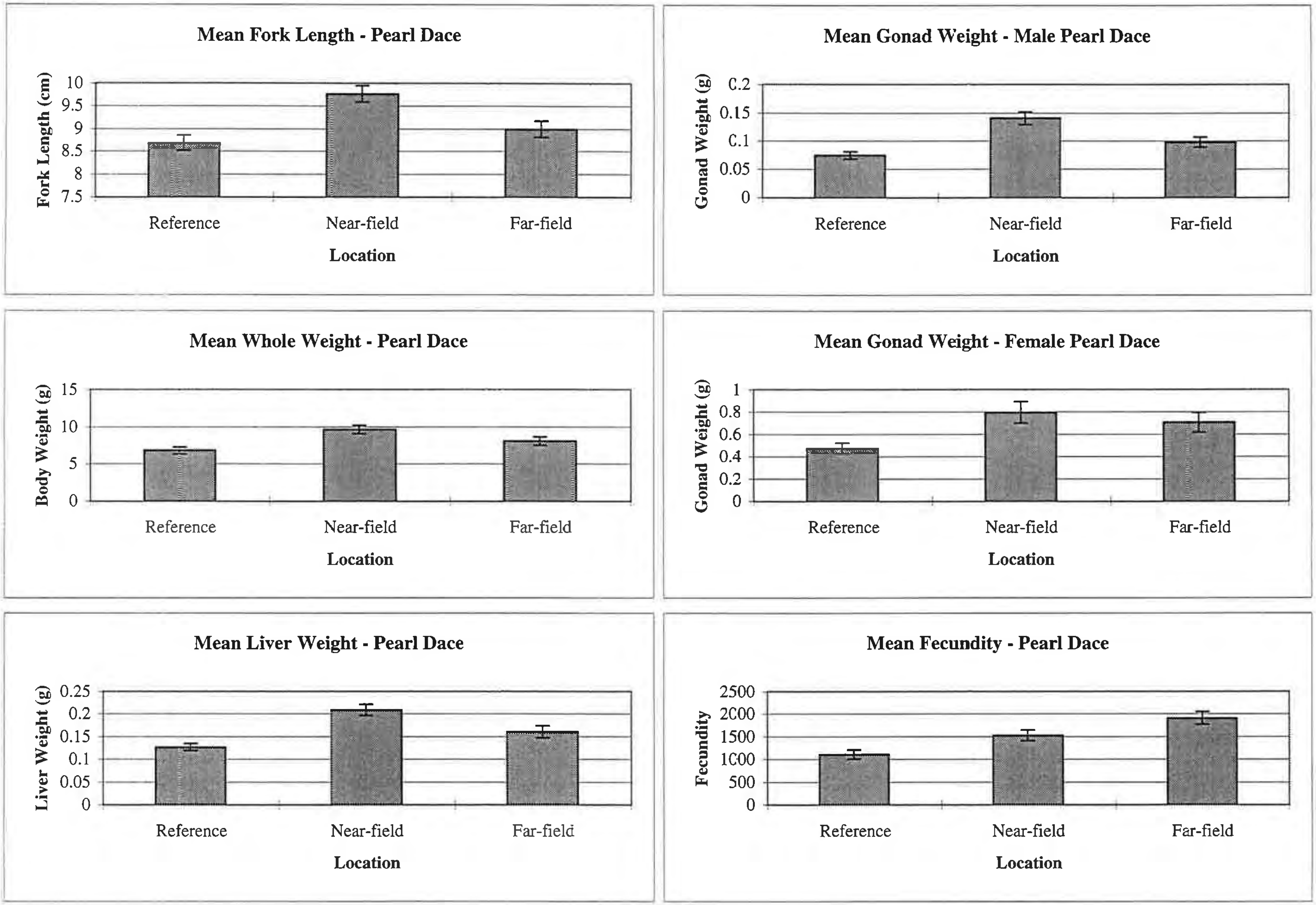


Figure 4.9: Fork Length, Body Weight, Liver Weight, Gonad Weight and Fecundity of Pearl Dace Collected at Dome Mine, October 1997.
Area Means (± 1 S.E.).

Mean values at age for adult yellow perch length, total body weight, fecundity (number of eggs) and gonad and liver weight were similar for reference and exposure groups (Figure 4.10; Table 4.10a).

4.6.3 Caged Yellow Perch

Biological measurements taken on caged yellow perch used in tissue analysis are presented in Appendix 6, Table A6.7. As noted in Section 2.0, all fish were young-of-the-year collected from a nearby lake uninfluenced by mining. Pre-exposure viscera metal and metallothionein levels are also provided in Appendix 6, Table A6.6.

All fish survived the ten-day exposure at all reference and exposure sites, including in the far-field area where pearl dace were apparently absent.

4.6.4 Metals and Metallothionein

Results of metal and metallothionein analyses on pearl dace viscera, adult yellow perch tissues and caged yellow perch viscera are provided in Appendix 6, Tables A6.1 to A6.4 (yellow perch tissues), Table A6.5 (pearl dace viscera) and Table A6.6 (caged yellow perch viscera). Mean tissue values for metallothionein and key metals (zinc, silver, copper, nickel, selenium and cadmium) are shown in Figures 4.11 to 4.14 and in Table 4.10b.

Pearl Dace Viscera

Mean cadmium, silver, cobalt, selenium, copper and zinc concentrations in pearl dace viscera were all highest in the near-field area (Figure 4.11, Table A6.5, Appendix 6). Mean concentrations of cadmium, selenium and zinc in the far-field pearl dace viscera were similar to levels measured in the reference area fish. Mean concentrations of copper and silver for far-field pearl dace viscera were higher than reference levels and lower than viscera concentrations in the near-field fish, clearly showing a mine-related trend. Nickel viscera concentrations were highest in fish from the far-field area. Copper levels in viscera followed a similar trend to sediment and water concentrations. Overall, the strongest mine-related trends were reflected in viscera concentrations of selenium, silver and copper.

The corresponding metallothionein levels in pearl dace viscera did not appear to reflect the trends in concentrations of copper, silver, nickel, selenium, zinc or cadmium and also did

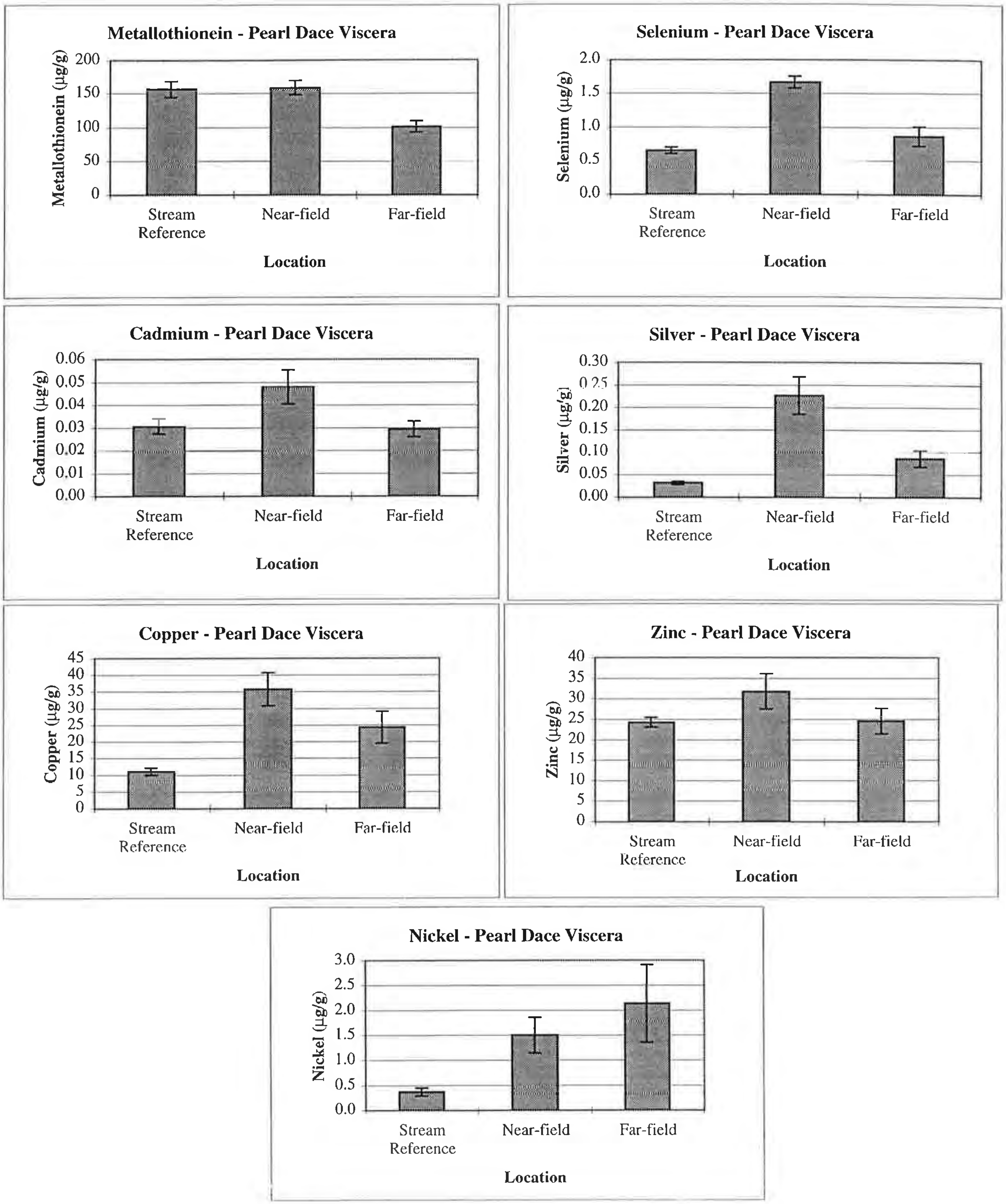


Figure 4.11: Concentration of Metallothionein, Cadmium, Copper, Nickel, Selenium, Silver and Zinc in Pearl Dace Viscera, Dome Mine, October 1997.

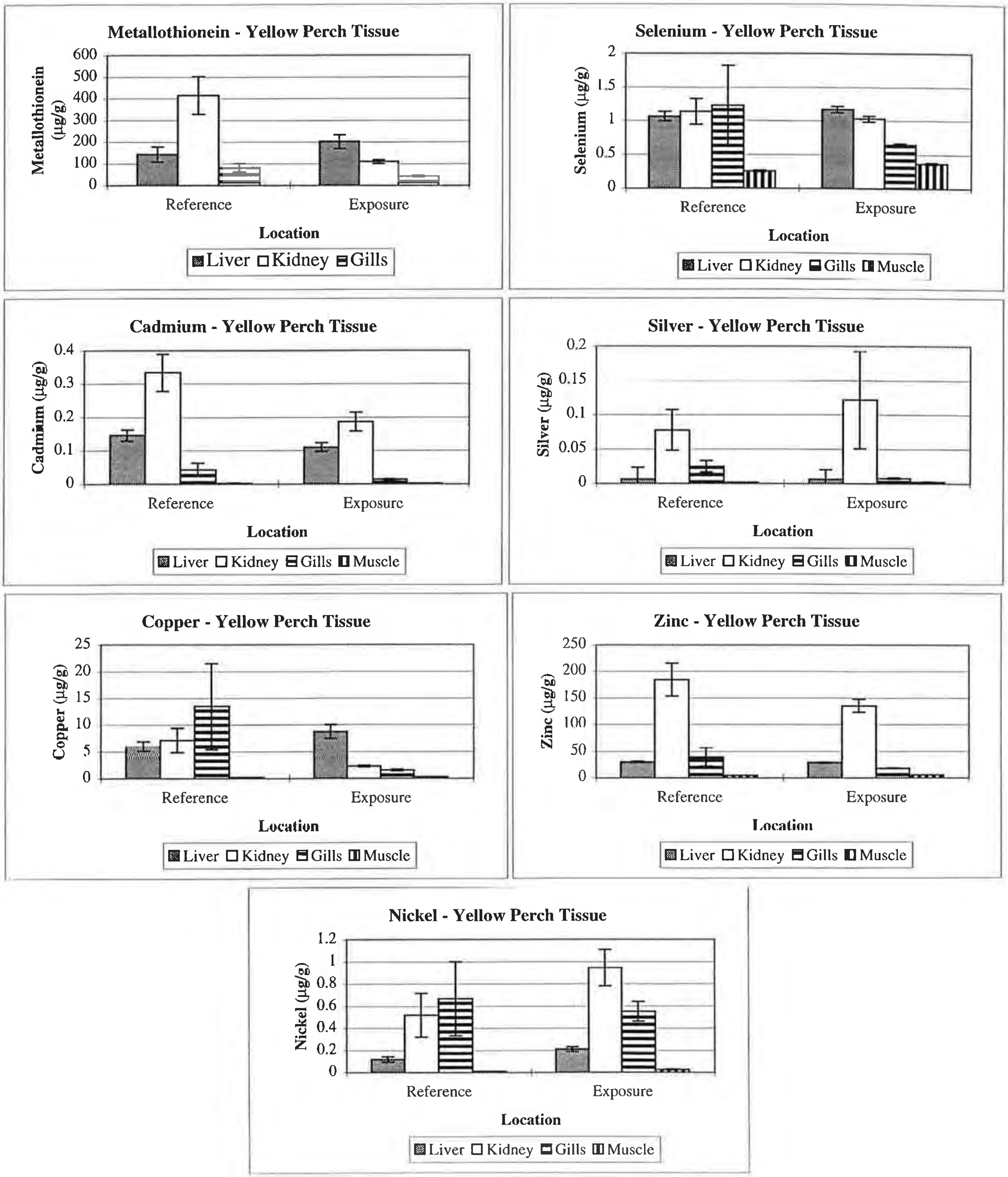


Figure 4.12: Mean Concentration of Selected Metals in Yellow Perch Tissues, Dome Mine, October 1997.
Area Means (± 1 S.E.)

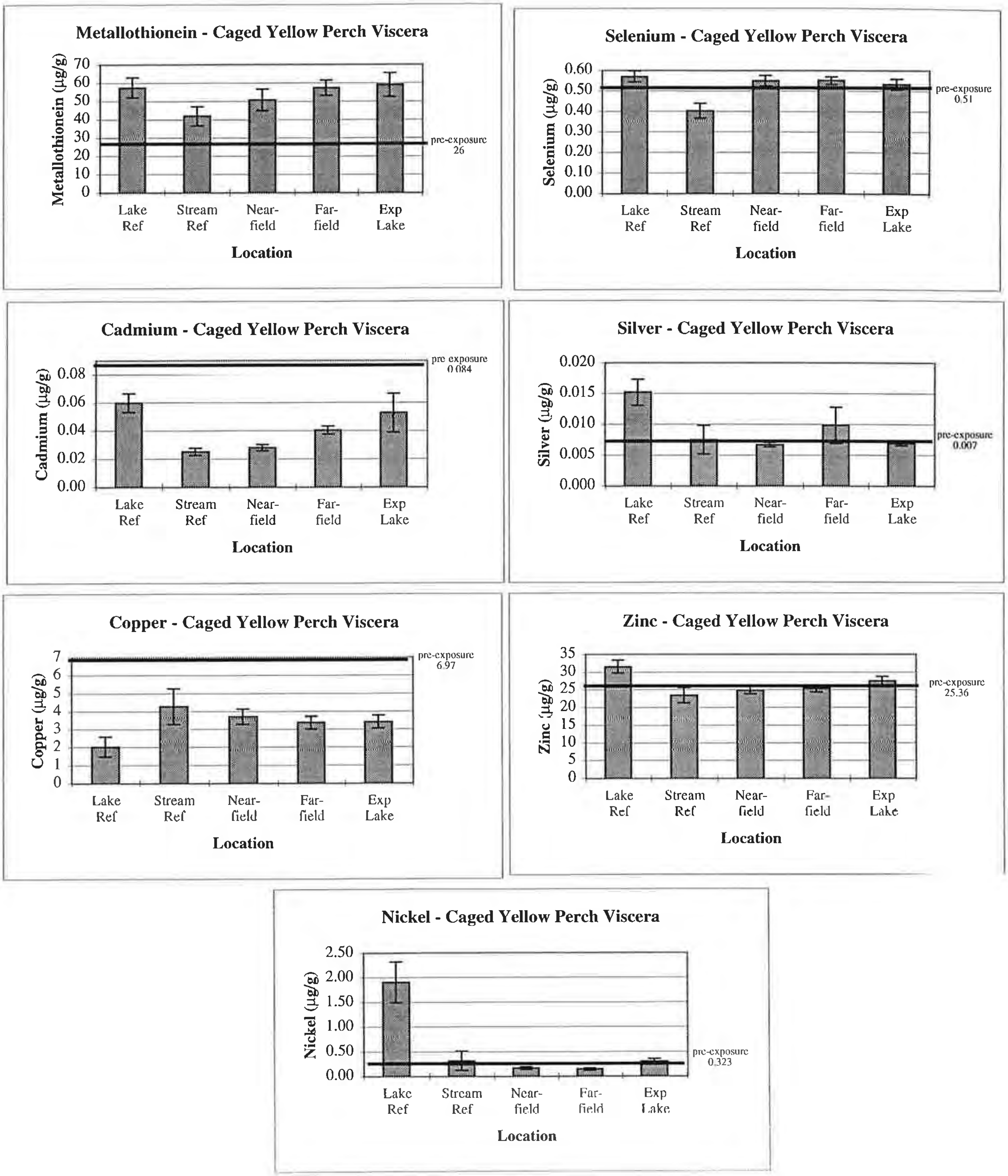


Figure 4.13: Concentration of Metallothionein, Cadmium, Copper, Nickel, Selenium, Silver and Zinc in Caged Yellow Perch Viscera Compared to Mean Pre-exposure Levels, Dome Mine, October 1997.

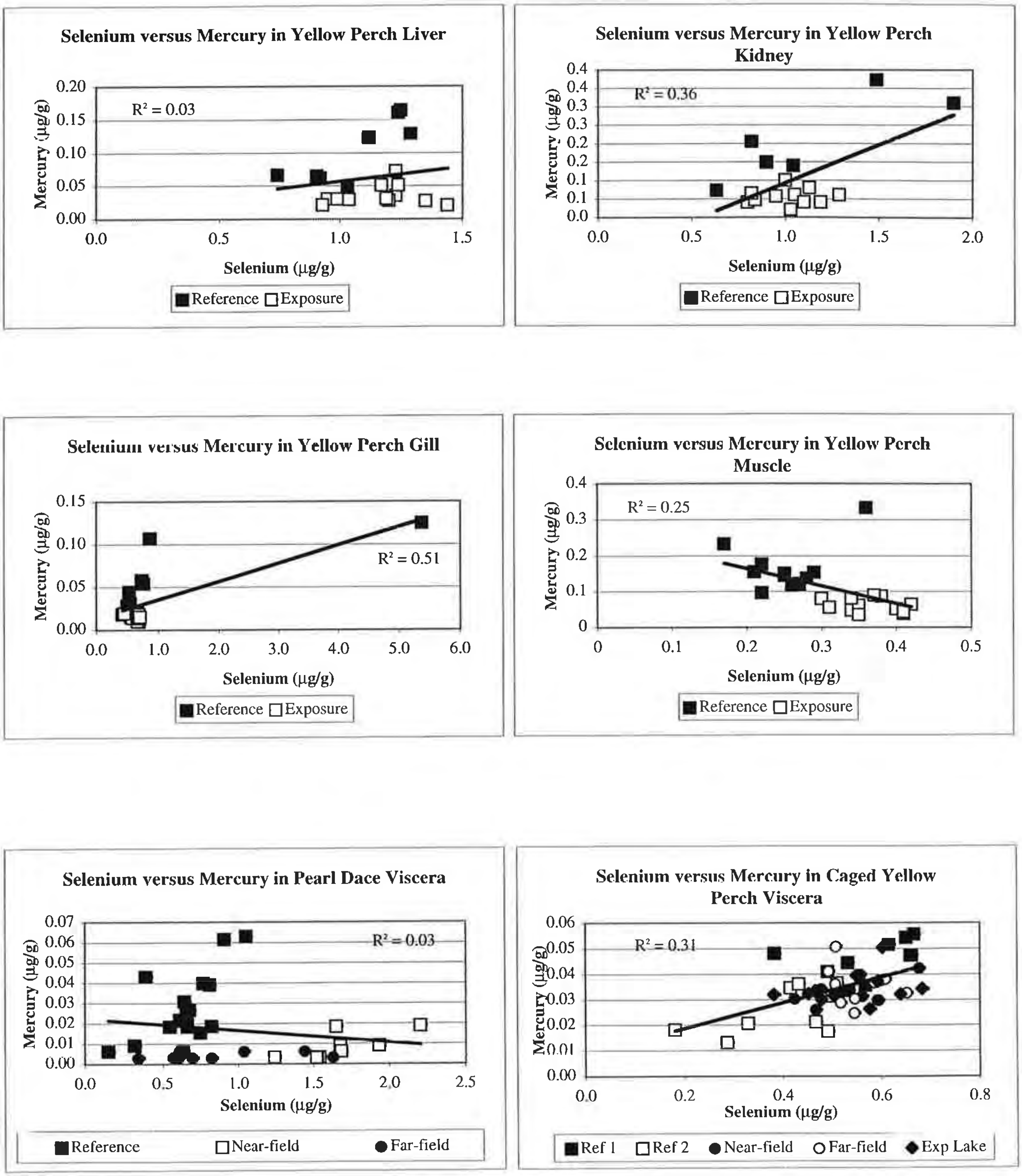


Figure 4.14: Concentration of Selenium versus Mercury in Yellow Perch and Pearl Dace Tissue. Dome Mine, October 1997.

Table 4.10b: Summary of Tissue Metallothionein and Selected Metal Concentrations, μg/g fresh weight, Dome Mine
(values are mean +/- 1 S.E.)

Yellow Perch Component	Reference Area (McDonald's Lake)				Exposure Area (Porcupine Lake)			
	Liver	Kidney	Gill	Muscle	Liver	Kidney	Gill	Muscle
Metallothionein	142 ± 34.7	413 ± 86.6	81.2 ± 18.4	not measured	201 ± 32.3	108 ± 9.73	42.0 ± 4.21	not measured
Cadmium	0.145 ± 0.017	0.333 ± 0.057	0.042 ± 0.019	0.002 ± 0.0004	0.110 ± 0.013	0.186 ± 0.028	0.014 ± 0.001	0.002 ± 0.0002
Copper	5.97 ± 0.858	7.12 ± 2.26	13.4 ± 8.10	0.158 ± 0.012	8.74 ± 1.30	2.29 ± 0.156	1.52 ± 0.166	0.219 ± 0.009
Nickel	0.118 ± 0.024	0.516 ± 0.199	0.665 ± 0.332	0.010 ± 0.000	0.210 ± 0.022	0.943 ± 0.165	0.549 ± 0.089	0.025 ± 0.003
Selenium	1.06 ± 0.069	1.13 ± 0.193	1.22 ± 0.596	0.254 ± 0.014	1.16 ± 0.046	1.03 ± 0.044	0.641 ± 0.021	0.365 ± 0.012
Silver	0.006 ± 0.0008	0.077 ± 0.030	0.025 ± 0.008	0.001 ± 0	0.006 ± 0.0009	0.121 ± 0.071	0.007 ± 0.001	0.002 ± 0.0005
Zinc	29.6 ± 1.26	184 ± 31.4	39.1 ± 17.5	4.20 ± 0.186	28.7 ± 0.856	135 ± 12.2	17.8 ± 0.547	4.93 ± 0.162

Pearl Dace Component	South Porcupine River		
	Reference Areas	Near-field	Far-field
	Viscera	Viscera	Viscera
Metallothionein	156 ± 11.9	159 ± 10.7	101 ± 7.99
Cadmium	0.031 ± 0.003	0.048 ± 0.007	0.029 ± 0.003
Copper	11.1 ± 1.11	35.7 ± 4.97	24.3 ± 4.86
Nickel	0.364 ± 0.075	1.50 ± 0.358	2.13 ± 0.783
Selenium	0.650 ± 0.049	1.67 ± 0.091	0.861 ± 0.143
Silver	0.031 ± 0.004	0.227 ± 0.042	0.086 ± 0.018
Zinc	24.2 ± 1.18	31.8 ± 4.29	24.5 ± 3.13

Caged Yellow Perch Component	Lake Reference Area	South Porcupine River			
		Stream Reference Area	Near-field	Far-field	Lake Exposure
	Viscera	Viscera	Viscera	Viscera	Viscera
Metallothionein	57.4 ± 5.39	41.8 ± 5.29	50.8 ± 5.78	57.3 ± 4.22	58.9 ± 6.53
Cadmium	0.060 ± 0.007	0.025 ± 0.002	0.028 ± 0.002	0.040 ± 0.003	0.053 ± 0.014
Copper	2.02 ± 0.562	4.27 ± 0.989	3.69 ± 0.422	3.37 ± 0.352	3.41 ± 0.365
Nickel	1.91 ± 0.415	0.311 ± 0.197	0.163 ± 0.026	0.143 ± 0.023	0.297 ± 0.053
Selenium	0.571 ± 0.027	0.402 ± 0.037	0.550 ± 0.027	0.551 ± 0.018	0.533 ± 0.026
Silver	0.015 ± 0.002	0.008 ± 0.002	0.007 ± 0.0004	0.010 ± 0.003	0.007 ± 0.0003
Zinc	31.5 ± 1.82	23.4 ± 2.15	24.8 ± 1.05	25.3 ± 0.967	27.5 ± 1.17

not reflect a mine-related trend. Mean metallothionein levels were similar in reference and near-field areas even though metal levels were substantially higher in the near-field fish (Figure 4.11). Mean metallothionein levels were lowest in far-field pearl dace although mean metal levels in these fish were generally higher than reference fish.

Yellow Perch

Liver

Mean concentrations of cadmium, zinc and silver in yellow perch liver were similar between reference and exposure lakes, whereas copper, nickel and selenium in liver showed a slight trend of higher levels in the exposure lake (Figure 4.12).

Kidney

Yellow perch kidneys had lower mean levels of copper, cadmium, zinc and selenium in the exposure lake compared to the reference lake (Figure 4.12). This is the opposite to the trend in water concentrations of these metals which were higher in the exposure lake. Mean kidney concentrations of nickel and silver were higher in exposed fish compared to mean levels in reference fish, which reflected the trend observed in water chemistry for these metals.

Gill

Mean concentrations of all six key metals in yellow perch gill were higher in the reference fish compared to mean levels in the exposed fish (Figure 4.12). This is opposite to the trend in water chemistry. This trend was most noticeable with copper which was substantially higher in reference fish gill compared to exposure fish even though aqueous copper exceeded the CWQG in the exposure lake but not in the reference lake.

Muscle

Muscle concentrations of all metals, with the exception of mercury, were much lower than the levels measured in the other tissues (Appendix 6, Table A 6.4; Figure 4.12). For mercury the highest tissue concentrations were measured in the muscle. Muscle concentrations of most metals were higher in exposure perch.

Metallothionein

Examination of the mean metallothionein data shows that tissue metallothionein levels were higher in gill and kidney in reference fish and slightly higher in liver in exposure fish (Figure 4.12). Only liver metallothionein levels showed a mine-related trend with levels slightly higher in exposure fish where waterborne concentrations of most metals were also higher and where liver metal concentrations were similar to or higher than levels in reference fish. Overall, the mean tissue metallothionein levels appeared to mirror the tissue metal concentrations discussed above. However, the gill and kidney did not reflect a mine-related trend in metallothionein or metal concentrations nor did they reflect the trend in water and sediment concentrations for the same metals.

Caged Yellow Perch

There was no consistent trend among any of the mean metal concentrations measured in caged yellow perch viscera (Figure 4.13) after a ten-day exposure period. The mean concentrations of metals in viscera did not reflect the gradient in waterborne metals and did not show a mine-related trend.

It was noted that the mean pre-exposure concentrations of most metals in viscera were higher than at the end of the ten-day exposure period, suggesting that the caged yellow perch were depurating metals (Figure 4.13). The possible explanation for this trend is that the analysis of viscera metals includes the metals in the material within the alimentary canal and not just bioaccumulated metals. The caged yellow perch were not fed during the ten-day exposure so this material would have been cleared from their systems and not included in the analysis of the viscera from the exposed fish. These data suggest that careful consideration is needed when comparing viscera metals versus metallothionein response or when comparing metals in caged fish and pearl dace viscera to aqueous metals.

Mean metallothionein levels in caged yellow perch viscera also did not show a mine-related trend or reflect water concentrations of most metals. The trend in mean metallothionein levels was most similar to the trend in viscera concentrations of selenium (Figure 4.13). Interestingly, the mean metallothionein levels increased at all stations compared to the mean pre-exposure levels, even though the viscera concentrations of all metals decreased or remained relatively unchanged (Figure 4.13; Table A6.5, Appendix

6). These data suggest that the caged perch are responding to waterborne concentrations of some contaminant and that there is a weak relationship between viscera metals and metallothionein in the caged perch.

Metallothionein levels in pearl dace viscera were generally twice the levels measured in caged yellow perch and caged yellow perch viscera levels were similar to the levels measured in adult yellow perch gills. Metallothionein levels in adult yellow perch kidney and liver were generally more than twice the levels in caged perch viscera.

There was a similar trend in viscera cadmium concentrations between pearl dace and caged yellow perch, however, copper levels in pearl dace were 3 to 10 (near field) times higher than levels measured in caged and pre-exposure yellow perch viscera. It is unknown whether this difference is due to bioaccumulated metals or to stomach content. Sediment copper concentrations were highest in the near-field area. Zinc concentrations in yellow perch viscera (caged and pre-exposure) after a ten-day exposure were similar to the levels in pearl dace viscera.

4.6.5 General Correlations

Recent studies have shown an ameliorative effect of tissue selenium concentrations on the bioaccumulation of mercury (Jack Klaverkamp, Freshwater Institute, pers. comm., 1998). For example, a study by Turner and Swick (1983) showed that the presence of selenium decreases mercury uptake. In order to explore this relationship with the Dome Mine data, plots of mercury against selenium were done for each tissue type for each species (Figure 4.14). The trend is in the right direction only for muscle tissue, but the correlation is weak.

Metallothionein versus Metal Concentrations

Correlation analysis of metals in tissues versus metallothionein in tissues indicates some significant ($p<0.05$) relationships (Table 4.11). The strongest relationships occur between copper in yellow perch liver and mercury in yellow perch kidney.

No strong correlations were observed between viscera metals and metallothionein levels in pearl dace or caged yellow perch. Significant correlations were noted for mercury and cadmium but they were very weak (Table 4.11). The lack of significant correlations between viscera metals and metallothionein may be influenced by the concentration of metals in the alimentary canal as opposed to bioaccumulated metals in the viscera.

Table 4.11: Pearson Correlation Matrix of Metals and Metallothionein in Fish Tissues

Pearson Correlation Coefficients with 1-tailed Probabilities

Dome Mine

	Yellow perch						Pearl dace		Caged Yellow perch	
	Pearson Correlation Coefficients			Probabilities			Correlation	Probabilities	Correlation	Probabilities
	Metallothionein			**Metallothionein**			**Metallothionein**	**Metallothionein**	**Metallothionein**	**Metallothionein**
	Liver	Kidney	Gill	Liver	Kidney	Gill	Viscera	Viscera	Viscera	Viscera
CdCuZn	0.422	0.418	0.155	0.032	0.042	0.258	0.181	0.146	-0.023	0.436
Mercury	-0.557	0.847	0.527	0.005	4.62E-06	0.008	0.366	0.014	-	-
Silver	0.232	-0.154	0.132	0.162	0.270	0.290	0.170	0.160	-	-
Aluminum	-0.556	0.212	-0.078	0.005	0.199	0.372	-0.154	0.185	0.119	0.206
Arsenic	-	-	-	-	-	-	-0.076	0.329	-	-
Barium	-	-	0.208	-	-	0.190	-0.414	0.006	-	-
Cadmium	-0.200	0.404	0.100	0.198	0.048	0.338	0.295	0.041	0.352	0.006
Cobalt	0.276	0.094	0.033	0.119	0.355	0.445	0.002	0.494	0.013	0.463
Chromium	-	-	0.154	-	-	0.259	-0.140	0.207	-	-
Copper	0.769	0.384	-0.042	3.73E-05	0.058	0.430	0.192	0.131	0.004	0.489
Iron	-0.211	0.634	0.153	0.186	0.002	0.260	-0.043	0.401	0.112	0.219
Molybdenum	0.209			0.188	-	-	-0.086	0.308	-0.149	0.152
Nickel	0.128	-0.429	-0.342	0.295	0.038	0.070	-0.190	0.134	0.019	0.448
Lead	-0.750	0.468	0.406	6.93E-05	0.025	0.038	0.189	0.135	0.140	0.165
Antimony	-0.286	0.169	0.147	0.111	0.252	0.268	0.076	0.329	-0.079	0.292
Selenium	-0.344	0.436	0.198	0.069	0.035	0.202	0.179	0.149	0.195	0.087
Vanadium	-0.588	0.427	0.157	0.003	0.039	0.255	-0.171	0.159	-	-
Zinc	-0.053	0.408	0.219	0.413	0.046	0.177	0.191	0.132	-0.006	0.483

Significant at $\alpha = 0.05$

N	20	18	20				36		50	
Degrees of Freedom	18	16	18				34		48	

Note: Metallothionein is correlated with metals from same tissue only

5.0 HYPOTHESIS TESTING

5.1 Methods

The eleven hypotheses considered to be testable at Dome and the sediment quality triad are listed in Table 5.1. The table also provides a more specific listing of the "effect" (response) and "exposure" (predictor) variables examined under each hypothesis. The general reasoning behind all of these hypotheses is that a mine "effect" is a measurable difference between reference and exposure locations, and/or a trend between locations that are exposed to different degrees. Throughout this section, the term "significant" is used when a statistical test was performed and the level of significance was $p<0.05$.

The hypotheses address either the ability of a particular monitoring tool to detect such an effect (and, in aggregate, whether an effect exists) (e.g., H5 to H8), or the **relative** ability of two different monitoring tools to detect such an effect (e.g., H1 to H4). Hypotheses H9 through H12 address the **relative** ability of two monitoring tools to detect a correlation between specific exposure and response variables (effect), whereas Hypothesis H13 addresses the ability of a particular toxicity testing tool to show such a correlation.

These different types of hypotheses require different methods of statistical analysis. The following subsections describe the statistical approach needed for each category. In all cases, appropriate data transformations were applied prior to statistical analysis, such as log transformation for chemical concentrations, or other parameters that span a wide range, and arcsine square-root transformations for percent response variables. A significance criterion was used for all the statistical analyses, and use of the term "significant" implies that this criterion was met.

It should be recognized that the term "predictor" variable is not intended to mean that the measure of exposure used (e.g., metal concentration in water) can be used to "predict" a specific biological response at all mine sites or in other surveys at this mine site. Nor does it imply that the predictor is necessarily the cause of a biological effect. Rather, the predictive ability is only suggested by correlation between effect and exposure measures.

TABLE 5.1: VARIABLES AND HYPOTHESES AT DOME MINE

Hypothesis	Response at Effect Variables (Y)	Predictor at Exposure Variables (X)	Null Hypothesis (Ho)	Comment
H1	Sediment Toxicity Response i Sediment Toxicity Response j	River Area Identifier	no trend or area x tool interaction by ANOVA	*Hyalella, Chironomus* and *Tubifex* tests are the monitoring tools of interest.
H2	Metal i in Tissue i Metal i in Tissue j	Lake Identifier	no R/E difference by ANOVA	Tissues for (gill, kidney, liver, muscle) yellow perch in lakes.
	Metal in Viscera	River Identifier	no R/E difference by ANOVA	Viscera in pearl dace and caged yellow perch.
H3	MT in Tissue i MT in Tissue j	Lake Identifier	no R/E difference by ANOVA	Tissues for (gill, kidney, liver, muscle) yellow perch in lakes.
	MT in Viscera	River Identifier	no R/E difference by ANOVA	Viscera in pearl dace and caged yellow perch.
H4	Metal i in Tissue j MT in Tissue j	Lake Identifier	no R/E difference by ANOVA	Tissues for (gill, kidney, liver, muscle) yellow perch in lakes.
	Metal in Viscera MT in Viscera	River Identifier River Identifier	no R/E tool interaction no R/E tool interaction	Viscera in pearl dace and caged yellow perch. Viscera in pearl dace and caged yellow perch.
H5	CPUE/BPUE for pearl dace	River Identifier		Qualitative analysis.
H6 (benthos)	No. of Taxa Benthic Density Indicator Taxa	River Identifier	no trend or R/E difference by ANOVA	Collections at 7 stations per area, 2 exposure areas and 1 reference area.
H7	Weight at age Length at age	Lake Identifier	no R/E difference by ANOVA	Analysis done separately for males and females. Used age as a covariate as appropriate.
	Weight Length	River Identifier	no trend or R/E difference by ANOVA	Male and female pearl dace done separately. Age not used as covariate.
H8	Liver weight, gonad weight by sex, at age. Fecundity at age (females).	Lake Identifier	no R/E difference by ANOVA	Yellow perch, age used as a covariate.
	Liver Weight, Gonad Weight, Fecundity	River Identifier	no trend or R/E difference by ANOVA	Pearl dace; males and females separately, age not used as a covariate.
H9	Length and Weight Gonad and Liver Weight, Fecundity Benthic Community Indices	Dissolved Metal in Water (Tool 1) Total Metal in Water (Tool 2)	same correlation	Used pearl dace for fish variables.
H10	Benthic Density No. of Benthic Taxa Indicator Taxa Sediment Toxicity Endpoints	Partial Metal i in Sediment (1) Total Metal i in Sediment (2) SEM/AVS Ratio	same correlation	Use various sediment chemistry results.
H11	Benthic Density No. of Benthic Taxa Indicator Taxa	Sediment Toxicity Results	same correlation	Use various toxicity endpoints (*Hyalella, Chironomus*, *Tubifex* tests).
H12	Metal I in Tissue j MT in Tissue j	Metal i in Water (total and dissolved) Metal i in Sediment (total and partial)	same correlations	Viscera for pearl dace versus water and sediment chemistry. Viscera caged yellow perch versus water chemistry.
Sediment Triad Hypotheses	Benthic PCs Sediment Toxicity Endpoints Sediment Chemistry PCs	Benthic Variables (B) Toxicity Variables (T) Chemistry Variables (C)	no correlation C-B, C-T and B-T	Sphericity test Mantel's test

Definitions:

MT	=	metallothionein
R/E	=	reference/exposure
CPUE	=	catch-per-unit-effort (number of fish caught per unit fishing effort)
BPUE	=	biomass-per-unit-effort (mass of fish caught per unit fishing effort)

5.1.1 H1 through H4 - Comparison of Tools to Detect an Effect

Hypotheses H1 through H4 are tool comparison tests. Tools (response measures) are tested pairwise to determine their relative ability to detect a mine related impact. From a group of comparable tools (e.g., toxicity tests), this comparison allows the selection of the tool or tools that can best measure the impact of mine-related exposure. H1 compares toxicity endpoints (sediment toxicity to three common test organisms), whereas H2 through H4 examine metals and metallothionein in various fish tissues. Specifically, H2 compares concentration of a single metal at a time in pairs of organ tissues, so here, tissues are the tools for comparison. Similarly, H3 compares metallothionein concentration in pairs of organ tissues, so again tissues are the tools being compared. In H4, a metal concentration is compared to metallothionein concentration in the same organ tissue or group of tissues, so the tool comparison in this case is between metal and metallothionein, rather than between two tissues. In all four hypotheses, the analysis is the same. An example involving H1 which also applies to H4 for pearl dace is discussed below in detail. However, H2 and H3 could not be tested in an identical manner as there was only one exposure area for adult yellow perch (simple CI design).

Hypothesis H1 addresses the **relative** ability of three sediment toxicity test tools (response measures) to detect a mine effect. In particular, the *Hyalella azteca*, *Chironomus riparius* and *Tubifex tubifex* tests were compared to determine whether these tools differ in their ability to detect a mine effect (i.e., a reference versus exposure area difference, or a trend with degree of exposure within the exposure area - near-field response different than far-field). An area identifier, ordered within the exposure area to reflect distance from the mine site (i.e., near-field and far-field stream areas), was used as a surrogate for degree of exposure to mine-related contaminants. It is reasonable to assume that with increased distance there will be an attenuation in contaminant levels. The use of direct measures of exposure in evaluating sediment toxicity test results is included within the context of the overall Sediment Quality Triad hypothesis (Section 5.1.5). Analysis of variance (ANOVA) was used to address this hypothesis.

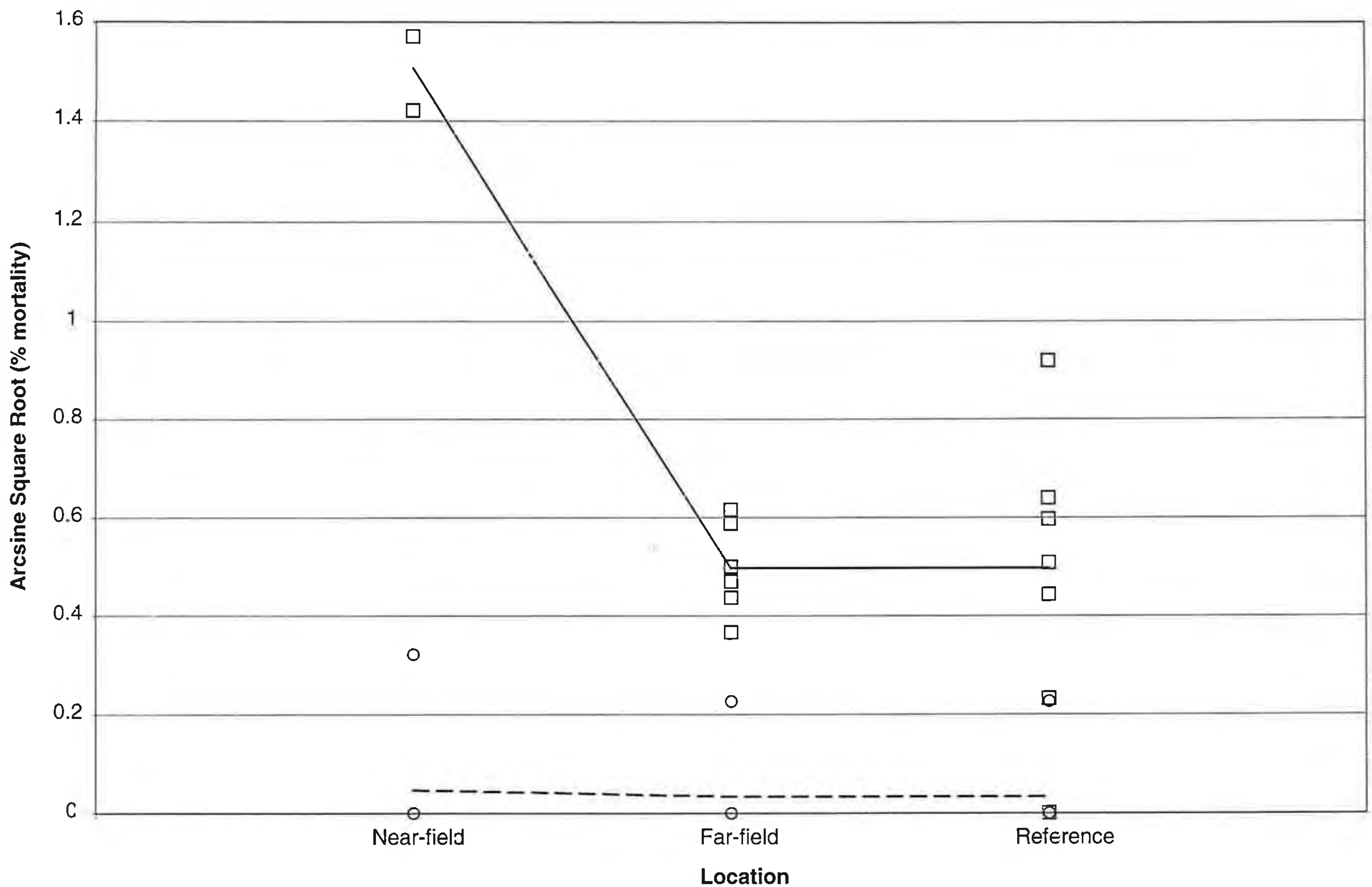
In general, ANOVA partitions the overall variance in the response measure (mine effect) into various terms representing effects of particular interest. In the case of Dome Mine, with only one stream reference area and two exposure areas, there is limited opportunity for partitioning of “among area” effects. In order to determine whether two toxicity testing tools differ in their ability to detect mine effects at Dome, a simple ANOVA was used to determine whether there was a significant area x tool interaction (i.e., two tools showing different patterns of response with exposure level). If there was, then an examination of a plot of the interaction, such as Figure 5.1 or Figure 5.2, was undertaken to confirm that the pattern was consistent with one toxicity tool being a better indicator of mine effects.

For example, in Figure 5.1, *Hyalella* mortality in sediments (Tool 1) gives a response that decreases with degree of exposure, from near field to far field, whereas *Tubifex* mortality (Tool 2) does not respond to degree of exposure. This produces a significant area x tool interaction in the ANOVA, and indicates that *Hyalella* mortality was a superior tool in demonstrating a mine effect. In Figure 5.2, *Hyalella* mortality (Tool 1) distinguishes near-field from far-field areas, whereas *Chironomus* mortality (Tool 2) only distinguishes exposure from reference areas. This produces a significant area x tool interaction in the ANOVA, because the tools have different response patterns, but does not indicate that either tool was superior.

For the testing of Hypotheses H2 and H3 with adult yellow perch captured in McDonald's Lake (reference) and Porcupine Lake (exposure), there was only a single level of exposure and mine effects are identified only by detection of reference-exposure differences using ANOVA. A test of "trend" was simply by comparison of responses at the reference and exposure areas. A significant interaction between the two tools being compared suggests a greater effectiveness in the tool with the larger difference between exposure area response and reference area response. Figure 5.3 illustrates this approach.

5.1.2 H6 Through H8 - Fish Growth, Organ Size and Benthic Community Responses

Hypotheses H6 through H8 address the ability of a particular community index tool (response measure) to detect effects related to mine exposure. At Dome Mine, a response variable, such as fish growth or number of benthic taxa was compared by ANOVA for stations across the three areas (reference, near field, and far field) to determine whether area means were significantly different (i.e., whether the response measure varies more among areas than it does within areas). If so, data plots were examined to determine whether the pattern of area differences was consistent with a mine effect.



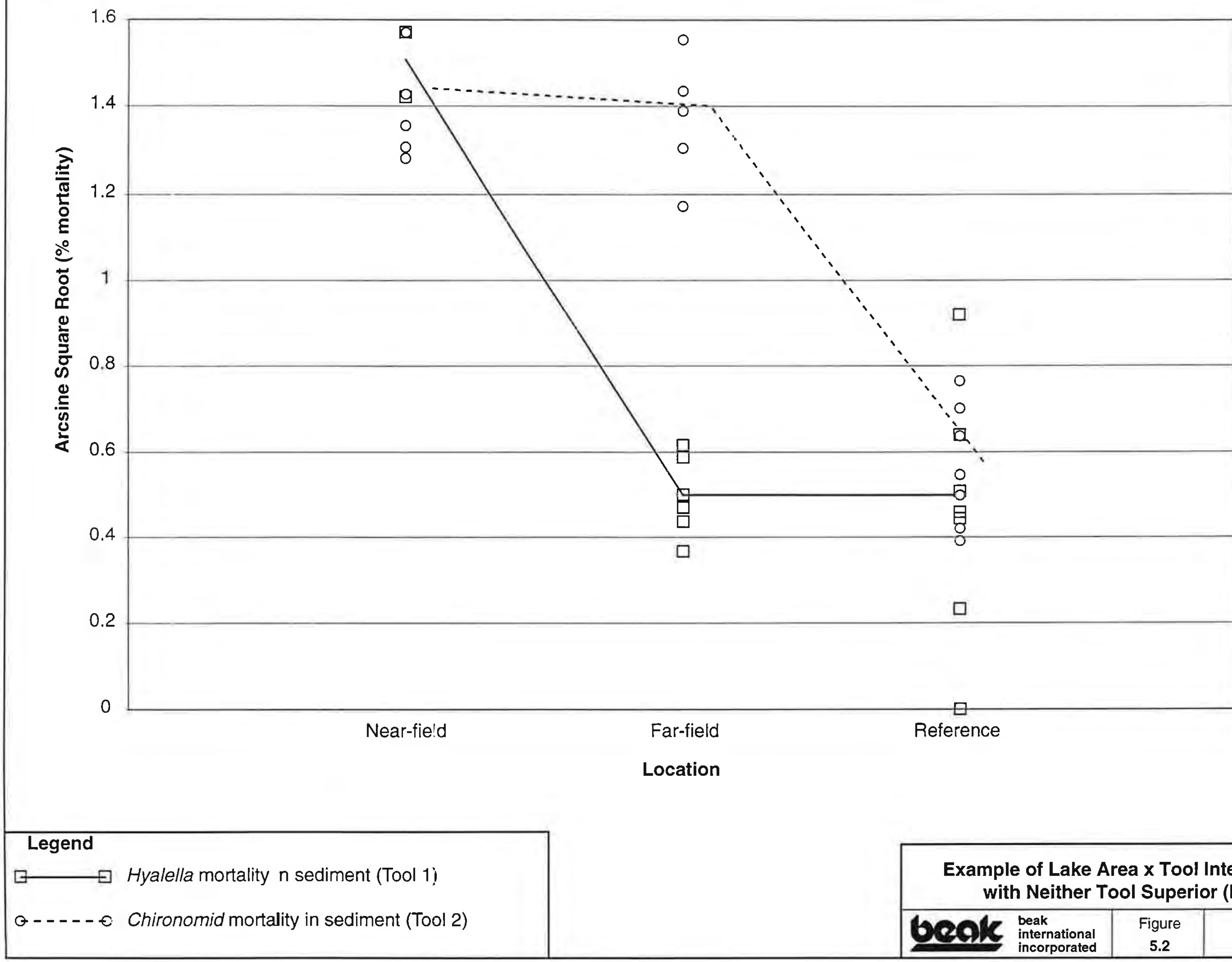
Legend

Hyalella mortality in sediment (Tool 1)

Tubifex mortality in sediment (Tool 2)

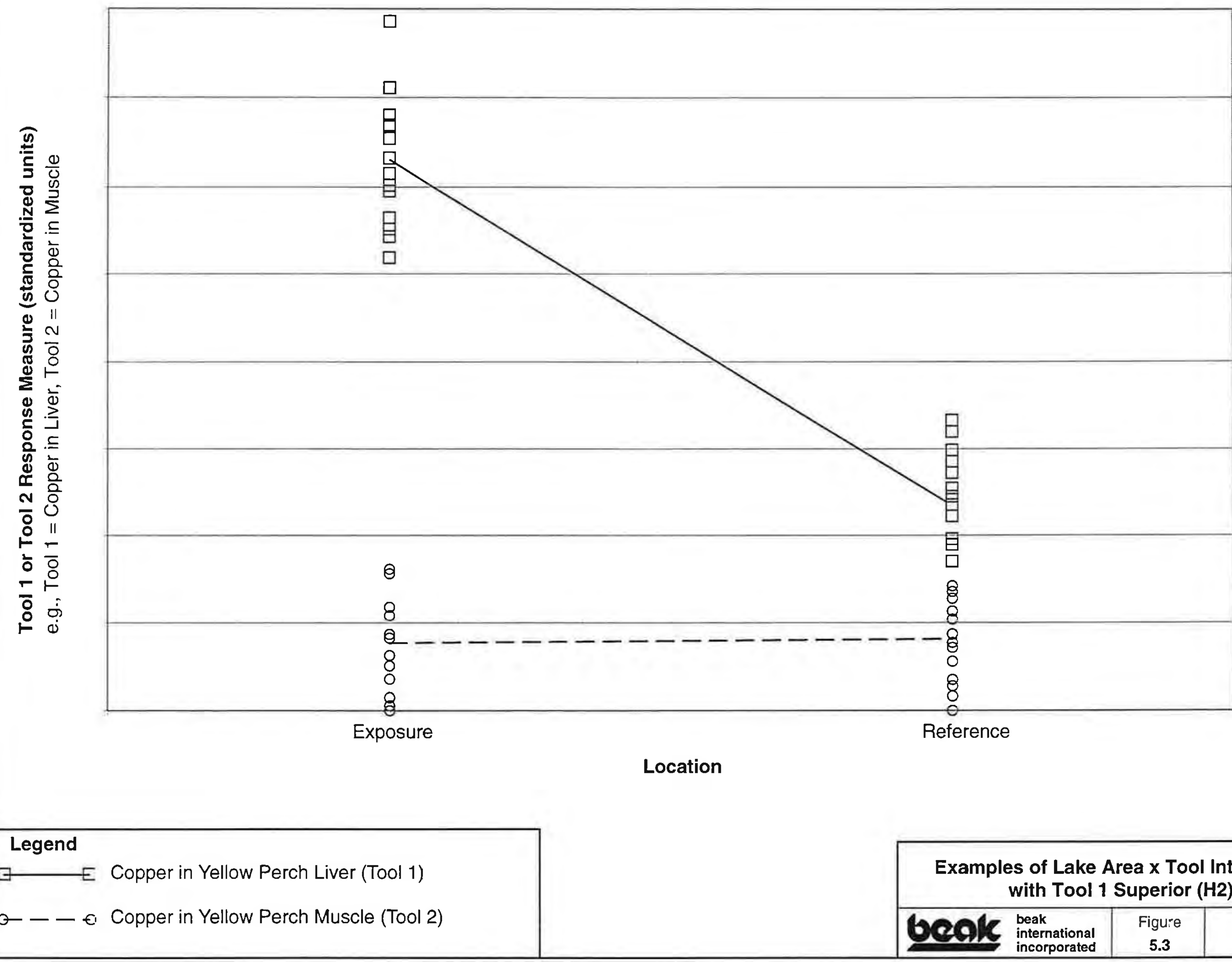
Examples of Lake Area x Tool Interaction with Tool 1 Superior (H1)

beak international incorporated	Figure 5.1	June 1998



Example of Lake Area x Tool Interaction with Neither Tool Superior (H1)

beak international incorporated	Figure 5.2	June 1998



Examples of Lake Area x Tool Interaction with Tool 1 Superior (H2)

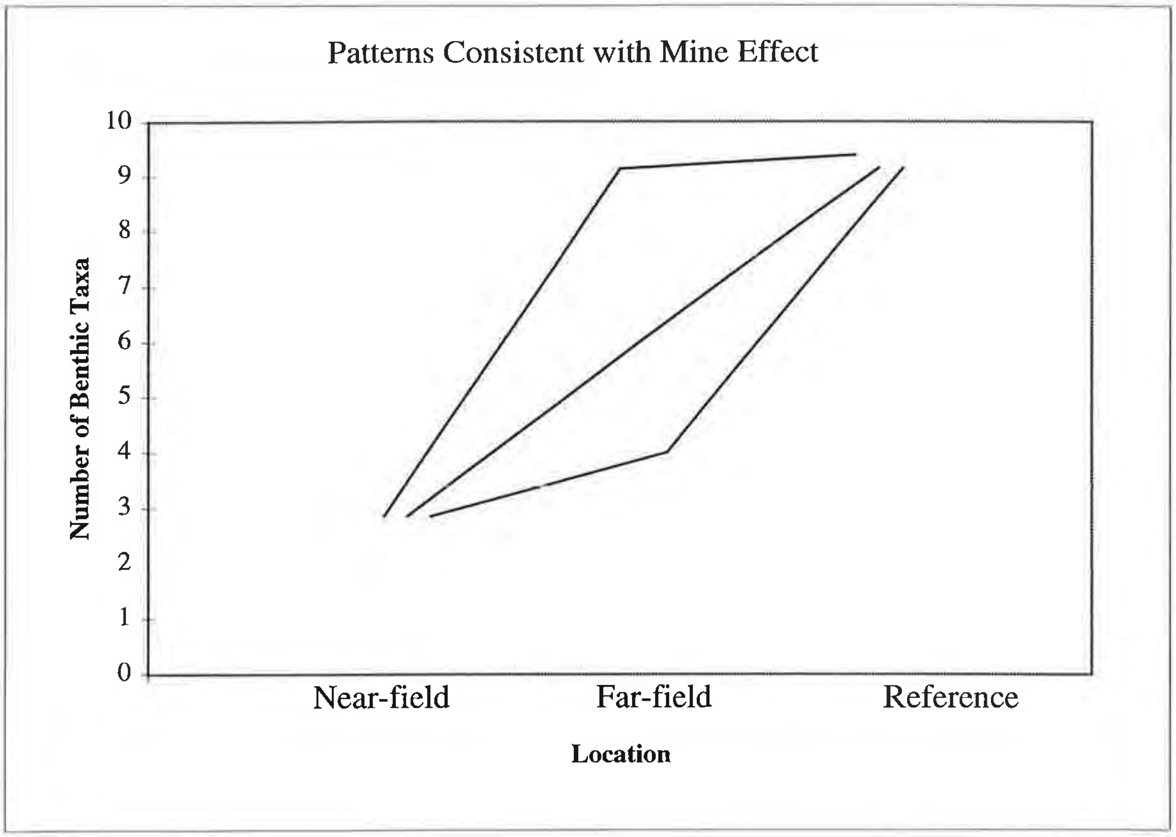
beak	beak international incorporated	Figure 5.3	June 1998

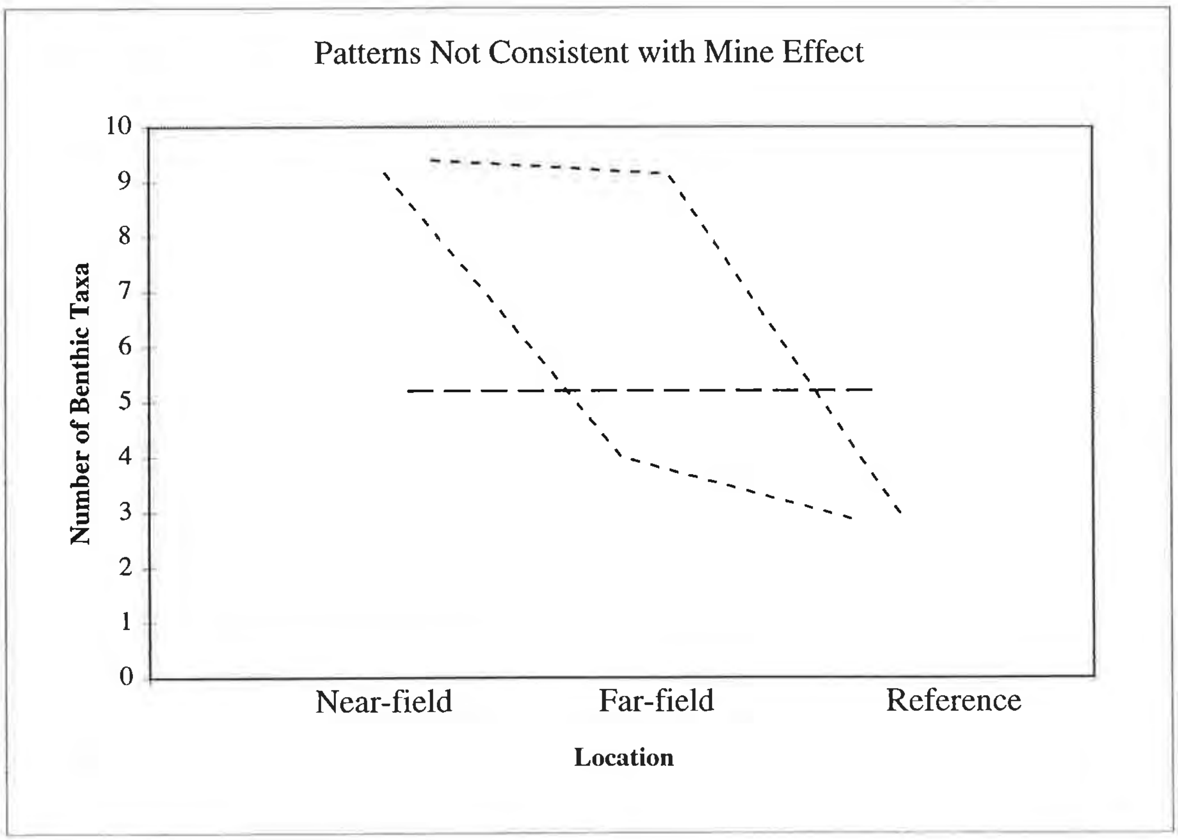
Hypothesis H6 compares a number of indices selected to characterize benthic communities (e.g., number of taxa, number of individuals, abundance of particular indicator taxa) in the three areas. Hypothesis H7 examines area differences in age-adjusted weight and length for yellow perch or simply weight and length for pearl dace, and Hypothesis H8 tests for area differences in liver and gonad weights of fish species and for each sex. Below, an example involving Hypothesis H6 is discussed in detail.

Hypothesis H6 addresses the ability of a particular benthic index tool (response measure) to detect a mine effect. For example, in H6, numbers of benthic taxa were compared across areas to determine whether this tool demonstrates a mine effect (i.e., a reference versus exposure area difference, or a trend with degree of exposure within the exposure area). However, the overall objective of testing H6 was to determine if benthic invertebrate community assessments are useful in determining mine effects when using a suite of metrics rather than testing specifically whether or not a particular metric was useful. An area identifier, ordered within the exposure zone to reflect distance from the mine site (i.e., near-field and far-field stream areas), was used as a surrogate for degree of exposure to mine discharges. ANOVA was used to address this hypothesis.

In general, ANOVA partitions the overall variance in the response measure into a number of terms representing effects of particular interest. In the case of Dome Mine, with only one reference area in each habitat type (stream or lake), and one (lake) or two exposure areas (stream), there is limited opportunity for partitioning of "among-area" effects. In order to determine whether a benthic index tool could detect a mine effect, a simple test by ANOVA was used to determine whether the index varies more among areas than it does within areas. If so, then an examination of the pattern of differences between areas was undertaken to confirm that the pattern of response with exposure level was consistent with a mine effect.

For example, in Figure 5.4, the top graph illustrates a number of response patterns that are consistent with a toxic mine effect (i.e., decreasing numbers of benthic taxa near the mine). The bottom graph illustrates a number of response patterns that are not typically consistent with a mine effect (i.e., greater numbers of taxa near the mine, or no trend with mine proximity). Professional judgement is always needed for interpretation of intermediate response patterns. For example, the bottom graph may represent a mine effect if a mine discharge, instead of having a toxic effect, was resulting in nutrient





Legend

- ——— patterns consistent with mine effect
- - - - - - patterns not consistent with mine effect
- — — — no pattern (no difference among areas)

Examples of Response Patterns Consistent (or not) with Mine Effects (H6)

beak international incorporated	Figure 5.4	April 1998

enrichment of an oligotrophic environment which would lead to more benthic invertebrate taxa.

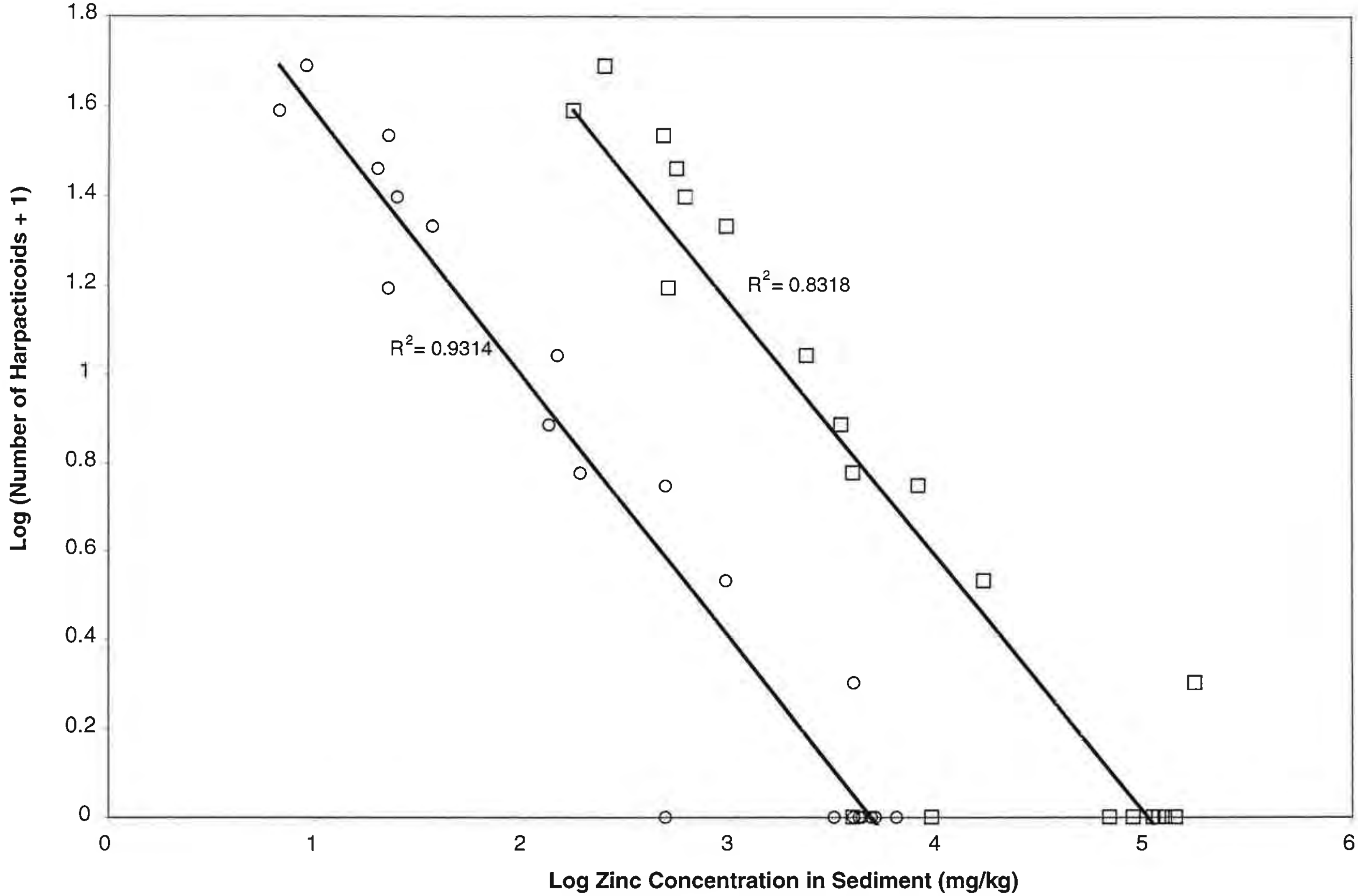
For H7, the response measure (fish weight or length) varies with fish age for yellow perch (not required for pearl dace). Therefore, an age covariate was added to the ANOVA model in order to adjust all fish to a common age. The statistical analysis of age-adjusted data is as described above.

5.1.3 H9 through H12 - Tool Integration Hypotheses

Hypotheses H9 to H12 address the **relative** ability of two monitoring tools to detect a mine effect. For example, in H9, dissolved metal in water was compared to total metal in water, for each of the key metals, to determine whether these two monitoring tools differ in their ability to detect a mine effect (i.e., a correlation between a biological response measure, such as number of taxa, and the metal predictor variable). Correlation analysis was used to address this hypothesis, as described below.

The squared coefficient of correlation (r^2) between the response measure (Y) and each predictor variable (X1 or X2) indicates the proportion of variance in the response measure that is explained by the predictor (i.e., by the corresponding line in Figure 5.5). The best predictor, for each pair compared, is the one which explains the highest proportion of variance (i.e., has the highest r^2 and hence the highest r). No statistical test was performed to determine whether r_1 differs significantly from r_2, since the two r values are based on the same Y data set and are not independent. However, the individual r values were tested for statistical significance. Two r values were compared, to draw inferences about which monitoring tool is better, only when at least one of the r values was of the correct sign (negative or positive) to suggest a mine effect, and statistically distinguishable from zero based on a one-tailed test.

At Dome Mine, the degree of significance may be somewhat overstated, since the sampling stations are clustered in two or three areas (one reference and two exposure areas) and therefore may not be independent as assumed by the correlation test procedure. The clustering of stations in a few areas was necessary based on the limnological features of the study area as discussed in Section 2.2.



Legend

□ Log Total Zinc in Sediment

○ Log Zinc by Partial Extraction in Sediment

Example of Approach to Testing H10

beak international incorporated | Figure 5.5 | April 1998

When differences between r values are small (e.g., ≤0.1), even though one or both r values may be statistically significant, a judgement is generally not made that the tool with the slightly higher r value is better able to detect an effect. Also, the correlations are generally calculated for many exposure measures (metals), so that judgements with respect to which exposure measure tool (e.g., total versus dissolved metal concentration in water) is more strongly correlated with biological response are made by the weight-of-evidence based on all r values for each tool. The exposure and response measures selected for inclusion in this analysis were those which showed an apparent spatial relationship to the mine site (i.e., trend among exposure reaches or difference between reference and exposure reaches).

Hypothesis H9 was tested by correlation between benthic or fish index values and metal concentrations in water (dissolved or total) from stations in three river areas (reference, near field, far field). Hypothesis H10 was tested in a similar manner by correlation of benthic or fish index values versus sediment chemistry and sediment toxicity versus sediment chemistry, based on near-field, far-field and reference stream data. The sediment chemistry tools included total metal concentrations (hydrogen peroxide/nitric acid extraction), partial metal concentrations (hydroxylamine extraction) and the ratio of the molar sum of simultaneously-extracted metals (SEM) and acid volatile sulphide (AVS). Metals included in the SEM value are Cd, Cu, Ni, Pb and Zn. These are the metals most often contributing to toxicity and potentially rendered non-bioavailable by the formation of metal monosulphides.

Hypothesis H11 examines the remaining component of the "sediment quality triad" - the correlation between benthic indices and sediment toxicity - based on near-field, far-field and reference stream data. The toxicity tests include amphipod (*Hyalella azteca*), chironomid (*Chironomus riparius*) and oligochaete (*Tubifex tubifex*) tests on sediment samples from each stream station.

Hypothesis H12 examines the correlation between water and sediment chemistry measurements and concentrations of metals and metallothionein in fish tissues. For fish, station means were used as values in order to permit pairing with water and sediment chemistry values. Only analysis of pearl dace viscera and caged yellow perch were represented by enough areas to be used in this analysis.

5.1.4 H13 - Chronic Toxicity - Linkage with Benthic Results

Hypothesis H13 addresses the ability of a particular effluent toxicity testing tool to predict a mine effect that has been otherwise demonstrated (e.g., a benthic index response to exposure). For example, H13 might address whether a specific benthic response can be predicted from effluent toxicity to *Ceriodaphnia, Selenastrum*, fathead minnow or duckweed.

In order to test this hypothesis, it is necessary to estimate the receiving water toxicity to each species in the near-field and far-field areas, based on the effluent toxicity information and the expected downstream dilution of effluent close to the time of the survey. Unfortunately, the mine stopped discharging effluent on 12 August 1997. The fall reproduction period for benthos is generally from mid-August to late September. Therefore, if the effluent had a toxic effect the area could have been recolonized by new insect taxa between the time the effluent was no longer being discharged and the time of the survey in October.

Consequently, Hypothesis H13 can only be addressed in a qualitative manner by using the effluent toxicity values and the effluent concentrations in each of the exposure areas to predict whether an effect might have occurred during the time of discharge.

5.1.5 Triad Hypotheses

The “triad” hypothesis addresses the issue of whether chemical contaminants may be responsible for biological “effects” that are apparent in the study area. This hypothesis has not been articulated explicitly in the set of 13 hypotheses that were developed by the AETE (Section 1.0); however, it is consistent with the interest in H9 through H13 about the ability or relative ability of monitoring tools to detect correlations or relationships between chemical, toxicological and biological parameters. The basic approach to evaluation of the triad hypothesis was to simultaneously examine three types of correlations: chemical-toxicological (C-T), toxicological-biological (T-B) and chemical-biological (C-B). These are the three “arms” of the triad that would support an interpretation that chemical contaminants are responsible for biological effects. There should be significant correlations on all three arms before the hypothesis that chemical contaminants are the cause of the effect is accepted. Note that none of the 13 hypotheses is specific to the testing of C-T correlations.

Statistical approaches to triad evaluation follow Green and Montagna (1996) and Chapman (1996). One approach is to examine the three bivariate correlations (C-T, T-B, C-B) for different sets of chemistry, toxicity and biology monitoring tools. Then, the overall evaluation of the triad hypothesis is based on "weight-of-evidence" considerations (i.e., are there sets of parameters showing significant C-T, T-B **and** C-B correlations, how many sets are there that meet this criterion, and how strong are the correlations in general?). This approach is simple, but rather tedious when there are many different chemistry, toxicity and biology monitoring tools to be paired in different ways.

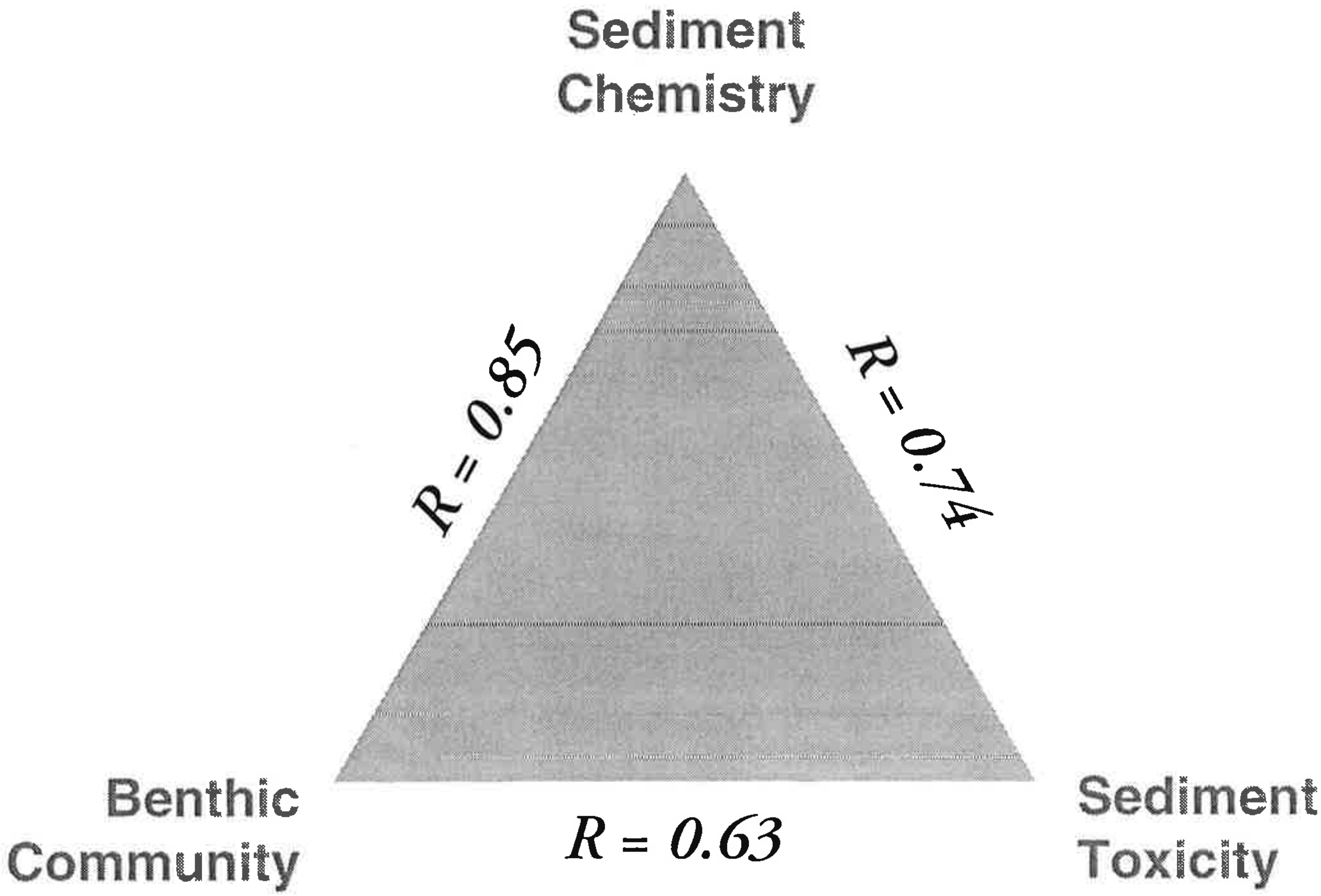
A more holistic approach was applied using principal components analysis (PCA) to reduce the large number of variables to one or two dominant principal components (PCs) representing the mine effect gradient in chemistry (based on the original chemical variables), one or two representing the gradient in toxicity, and one or two representing the gradient in biology. Then multiple correlation coefficients (R) can be computed using the PC variables to represent the dominant C-T, T-B and C-B correlations (if any) on each arm of the triad. Mantel's test was used to produce a single measure of concordance on each arm of the triad, equivalent to R^2 (e.g., Figure 5.6). Finally, Bartlett's test of sphericity can be applied to determine if there is a significant overall concordance across the three arms of the triad.

5.2 Results

The general conclusions with respect to the hypotheses tested at Dome Mine are summarized in Table 5.2. The following sections present the findings in more detail based on the statistical tables and figures provided in Appendix 7. The discussion is focused on results that meet the significance criterion of $p \leq 0.05$. Use of the term "significant" implies that this criterion was met, although "suggested" results may be mentioned as such when the criterion is approached but not achieved.

5.2.1 H1 - Sediment Toxicity as a Response to Exposure

Figures illustrating the sediment toxicity response patterns and ANOVA tables showing tests for significant differences in response patterns between toxicity tests are provided in Appendix 7. Based on these patterns and statistical test results, the key findings regarding Hypothesis H1 are outlined below.



Approach to Evaluation of the Sediment Quality Triad			
beak	beak international incorporated	Figure **5.6**	June 1998

TABLE 5.2: SUMMARY OF GENERAL CONCLUSIONS OF HYPOTHESES TESTED AT DOME MINE

Hypothesis	Response at Effect Variables (Y)	Predictor at Exposure Variables (X)	Null Hypothesis (Ho)	Comment
H1	Sediment Toxicity Response i Sediment Toxicity Response j	River Area Identifier	no trend or area x tool interaction by ANOVA	No mine-related response in *Tubifex* or *Chironomus*. Mine-related trend in *Hyalella* mortality and growth; therefore, it is the better tool.
H2	Metal i in Tissue i Metal i in Tissue j	Lake Identifier	no R/E difference by ANOVA	Significant exposure area difference for Zn, Co, Cu, Fe, Al, Se and Va in yellow perch muscle; Mo and Ni in liver and Ni in kidney. Overall, muscle was the most effective tissue in showing reference-exposure area differences. Both liver and kidney were equally effective in detecting a mine response to nickel.
	Metal in Viscera	River Identifier	no R/E difference by ANOVA	Significant mine-related response in pearl dace viscera for Ag, Cd, Cu and Se.
H3	MT in Tissue i MT in Tissue j	Lake Identifier	no R/E difference by ANOVA	No mine-related pattern. MT in yellow perch gill and kidney higher in reference area. No significant R/E difference in liver.
	MT in Viscera	River Identifier	no R/E difference by ANOVA	No mine-related pattern for MT in pearl dace or caged yellow perch viscera.
H4	Metal i in Tissue j MT in Tissue j	Lake Identifier	no R/E difference by ANOVA	Liver Mo and Ni better than MT for showing mine-related response. Ni in kidney better than MT. No significant mine-related trends in gill. Overall, tissue metals were a more effective tool than MT.
	Metal in Viscera MT in Viscera	River Identifier	no R/E tool interaction	Metals in pearl dace viscera (Cd, Ag, Cu, Ni, Mo, Al) showed mine-related trend; MT did not. Viscera metals better tool than MT. Caged fish were not effective in evaluating Hypothesis H4.
H5	CPUE for pearl dace or yellow perch	River Identifier		Qualitative analysis. Not effective but due to habitat differences and introduced species.
H6 (benthos)	No. of Taxa Benthic Density EPT Index Indicator Taxa	River Identifier	no trend or R/E difference by ANOVA	Benthic indices such as number of taxa, density, EPT index (generic level) and indicator taxa all showed significant mine-related trends.
H7	Weight at age Length at age	Lake Identifier	no R/E difference by ANOVA	Significant increase in length and weight of perch at age in exposure area.
	Weight Length	River Identifier	no trend or R/E difference by ANOVA	Significant increase in length and weight in exposure area for pearl dace.
H8	Liver weight, gonad weight by sex, at age. Fecundity at age (females).	Lake Identifier	no R/E difference by ANOVA	In yellow perch, no significant reference-exposure difference in gonad weight (males and females) and fecundity at age. Livers significantly larger in exposed yellow perch. Gonad weight (body weight adjusted) for males and females lower in exposure area. Liver weight adjusted for body weight showed no change.

TABLE 5.2: SUMMARY OF GENERAL CONCLUSIONS OF HYPOTHESES TESTED AT DOME MINE

Hypothesis	Response at Effect Variables (Y)	Predictor at Exposure Variables (X)	Null Hypothesis (Ho)	Comment
H8 (cont'd)	Liver Weight, Gonad Weight, Fecundity	River Identifier	no trend or R/E difference by ANOVA	Significantly larger pearl dace gonad and liver weights in exposed females and males. Pearl dace fecundity higher in exposure area. Female dace body weight-adjusted gonad weight and fecundity lower in exposure area. Liver weight unchanged when adjusted for body weight.
H9	Length and Weight Gonad and Liver Weight, Fecundity Benthic Community Indices	Dissolved Metal in Water (Tool 1) Total Metal in Water (Tool 2)	same correlation	Total and dissolved arsenic negatively correlated with fecundity whereas Mg and Ni positively correlated. No mine-related correlations with benthic indices except for negative correlations of total and dissolved Co, Cu, K, Mg, Ni with % chironomids. Body weight-adjusted female gonad weight negatively correlated with Co and Cu. Dissolved and total metals equally effective, although limited.
H10	Benthic Density No. of Benthic Taxa Indicator Taxa Sediment Toxicity Endpoints	Partial Metal i in Sediment (1) Total Metal i in Sediment (2) SEM/AVS Ratio	same correlation	Total and partial metals similarly correlated with benthic indices and are therefore equally effective. *Hyalella* mortality positively correlated with total and partial As, Co, Cr, Cu, Fe, Hg, Mg and Ni. No correlation with SEM/AVS and benthos or toxicity results.
H11	Benthic Density No. of Benthic Taxa Indicator Taxa	Sediment Toxicity Results	same correlation	*Hyalella* mortality and growth correlated with most benthic indices. *Hyalella* test effective in predicting impacts on benthic community.
H12	Metal i in Tissue j MT in Tissue j	Metal i in Water (total and dissolved) Metal i in Sediment (total and partial)	same correlations	Total and dissolved Co, Cu, Ni correlated with pearl dace viscera, no mine-related response between MT and aqueous metals. Sediment total and partial Ni and Co correlated with viscera metals, also partial arsenic. No overall difference in correlations of total and dissolved aqueous metals or total and partial sediment metal versus viscera concentrations.
H13	Benthic N No. of Benthic Taxa EPT Index Fish Measurements	Predicted % Inhibition in Exposure Reach based on effluent toxicity testing and downstream dilution factors	qualitative	Effluent toxicity tests appeared effective in predicting effects on benthic communities and in predicting that there would be no effects on fish growth. Fathead minnow test not effective in predicting body weight-adjusted effects in fish.
Sediment Triad Hypotheses	Benthic PCs Sediment Toxicity Endpoints Sediment Chemistry PCs	Benthic Variables (B) Toxicity Variables (T) Chemistry Variables (C)	no correlation C-B, C-T and B-T	Overall, triad was significant. Significant correlations for C-T and B-T arms.

Tubifex tests were not sensitive for monitoring toxicity of sediments at the Dome Mine site. Mortality, cocoon and young production, and percent hatching all showed no significant area-specific response. In other words, the location of the sediment sample (reference, near field, or far field) had no effect on mortality or reproduction of *Tubifex*. *Chironomus* midge larvae also showed no difference in mortality or growth among areas.

Hyalella showed significant variation in mortality. *Hyalella* mortality was greatest in sediment samples collected from the near-field area, and lowest in far-field samples, consistent with a mine-related effect. Reference area mortality of *Hyalella* was slightly greater than that found in far-field samples. There was also a significant area specific response in the sublethal endpoint (growth) for *Hyalella,* where growth was significantly lower in exposure areas. Although *Chironomus* growth did not show a significant difference among areas, it did show the same trend as *Hyalella* growth (i.e., there was no significant reach by tool interaction when *Hyalella* growth was compared to *Chironomus* growth).

In summary, testing of hypothesis H1 indicated that only the *Hyalella* test demonstrated a significant mine-related effect at the Dome Mine site.

5.2.2 H2 - Comparison of Metals in Fish Tissues

Figures illustrating the response patterns of metals in different tissues and ANOVA tables showing tests for significant differences in response patterns between tissues are provided in Appendix 7. Based on these patterns and statistical test results, the key findings regarding H2 are outlined below.

Tissues (kidney, liver, gill, muscle) of yellow perch were analyzed for concentrations of 19 metals. Tissue concentrations of each metal were tested to determine which metals showed significant mine-related exposure response trends (i.e., exposure area tissue concentrations significantly higher than reference levels). The tissues showing significant trends were then compared, pairwise, for each metal and for metallothionein, to determine which tissue was most sensitive in detecting a difference between the reference and exposure area in terms of metal bioaccumulation or metallothionein induction. The tables identifying cases where significant reference-exposure differences occurred for each metal and the directions of the differences (i.e., whether exposure or reference tissue metals were higher) are provided in Appendix 7, Table A7.1. This screening was also done for pearl dace (Table A7.2) and caged yellow perch (Table A7.3) viscera even though they are not tested as part of Hypothesis H2.

In adult yellow perch, muscle concentrations of aluminum, zinc, cobalt, copper, iron, selenium and vanadium showed a significant mine exposure response, whereby the concentrations of these metals were higher in the exposure lake muscle tissue compared to the reference lake. Molybdenum in liver and nickel in liver and kidney also showed a significant reference-exposure area difference that reflected a mine-related response (i.e., higher concentrations in exposure lake).

In the cases of mercury (all tissues), aluminum (liver), cadmium (kidney), cobalt (liver), copper (gill, kidney), iron (all tissues), vanadium (liver), silver (gill) and chromium (gill), significantly higher concentrations were measured in the reference area yellow perch (i.e., these metals did not show a mine-related trend). Only aluminum in liver reflected waterborne concentrations of aluminum. Waterborne concentrations of cobalt, copper, iron and chromium were higher in the exposure lake, whereas mercury, cadmium, vanadium and silver were below method detection limits in all water samples from both lakes.

Copper, which was the only metal that exceeded CWQG in the exposure area (total and dissolved), showed different response patterns in the different tissues. Copper in yellow perch muscle (also in liver but not significantly) was significantly greater in exposure area samples than in reference fish samples, but in gills and kidneys of the same fish the difference was reversed, with significantly higher concentrations in reference-area perch than in perch from the exposure lake. The muscle and liver (not significant) response patterns were both consistent in showing a mine effect (i.e., interaction term not significant), however, copper in muscle tissue is considered to be more effective in showing this trend because the trends were significant.

Nickel was the only metal that showed a significant mine-exposure response in two tissues, liver and kidney. Statistical analysis indicated that both tissues showed the same trend and neither could be considered a better tissue than the other in showing a mine-related response.

Although not a component of Hypothesis H2, metal concentrations in pearl dace viscera showed a significant mine-related trend for silver, cadmium, copper and selenium (i.e., lowest in the reference dace viscera, highest in the near field followed by the far field). For aluminum, barium, molybdenum and nickel, concentrations were highest in far-field fish followed by near-field and then reference fish. These results closely reflect the trends in sediment chemistry discussed above.

A direct comparison of the effectiveness of pearl dace viscera versus adult yellow perch tissues cannot be made since the fish were collected from different areas. Pearl dace would have been exposed to higher concentrations of water and sediment metals than yellow perch during effluent discharge.

5.2.3 H3 - Comparison of Metallothionein in Fish Tissues

Metallothionein in liver showed a different pattern of variation between areas than did gills and kidneys. Liver metallothionein, although slightly higher in the exposure area, was not significantly different than levels in the reference area ($p = 0.149$), but the pattern was opposite and significant in gill and kidney tissues (Table A7.1, Appendix 7). Although these latter two tissues showed the same trend in concentration between areas, kidney concentrations showed a significantly ($p = 0.045$) greater change between reference and exposure areas than did gill concentrations.

Although not a component of Hypothesis H3, mean metallothionein concentrations in pearl dace viscera were not significantly different between reference and near-field areas, but concentrations in both areas were significantly higher than in the far-field area (Table A7.2, Appendix 7). There was also no significant mine-related trend for metallothionein concentrations in caged yellow perch viscera.

5.2.4 H4 - Comparison of Metal versus Metallothionein as a Response to Exposure

Figures comparing the response patterns of metals versus metallothionein and ANOVA tables showing tests for significant differences in these response patterns, are provided in Appendix 7.

Adult Yellow Perch

Comparisons for adult yellow perch were limited to one reference and one exposure area, and comparisons of cadmium, copper, lead, zinc, silver, selenium, nickel and molybdenum to metallothionein were performed on three separate tissues for each fish (gill, kidney, and liver). The metals selected for comparison were based on the results of Hypothesis H2.

In livers of adult yellow perch, the comparisons of cadmium and molybdenum versus metallothionein concentrations displayed significant differences in the patterns of response between reference and exposure areas. Metallothionein increased in concentration with exposure to mine effluent, whereas cadmium in the same tissue decreased in concentration from reference to exposure areas. In this comparison of two tools that did not show significant differences between areas, metallothionein would be considered to be more effective (i.e., a significant interaction term and metallothionein showed a trend in the right direction). However, in the comparison of molybdenum to metallothionein, molybdenum in liver was the more effective tool. Molybdenum did show a significant difference between reference and exposure areas, whereas metallothionein did not. Overall, metal responses in liver were more effective indicators of mine exposure because liver showed significant mine-related trends in concentrations of molybdenum and nickel.

In kidneys of adult yellow perch, metallothionein showed no significant mine-related trend. Metallothionein levels were significantly higher in reference fish. In contrast, nickel concentrations in kidney showed a significant mine-related trend and therefore would be considered to be a more effective tool than metallothionein.

In gills of adult yellow perch none of the metals or metallothionein showed a significant mine-related trend. Metallothionein and concentrations of mercury, copper, iron, silver and chromium were significantly higher in reference yellow perch gill.

In summary, metallothionein did not show a significant mine-exposure response in any tissue. However, tissue metals did show a significant mine-related response for a number of metals and would therefore be considered a more effective tool for monitoring mine exposure in fish.

Adult Pearl Dace

Cadmium, barium, silver, selenium, copper, nickel, molybdenum, aluminum and metallothionein concentrations all showed significant among-area variation in viscera of adult pearl dace; arsenic, iron, cobalt, chromium, zinc and lead did not (Table A7.2, Appendix 7).

Mean metallothionein concentration was almost identical in fish from reference and near-field areas and significantly higher than in fish from the far field. In contrast, copper concentration was lowest in the reference area, highest in the near-field, and intermediate in the far-field. Accordingly, this comparison (copper vs. metallothionein) shows a significant difference between these two tools in terms of direction and strength of trend with viscera copper concentrations being the better tool. The same is true for silver, molybdenum, nickel, aluminum and selenium.

Lead did not vary significantly among areas, and in comparison with metallothionein, lead shows a significantly different response pattern. Cadmium also varied among areas, but in a pattern similar to that displayed by metallothionein, so these two tools do not show significantly different response patterns.

Overall, metals in pearl dace viscera were more effective at showing mine-exposure responses in fish than metallothionein concentrations. The ineffectiveness of metallothionein as a tool for monitoring fish exposure may be influenced by the metals in the alimentary canal of pearl dace and/or by the fact that the mine stopped discharging effluent two months prior to the survey.

Caged Yellow Perch

Young of the year yellow perch were caged in five areas from McDonald's Lake to Porcupine Lake, with corresponding water chemistry collected at each cage site. Aluminum, lead, copper, and nickel concentrations in caged perch viscera showed significantly different patterns of variation among areas compared to the pattern of variation for metallothionein.

Metallothionein did not vary significantly among areas, whereas aluminum, lead and nickel in viscera decreased between McDonald's Lake and the reference area in South

Porcupine River (Station D2). Although these metals and metallothionein responded differently to exposure, neither was effective in showing a mine-related trend. Copper concentrations in caged perch viscera increased in the stream reference site and remained higher downstream of the mine compared to levels in perch caged in McDonald's Lake. Although this result was not effective in showing a mine-related trend, it did reflect the copper concentrations in water, which were elevated at the stream reference site due to historical contamination and further elevated downstream of the mine potentially due to the Dome operation.

The caged fish results are confounded by the fact that the mine was not discharging during the survey and because the pre-exposure fish generally had higher metal levels in viscera. Due to these confounding factors, no useful generalization can be made with the caged fish data about the effectiveness of viscera metals versus metallothionein in showing mine-related responses.

5.2.5 H6 - Benthic Community Measures as Responses to Exposure

Figures illustrating the response patterns of benthic community indices, and ANOVA tables showing tests for significant differences between reference and exposure areas, are included in Appendix 7. Based on these patterns and statistical test results, the key findings regarding H6 are outlined below.

Most benthic indices showed significant among-area variation. The most widely used indices (number of taxa; EPT Index at the generic level; and log number of individuals) all highlight the near-field area as a zone of decreased density and diversity, whereas the far-field community appeared more characteristic of an unstressed area than did the reference area. The healthier community in the far-field area compared to the reference area may be due to the increased river flow from the contribution from the North Porcupine River or to the fact that the reference area was contaminated with a number of metals (e.g., arsenic) originating from historical mine operations. In addition, the benthic community structure in the beaver pond reference area was also slightly different, probably due to the fact that there was lower flow compared to the other areas.

Percent *Pisidium* also showed a significant mine-related trend at the Dome site. *Pisidium* were absent in the near-field, common in the reference area, and reached their highest percent abundance in the far-field area of the South Porcupine River.

A high percentage of chironomid midges often characterizes stressed communities and this index varied significantly among the areas of the South Porcupine River. Percent chironomids was greatest in the beaver pond section of the reference area, and generally lower in both exposure areas. Percent *Tanytarsus* (a genus of Chironomidae considered sensitive to metals) also showed significant differences among areas, with greatest values at reference area stations and lowest values at near-field area stations, consistent with a mine effect. These results that are based on the chironomid community are interesting in that they do not seem to reflect the results of the sediment toxicity tests using *Chironomus* which showed no significant mine-related trends.

5.2.6 H7 - Fish Growth and Condition as a Response to Exposure

Figures illustrating the response patterns of fish length and weight and ANOVA/ANCOVA tables showing tests for significant differences between reference and exposure areas, are provided in Appendix 7. Based on these patterns and statistical test results, the key findings regarding H7 are outlined below.

Adult Pearl Dace

Plots of length and weight data for each sex were inspected to determine if sexes should be analyzed separately. Male and female dace appeared to have similar ranges and distributions of length and weight, so the effect of mine effluent exposure on length and weight was examined by Analysis of Covariance (ANCOVA), with age as a covariate. This analysis was performed on a subset of 48 dace for which ages were determined by scales. All dace were found to be one or two years-old. In the cases of both length and weight, the age covariate was non-significant and therefore, the data for all dace were re-analyzed without the covariate.

Mine exposure was associated with significant variation in the length of pearl dace collected at the Dome Mine site. Length of adult pearl dace was greatest in the near-field, and lowest in the reference area. This same significant pattern of variation was observed for weight of pearl dace (i.e., heaviest mean weight of dace occurred in the near-field area, intermediate mean weight was found in the far-field area, and the lowest mean weight occurred in the reference area).

The significant trends in length and weight are generally considered inconsistent with a mine-related impact or reduced food base.

Adult Yellow Perch

Inspection of perch length and weight suggested that, again, male and female perch had similar ranges and distributions of length and weight at Dome Mine. However, the age covariate in the ANCOVA was significant, so length and weight were adjusted accordingly before testing for effects of mine exposure. Both length and weight were significantly enhanced in the mine exposure area (Porcupine Lake) compared to the reference area (McDonald's Lake). Again, these results are generally inconsistent with a mine effect and may reflect fish community changes (i.e., rock bass competition in McDonald's Lake).

Caged Yellow Perch

Yellow perch captured for caged fish studies were all young-of-the-year. Mine exposure during the ten-day cage study did not significantly affect either length or weight of these fish.

5.2.7 H8 - Fish Gonad and Liver Weight and Fecundity

Figures illustrating the response patterns of fish gonad and liver weights and fecundity, and ANOVA/ANCOVA tables showing tests for significant differences between reference and exposure areas, are provided in Appendix 7. Based on these patterns and statistical test results, the key findings regarding H8 are outlined below.

Adult Pearl Dace

Gonad weight was examined separately for the two sexes. The age covariate for female dace was not significant and the results showed significant among area variation in gonad weight. The highest mean gonad weight for female dace was found in the near-field area, gonad weights were reduced in the far-field area, and the lowest mean gonad weights were found in female dace from the reference area. This trend is not consistent with a mine effect, whereby it would be expected that gonad weight would be lower if affected by mine exposure.

Male gonad weight followed the same significant among area pattern: greatest in the near-field and lowest in the reference area. Again, the age covariate was not significant.

The Pulp and Paper EEM Technical Guidance Manual (Environment Canada, 1998) recommends that when interpreting fish gonad weight, the measurements should be adjusted for body weight. When the gonad weights were adjusted for body weight, which was found to be significantly higher in exposed dace (both males and females), adjusted gonad weight for female dace was significantly lower in the near-field and far-field fish compared to the reference fish. In males there was no significant difference in adjusted gonad weight between exposed and reference fish.

ANOVA showed significant variation in fecundity of female pearl dace with degree of mine exposure. Fecundity increased in a downstream direction, such that lowest mean fecundity was found in the reference area and highest mean fecundity was found in dace from the far-field area immediately upstream from the confluence with the North Porcupine River. However, when fecundity was adjusted for body weight, it also showed significant variation among areas but the pattern was different than seen with unadjusted data. Body weight adjusted fecundity was lowest in the near-field fish and highest in the far-field fish, which was consistent with a mine-related effect.

Liver weights of male and female dace appeared similar, and the age covariate was again not significant. Significant variation among areas was found, following the same pattern shown in gonad weight (i.e., highest mean liver weights in the near-field area) with lower weights typifying dace from the far-field area. Lowest mean liver weight was recorded from dace in the reference area. However, unlike the results for gonad weight, when the liver weight was adjusted for body weight there was no longer a significant variation in liver weight among the three areas.

Adult Yellow Perch

Male and female gonad weights were analyzed separately. However, in contrast to the results for pearl dace, the age covariate for both male and female perch significantly affected gonad weight, so the analysis included the age covariate.

Neither male nor female gonad weights (age adjusted) appeared affected by mine exposure, because exposure area and reference area gonad weights were similar.

However, when the gonad weights were adjusted for body weight, which is considered to be the more appropriate covariate (Environment Canada, 1998), adjusted gonad weights for male and female yellow perch were significantly smaller in the exposed fish.

Age-adjusted fecundity of female perch (significant age covariate) was not influenced by mine exposure, since age-adjusted fecundity was similar in exposure and reference areas. The same holds true for fecundity adjusted for body weight.

Liver weight appeared similar among male and female perch, but age had a significant effect on liver weight and was used as a covariate in the analysis. Liver weight, adjusted for age difference, was significantly greater in the exposure area in Porcupine Lake compared to values for McDonald's Lake perch (reference). However, when liver weight was adjusted for body weight, which is generally considered to be the more appropriate covariate (Environment Canada, 1998), liver weight did not differ significantly among areas.

5.2.8 H9 - Dissolved versus Total Metal in Water as a Predictor of Biological Response

Hypotheses H9 through H12 involve examination of correlation coefficients between measured parameters. The correlations for H9 were computed using all reference and exposure area pearl dace growth and organ size/fecundity measurements found significant in testing of Hypotheses H7 and H8 with metals that showed apparent area differences in water or tissues. The metals used were arsenic, cobalt, copper, potassium, magnesium and nickel. Selenium, cadmium and silver which showed trends in tissues among areas could not be tested because most values in water samples were below detection limits. The correlation matrix is shown in Appendix 7. Hypothesis H9 could not be tested with adult yellow perch because there was only one exposure area.

Both dissolved and total metal measurements for copper, cobalt and magnesium showed high correlations with % chironomids that were significant. These metals were negatively correlated with percent abundance of chironomids. Zinc (dissolved and total) showed significant positive correlations with number of taxa, EPT taxa and total abundance which are not consistent with a mine effect. Overall, there were very few significant correlations and no consistent trends to support that dissolved or total aqueous metals were very effective tools in suggesting cause-effect relationships associated with impacts on the benthic community.

Correlations between water chemistry and fish health measures were limited to pearl dace because there was only one exposure area for adult yellow perch. Only one metal was negatively correlated significantly with a single pearl dace measurement: fecundity was negatively correlated with dissolved and total arsenic. Because the pearl dace in the exposure area were larger and had higher fecundity than fish in the reference area, a number of metals were significantly positively correlated with gonad weight and fecundity. These correlations are not consistent with a mine effect. Female gonad weight, adjusted for body weight, was significantly correlated with cobalt and copper (total and dissolved). The correlations were negative and indicative of a mine-related response. There were no significant correlations between metals and body weight-adjusted fecundity. Overall, aqueous metal correlations with fish effects did not suggest a cause-effect linkage to the Dome Mine operation, with the exception of body weight-adjusted female gonad weight which was correlated negatively with cobalt and copper.

5.2.9 H10 - Total versus Partial Metals in Sediments as Predictors of Biological Response

Tables showing correlation coefficients between sediment measurements (total, partial, SEM/AVS ratio) and benthic and sediment toxicity testing results are presented in Appendix 7. Benthic community and sediment toxicity responses that showed significant among area variation were correlated with metals that showed variation among areas.

In most cases, significant correlations of metal concentration with benthic indices were found for both total and partial measurements, but correlations were suggestive of cause-effect linkages with mine exposure (i.e. a negative correlation) in only a few cases. Significant negative correlations were noted for arsenic versus number of taxa, EPT taxa, abundance and % *Pisidium.* Copper which exceeded the PEL levels was only negatively correlated significantly with % chironomids.

Partial molybdenum was negatively correlated with number of taxa, abundance, % chironomids and % *Tanytarsus,* whereas total molybdenum was only correlated with % chironomids. Molybdenum was the only metal that showed a mine-related trend in sediment quality with partial extraction concentrations but not with total extraction concentrations, suggesting that its bioavailability may be associated with the mine operation.

A number of metals also showed positive correlations with some of the benthic indices (e.g., cadmium and total abundance).

Generally, correlations of partial extraction metals with benthic indices were similar to correlations with total metals, although there was no consistent indication of cause-effect relationships that could be related to the Dome Mine. This lack of a consistent trend in correlations is likely influenced by habitat factors (e.g., benthic stations in the beaver pond), as well as other sources of contamination in the reference area. The benthic community may be responding to different metals among areas or to a combination of metals. There may have also been other parameters that affected the community during the discharge period such as cyanide that was detectable in effluent samples but not in the receiving water samples at the time of the survey.

The SEM molar sum, and SEM/AVS showed little promise as a predictor of benthic community health: only SEM/AVS was positively correlated with percent *Tanytarsus*. As discussed previously, the SEM/AVS ratio was developed on the basis that it reflected acute toxicity of sediments due to some metals (i.e., cadmium, copper, nickel, lead and zinc) and does not account for all metals (e.g., arsenic, mercury). The benthic community impacts at Dome could be due to other factors not measured or metals that are not included in the SEM/AVS ratio.

Hyalella mortality was positively correlated with arsenic, cobalt, chromium, copper, iron, mercury, magnesium, nickel and partial molybdenum, consistent with a mine effect. The only significant negative correlation was with total cadmium. Some of these metals were not correlated with *Hyalella* growth (e.g., arsenic, cobalt, chromium, copper, iron). *Hyalella* mortality appears to be responding to the metal contaminants in the sediments, many of which were associated with the Dome Mine.

5.2.10 H11 - Correlation of Sediment Toxicity with Benthic Indices

Tables showing correlation coefficients between toxicity endpoints (*Hyalella* growth and mortality) and benthic indices (total density, numbers of taxa, % indicator taxa) showing significant mine-related trends are provided in Appendix 7.

Since only *Hyalella* mortality and growth varied significantly among mine exposure and reference areas, it is logical that this toxicity test shows the only significant correlations with benthic indices. *Hyalella* mortality is negatively correlated significantly with four standard benthic community indices: number of taxa, EPT taxa at the generic level, % *Pisidium* and log abundance. As would be expected, *Hyalella* growth showed a significant positive correlation with number of taxa, log abundance, and % *Tanytarsus*.

The results of Hypothesis H11 indicate that the *Hyalella* sediment toxicity test was an effective predictor of mine-related impacts on the benthic invertebrate community.

5.2.11 H12 - Correlation of Water and Sediment Chemistry with Fish Tissue Chemistry

Tables showing correlation matrices between total and dissolved concentrations in water and total and partial metals in sediments versus fish viscera metal and metallothionein concentrations are presented in Appendix 7. Correlations could not be done for silver, cadmium and selenium which showed significant exposure-reference area differences in viscera levels because aqueous concentrations of these metals were below detection limits at most stations. Correlations could not be done with adult yellow perch tissues because there was only one exposure area.

Total and dissolved cobalt, copper and nickel concentrations in water were highly correlated (correlation coefficients > 0.9) with concentrations of these metals in pearl dace viscera. Dissolved and total metal concentrations were equally correlated with the viscera metals, therefore, one tool could not be considered more effective than the other.

Only zinc (total and dissolved) in water showed a significant correlation with metallothionein levels in viscera. However, this was a negative correlation and is contrary to the expected relationship of zinc to metallothionein. It is expected that as zinc increases, metallothionein concentration should also increase (i.e., positive correlation). None of the metals showed a significant positive correlation with metallothionein levels in pearl dace viscera. The lack of positive correlations may be confounded by the fact that the mine was not discharging at the time of the survey.

Total and partial sediment concentrations of nickel and cobalt were positively correlated with pearl dace viscera concentrations of these metals. Partial arsenic sediment concentrations were also significantly correlated with viscera concentrations of this metal. Total arsenic in sediments showed a correlation of 0.8 but was not significant because of the few number of areas sampled at Dome. Interestingly, nickel and arsenic were the only two metals where the partial concentrations still exceeded their respective CSQG PELs.

Total silver also had a high correlation (0.88) with viscera levels but was not significant. In contrast to these results, total cadmium in sediments was negatively correlated with cadmium in viscera suggesting that sediment cadmium was not a good predictor of cadmium bioaccumulation.

Total arsenic was the only metal in sediment that was significantly correlated with pearl dace viscera metallothionein levels, whereas total mercury was significantly negatively correlated with metallothionein. These results appear to have little meaning in monitoring mine-related responses at the Dome Mine site.

Correlations with total and partial metals were similar indicating that one tool could not be considered more effective than the other.

5.2.12 H13 - Chronic Toxicity Linkages with Benthic and Fish Monitoring Results

Because there were only two effluent samples that represented the actual Dome effluent that was discharged to South Porcupine River and due to the fact that the mine stopped discharging almost two months before the field survey, this hypothesis could not be tested. However, as discussed in Section 2, effluent concentrations in the exposure area were estimated to be 37% in the near-field and 16% in the far-field during the time of effluent discharge.

The lowest IC25 values for *Ceriodaphnia, Pimephales*, *Selenastrum*, and *Lemna,* representing effluent that was discharged to the river, were <6.25, 47, 27 and 3.7% effluent, respectively. The estimated effluent concentration in the river exceeded all of these values except for the IC_{25} for fathead minnow. Therefore, the results of the chronic toxicity tests, with the exception of fathead minnow, suggest that an effect on biological communities might be expected in the exposure area. Results of testing Hypothesis H6 indicate that there were significant changes in the benthic community in the exposure area compared to the communities in the reference area.

Results of Hypotheses H7 and H8 for pearl dace indicated that there were detrimental effects in the exposure area when the measurements were adjusted for body weight. The near-field female pearl dace had significantly lower gonad weights (body weight adjusted) than in the reference area and this effect was also reflected in fecundity (i.e., body weight adjusted fecundity lower in the near-field fish). The highest liver weights for male and female dace were also noted in fish from the near-field area, however when adjusted for body weight there was no difference. In yellow perch, only gonad weight, adjusted for body weight, showed significant negative effects in exposed perch (i.e., lower gonad weight).

The results of the fathead minnow tests did not predict these results in resident fish. Concentrations of mine effluent in South Porcupine River and Porcupine Lake were lower than the lowest IC_{25} for fathead minnow (IC_{25} 47%). Therefore, the fathead minnow results were not effective in predicting that effects on fish would be expected in the receiving environment.

The data suggest that *Ceriodaphnia, Selenastrum* and *Lemna* chronic toxicity tests were effective in predicting effects on the benthic community and the fathead minnow tests were not effective in predicting that detrimental effects would be observed in resident fish. However, as seen for Dome (i.e., contamination entering upstream of the discharge), mine sites may have other sources of contaminants which are not accounted for by testing of the main mine effluents.

5.2.13 Triad Hypotheses

There are a number of combinations of chemistry (C), toxicity (T) and biology (B) monitoring tools that show significant correlations on all three arms of the "triad". The correlations involving total metals are slightly higher, in general, than those involving partial metals. The correlations involving *Hyalella* mortality and growth were generally higher than those involving other toxicity measures. The C-B correlations involving number of taxa, log abundance, EPT index, % chironomids and % *Pisidium* with sediment chemistry were generally higher than those involving other benthic community measures with sediment chemistry. Correlation coefficients for some of the stronger monitoring tool combinations are provided in Appendix 7.

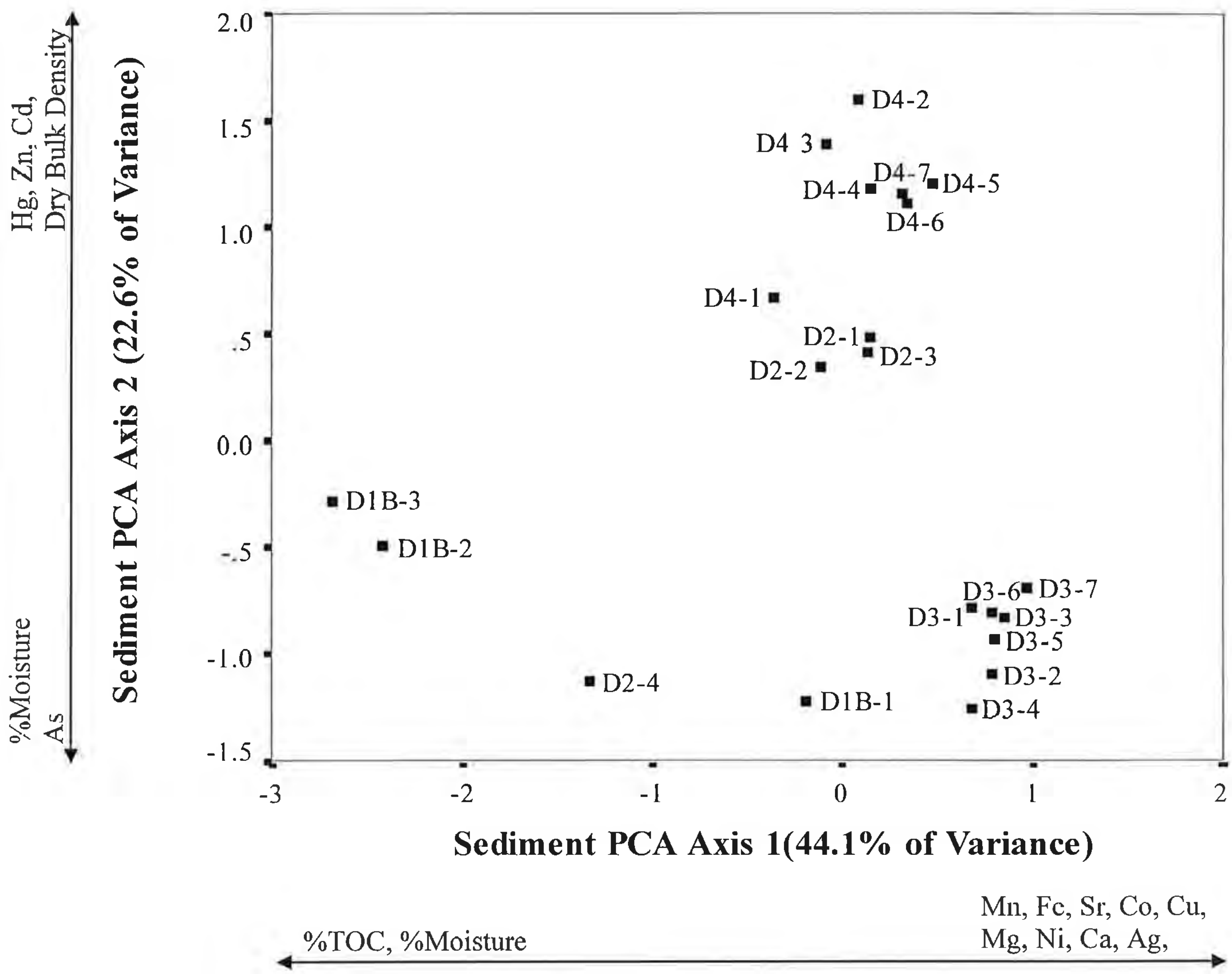
A more holistic evaluation of the sediment quality triad, involving multivariate analysis, is presented in Appendix 7. The many sediment chemistry variables were reduced by principal components analysis (PCA) to two sediment principal components (SPCs) representing sediment chemistry gradients. This PCA used total metals but not partial metals or SEM/AVS results because total metals were as effective in hypothesis testing.

The dominant SPC1, accounting for most (44%) of the overall variation in sediment quality, primarily represents a mine effect gradient with lower moisture and organic content and higher concentrations of manganese, iron, strontium, cobalt, copper, magnesium, molybdenum, nickel, calcium and silver, in the near-field (Figure 5.7). The subdominant SPC2, accounting for 23% of the variation in sediment quality, primarily separates the near-field and some reference stations from the far-field and other reference stations, based on higher arsenic and moisture in the first group, and higher mercury, zinc, cadmium and sediment density in the second group. It reflects the influence of historical arsenic sources and the beaver dam upstream of Dome Mine, and mercury, zinc and cadmium sources in the North Porcupine River.

The many benthic community variables were reduced by PCA to two benthic principal components (BPCs) representing gradients in the biological make-up of the community. The dominant BPC1, accounting for only 21.5% of the overall variation in taxa composition, separated far-field stations from near-field and reference stations based on higher densities of *Paratanytarsus,* Ostracoda, *Caenis,* Hydracarina, *Mallochohelea* and *Hydroptila* at the far-field stations (Figure 5.8). The subdominant BPC2, accounting for 16.5% of the variation in taxa composition, separated two reference stations from all the other stations based on higher densities of *Ablabesmyia, Gyraulus,* Leptophlebiidae, *Endochironomus, Halipus* and Tricladida.

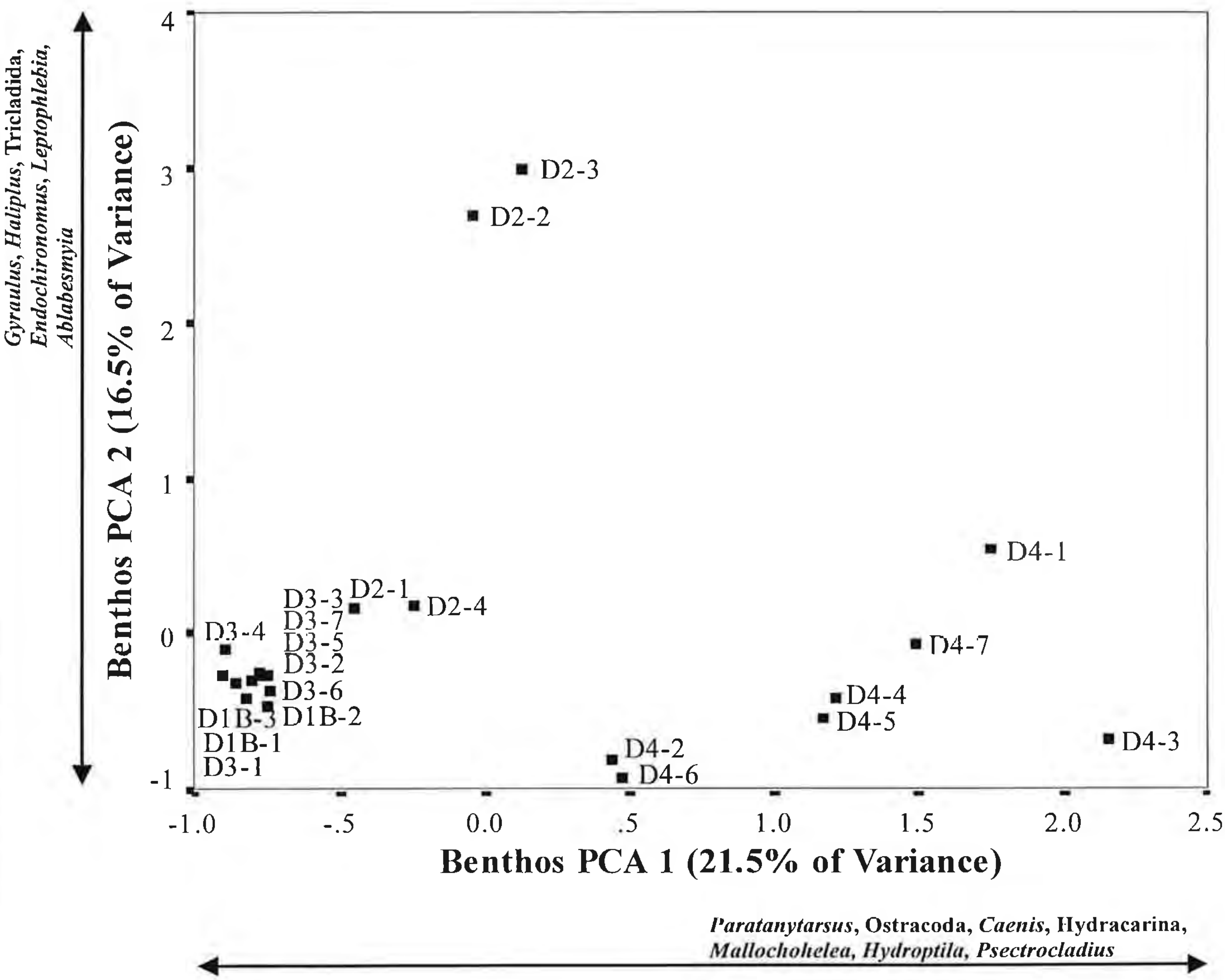
The separation of stations into groups (e.g., reference, near-field and far-field) was not as distinct as would be expected. The reference stations were separated into two groups likely because the benthic community at reference area Stations D1B-1, 2, 3 was influenced by habitat conditions (i.e., beaver dam) and the community at reference Stations D2-1, 2, 3, 4 was affected by contamination from historical mining operations.

The dominant sediment quality gradient (SPC1) was significantly correlated with *Hyalella azteca* mortality and growth (multiple R = 0.66, p = 0.013; Figure 5.9). SPC2 was also significantly correlated with these same toxicity measures, suggesting toxicity contributions from arsenic as well as other metals like nickel and copper. This gradient (SPC2) was also significantly correlated with the benthic community (BPC1) (multiple R = 0.84, p<0.001), however, SPC1 was not (multiple R = 0.04, p = 0.431). This



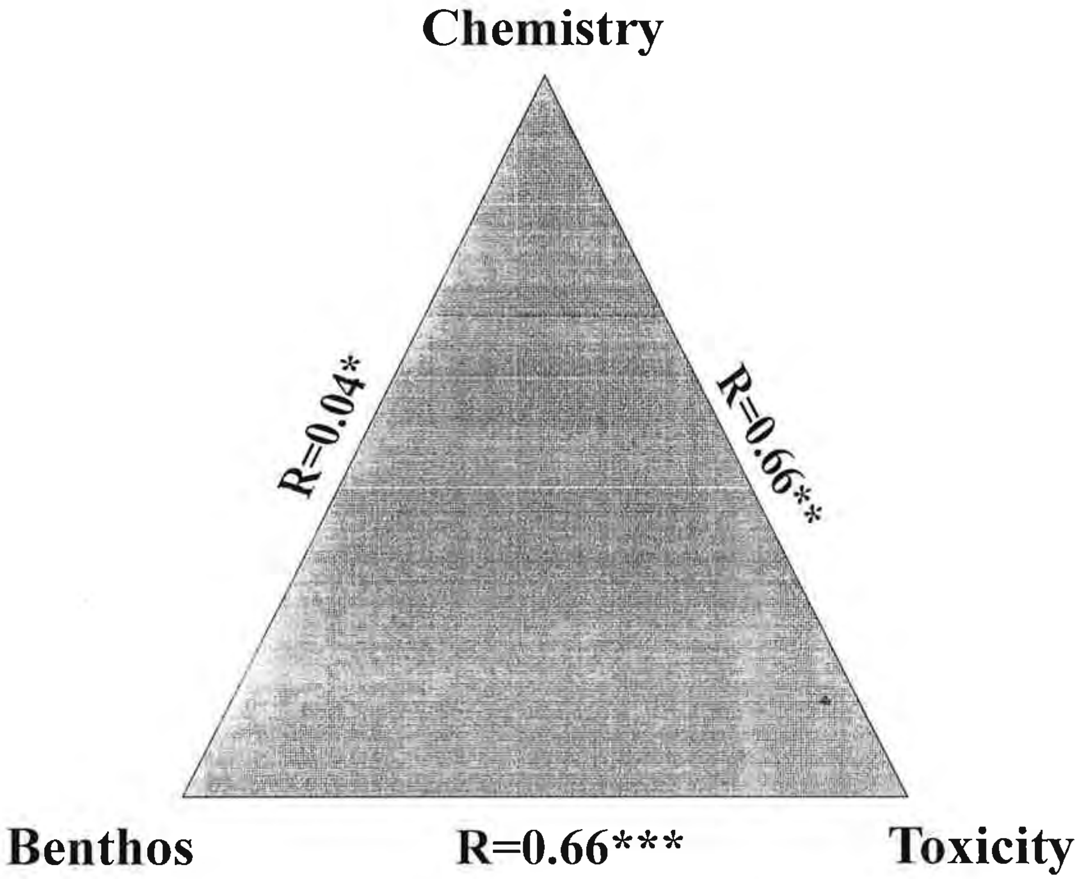
Sediment PCA Results
Dome Mine Stream Stations

beak international incorporated	Figure 5.7	May 1998



Benthic Macroinvertebrate PCA Results
Dome Mine Stream Stations

beak international incorporated	Figure 5.8	May 1998



Bartlett Sphericity Test = 33.9 (p<0.001)

*** the relationship between sediment chemistry PCA Axis 1 and Benthic PC1 is not statistically significant. Sediment PCA 1 represents a gradient in metals (Mn, Fe, Sr, Co, Cu, Mg, Ni, Ca, Ag) related to the mine operation and %Moisture and %TOC. Benthic PC1 represents a gradient in moderately tolerant taxa.**

**** the relationship between sediment chemistry PCA Axis 1 and the toxicity tests (*Hyalella* mortality and *Hyalella* growth) is statistically significant. Sediment PCA 1 represents a gradient in metals (Mn, Fe, Sr, Co, Cu, Mg, Ni, Ca, Ag),%Moisture and %TOC.**

***** the relationship between Benthic PCA Axis 1 and the toxicity tests (*Hyalella* mortality and *Hyalella* growth) is statistically significant. Benthic PC1 represents a gradient in moderately tolerant taxa.**

Triad Approach to Evaluate Dome Mine Sediment Quality		
beak international incorporated	Figure 5.9	May 1998

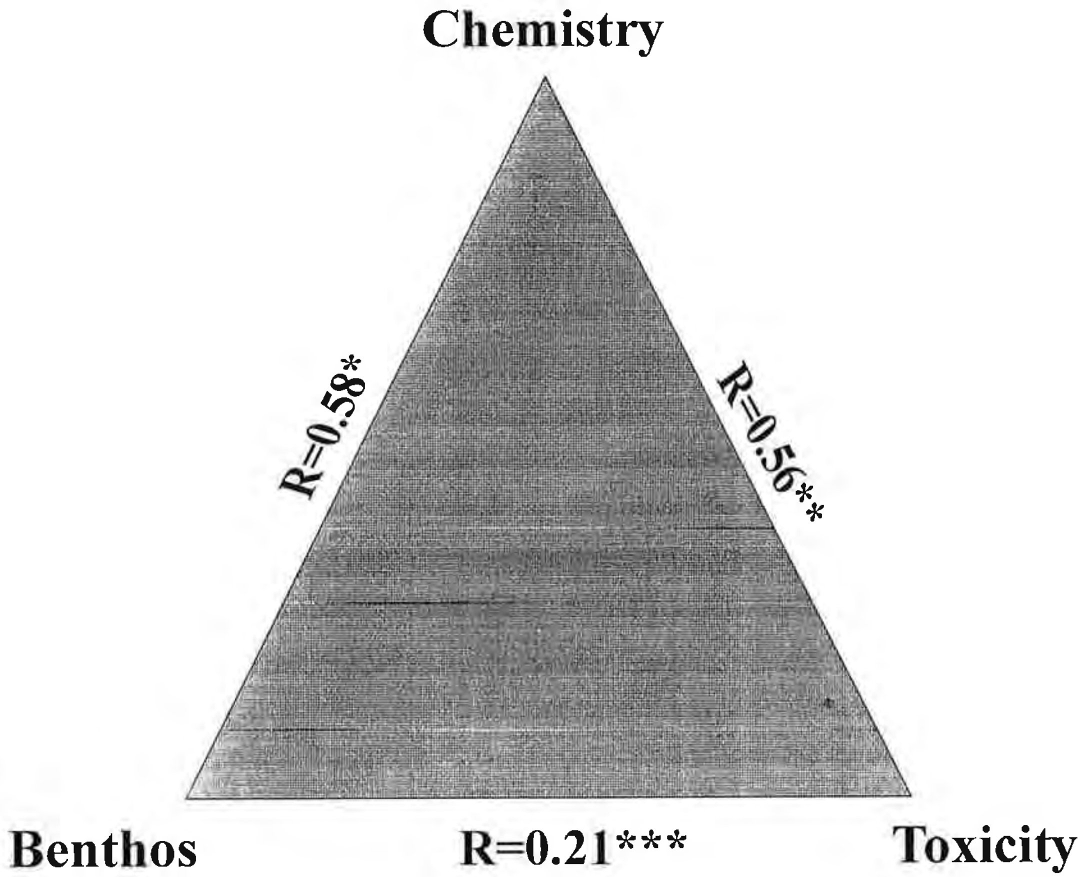
correlation suggests that arsenic and/or percent moisture may be influencing the near-field and reference benthic communities.

The dominant benthic community gradient, BPC1, was significantly correlated with *Hyalella* mortality and growth, which were the only toxicity endpoints showing a mine-related response.

Based on Bartlett's sphericity test, and using only the dominant sediment quality and benthic community gradients, the sediment quality triad overall is significant, demonstrating that chemistry, benthic and toxicity tools are effectively linked.

To illustrate an alternate approach, Mantel's test was performed in parallel with the previous analysis. For each of the benthic community, sediment chemistry (total metals) and sediment toxicity datasets (appropriately transformed), euclidean distance matrices were derived indicating overall similarities between pairs of stations.

Results of the Mantel's tests comparing the euclidean distance matrices for sediment chemistry, sediment toxicity and the benthic community indicated that there were significant correlations on the C-B and C-T arms of the triad (Figure 5.10). However, the benthic community was not significantly correlated with sediment toxicity. Overall, the Bartlett's sphericity test performed on these correlations suggests that sediment chemistry and biological response tools are effectively linked and support the conclusion reached above using PCA.



Bartlett Sphericity Test = 14.74 ($p<0.01$)

* the relationship between sediment chemistry and the benthic community is statistically significant.

** the relationship between sediment chemistry and the toxicity tests is statistically significant.

*** the relationship between the benthic community and the toxicity tests is not statistically significant.

Note: the 'R' as used here is equal to the $\sqrt{Z_M}$ presented in the table of Mantel results (Appendix 4), each Z_M is based on concordance of two euclidean distance matrices.

Triad Approach Using Mantel's Test to Evaluate Dome Mine Sediment Quality		
beak international incorporated	Figure 5.10	May 1998

6.0 EVALUATION OF AQUATIC EFFECTS TECHNOLOGIES

6.1 Introduction

The Dome Mine Field Evaluation program evaluated several of the aquatic effects monitoring "tools" considered by the AETE program. These tools were evaluated through testing eleven of the thirteen hypotheses pertinent to the 1997 field program, as well as by examination of tool performance indicators other than those specific to these hypotheses (e.g., sediment quality triad, chironomid deformities, other cause-effect relationships, practical aspects). Hypothesis H13 was assessed qualitatively. To avoid repetition, the cost-effectiveness aspects of the monitoring technologies are considered collectively in a summary report on all four of the 1997 field sites, because costs for each specific technology were approximately equal at the four sites (BEAK and GOLDER, 1998b). The summary report also evaluates the overall effectiveness of each monitoring tool, based on the results of all four mine sites.

Monitoring tools may be organized within "tool boxes" under the four guiding questions formulated under the AETE program to develop the hypotheses tested (from Section 1.1):

1. Are contaminants getting into the system?
2. Are contaminants bioavailable?
3. Is there a measurable (biological) response? and
4. Are contaminants causing the response?

Tool boxes and monitoring tools may be categorized under these four questions. Some tools may logically fit under more than one question; for example, toxicity testing tools may fit under Questions 1, 2 or 3. Table 6.1 provides a reasonable framework for organization of these tools, although alternate frameworks may be equally valid.

The fourth question cannot be answered by the application of individual tools, unlike the first three questions. Rather, the fourth question can be answered only by integrating the use of tools between and among tool boxes through testing for statistical linkages between potential cause and effect variables (e.g., do chemical concentrations and biological measurements correlate with one another?). The most effective tools are clearly those used in combinations that provide a yes answer to Question No. 4.

TABLE 6.1: GUIDING QUESTIONS, TOOL BOXES AND TOOLS CONSIDERED IN THE 1997 FIELD PROGRAM. TOOL BOXES AND TOOLS IN BOLD PRINT ARE SPECIFICALLY CONSIDERED AT DOME MINE

Question	Tool Boxes	Tools
Are contaminants getting into the system?	**Water chemistry**	• **total metal concentrations** • **dissolved metal concentrations**
	Sediment chemistry	• **total metal concentrations** • **partial metal concentrations** • **acid volatile sulphide and sequentially extracted metals**
Are contaminants bioavailable?	**Fish tissues**	• **organ/tissue metal concentration** • **organ/tissue metallothionein concentration**
Is there a measurable response?	**Effluent chronic toxicity**[1]	• **fathead minnow survival and growth test** • ***Ceriodaphnia dubia*** **(microcrustacean) survival and reproduction test** • ***Selenastrum capricornutum*** **(algae) growth test** • ***Lemna minor*** **(duckweed) growth test**
	Sediment toxicity	• ***Chironomus riparius*** **(larval insect) survival and growth test** • ***Hyalella azteca*** **(crustacean) survival and growth test** • ***Tubifex tubifex*** **(aquatic worm) survival and reproduction test**
	Fish health indicators	• **fish growth (length, weight and age)** • **fish organ size, fecundity**
	Fish population/community health indicators	• fish catch-per-unit-effort (CPUE - by species and total) • fish biomass-per-unit-effort (BPUE - by species and total)
	Benthic community health indicators	• **densities of benthic invertebrates** • **numbers of benthic taxa** • **benthic community indices (e.g., EPT index)** • **frequency of chironomid deformity**
	Periphyton community health indicators	• periphyton community biomass • numbers of periphyton taxa
Are contaminants causing the response?	**Pair-wise combinations of the above tool boxes**	• **chemistry x biology tool correlations** • **toxicity x biology tool correlations** • **chemistry x toxicity tool correlations** • **Sediment Quality Triad**

[1] Effluent chronic toxicity measured in the laboratory may also be categorized under Questions 1 or 2 (Are contaminants getting into the system? or, Are contaminants bioavailable?).

The hypotheses are formulated to answer two general types of questions:

- Is the tool effective in measuring a mine effect (i.e., is there a reference - exposure difference or an exposure area gradient)?; and
- Is one tool more effective than another in measuring an effect?

The "effectiveness" of monitoring tools as discussed herein is specific to the Dome Mine data set. Dome Mine represents one of four mine sites considered in the AETE 1997 Field Evaluation Program, and only one of numerous mine sites across Canada. A tool that is found to be of little value at Dome Mine for detecting mine effects may be very useful at other sites and vice versa. Therefore, the reader is cautioned not to assume that the conclusions drawn with Dome Mine data will necessarily be broadly valid at mines across Canada. As shown in the AETE 1997 Field Program Summary Report (BEAK and Golder, 1998b), monitoring tools can respond very differently from site to site. Also, the presence or absence of a particular mine-related effect may simply reflect exposure level or metal bioavailability at the site. In the latter case, the absence of an effect may simply indicate that the tool was suitable for showing no effect. However, the degree of impact found at Dome Mine and the aqueous and sediment concentrations of metals present are consistent with conditions which should demonstrate the effectiveness of monitoring tools unless they are insensitive.

6.2 Are Contaminants Getting Into the System?

6.2.1 Water Chemistry Tool Box

Hypothesis Testing Aspects

At Dome Mine, water chemistry sampling in the lower reaches of South Porcupine River and Porcupine Lake showed that metals were "getting into the system". This was demonstrated by elevated downstream concentrations of total and dissolved metals (e.g., copper, cobalt, magnesium, nickel, potassium, cadmium, aluminum). Iron, mercury and arsenic concentrations in water showed that contaminants were also entering the system from other sources upstream of the mine discharge and from the North Porcupine River.

In testing of Hypotheses H9, elevated aqueous metal concentrations measured in South Porcupine River were associated with enhanced fish and organ size and higher fecundity (number of eggs) when the data was not adjusted for body weight which was also higher in the exposed fish. When correlations were done with body-weight adjusted data. Cobalt and copper were significantly negatively correlated with female gonad weight. However, the effects observed for the most part were contrary to a metal toxicity response. Testing of Hypothesis H12 showed that there were significant correlations between total and dissolved aqueous metals with viscera metals (cobalt, copper, nickel).

Overall, the water chemistry tools (dissolved and total metals) were effective in showing that contaminants were entering the system from the mine, as well as from other sources. The water chemistry tools were somewhat effective in demonstrating cause-effect relationships with benthos or fish effects (cobalt and copper correlated with female gonad weight); however, the tools were effective in linking metals entering the system with bioaccumulated metals in fish tissues (e.g., copper, cobalt, nickel). Overall, dissolved and total metals were equally effective monitoring tools, although the number of significant correlations that appeared to be mine related were limited.

Other Considerations

The collection of dissolved metal samples according to the methods described in Annex 1 and in this document was not onerous, but required approximately six technician hours (additional relative to total metal samples) to filter and preserve the 22 samples (20 plus field duplicates).

The syringe and filter apparatus required, based on recommendations by chemists with the Geological Survey of Canada (GSC), were difficult to procure in Canada. Importation of the syringes from the U.S. required over one month due to delays at Canada Customs. Availability of similar filtration materials necessary for ultra-trace metal work may be problematic in the future, requiring careful planning.

The commercial laboratory used required very specific instruction to provide sampling containers and filtration materials consistent with the recommendations provided by GSC. For example, commercial laboratories often provide low density rather than high density polyethylene containers for metal samples, and may also provide containers with coloured lids such as “Falcon” tubes to consultants or mining companies. GSC has shown that such containers can contribute low levels of metals to water samples, and thus may not be suitable in aquatic effects monitoring where metal concentrations of interest are equal to or often below surface water quality guidelines.

The filtration procedure involved squeezing the water through a syringe-mounted filter, and was somewhat difficult and time-consuming due to the slow rate of filtration, rinsing requirements, etc. Also, where suspended solids levels are higher, filters became quickly clogged and required replacement.

Sample contamination was generally not apparent in the dissolved metal results, as dissolved metal concentrations were generally less than total metal concentrations (with exceptions occurring mainly at low concentrations near the detection limits and due to analytical variability). The filter blanks showed no signs of contamination when the data were compared to the data for the trip blank.

6.2.2 Sediment Chemistry Tool Box

Hypothesis Testing Aspects

In the exposure areas of the South Porcupine River, sediment concentrations of most metals demonstrated that contaminants were getting into the system. However, contaminants were entering the system from abandoned mine operations, as well as from the Dome Mine. The sediment chemistry tools of total metals, partial metals and SEM/AVS were evaluated through Hypotheses H10 and H12, by identifying reference versus exposure differences or concentration trends within the exposure area between near field and far field and by examination of sediment metals as causal agents for biological responses (both benthic and sediment toxicity).

In general, reference-exposure differences and exposure area trends were observed for copper, nickel, cobalt, iron, manganese, and silver and to a lesser degree for chromium and molybdenum.

Total metal and partial metal concentrations provided value in predicting biological effects in sediment toxicity using *Hyalella* and to a lesser extent in predicting effects on benthos and fish (bioaccumulation). Correlations were similar for total and partial metals with benthic community responses, toxicity or metals in viscera. The SEM/AVS results did not show any significant correlation with the benthic metrics, indicating that this sediment tool was not effective in predicting effects at Dome Mine. Based on the Dome data, it appears that the toxicity and benthic community effects may be due to other metals or parameters not accounted for in the SEM/AVS ratio (e.g., arsenic).

Other Considerations

The use of partial metals requires that the field crew has access to a freezer or dry ice because the samples have to be frozen after collection. The samples must also be kept frozen during transport to the analytical laboratory. In some field situations, this could increase the cost of sample collection, further decreasing the cost-effectiveness of this tool when compared to sampling for total metals.

Sediment metal analyses may be more effective than aqueous metal analyses in situations where aqueous metal concentrations are affected only sporadically (e.g., only in response to runoff or to intermittent effluent discharge), with concentrations approaching reference conditions between these impact events. This is because sediments will act to integrate metal loadings gradually over time whereas the water column may flush more rapidly. In fact, hypothesis testing showed this to be the case at Dome. Sediment metals were more highly correlated than aqueous metals with benthic parameters and viscera metals in pearl dace.

The ineffectiveness of AVS and SEM determinations is perhaps not surprising, given the underlying assumptions in the SEM/AVS model. The SEM/AVS model relates the molar concentration ratio of potentially toxic simultaneously extracted metals (Cd, Cu, Pb, Ni, Zn) to the molar concentration of amorphous solid metal sulphide (predominantly FeS; Allen *et al.*, 1993). Where the SEM/AVS ratio is >1.0, some of the metals may not be rendered unavailable by formation of metal sulphides and toxicity may occur (e.g., Long *et al.*, 1998). At lower ratio values, toxicity should not occur. However, this ratio does not account for arsenic which was a major contaminant at Dome. Arsenic was negatively correlated with many of the benthic parameters and positively correlated with *Hyalella* mortality.

6.3 Are Contaminants Bioavailable?

This question is answered through the measurement of metal bioaccumulation or biochemical responses to metal bioaccumulation.

6.3.1 Tissue Metal Concentrations

Hypothesis Testing Aspects

The effectiveness of tissue metal concentrations as indicators of metal bioaccumulation is measured from the identification of differences between exposure and reference areas, with higher values in the exposure area required to indicate effectiveness. Tissues showing greater exposure-reference differences are considered more effective than those showing smaller differences for the same metal.

At Dome Mine, four of the five tissues (kidney, liver, muscle, viscera, not gill) were effective in showing exposure-reference differences for some metals. However, muscle tissue was the most effective because it showed significant mine-related trends for more metals than any of the other tissues (e.g., aluminum, zinc, cobalt, copper, iron, selenium, vanadium). The other tissues, such as liver and kidney, only showed significant mine-related responses for nickel and molybdenum. Viscera showed significant exposure-reference differences for silver, cadmium, selenium, molybdenum, nickel, aluminum and copper.

Hypothesis 12, which compares correlations between metals in water and metals in fish viscera, showed significant correlations for cobalt, copper and nickel. These correlations are consistent with exposure-reference differences in H2. Total and partial sediment nickel and cobalt were also correlated with viscera levels of these metals. Hypothesis 12 was less effective in testing tissue metal tools for cadmium, selenium and silver because of the large number of non-detect concentrations in the water chemistry data set.

Other Considerations

From a practical standpoint, collection of tissues for metal analysis was not problematic, although more effort was required for adult fish dissection than was necessary for small fish viscera or for collection of muscle tissue. The coldwater conditions in October were conducive to maintaining viable fish for dissection, although viability was necessary for metallothionein rather than for metals.

The degree to which metals in the alimentary canal of fish, rather than bioaccumulated metals, affects the data interpretation is unknown. The caged fish provided some data that tended to suggest that metal levels in the gut need to be considered.

6.3.2 Tissue Metallothionein Concentrations

Hypothesis Testing Aspects

The effectiveness of tissue metallothionein concentrations as indicators of exposure to bioavailable metals from mine exposure is measured by identification of differences between exposure and reference areas, with higher values in the exposure area required to indicate effectiveness. Where more than one tissue type (gill, kidney, liver) shows a significantly elevated exposure area response, the tissue(s) having larger exposure-reference differences are identified as more effective.

At Dome Mine, there were no significant reference-exposure differences that were related to mine exposure. Metallothionein was significantly higher in reference gill and kidney, and equal in reference and near-field viscera and liver. The degree to which the fact that the mine was not discharging at the time of the fish collections affected the results of the metallothionein hypothesis testing is unknown.

Comparison of the metallothionein in response to the tissue bioaccumulation response indicated that tissue metals were a more effective tool in demonstrating mine exposure and bioavailability of metals.

Other Considerations

The collection of tissues for metallothionein analysis was not problematic, although the effort required for sample collection was greater than for fish viscera. The coldwater conditions of October were conducive to maintaining fish viability until dissection, as required for metallothionein analysis. Maintenance of a dry ice supply was expensive although not problematic because there was a supplier in Timmins, Ontario.

6.4 Is There A Measurable Effect?

The answer to this question is evaluated through Hypotheses H1, and H6 through H13. The hypotheses tested at Dome Mine are based on a measurable effect in fish and benthos (H6 through H8) and on the integration of tools hypotheses (H9 through H12) which look for correlations between the measurable effects and the causal agents. Hypothesis H11 actually examines correlations between two measurable effects (sediment toxicity and benthic invertebrate community response).

6.4.1 Sediment Toxicity

Hypothesis Testing Aspects

The effectiveness of sediment toxicity as an indicator of metal bioavailability is measured from the identification of differences in toxicity between reference and exposure areas and/or the occurrence of trends within the exposure areas (near-field to far-field). Effectiveness is also determined by the strength of correlations between possible causal agents (metals in sediment) and sediment toxicity and between sediment toxicity and the benthic community.

Sediment toxicity reflecting mine exposure was evident only in mortality and growth impairment in *Hyalella*. The sediment toxicity was correlated with a number of sediment metals and with benthic community metrics. These results suggest that metals in exposure area sediments were bioavailable. Thus, sediment toxicity was effective in responding to sediment contamination at Dome Mine and was helpful in predicting effects on benthic communities.

Other Considerations

From a practical standpoint, sediment toxicity was readily assessed at Dome Mine. *Hyalella* and *Chironomus* showed reduced survival in some sediments, while *Tubifex* showed no significant lethality response. *Tubifex* testing is not currently widely available from commercial laboratories. Commercial testing capability is widely available for sediment testing with *Chironomus* and *Hyalella*.

6.4.2 Benthic Community Health Indicators

Hypothesis Testing Aspects

Monitoring of benthic community parameters was effective in identifying response to mining effects in the exposure areas at Dome Mine, with effects on total density, total numbers of taxa, EPT index at the genera level and on other specific indicator taxa. This effectiveness was evident in terms of reference-exposure differences and with respect to correlations with sediment metal concentrations in H10 and in the sediment quality triad. No associations were seen between benthic indices and SEM/AVS results, suggesting that this was not an effective tool in predicting benthic effects.

Other Considerations

The collection of benthos for analysis at Dome Mine was accomplished readily and required routine effort. The data interpretation at the Dome Mine was confounded by the presence of metal loadings from other sources and by the changes in habitat at the three reference stations located furthest upstream in the beaver pond.

The incidence of chironomid deformity, based on examination of mouth parts in mounted specimens, was low throughout the reference and exposure areas (Appendix 5), indicating that this tool would be ineffective in measuring biological responses to metals at Dome Mine.

6.4.3 Fish Health Indicators

Hypothesis Testing Aspects

Fish health indicators were evaluated by assessing reference-exposure differences in length, weight, organ size (gonad and liver) and fecundity (number of eggs). Length and weight of pearl dace and at age for yellow perch were found to be significantly higher in exposed fish, which is not typically considered to be consistent with a mine-related effect.

In the yellow perch there was no significant difference in gonad weight at age and fecundity at age, however, when these measures were adjusted for body weight, gonad weight was significantly lower in exposure perch. There was no change in body weight adjusted fecundity. In pearl dace, the gonad weight in male and females was significantly higher in exposure fish, but when these weights were adjusted for body weight female gonad weight was significantly lower in exposed fish and unchanged in exposed males. Pearl dace fecundity changed from a significant increase in exposure dace to a significant decrease for body weight-adjusted fecundity.

Liver weight at age was significantly higher in exposed perch but there was no mine-related effect when liver weight was adjusted for body weight. Liver weight in pearl dace changed from a significant increase in exposure fish to no change using body-weight adjusted data.

Hypothesis H9 indicated that some metals measured in water (i.e., cobalt, copper) were correlated with body weight-adjusted gonad weight in female pearl dace.

Other Considerations

The collection of fish for health indicator measurements is straightforward and does not require the fish to be alive at the time of capture. Generally, the only drawbacks with the fish health related tools is that the time required to capture the requisite number of fish can be extensive and the impacts on the fish population by the death of the sentinel species, as well as other species that are captured incidentally can be substantial.

6.4.4 Effluent Toxicity

Sublethal testing of three Dome Mine effluent samples indicated that the effluent was highly toxic. IC25s for *Ceriodaphnia*, duckweed and algae were generally less than effluent concentration in the river during discharge. These three tests were effective in predicting the effects on the benthic community. Results of the fathead minnow tests suggested that there would not be detrimental effects on resident fish. There were no detrimental effects on resident pearl dace or yellow perch in the exposure area when the data for health measures were not adjusted for body weight. However, when the health measures were adjusted for body weight a number of mine-related effects were evident (e.g., lower gonad weight and fecundity) which the fathead minnow results did not predict.

The effluent toxicity tests were also effective in demonstrating that contaminants were getting into the system and that contaminants were bioavailable.

6.5 Are Contaminants Causing the Responses?

As indicated previously, this question is not answered directly through the application of specific monitoring tools evaluated in this study, or through any of the hypotheses tested. Rather, the question is evaluated only by a weight-of-evidence provided by affirmative responses to the first three questions, and particularly by the strength of correlations between exposure indicators (chemical concentrations) and biological responses in hypotheses H9 through H13.

At Dome Mine, evidence indicates that contaminants are getting into the system and are bioavailable (based on bioaccumulated metals in fish and effluent and sediment toxicity data), and that certain biological responses are correlated with metal concentrations in the environment. Certain benthic community and fish population responses and bioaccumulated metals in tissues were correlated with sediment and water concentrations of metals. The directions of exposure-response relationships were consistent with biological effects due to mine-related contaminants. Furthermore, *in situ* toxicity predicted from laboratory toxicity testing also reflected biological effects. Accordingly, the field data support a conclusion that "contaminants are causing the responses". However, dose-response relationships in the field do not necessarily prove cause and effect. Rather, a combination of controlled laboratory testing of metal toxicity and field evidence such as provided herein would be appropriate to provide further detail on cause and effect (e.g., which metals individually or in combination produce a response).

Sediment Quality Triad

The sediment quality triad also uses a weight of evidence approach to suggest if contaminants are causing the response. The analysis of the sediment quality triad showed that overall, linkages were strong between sediment chemistry and toxicity and between toxicity and the benthic community response. However, the linkage between sediment chemistry and benthic community response was not strong. Results also suggested that the causes of benthic and toxicity responses may be different or habitat difference may have influenced the ability of the tools to establish relationships between contaminated effects. Overall, the analysis shows that as a group, sediment toxicity and benthic community tools were responsive to sediment quality conditions.

6.6 Section Summary

Table 6.2 provides a summary of whether or not the aquatic monitoring tools evaluated at Dome Mine demonstrated a mine-related effect. Table 6.3 compares the effectiveness of alternate tools that may be used to measure metal concentrations, metal bioavailability or biological response.

Some of the tools evaluated were effective at demonstrating an effect at Dome Mine, whereas others were not. Effective tools included most in the water and sediment chemistry tool boxes (with the exception of SEM/AVS) and in the benthic community tool

TABLE 6.2: EFFECTIVENESS OF MONITORING TOOLS TESTED AT DOME MINE

Tool Boxes	Tools	Effectiveness			Comment
		Effect Demonstrated	Effect Partially Demonstrated	Effect Not Demonstrated	
Water Chemistry	Total Metals	√			Increased concentrations of Cu, Mg, Co, Ni and K at all river exposure stations. All metals detected above MDL were elevated in exposure lake.
	Dissolved Metals	√			Only arsenic showed mine-related relationship with unadjusted dace fecundity. Body weight-adjusted female gonad weight showed mine-related relationship with cobalt and copper. Some metals showed expected relationship with % chironomids. Relationships between total and dissolved and tissue metals were similar.
Sediment Chemistry	Total Metals Partial Metals	√ √			Mine-related trends in Cu, Ni, Co, Fe, Mg, Ag. Correlations similar between total and partial metals and benthic and toxicity effects.
	SEM/AVS			√	SEM/AVS was an ineffective predictor of biological impact or sediment toxicity at this site potentially because these effects are related to parameters not included in the SEM/AVS ratio.
Sediment Toxicity	*Hyalella azteca* *Chironomus riparius* *Tubifex tubifex*	√		 √ √	Only *Hyalella* mortality and growth were effective in showing mine-related trends. These endpoints were correlated with benthos effects.
Fish Tissues	**Yellow Perch**				
	Metals:				
	• Muscle	√			Muscle was the most effective tissue showing mine-related trends in Zn, Ag, Co, Cu, Fe, Se, Al and Va.
	• Liver		√		Showed some trends but only in Mo and Ni.
	• Gill			√	Unresponsive to mine exposure.
	• Kidney		√		Only effective for Ni.

TABLE 6.2: EFFECTIVENESS OF MONITORING TOOLS TESTED AT DOME MINE (cont'd)

Tool Boxes	Tools	Effectiveness			Comment
		Effect Demonstrated	Effect Partially Demonstrated	Effect Not Demonstrated	
	Pearl Dace				
	• Viscera	√			Demonstrated a mine-related response to Ag, Cd, Cu, Se, Mo, Ni and Al.
	Caged Yellow Perch				
	• Viscera			√	Not effective in showing mine response or in testing Hypotheses H2, H3 and H4.
	Yellow Perch MT				
	• Liver			√	No mine-related pattern. No significant reference/exposure difference in liver. Correlation between Cu in liver and MT.
	• Gill			√	No mine-related pattern. MT in perch gill and kidney higher in reference area. Correlation between Hg in kidney and MT.
	• Kidney			√	
	Pearl Dace MT				
	• Viscera			√	No mine-related pattern. No strong correlations between viscera metals and MT. Correlations between Hg and Cd and MT were weak.
Fish Health Indicators	**Body Size**				
	• Yellow perch			√	Difference in weight and length at age but higher in exposed fish not a typical mine effect.
	• Pearl dace			√	Difference in weight and length but highest in near-field dace not a typical mine effect.

TABLE 6.2: EFFECTIVENESS OF MONITORING TOOLS TESTED AT DOME MINE (cont'd)

Tool Boxes	Tools	Effectiveness			Comment
		Effect Demonstrated	Effect Partially Demonstrated	Effect Not Demonstrated	
	Liver Weight				
	• Yellow perch		√		Liver weight at age higher in exposed fish may reflect a response to exposure, however no difference when adjusted for body weight.
	• Pearl dace		√		Liver weight higher in exposed fish may reflect a response to exposure, however no difference when adjusted for body weight.
	Gonad Weight				
	• Yellow perch		√		No reference-exposure difference in males or females, age adjusted but body weight adjusted gonads were lower in exposed fish.
	• Pearl dace		√		Male and female gonad weight higher in exposed fish. Not characteristic of a mine-related effect, however, when body weight adjusted significantly lower in exposed female dace and no difference in males.
	Fecundity				
	• Yellow perch			√	No reference-exposure difference in fecundity, age adjusted or body weight adjusted.
	• Pearl dace		√		Fecundity highest in exposed dace but lowest in near-field dace when adjusted for body weight.
Fish Population/ Community Health Indicators	**CPUE**			√	Ineffective at showing mine-related response because of habitat differences and an introduced species (rock bass). A more detailed preliminary survey may have avoided these confounding factors.

TABLE 6.2: EFFECTIVENESS OF MONITORING TOOLS TESTED AT DOME MINE (cont'd)

Tool Boxes	Tools	Effectiveness			Comment
		Effect Demonstrated	Effect Partially Demonstrated	Effect Not Demonstrated	
Benthic Community Health Indicators	Benthic Density	√			Mine-related effects demonstrated with most metrics used.
	No. of Taxa	√			
	Abundances of Indicator Taxa	√			
Effluent Toxicity	*Ceriodaphnia*	√			Effective in predicting effects on benthos.
	Algae	√			Effective in predicting effects on benthos.
	Duckweed	√			Effective in predicting effects on benthos.
	Fathead minnow		√		Effective in predicting that there would be no effects on fish; however, when fish measures were adjusted by body weight, mine-related effects were evident and the fathead minnow test did not predict these effects.

TABLE 6.3: COMPARATIVE EFFECTIVENESS OF MONITORING TOOLS AT DOME MINE

Tools	Comparison
Total Metals vs Dissolved Metals in Water	Total and dissolved metal concentrations approximately equal in reflecting elevated metal concentrations. Concentrations of both appeared unrelated to biological effects, although some correlations occurred between metal concentrations and tissue response.
Total Metals, Partial Metals and SEM/AVS in Sediment	Total and partial metals were, on average, comparable in reflecting benthic effects and toxicity effects. The SEM/AVS ratio was unrelated to benthic effects or sediment toxicity at this site.
Sediment Toxicity Tests	*Hyalella* test was effective in reflecting mine-related impact.
Benthic Community Health Indicators (density, no. of taxa, indicator taxa)	Several indices were effective in reflecting mine-related impact including total density, no. of taxa, EPT and abundance of indicator taxa.
Fish Tissues - Metals	Yellow perch muscle was superior in indicating mine exposure compared to other tissues used for perch. Pearl dace viscera was most effective in showing mine-related trends moreso than perch tissues.
Fish Tissues - Metallothionein	MT did not show a mine-related response in any tissues.
Fish Tissues - Metals vs Metallothionein	MT did not respond to exposure. Metals in perch muscle and pearl dace viscera were more effective.
Fish Health Indicators	Among the responses examined (length, weight, liver weight, gonad weight, fecundity), only liver weight showed responses that could potentially represent effects, i.e., greater liver weight in exposed fish. However, when the reproductive measures were adjusted for body weight, mine-related effects were reflected in yellow perch (male and female) and female pearl dace.
Effluent Toxicity	Effluent toxicity results were effective in predicting effects or lack of effects on benthic and fish communities.

box, and some of the fish tissue tools, as well as some body-weight adjusted fish health indicators. Ineffective tools included the fish health indicators not adjusted for body weight, fish population/community (due to natural habitat factors and introduced species), and metallothionein tools and some tests in the sediment toxicity tool box (e.g., *Chironomus* and *Tubifex*) which were limited in effectiveness.

An effect was partially demonstrated when a response occurred for a limited number of endpoint measurements for the tool considered, or in some instances when the "effect" was in a direction inconsistent with impact. For example, metals in liver and kidney were partially affected because the responses occurred for limited numbers of key metals. Also, most fish health effects were partially demonstrated because the effects occurred either when the response was adjusted or not adjusted for body weight, or when the effect was in a direction not indicating adverse impact.

The limited effectiveness of some of these tools may be due to low metal bioavailability or due to the fact that the mine stopped discharging effluent two months before the field survey. The ineffectiveness of some tools might also be due to the confounding effects of other sources of contaminants. Of the tools in the same tool box ranked as effective (e.g., dissolved and total metals, total and partial metals), major differences in effectiveness were not evident at Dome Mine. Therefore, the costs of each tool will be important in the selection of which is considered to be the most cost-effective monitoring technology. These comparisons are provided in a separate document which summarizes the results of all four mine sites studied in 1997 (Heath Steele, Myra Falls, Dome and Mattabi) and evaluates the cost-effectiveness of each monitoring tool (BEAK and Golder, 1998b).

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APPENDIX 1

Quality Assurance/Quality Control

BEAK MEMO

To: **Paul McKee, Project Manager**
Dennis Farara, Project Manager

From: Pierre Stecko, QA Officer

Ref: **AETE 1997 - Dome Mine Data QA Report**

Date: May 28, 1998

We have reviewed the 1997 AETE data collected from the Dome mine and have conducted a data quality assessment (DQA) in comparison to the data quality objectives (DQO) outlined in the Quality Management Plan (QMP). A summary of the results of the data quality assessment is presented below, categorized by study.

Benthos (Table A1.1)

DQOs for percent recovery (≥ 95%) were met, based on samples D1B-1 and D4-2. Laboratory precision (≥ 80%) was met for samples D3-2 and D4-6. **NO FLAGS.**

Water Chemistry - Conventional and Aggregate Parameters (Table A1.2)

Trip and filter blanks met DQOs in all cases. There were no DQOs set for laboratory precision for water chemistry. However, we have flagged parameters with >50% difference (as a percentage of the mean). **FLAGS:** Differences of greater than 50% between field duplicates were observed for acidity and ion balance in filtered water from D4B-2.

Water Chemistry - Metals and Nutrients (Table A1.2)

Trip and filter blanks met specified DQOs. However, very low, but detectable concentrations of copper and zinc occurred in the blanks (up to 1.1 and 2 µg/L, respectively), suggesting that some contribution from the deionized water, the fixing or analysis reagents, or the sample jars (or lids) may have occurred. In addition, none of the metals exhibited differences greater than 50% between laboratory replicates or field duplicates. **FLAGS:** Differences of greater than 50% between replicates were observed for total phosphorus in filtered water from D1-1, and differences of greater than 50%

between field duplicates were observed for ammonia and total phosphorus in filtered water from D4B-2.

Sediment

a) Total Metals (Table A1.3)

Recovery of total metals in matrix spikes varied from 82 to 140%, while the DQO for laboratory accuracy was 10% (i.e., 90 to 110% recovery). **FLAGS:** Aluminum (D4-2; 140%), antimony (D3-3; 120%), arsenic (D4-2; 120%), beryllium (D4-2; 120%), and molybdenum (D3-3; 120%). In addition, DQO for laboratory precision between replicates (10%) was exceeded for loss on ignition at D3-1; for aluminum, antimony, chromium, selenium, and zinc at D3-3; and for antimony and beryllium at D4-2.

b) Partial Extraction (Table A1.4)

No matrix spiking was conducted for QA/QC of partially extracted Dome sediments. **FLAGS:** The DQO for laboratory precision between replicates (10%) was exceeded for copper, iron, molybdenum, and zinc at D3-4; and titanium at D4-3.

c) Simultaneously Extracted Metals (Table A1.5)

The concentration of metals extracted with the acid volatile sulphides was assessed for laboratory precision (10%) in two replicate samples. **FLAGS:** For the key simultaneously extracted metals, the following are flagged: nickel and zinc at D3-3. In addition, the estimate of SEM to AVS is flagged at both D3-3 and D4-4.

There are a number of potential sources of variability in the SEM/AVS extraction. First, the method uses a wet extraction, therefore variability can easily be introduced in sub-sampling for the estimate of the wet/dry ratio (i.e., if a particularly wet sub-sample is taken, metals concentration of a dry weight basis will be overestimated). In addition, the SEM/AVS technique is very redox sensitive, and small scale variability could significantly influence the comparability of sub-samples.

d) Comparisons of Metal Concentrations in Different Extracts

The amount of metal mobilized by the different extractants was checked for discrepancies. Total metals were assessed using a nitric acid and peroxide mix. To determine the comparability to Canadian Sediment Quality Guidelines (which are developed for metals extracted with aqua regia), some samples were extracted with aqua regia for comparison. The two methods compared well, although some significant differences were flagged for cadmium, chromium, molybdenum and silver (Table A1.6). Concentrations removed by the partial extraction were always lower than those removed by the aqua regia and total extraction, consistent with the weaker nature of the extractant used. There were some inconsistencies in the comparison of simultaneously extracted metals and total metals (i.e., SEM were often greater than total metals; Table A1.7). As discussed above, this may be the result of the wet weight to dry weight conversion.

Water Toxicity (Table A1.8)

DQOs specified for minimum significant difference, control mortality, reference toxicant variability; and accuracy of the reference toxicant were achieved. **FLAG:** The variability of the control for sample PE-3 in the *Ceriodaphnia dubia* test was greater than the DQO specified for control variability (43% vs. a DQO of 40%).

Sediment Toxicity (Table A1.9)

Control mortality was always below the specified DQO of 30%. In addition, we reviewed coefficients of variation for the controls, variation between initial test and re-tests and the reference toxicant results (control charts) and there were no deviations of concern. **NO FLAGS.**

Table A1.1: Dome Benthos QA/QC

Station	Number of Animals Recovered	Number of Animals in Re sort	Percent Recovery
D1B-1	293	13	96
D4-2	558	30	95

CALCULATION OF SUBSAMPLING ERROR FOR BENTHIC INVERTEBRATE SAMPLES FROM PLACER DOME

Station	Number of Animals in Fraction 1	Number of Animals in Fraction 2	Standard Deviation	Coefficient of Variation
D3-2	185	199	9.90	5.16
D4-6	714	725	7.78	1.08

SAMPLES THAT REQUIRED SUBSAMPLING FOR PLACER DOME

Station	Fraction Sorted
D1B-1	1/4
D1B-2	1/8
D1B-3	1/8
D2-1	1/8
D2-2	1/8
D2-3	1/8
D2-4	1/8
D3-1	1/4
D3-2	1/4*
D3-3	1/4
D3-4	1/4
D3-5	1/4
D3-6	1/4
D3-7	1/4
D4-1	1/16
D4-2	1/8
D4-3	1/8
D4-4	1/4
D4-5	1/8
D4-6	1/10*
D4-7	1/10

* additional fraction sorted for subsampling error

Table A1.2: Dome Water Chemistry QA/QC

Analysis of Water			EXPOSURE STATIONS					
Parameter	LOQ	Units	D1-1 Total	D1-1 Total Lab Rep	DQA (% diff) vs. LR	D1-1 Dissolved	D1-1 Dissolved Lab Rep	DQA (% diff) vs. LR
Acidity(as CaCO3)	1	mg/L	10	12	18.18	-	-	-
Alkalinity(as CaCO3)	1	mg/L	114	114	0.00	-	-	-
Aluminum	0.005	mg/L	0.018	-	-	0.013	-	-
Ammonia(as N)	0.05	mg/L	nd	0.05	-	-	-	-
Anion Sum	na	meq/L	3.16	-	-	-	-	-
Antimony	0.0005	mg/L	nd	-	-	nd	-	-
Arsenic	0.002	mg/L	0.002	-	-	0.002	-	-
Barium	0.005	mg/L	0.008	-	-	0.008	-	-
Beryllium	0.005	mg/L	nd	-	-	nd	-	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	113	-	-	-	-	-
Bismuth	0.002	mg/L	nd	-	-	nd	-	-
Boron	0.005	mg/L	0.019	0.019	0.00	nd	nd	-
Cadmium	0.00005	mg/L	nd	-	-	nd	-	-
Calcium	0.1	mg/L	33.9	35	3.19	35.6	36.1	1.39
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	-	-	-	-
Cation Sum	na	meq/L	3.05	-	-	-	-	-
Chloride	1	mg/L	26	26	0.00	-	-	-
Chromium	0.0005	mg/L	0.0007	-	-	nd	-	-
Cobalt	0.0002	mg/L	nd	-	-	nd	-	-
Colour	5	TCU	15	15	0.00	-	-	-
Conductivity - @25øC	1	us/cm	272	273	0.37	-	-	-
Copper	0.0003	mg/L	0.0007	-	-	0.0007	-	-
Cyanates	0.5	mg/L	-	-	-	nd	nd	-
Cyanide, Free	0.002	mg/L	-	-	-	nd	nd	-
Cyanide, Total	0.002	mg/L	-	-	-	nd	nd	-
Cyanide, weak acid dissociable	0.002	mg/L	-	-	-	nd	-	-
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	-	-	24.5	24.2	1.23
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	-	-	7	6.7	4.38
Hardness(as CaCO3)	0.1	mg/L	119	-	-	-	-	-
Ion Balance	0.01	%	1.84	-	-	-	-	-
Iron	0.02	mg/L	0.06	-	-	nd	-	-
Langelier Index at 20øC	na	na	0.088	-	-	-	-	-
Langelier Index at 4øC	na	na	-0.312	-	-	-	-	-
Lead	0.0001	mg/L	nd	-	-	0.0002	-	-
Magnesium	0.1	mg/L	6.6	6.7	1.50	7.2	7.3	1.38
Manganese	0.0005	mg/L	0.0043	-	-	0.0013	-	-
Mercury (total)	0.0001	mg/L	nd	nd	-	-	-	-
Mercury (dissolved)	0.0001	mg/L	-	-	-	nd	nd	-
Molybdenum	0.0001	mg/L	nd	-	-	nd	-	-
Nickel	0.001	mg/L	0.002	-	-	0.002	-	-
Nitrate(as N)	0.05	mg/L	nd	nd	-	-	-	-
Nitrite(as N)	0.01	mg/L	nd	nd	-	-	-	-
Orthophosphate(as P)	0.01	mg/L	nd	nd	-	-	-	-
pH	0.1	Units	7.9	8	1.26	-	-	-
Phosphorus	0.1	mg/L	nd	nd	-	nd	nd	-
Phosphorus, Total	0.01	mg/L	0.01	0.02	66.67	-	-	-
Potassium	0.5	mg/L	0.6	0.8	28.57	nd	nd	-
Reactive Silica(SiO2)	0.5	mg/L	2.1	2.1	0.00	-	-	-
Saturation pH at 20øC	na	units	7.84	-	-	-	-	-
Saturation pH at 4øC	na	units	8.24	-	-	-	-	-
Selenium	0.002	mg/L	nd	-	-	nd	-	-
Silver	0.00005	mg/L	nd	-	-	nd	-	-
Sodium	0.1	mg/L	15.2	15.7	3.24	15.2	15.4	1.31
Strontium	0.005	mg/L	0.049	-	-	0.049	-	-
Sulphate	2	mg/L	8	8	0.00	-	-	-
Thallium	0.0001	mg/L	nd	-	-	nd	-	-
Tin	0.002	mg/L	nd	-	-	nd	-	-
Titanium	0.002	mg/L	nd	-	-	nd	-	-
Total Dissolved Solids(Calculated)	1	mg/L	-	-	-	162	-	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.31	0.29	6.67	-	-	-
Total Suspended Solids	1	mg/L	nd	nd	-	-	-	-
Turbidity	0.1	NTU	0.8	0.9	11.76	-	-	-
Uranium	0.0001	mg/L	nd	-	-	nd	-	-
Vanadium	0.002	mg/L	nd	-	-	nd	-	-
Zinc	0.001	mg/L	0.001	-	-	nd	-	-
Fluoride	0.02	mg/L	0.03	0.03	0.00	-	-	-

Table A1.2: Dome Water Chemistry QA/QC

Analysis of Water Parameter	LOQ	Units	EXPOSURE STATIONS D4B-1 Total	 D4B-1 Total Lab Rep	 **DQA** **(% diff)** **vs. LR**	 D4B-1 Dissolved	 D4B-1 Dissolved Lab Rep	 **DQA** **(% diff)** **vs. LR**
Acidity(as CaCO3)	1	mg/L	8	6	**28.57**	-	-	-
Alkalinity(as CaCO3)	1	mg/L	215	222	**3.20**	-	-	-
Aluminum	0.005	mg/L	nd	-	-	nd	-	-
Ammonia(as N)	0.05	mg/L	nd	nd	-	-	-	-
Anion Sum	na	meq/L	14.3	-	-	-	-	-
Antimony	0.0005	mg/L	0.0019	-	-	0.002	-	-
Arsenic	0.002	mg/L	0.011	-	-	0.011	-	-
Barium	0.005	mg/L	0.031	-	-	0.032	-	-
Beryllium	0.005	mg/L	nd	-	-	nd	-	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	212	-	-	-	-	-
Bismuth	0.002	mg/L	nd	-	-	nd	-	-
Boron	0.005	mg/L	0.092	0.105	**13.20**	0.102	0.1	**1.98**
Cadmium	0.00005	mg/L	nd	-	-	0.00008	-	-
Calcium	0.1	mg/L	155	153	**1.30**	158	160	**1.26**
Carbonate(as CaCO3, calculated)	1	mg/L	3	-	-	-	-	-
Cation Sum	na	meq/L	14.8	-	-	-	-	-
Chloride	1	mg/L	47	46	**2.15**	-	-	-
Chromium	0.0005	mg/L	0.0008	-	-	nd	-	-
Cobalt	0.0002	mg/L	0.0054	-	-	0.0048	-	-
Colour	5	TCU	13	13	**0.00**	-	-	-
Conductivity - @25oC	1	us/cm	1220	1220	**0.00**	-	-	-
Copper	0.0003	mg/L	0.0156	-	-	0.0114	-	-
Cyanates	0.5	mg/L	-	-	-	nd	nd	-
Cyanide, Free	0.002	mg/L	-	-	-	nd	nd	-
Cyanide, Total	0.002	mg/L	-	-	-	nd	nd	-
Cyanide, weak acid dissociable	0.002	mg/L	-	-	-	nd	-	-
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	-	-	48	49	**2.06**
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	-	-	6.4	5.8	**9.84**
Hardness(as CaCO3)	0.1	mg/L	582	-	-	-	-	-
Ion Balance	0.01	%	1.9	-	-	-	-	-
Iron	0.02	mg/L	0.11	-	-	nd	-	-
Langelier Index at 20oC	na	na	1.17	-	-	-	-	-
Langelier Index at 4oC	na	na	0.77	-	-	-	-	-
Lead	0.0001	mg/L	nd	-	-	0.0001	-	-
Magnesium	0.1	mg/L	42.4	41.7	**1.66**	45.7	46	**0.65**
Manganese	0.0005	mg/L	0.0197	-	-	0.0186	-	-
Mercury (total)	0.0001	mg/L	nd	nd	-	-	-	-
Mercury (dissolved)	0.0001	mg/L	-	-	-	nd	nd	-
Molybdenum	0.0001	mg/L	0.0135	-	-	0.0124	-	-
Nickel	0.001	mg/L	0.069	-	-	0.063	-	-
Nitrate(as N)	0.05	mg/L	8.06	8	**0.75**	-	-	-
Nitrite(as N)	0.01	mg/L	nd	nd	-	-	-	-
Orthophosphate(as P)	0.01	mg/L	nd	nd	-	-	-	-
pH	0.1	Units	8.2	8.2	**0.00**	-	-	-
Phosphorus	0.1	mg/L	nd	nd	-	nd	nd	-
Phosphorus, Total	0.01	mg/L	0.02	0.02	**0.00**	-	-	-
Potassium	0.5	mg/L	20.2	19.9	**1.50**	19.9	20.5	**2.97**
Reactive Silica(SiO2)	0.5	mg/L	1.8	1.8	**0.00**	-	-	-
Saturation pH at 20oC	na	units	6.99	-	-	-	-	-
Saturation pH at 4oC	na	units	7.39	-	-	-	-	-
Selenium	0.002	mg/L	0.002	-	-	0.002	-	-
Silver	0.00005	mg/L	nd	-	-	nd	-	-
Sodium	0.1	mg/L	63.9	63.1	**1.26**	61.5	63.1	**2.57**
Strontium	0.005	mg/L	0.489	-	-	0.496	-	-
Sulphate	2	mg/L	389	na	-	-	-	-
Thallium	0.0001	mg/L	nd	-	-	nd	-	-
Tin	0.002	mg/L	nd	-	-	nd	-	-
Titanium	0.002	mg/L	0.007	-	-	0.006	-	-
Total Dissolved Solids(Calculated)	1	mg/L	887	-	-	-	-	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.91	0.79	**14.12**	-	-	-
Total Suspended Solids	1	mg/L	2	2	**0.00**	-	-	-
Turbidity	0.1	NTU	0.4	0.4	**0.00**	-	-	-
Uranium	0.0001	mg/L	0.0014	-	-	0.0012	-	-
Vanadium	0.002	mg/L	nd	-	-	nd	-	-
Zinc	0.001	mg/L	0.008	-	-	0.01	-	-
Fluoride	0.02	mg/L	nd!(0.10)	nd!(0.10)	-	-	-	-

Table A1.2: Dome Water Chemistry QA/QC

Analysis of Water Parameter	LOQ	Units	EXPOSURE STATIONS D4B-2 Total	D4B-2 Total Field Dup	DQA (% diff) vs. FD	D4B-2 Dissolved	D4B-2 Dissolved Field Dup	DQA (% diff) vs. FD
Acidity(as CaCO3)	1	mg/L	2	12	**142.86**	-	-	-
Alkalinity(as CaCO3)	1	mg/L	181	230	**23.84**	-	-	-
Aluminum	0.005	mg/L	0.008	0.007	**13.33**	0.006	nd	-
Ammonia(as N)	0.05	mg/L	0.05	0.12	**82.35**	-	-	-
Anion Sum	na	meq/L	13.2	14.7	**10.75**	-	-	-
Antimony	0.0005	mg/L	0.0016	0.0022	**31.58**	0.0017	0.0018	**5.71**
Arsenic	0.002	mg/L	0.011	0.011	**0.00**	0.009	0.009	**0.00**
Barium	0.005	mg/L	0.032	0.032	**0.00**	0.034	0.034	**0.00**
Beryllium	0.005	mg/L	nd	nd	-	nd	nd	-
Bicarbonate(as CaCO3, calculated)	1	mg/L	178	228	**24.63**	-	-	-
Bismuth	0.002	mg/L	nd	nd	-	nd	nd	-
Boron	0.005	mg/L	0.123	0.079	**43.56**	0.096	0.095	**1.05**
Cadmium	0.00005	mg/L	nd	nd	-	nd	0.00006	-
Calcium	0.1	mg/L	147	143	**2.76**	149	151	**1.33**
Carbonate(as CaCO3, calculated)	1	mg/L	3	2	**40.00**	-	-	-
Cation Sum	na	meq/L	14.2	14.3	**0.70**	-	-	-
Chloride	1	mg/L	47	51	**8.16**	-	-	-
Chromium	0.0005	mg/L	0.0009	0.0008	**11.76**	0.0006	0.0005	**18.18**
Cobalt	0.0002	mg/L	0.0053	0.0053	**0.00**	0.0049	0.0049	**0.00**
Colour	5	TCU	13	13	**0.00**	-	-	-
Conductivity - @25øC	1	us/cm	1190	1190	**0.00**	-	-	-
Copper	0.0003	mg/L	0.0103	0.0102	**0.98**	0.0091	0.0091	**0.00**
Cyanates	0.5	mg/L	-	-	-	nd	nd	-
Cyanide, Free	0.002	mg/L	-	-	-	nd	nd	-
Cyanide, Total	0.002	mg/L	-	-	-	nd	nd	-
Cyanide, weak acid dissociable	0.002	mg/L	-	-	-	nd	nd	-
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	-	-	46	48	**4.26**
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	-	-	6.1	5.7	**6.78**
Hardness(as CaCO3)	0.1	mg/L	545	552	**1.28**	-	-	-
Ion Balance	0.01	%	3.61	1.39	**88.80**	-	-	-
Iron	0.02	mg/L	0.23	0.23	**0.00**	0.02	0.02	**0.00**
Langelier Index at 20øC	na	na	1.15	1.06	**8.14**	-	-	-
Langelier Index at 4øC	na	na	0.753	0.659	**13.31**	-	-	-
Lead	0.0001	mg/L	nd	nd	-	0.0001	nd	-
Magnesium	0.1	mg/L	39.7	38.4	**3.33**	42.1	42.7	**1.42**
Manganese	0.0005	mg/L	0.112	0.109	**2.71**	0.128	0.102	**22.61**
Mercury (total)	0.0001	mg/L	nd	nd	-	-	-	-
Mercury (dissolved)	0.0001	mg/L	-	-	-	nd	nd	-
Molybdenum	0.0001	mg/L	0.012	0.0121	**0.83**	0.0111	0.0115	**3.54**
Nickel	0.001	mg/L	0.066	0.067	**1.50**	0.063	0.064	**1.57**
Nitrate(as N)	0.05	mg/L	6.54	7.12	**8.49**	-	-	-
Nitrite(as N)	0.01	mg/L	nd	nd	-	-	-	-
Orthophosphate(as P)	0.01	mg/L	nd	nd	-	-	-	-
pH	0.1	Units	8.2	8	**2.47**	-	-	-
Phosphorus	0.1	mg/L	nd	nd	-	nd	nd	-
Phosphorus, Total	0.01	mg/L	0.01	0.02	**66.67**	-	-	-
Potassium	0.5	mg/L	20.5	19.8	**3.47**	20	19.9	**0.50**
Reactive Silica(SiO2)	0.5	mg/L	2.6	2.5	**3.92**	-	-	-
Saturation pH at 20øC	na	units	7.09	6.98	**1.56**	-	-	-
Saturation pH at 4øC	na	units	7.49	7.38	**1.48**	-	-	-
Selenium	0.002	mg/L	nd	0.002	-	nd	nd	-
Silver	0.00005	mg/L	nd	nd	-	nd	nd	-
Sodium	0.1	mg/L	66.1	63.2	**4.49**	63.7	63.1	**0.95**
Strontium	0.005	mg/L	0.449	0.446	**0.67**	0.465	0.474	**1.92**
Sulphate	2	mg/L	374	392	**4.70**	-	-	-
Thallium	0.0001	mg/L	nd	nd	-	nd	nd	-
Tin	0.002	mg/L	nd	nd	-	nd	nd	-
Titanium	0.002	mg/L	0.007	0.007	**0.00**	0.006	0.006	**0.00**
Total Dissolved Solids(Calculated)	1	mg/L	-	-	-	836	891	**6.37**
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.79	0.81	**2.50**	-	-	-
Total Suspended Solids	1	mg/L	3	3	**0.00**	-	-	-
Turbidity	0.1	NTU	0.4	0.5	**22.22**	-	-	-
Uranium	0.0001	mg/L	0.0012	0.0012	**0.00**	0.001	0.0011	**9.52**
Vanadium	0.002	mg/L	nd	nd	-	nd	nd	-
Zinc	0.001	mg/L	0.008	0.008	**0.00**	0.007	0.007	**0.00**
Fluoride	0.02	mg/L	nd	1.97	-	-	-	-

Table A1.2: Dome Water Chemistry QA/QC

Analysis of Water Parameter	LOQ	Units	BLANKS Trip Blank	Filter Blank D4-1	Filter Blank D6-1	Filter Blank D6-2	Filter Blank D6-3
Acidity(as CaCO3)	1	mg/L	2	-	-	-	-
Alkalinity(as CaCO3)	1	mg/L	nd	-	-	-	-
Aluminum	0.005	mg/L	nd	nd	nd	nd	nd
Ammonia(as N)	0.05	mg/L	0.08	-	-	-	-
Anion Sum	na	meq/L	0.022	-	-	-	-
Antimony	0.0005	mg/L	nd	nd	nd	nd	nd
Arsenic	0.002	mg/L	nd	nd	nd	nd	nd
Barium	0.005	mg/L	nd	nd	nd	nd	nd
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	nd	-	-	-	-
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd
Boron	0.005	mg/L	0.008	0.224	nd	nd	0.006
Cadmium	0.00005	mg/L	nd	nd	0.00005	nd	nd
Calcium	0.1	mg/L	0.4	0.4	0.4	0.4	0.4
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	-	-	-
Cation Sum	na	meq/L	0.039	-	-	-	-
Chloride	1	mg/L	nd	-	-	-	-
Chromium	0.0005	mg/L	0.0009	0.0006	nd	nd	nd
Cobalt	0.0002	mg/L	nd	nd	nd	nd	nd
Colour	5	TCU	nd	-	-	-	-
Conductivity - @25oC	1	us/cm	6	-	-	-	-
Copper	0.0003	mg/L	0.0011	nd	nd	nd	nd
Cyanates	0.5	mg/L	nd	-	-	-	-
Cyanide, Free	0.002	mg/L	nd	-	-	-	-
Cyanide, Total	0.002	mg/L	nd	-	-	-	-
Cyanide, weak acid dissociable	0.002	mg/L	nd	-	-	-	-
Dissolved Inorganic Carbon(as C)	0.2	mg/L	0.3	-	-	-	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	ns	-	-	-	-
Hardness(as CaCO3)	0.1	mg/L	1.2	-	-	-	-
Ion Balance	0.01	%	28	-	-	-	-
Iron	0.02	mg/L	0.05	0.05	nd	nd	nd
Langelier Index at 20oC	na	na	-5.34	-	-	-	-
Langelier Index at 4oC	na	na	-5.74	-	-	-	-
Lead	0.0001	mg/L	0.0002	0.0002	nd	nd	nd
Magnesium	0.1	mg/L	nd	nd	nd	nd	nd
Manganese	0.0005	mg/L	nd	nd	nd	nd	nd
Mercury (total)	0.0001	mg/L	-	nd	-	-	-
Mercury (dissolved)	0.0001	mg/L	nd	-	-	-	-
Molybdenum	0.0001	mg/L	nd	nd	nd	nd	nd
Nickel	0.001	mg/L	nd	nd	nd	nd	nd
Nitrate(as N)	0.05	mg/L	nd	-	-	-	-
Nitrite(as N)	0.01	mg/L	nd	-	-	-	-
Orthophosphate(as P)	0.01	mg/L	nd	-	-	-	-
pH	0.1	Units	6.5	-	-	-	-
Phosphorus	0.1	mg/L	0.2	nd	nd	nd	nd
Phosphorus, Total	0.01	mg/L	nd	-	-	-	-
Potassium	0.5	mg/L	nd	nd	0.6	nd	0.7
Reactive Silica(SiO2)	0.5	mg/L	2.6	-	-	-	-
Saturation pH at 20oC	na	units	11.8	-	-	-	-
Saturation pH at 4oC	na	units	12.2	-	-	-	-
Selenium	0.002	mg/L	nd	nd	nd	nd	nd
Silver	0.00005	mg/L	0.00007	nd	nd	nd	nd
Sodium	0.1	mg/L	nd	0.4	nd	nd	nd
Strontium	0.005	mg/L	nd	nd	nd	nd	nd
Sulphate	2	mg/L	nd	-	-	-	-
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	nd	nd
Titanium	0.002	mg/L	nd	nd	nd	nd	nd
Total Dissolved Solids(Calculated)	1	mg/L	4	-	-	-	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	nd	-	-	-	-
Total Suspended Solids	1	mg/L	1	-	-	-	-
Turbidity	0.1	NTU	0.2	-	-	-	-
Uranium	0.0001	mg/L	nd	nd	nd	nd	nd
Vanadium	0.002	mg/L	nd	nd	nd	nd	nd
Zinc	0.001	mg/L	0.002	0.002	0.001	0.002	0.002
Fluoride	0.02	mg/L	nd				

Table A1.3: Dome Sediment QA/QC - Total Metals

Component	MDL	Units	D1B-1-S	D1B-1-S Replicate	DQA (% diff) vs. R	D2-3-S	D2-3-S Replicate	DQA (% diff) vs. R	D2-3-S M. Spike	D2-3-S MS % Rec.
Aluminum	1	mg/kg	4500	-	-	8100	-	-	-	-
Antimony	0.2	"	0.7	-	-	<	-	-	-	-
Arsenic	0.5	"	1100	-	-	200	-	-	-	-
Barium	0.5	"	22	-	-	41	-	-	-	-
Beryllium	0.2	"	<	-	-	<	-	-	-	-
Bismuth	0.5	"	<	-	-	<	-	-	-	-
Boron	2.5	"	<	-	-	<	-	-	-	-
Cadmium	0.05	"	0.24	-	-	0.44	-	-	-	-
Chromium	0.6	"	150	-	-	52	-	-	-	-
Cobalt	0.2	"	33	-	-	20	-	-	-	-
Copper	0.2	"	58	-	-	320	-	-	-	-
Iron	20	"	18000	-	-	26000	-	-	-	-
Lead	0.1	"	59	-	-	21	-	-	-	-
Manganese	1	"	420	-	-	830	-	-	-	-
Molybdenum	0.2	"	0.6	-	-	6.1	-	-	-	-
Nickel	0.5	"	250	-	-	52	-	-	-	-
Selenium	1	"	3.2	-	-	1.7	-	-	-	-
Silver	0.05	"	0.21	-	-	0.42	-	-	-	-
Strontium	0.5	"	41	-	-	42	-	-	-	-
Thallium	0.2	"	<	-	-	<	-	-	-	-
Tin	0.2	"	2.7	-	-	1.2	-	-	-	-
Titanium	0.3	"	63	-	-	260	-	-	-	-
Vanadium	1	"	17	-	-	29	-	-	-	-
Zinc	1	"	78	-	-	220	-	-	-	-
Calcium	20	mg/kg	30900	-	-	34550	-	-	-	-
Magnesium	20	"	30325	-	-	16082.5	-	-	-	-
pH (20 DEG C)			7.3	7.3	0.00	7.1	-	-	-	-
Loss on Ignition	0.1	(%)	13	-	-	9.1	-	-	-	-
Coarse Gravel (>4.8mm)	0.1	"	<	-	-	<	-	-	-	-
Fine Gravel (2.0-4.8mm)	0.1	"	0.5	-	-	8.9	-	-	-	-
V. Coarse Sand (1.0-2.0mm)	0.1	"	0.5	-	-	2.8	-	-	-	-
Coarse Sand (0.50-1.0mm)	0.1	"	<0.4	-	-	7.8	-	-	-	-
Med. Sand (0.25-0.50mm)	0.1	"	3.5	-	-	11	-	-	-	-
Fine Sand (0.10-0.25mm)	0.1	"	7.3	-	-	6.5	-	-	-	-
V. Fine Sand (0.050-0.10mm)	0.1	"	16	-	-	7.7	-	-	-	-
Silt (0.002-0.050mm)	0.1	"	55	-	-	46	-	-	-	-
Clay (<0.002mm)	0.1	"	17	-	-	9.5	-	-	-	-
Mercury	0.04	mg/kg	0.11	-	-	0.15	0.13	-	1.2	100
TOC(Solid)	0.1	(%)	4.6	-	-	2.9	-	-	-	-

Table A1.3: Dome Sediment QA/QC - Total Metals

Component	MDL	Units	D3-1-S	D3-1-S Replicate	DQA (% diff) vs. R	D3-1-S field dup 1	DQA (% diff) vs. FD	D3-1-S field dup 2	DQA (% diff) vs. FD	DQA (% diff) FD1 vs. FD2	D3-1-S field dup M. Spike	D3-1-S field dup MS % Rec.
Aluminum	1	mg/kg	6300	-	-	6600	4.65	5700	10.00	14.63	NA	NA
Antimony	0.2	"	0.2	-	-	0.6	100.00	0.4	66.67	40.00	52	100
Arsenic	0.5	"	180	-	-	160	11.76	140	25.00	13.33	650	100
Barium	0.5	"	19	-	-	18	5.41	18	5.41	0.00	66	94
Beryllium	0.2	"	<	-	-	<	-	<	-	-	430	86
Bismuth	0.5	"	<	-	-	<	-	<	-	-	52	110
Boron	2.5	"	<	-	-	<	-	<	-	-	410	82
Cadmium	0.05	"	0.2	-	-	0.19	5.13	0.17	16.22	11.11	51	100
Chromium	0.6	"	59	-	-	64	8.13	55	7.02	15.13	560	100
Cobalt	0.2	"	41	-	-	36	12.99	33	21.62	8.70	550	100
Copper	0.2	"	390	-	-	320	19.72	290	29.41	9.84	790	97
Iron	20	"	30000	-	-	31000	3.28	28000	6.90	10.17	NA	NA
Lead	0.1	"	7.5	-	-	9.2	20.36	15	66.67	47.93	61	96
Manganese	1	"	870	-	-	890	2.27	820	5.92	8.19	1300	98
Molybdenum	0.2	"	5.3	-	-	4.5	16.33	4.6	14.14	2.20	57	110
Nickel	0.5	"	220	-	-	180	20.00	170	25.64	5.71	670	99
Selenium	1	"	1.2	-	-	3.2	90.91	2.3	62.86	32.73	510	100
Silver	0.05	"	1.7	-	-	1.3	26.67	1.3	26.67	0.00	26	98
Strontium	0.5	"	48	-	-	51	6.06	51	6.06	0.00	100	98
Thallium	0.2	"	<	-	-	<	-	<	-	-	53	110
Tin	0.2	"	2.2	-	-	8.3	116.19	10	127.87	18.58	58	96
Titanium	0.3	"	110	-	-	120	8.70	100	9.52	18.18	600	98
Vanadium	1	"	25	-	-	27	7.69	23	8.33	16.00	530	100
Zinc	1	"	65	-	-	61	6.35	54	18.49	12.17	560	100
Calcium	20	mg/kg	31575	-	-	31250	1.03	31025	1.76	0.72	-	-
Magnesium	20	"	24337.5	-	-	23920	1.73	23692.5	2.69	0.96	-	-
pH (20 DEG C)			7.3	-	-	7.12	2.50	-	-	-	-	-
Loss on Ignition	0.1	(%)	7.9	5.9	28.99	5.2	41.22	-	-	-	-	-
Coarse Gravel (>4.8mm)	0.1	"	<	-	-	<	-	-	-	-	-	-
Fine Gravel (2.0-4.8mm)	0.1	"	4.4	-	-	5.5	22.22	-	-	-	-	-
V. Coarse Sand (1.0-2.0mm)	0.1	"	0.8	-	-	0.9	11.76	-	-	-	-	-
Coarse Sand (0.50-1.0mm)	0.1	"	2.1	-	-	1	70.97	-	-	-	-	-
Med. Sand (0.25-0.50mm)	0.1	"	4.5	-	-	2.9	43.24	-	-	-	-	-
Fine Sand (0.10-0.25mm)	0.1	"	3.6	-	-	2.9	21.54	-	-	-	-	-
V. Fine Sand (0.050-0.10mm)	0.1	"	12	-	-	1.6	152.94	-	-	-	-	-
Silt (0.002-0.050mm)	0.1	"	63	-	-	51	21.05	-	-	-	-	-
Clay (<0.002mm)	0.1	"	9.4	-	-	34	113.36	-	-	-	-	-
Mercury	0.04	mg/kg	0.12	-	-	0.11	8.70	-	-	-	-	-
TOC(Solid)	0.1	(%)	2.1	-	-	1.8	15.38	-	-	-	-	-

Table A1.3: Dome Sediment QA/QC - Total Metals

Component	MDL	Units	D3-3-S	D3-3-S Replicate	DQA (% diff) vs. R	D3-3-S M. Spike	D3-3-S MS % Rec.	D3-4-S	D3-4-S Replicate	DQA (% diff) vs. R
Aluminum	1	mg/kg	6900	6200	10.69	NA	NA	5000	-	-
Antimony	0.2	"	0.7	0.4	54.55	58	120	0.7	-	-
Arsenic	0.5	"	290	270	7.14	NA	NA	280	-	-
Barium	0.5	"	21	20	4.88	74	110	23	-	-
Beryllium	0.2	"	<	<	-	NA	NA	<	-	-
Bismuth	0.5	"	<	<	-	53	110	<	-	-
Boron	2.5	"	4.9	5	2.02	NA	NA	<	-	-
Cadmium	0.05	"	0.23	0.25	8.33	55	110	0.25	-	-
Chromium	0.6	"	64	57	11.57	NA	NA	56	-	-
Cobalt	0.2	"	39	36	8.00	NA	NA	49	-	-
Copper	0.2	"	660	610	7.87	NA	NA	730	-	-
Iron	20	"	37000	34000	8.45	NA	NA	28000	-	-
Lead	0.1	"	10	10	0.00	63	110	12	-	-
Manganese	1	"	1100	1000	9.52	NA	NA	810	-	-
Molybdenum	0.2	"	4.9	4.7	4.17	63	120	7.3	-	-
Nickel	0.5	"	230	220	4.44	NA	NA	260	-	-
Selenium	1	"	2.2	1.3	51.43	NA	NA	2.7	-	-
Silver	0.05	"	2.4	2.2	8.70	28	100	5.1	-	-
Strontium	0.5	"	59	56	5.22	110	110	59	-	-
Thallium	0.2	"	<	<	-	54	110	<	-	-
Tin	0.2	"	2.1	2.2	4.65	58	110	3	-	-
Titanium	0.3	"	75	69	8.33	NA	NA	61	-	-
Vanadium	1	"	26	24	8.00	NA	NA	23	-	-
Zinc	1	"	110	97	12.56	NA	NA	64	-	-
Calcium	20	mg/kg	36700	36175	1.44	-	-	33525	-	-
Magnesium	20	"	26725	26250	1.79	-	-	26425	-	-
pH (20 DEG C)			7.33	-	-	-	-	7.01	7.01	0.00
Loss on Ignition	0.1	(%)	4.8	-	-	-	-	6.9	-	-
Coarse Gravel (>4.8mm)	0.1	"	<	-	-	-	-	<	-	-
Fine Gravel (2.0-4.8mm)	0.1	"	3.5	-	-	-	-	2.8	-	-
V. Coarse Sand (1.0-2.0mm)	0.1	"	0.5	-	-	-	-	0.2	-	-
Coarse Sand (0.50-1.0mm)	0.1	"	0.8	-	-	-	-	2.3	-	-
Med. Sand (0.25-0.50mm)	0.1	"	3.4	-	-	-	-	7.4	-	-
Fine Sand (0.10-0.25mm)	0.1	"	5.9	-	-	-	-	11	-	-
V. Fine Sand (0.050-0.10mm)	0.1	"	19	-	-	-	-	11	-	-
Silt (0.002-0.050mm)	0.1	"	56	-	-	-	-	51	-	-
Clay (<0.002mm)	0.1	"	12	-	-	-	-	15	-	-
Mercury	0.04	mg/kg	0.12	-	-	-	-	0.12	-	-
TOC(Solid)	0.1	(%)	2.2	-	-	-	-	2.5	-	-

Table A1.3: Dome Sediment QA/QC - Total Metals

Component	MDL	Units	D4-1-S	D4-1-S Replicate	DQA (% diff) vs. R	D4-1-S M. Spike	D4-1-S MS % Rec.	D4-4S	D4-4S Replicate	DQA (% diff) vs. R	D4-4S M. Spike	D4-4S MS % Rec.
Aluminum	1	mg/kg	6400	-	-	-	-	8300	-	-	-	-
Antimony	0.2	"	0.3	-	-	-	-	0.6	-	-	-	-
Arsenic	0.5	"	55	-	-	-	-	74	-	-	-	-
Barium	0.5	"	24	-	-	-	-	34	-	-	-	-
Beryllium	0.2	"	<	-	-	-	-	0.6	-	-	-	-
Bismuth	0.5	"	<	-	-	-	-	<	-	-	-	-
Boron	2.5	"	<	-	-	-	-		-	-	-	-
Cadmium	0.05	"	0.37	-	-	-	-	0.5		-		
Chromium	0.6	"	33	-	-	-	-	38	-	-	-	-
Cobalt	0.2	"	23	-	-	-	-	30	-	-	-	-
Copper	0.2	"	270	-	-	-	-	370	-	-	-	-
Iron	20	"	21000	-	-	-	-	23000	-	-	-	-
Lead	0.1	"	19	-	-	-	-	19	-	-	-	-
Manganese	1	"	500	-	-	-	-	690	-	-	-	-
Molybdenum	0.2	"	2.4	-	-	-	-	3.5	-	-	-	-
Nickel	0.5	"	140	-	-	-	-	160	-	-	-	-
Selenium	1	"	2.1	-	-	-	-	2.1	-	-	-	-
Silver	0.05	"	0.73	-	-	-	-	1.2	-	-	-	-
Strontium	0.5	"	35	-	-	-	-	44	-	-	-	-
Thallium	0.2	"	<	-	-	-	-	<	-	-	-	-
Tin	0.2	"	3.3	-	-	-	-	2	-	-	-	-
Titanium	0.3	"	230	-	-	-	-	180	-	-	-	-
Vanadium	1	"	21	-	-	-	-	25	-	-	-	-
Zinc	1	"	130	-	-	-	-	170	-	-	-	-
Calcium	20	mg/kg	14927.5	-	-	-	-	19567.5	-	-	-	-
Magnesium	20	"	10455	-	-	-	-	15170	-	-	-	-
pH (20 DEG C)			6.93	-	-	-	-			-		
Loss on Ignition	0.1	(%)	8.1	-	-	-	-	10	10	-	-	-
Coarse Gravel (>4.8mm)	0.1	"	<	-	-	-	-	<	-	-	-	-
Fine Gravel (2.0-4.8mm)	0.1	"	2.9	-	-	-	-	1.9	-	-	-	-
V. Coarse Sand (1.0-2.0mm)	0.1	"	0.9	-	-	-	-	0.6	-	-	-	-
Coarse Sand (0.50-1.0mm)	0.1	"	3.7	-	-	-	-	0.7	-	-	-	-
Med. Sand (0.25-0.50mm)	0.1	"	9.9	-	-	-	-	2.4	-	-	-	-
Fine Sand (0.10-0.25mm)	0.1	"	9.6	-	-	-	-	2.8	-	-	-	-
V. Fine Sand (0.050-0.10mm)	0.1	"	11	-	-	-	-	5.1	-	-	-	-
Silt (0.002-0.050mm)	0.1	"	27	-	-	-	-	59	-	-	-	-
Clay (<0.002mm)	0.1	"	35	-	-	-	-	28	-	-	-	-
Mercury	0.04	mg/kg	0.71	0.69	2.86	1.8	110	1.2	1.1	8.70	2.1	88
TOC(Solid)	0.1	(%)	3	-	-	-	-	3.1	-	-	-	-

Table A1.3: Dome Sediment QA/QC - Total Metals

Component	MDL	Units	D4-2S	D4-2S Replicate	DQA (% diff) vs. R	D4-2S M. Spike	D4-2S MS % Rec.	D4-2S field dup	DQA (% diff) vs. FD	DQA (% diff) R vs. FD
Aluminum	1	mg/kg	8400	8900	5.78	10000	140	7700	8.70	14.46
Antimony	0.2	"	0.3	0.2	40.00	52	100	0.2	40.00	0.00
Arsenic	0.5	"	72	73	1.38	600	120	65	10.22	11.59
Barium	0.5	"	43	42	2.35	84	84	33	26.32	24.00
Beryllium	0.2	"	0.3	0.2	40.00	580	120	0.5	50.00	85.71
Bismuth	0.5	"	<	<	-	48	95	<	-	-
Boron	2.5	"								
Cadmium	0.05	"	0.6	0.6	0.00	51	100	0.5	18.18	18.18
Chromium	0.6	"	39	42	7.41	550	100	37	5.26	12.66
Cobalt	0.2	"	26	27	3.77	540	100	24	8.00	11.76
Copper	0.2	"	310	320	3.17	850	110	280	10.17	13.33
Iron	20	"	23000	25000	8.33	NA	NA	22000	4.44	12.77
Lead	0.1	"	20	21	4.88	63	84	17	16.22	21.05
Manganese	1	"	740	770	3.97	1300	110	680	8.45	12.41
Molybdenum	0.2	"	2.8	2.9	3.51	53	100	2.2	24.00	27.45
Nickel	0.5	"	150	150	0.00	660	100	140	6.90	6.90
Selenium	1	"	2.3	2.1	9.09	520	100	1.3	55.56	47.06
Silver	0.05	"	1.1	1.1	0.00	25	98	0.8	31.58	31.58
Strontium	0.5	"	44	46	4.44	88	86	38	14.63	19.05
Thallium	0.2	"	<	<	-	48	96	<	-	-
Tin	0.2	"	1.2	1.1	8.70	51	100	0.9	28.57	20.00
Titanium	0.3	"	190	210	10.00	710	98	180	5.41	15.38
Vanadium	1	"	25	26	3.92	540	100	23	8.33	12.24
Zinc	1	"	170	170	0.00	710	110	160	6.06	6.06
Calcium	20	mg/kg	19075	18460	3.28	-	-	17937.5	6.15	2.87
Magnesium	20	"	15302.5	14822.5	3.19	-	-	14407.5	6.02	2.84
pH (20 DEG C)					-					
Loss on Ignition	0.1	(%)	9.9	-	-	-	-	9.8	1.02	-
Coarse Gravel (>4.8mm)	0.1	"	<	-	-			<	-	-
Fine Gravel (2.0-4.8mm)	0.1	"	0.6	-	-			0.8	28.57	-
V. Coarse Sand (1.0-2.0mm)	0.1	"	0.4	-	-	-	-	0.6	40.00	-
Coarse Sand (0.50-1.0mm)	0.1	"	1.5	-	-	-	-	2.3	42.11	-
Med. Sand (0.25-0.50mm)	0.1	"	2.2	-	-	-	-	3.4	42.86	-
Fine Sand (0.10-0.25mm)	0.1	"	5.4	-	-	-	-	2.7	66.67	-
V. Fine Sand (0.050-0.10mm)	0.1	"	6	-	-	-	-	16	90.91	-
Silt (0.002-0.050mm)	0.1	"	41	-	-	-	-	40	2.47	-
Clay (<0.002mm)	0.1	"	43	-	-	-	-	35	20.51	-
Mercury	0.04	mg/kg	1.2	-	-	-	-	1.1	8.70	-
TOC(Solid)	0.1	(%)	3	-	-	-	-	2.8	6.90	-

Table A1.4: Dome Sediment QA/QC - Partially Extracted Metals

Component	MDL	Units	D3-1	D3-1 field dup	DQA (% diff) vs. FD	D3-1 field dup2	DQA (% diff) vs. FD	DQA (% diff) FD1 vs. FD2	D3-4	D3-4 Replicate	DQA (% diff) vs. R
Aluminum (ext.)	1	mg/kg	308	268	13.82	243	23.63	9.89	280	255	9.34
Antimony (ext.)	0.2	"	<	<	-	<	-	-	0.2	<	-
Arsenic (ext.)	0.5	"	108	81	27.96	73	38.26	10.59	227	213	6.30
Barium (ext.)	0.5	"	16	11	33.55	11	31.56	2.05	15	15	1.84
Beryllium (ext.)	0.2	"	<	<	-	<	-	-	<	<	-
Bismuth (ext.)	0.5	"	<	<	-	<	-	-	<	<	-
Cadmium (ext.)	0.05	"	0.13	0.10	28.06	0.09	36.90	9.07	0.12	0.12	0.00
Chromium (ext.)	0.6	"	6.3	6.1	2.46	5.7	9.09	6.64	5.9	5.5	6.70
Cobalt (ext.)	0.2	"	9.7	9.2	5.63	8.3	15.78	10.17	18.0	17.6	2.30
Copper (ext.)	0.2	"	4.2	4.8	14.08	4.7	12.25	1.84	7.5	6.5	14.86
Iron (ext.)	20	"	10000	9300	7.25	8400	17.39	10.17	13000	18000	32.26
Lead (ext.)	0.1	"	3.8	2.6	37.74	2.6	38.71	1.01	3.9	4.0	3.28
Manganese (ext.)	1	"	615	552	10.82	499	20.85	10.09	683	642	6.21
Molybdenum (ext.)	0.2	"	0.5	0.3	41.66	0.3	51.98	10.91	0.5	0.4	19.05
Nickel (ext.)	0.5	"	101	81	21.85	72	34.27	12.66	180	171	4.71
Selenium (ext.)	1	"	<	<	-	<	-	-	<	<	-
Silver (ext.)	0.05	"	<	<	-	<	-	-	<	<	-
Strontium (ext.)	0.5	"	26	20	25.17	19	28.96	3.86	21	21	0.14
Thallium (ext.)	0.2	"	<	<	-	<	-	-	<	<	-
Tin (ext.)	0.2	"	<	<	-	<	-	-	<	<	-
Titanium (ext.)	0.3	"	2.1	0.4	128.43	0.4	135.40	12.32	0.3	<	-
Vanadium (ext.)	1	"	6.7	6.7	0.18	6.1	10.13	10.30	7.6	6.9	9.56
Zinc (ext.)	1	"	33	28	16.72	25	26.75	10.13	54	42	25.30
Calcium	20	mg/kg	33640	30220	10.71	32220	4.31	6.41	31820	32260	1.37
Magnesium	20	"	15002	13628	9.60	14464	3.65	5.95	14218	14450	1.62

Table A1.4: Dome Sediment QA/QC - Partially Extracted Metals

Component	MDL	Units	D4-2	D4-2 field dup	**DQA (% diff) vs. FD**	D4-3	D4-3 Replicate	**DQA (% diff) vs. R**
Aluminum (ext.)	1	mg/kg	334	298	**11.46**	411	433	**5.17**
Antimony (ext.)	0.2	"	<	<	-	<	<	-
Arsenic (ext.)	0.5	"	31	32	**3.01**	26	26	**2.52**
Barium (ext.)	0.5	"	17	16	**5.04**	15	15	**1.16**
Beryllium (ext.)	0.2	"	<	<	-	0.3	<	-
Bismuth (ext.)	0.5	"	<	<	-	<	<	-
Cadmium (ext.)	0.05	"	0.22	0.20	**5.93**	0.17	0.17	**0.48**
Chromium (ext.)	0.6	"	4.3	3.9	**9.59**	4.2	4.3	**4.04**
Cobalt (ext.)	0.2	"	7.8	6.9	**11.96**	6.7	6.9	**2.82**
Copper (ext.)	0.2	"	3.7	3.1	**17.86**	4.1	4.4	**6.92**
Iron (ext.)	20	"	6800	6500	**4.51**	6100	6200	**1.63**
Lead (ext.)	0.1	"	6.9	6.3	**8.56**	4.0	3.7	**6.60**
Manganese (ext.)	1	"	434	410	**5.73**	319	325	**1.89**
Molybdenum (ext.)	0.2	"	<	<	-	<	<	-
Nickel (ext.)	0.5	"	64	58	**10.42**	41	41	**0.03**
Selenium (ext.)	1	"	<	<	-	<	<	-
Silver (ext.)	0.05	"	<	<	-	<	<	-
Strontium (ext.)	0.5	"	22	24	**6.56**	20	19	**1.78**
Thallium (ext.)	0.2	"	<	<	-	<	<	-
Tin (ext.)	0.2	"	<	<	-	<	<	-
Titanium (ext.)	0.3	"	0.6	0.6	**2.82**	1.0	1.4	**37.14**
Vanadium (ext.)	1	"	6.0	6.0	**0.33**	7.1	7.2	**1.46**
Zinc (ext.)	1	"	77	71	**8.46**	59	61	**3.57**
Calcium	20	mg/kg	17432	17040	**2.27**	10280	10134	**1.43**
Magnesium	20	"	7070	6612	**6.69**	3884	3798	**2.24**

Table A1.5: Dome Sediment QA/QC - Simultaneously Extracted Metals

Component	MDL	Units	D3-1-S	D3-1-S field dup	DQA (% diff) vs. FD	D3-3-S	D3-3-S Replicate	DQA (% diff) vs. R	D3-6-S	D3-6-S Replicate	DQA (% diff) vs. R	D4-4S	D4-4S Replicate	DQA (% diff) vs. R
Aluminum	2	umol/g	88.4	92.3	**4.34**	144.3	96.2	**40.00**	70.3	103.1	**37.84**	73.5	57.3	**24.76**
Barium	0.1	"	0.2	0.2	**1.23**	0.3	0.3	**17.28**	0.1	0.2	**12.50**	0.2	0.2	**7.41**
Beryllium	0.1	"	<	<	-	<	<	-	<	<	-	<	<	-
Boron	1	"	1.3	2.7	**69.95**	3.5	8.2	**80.31**	1.9	2.0	**8.96**	1.7	1.9	**8.55**
Cadmium	0.05	"	<	<	-	<	<	-	<	<	-	<	<	-
Calcium	7	"	983.0	1035.6	**5.21**	2016.9	1543.8	**26.57**	1183.2	1325.2	**11.32**	461.3	503.2	**8.70**
Chromium	0.1	"	0.3	0.3	**5.43**	0.5	0.3	**41.86**	0.2	0.3	**33.33**	0.1	0.1	**42.42**
Cobalt	0.2	"	0.3	0.3	**2.47**	0.4	0.5	**3.77**	0.2	0.3	**8.33**	0.2	0.1	**3.77**
Copper	0.1	"	6.1	3.9	**43.82**	2.7	<	-	1.5	0.8	-	1.9	0.1	-
Iron	0.2	"	492.4	510.1	**3.53**	1001.6	769.1	**26.26**	543.9	634.6	**15.38**	283.1	271.1	**4.35**
Lead	0.4	"	<	<	-	<	<	-	<	<	-	<	<	-
Magnesium	3	"	710.9	747.2	**4.98**	1405.6	1035.7	**30.30**	796.8	937.5	**16.22**	274.1	274.1	**0.00**
Manganese	0.1	"	19.8	20.5	**3.43**	50.9	40.0	**24.00**	24.2	26.5	**9.09**	10.4	11.0	**5.71**
Molybdenum	0.1	"	<	<	-	<	<	-	<	<	-	<	<	-
Nickel	0.2	"	3.1	2.6	**16.25**	6.5	4.6	**33.85**	3.3	3.9	**14.93**	1.7	1.7	**0.00**
Potassium	10	"	<	<	-	<	<	-	<	<	-	<	<	-
Silver	0.1	"	<	<	-	<	<	-	<	<	-	<	<	-
Sodium	6	"	10.4	11.1	**6.69**	20.4	20.0	**2.15**	11.8	10.7	**9.76**	7.9	8.6	**8.85**
Strontium	0.1	"	0.6	0.6	**6.18**	1.3	0.9	**27.98**	0.7	0.7	**8.33**	0.4	0.4	**11.54**
Sulphur	3	"	12.4	17.9	**36.12**	23.0	18.7	**20.90**	27.6	25.6	**7.41**	7.9	62.8	**155.56**
Thallium	0.5	"	<	<	-	<	<	-	<	<	-	<	<	-
Tin	0.5	"	<	<	-	<	<	-	<	<	-	<	<	-
Titanium	0.3	"	0.9	0.9	**6.98**	1.1	0.9	**29.17**	0.8	0.9	**20.47**	0.9	0.9	**0.00**
Vanadium	0.1	"	0.2	0.2	**3.43**	0.4	0.3	**30.30**	0.2	0.3	**25.64**	0.1	0.1	**15.38**
Zinc	0.1	"	1.1	1.0	**10.67**	3.1	2.3	**28.57**	1.8	1.9	**5.13**	2.2	2.1	**2.41**
Zirconium	0.5	"	<	<	-	<	<	-	<	<	-	<	<	-
Sum of SEM (Cd/Cu/Ni/Pb/Zn)	0.1	umol/g	10.3	7.5	**31.09**	12.2	6.9	**55.64**	6.7	6.6	**1.23**	5.8	3.9	**39.14**
AV Sulphide	0.1	umol/g	135.0	97.5	**32.26**	42.0	49.0	**15.38**	174.0	180.0	**3.39**	37.3	20.4	**58.58**
SEM/AVS Ratio	0.1		0.08	0.08	**1.20**	0.29	0.14	**69.54**	0.04	0.04	**4.61**	0.15	0.19	**20.62**

Table A1.6: Dome Sediment - Comparison of Aqua Regia Metals to Total Metals

Component	MDL	Units	D2-1-S Total	D2-1-S AR	DQA (% diff) vs. R.	D3-7-S Total	D3-7-S AR	DQA (% diff) vs. R.
Aluminum	30	mg/kg	7900	6800	**14.97**	6500	4800	**30.09**
Barium	0.2	"	36	29	**21.54**	15	12	**22.22**
Beryllium	0.1	"	<	0.1	-	<	<	-
Boron	10	"	<	<	-	<	<	-
Cadmium	0.2	"	0.36	0.5	**32.56**	0.2	0.5	**85.71**
Calcium	20	"	-	27000	-	-	35000	-
Chromium	5	"	47	34	**32.10**	68	37	**59.05**
Cobalt	5	"	22	18	**20.00**	43	38	**12.35**
Copper	5	"	290	300	**3.39**	650	680	**4.51**
Iron	5	"	27000	26000	**3.77**	35000	35000	**0.00**
Lead	10	"	18	15	**18.18**	12	10	**18.18**
Magnesium	40	"	-	11000	-	-	20000	-
Manganese	5	"	830	800	**3.68**	990	1000	**1.01**
Molybdenum	1	"	6.1	2	**101.23**	5.1	2	**87.32**
Nickel	5	"	49	41	**17.78**	220	200	**9.52**
Phosphorus	50	"	-	520	-	-	410	-
Potassium	100	"	-	490	-	-	310	-
Silicon	10	"	-	480	-	-	550	-
Silver	0.5	"	0.45	<	-	2.6	1.4	**60.00**
Sodium	50	"	-	78	-	-	84	-
Strontium	0.1	"	37	29	**24.24**	55	45	**20.00**
Sulphur	10	"	-	6700	-	-	11000	-
Thallium	20	"	<	<	-	<	<	-
Tin	5	"	2.6	<	-	1.1	<	-
Titanium	5	"	230	210	**9.09**	68	59	**14.17**
Vanadium	10	"	29	22	**27.45**	28	19	**38.30**
Zinc	5	"	240	220	**8.70**	94	90	**4.35**
Zirconium	5	"	-	<	-	-	<	-

Table A1.7: Dome Sediment - Comparison of Simultaneously Extracted Metals to Total Metals

Component	MDL	Units	D1B-1-S SEM	D1B-1-S Tot	D1B-2-S SEM	D1B-2-S Tot	D1B-3-S SEM	D1B-3-S Tot	D2-1-S SEM	D2-1-S Tot	D2-2-S SEM	D2-2-S Tot
Aluminum	2	mg/kg	2689.9	4500	2166.2	2700	3502.6	2900	3374.1	7900	5062.6	6900
Barium	0.1	mg/kg	31.7	22	26.8	25	39.9	26	35.9	36	57.4	36
Beryllium	0.1	mg/kg	<	<	<	<	<	<	<	<	<	0.2
Boron	1	mg/kg	15.4	<	18.6	<	25.4	<	16.0	<	31.7	<
Cadmium	0.05	mg/kg	<	0.24	<	0.47	<	0.4	<	0.36	<	0.29
Chromium	0.1	mg/kg	34.6	150	5.3	29	5.7	14	12.7	47	17.4	40
Cobalt	0.2	mg/kg	50.0	33	<	5.8	<	4	11.1	22	16.6	19
Copper	0.1	mg/kg	<	58	<	12	<	10	154.9	290	120.9	260
Iron	0.2	mg/kg	29804.1	18000	4335.8	6000	7131.6	5000	19374.7	27000	27979.7	22000
Lead	0.4	mg/kg	<	59	<	16	<	11	<	18	<	16
Manganese	0.1	mg/kg	961.3	420	175.5	130	193.4	110	885.6	830	1512.2	780
Molybdenum	0.1	mg/kg	<	0.6	<	0.3	<	0.3	<	6.1	<	4.5
Nickel	0.2	mg/kg	432.3	250	27.8	32	20.5	13	34.3	49	83.1	43
Silver	0.1	mg/kg	<	0.21	<	0.09	<	0.08	<	0.45	<	0.33
Strontium	0.1	mg/kg	65.3	41	14.4	16	25.4	18	32.1	37	49.1	33
Thallium	0.5	mg/kg	<	<	<	<	<	<	<	<	<	<
Tin	0.5	mg/kg	<	2.7	<	2.3	<	3.4	<	2.6	<	2
Titanium	0.3	mg/kg	42.3	63	38.2	120	61.6	150	77.4	230	128.4	250
Vanadium	0.1	mg/kg	8.4	17	<	7.4	8.2	7.4	13.3	29	19.7	25
Zinc	0.1	mg/kg	153.7	78	61.9	50	169.0	64	270.9	240	362.6	190

Table A1.7: Dome Sediment - Comparison of Simultaneously Extracted Metals to Total Metals

Component	MDL	Units	D2-3-S SEM	D2-3-S Tot	D2-4-S SEM	D2-4-S Tot	D3-1-S SEM	D3-1-S Tot	D3-2-S SEM	D3-2-S Tot	D3-3-S SEM	D3-3-S Tot
Aluminum	2	mg/kg	4560.7	8100	6765.7	6300	2384.8	6300	2915.4	6800	3892.4	6900
Barium	0.1	mg/kg	44.5	41	70.5	33	22.8	19	33.8	16	43.9	21
Beryllium	0.1	mg/kg	<	<	<	<	<	<	<	<	<	<
Boron	1	mg/kg	35.7	<	33.8	<	14.0	<	26.8	<	37.9	4.9
Cadmium	0.05	mg/kg	<	0.44	<	0.52	<	0.2	<	0.19	<	0.23
Chromium	0.1	mg/kg	17.0	52	25.4	61	13.5	59	18.4	72	25.9	64
Cobalt	0.2	mg/kg	10.4	20	14.1	16	17.6	41	16.9	44	25.9	39
Copper	0.1	mg/kg	109.9	320	62.0	140	388.8	390	<	610	169.7	660
Iron	0.2	mg/kg	20896.7	26000	29623.2	17000	27498.5	30000	45300.9	37000	55935.3	37000
Lead	0.4	mg/kg	<	21	<	18	<	7.5	<	8.9	<	10
Manganese	0.1	mg/kg	989.7	830	592.4	290	1089.4	870	2072.8	1200	2796.3	1100
Molybdenum	0.1	mg/kg	<	6.1	<	2.2	<	5.3	<	3.8	<	4.9
Nickel	0.2	mg/kg	38.5	52	100.1	61	181.4	220	230.1	240	379.2	230
Silver	0.1	mg/kg	<	0.42	<	0.17	<	1.7	<	1.4	<	2.4
Strontium	0.1	mg/kg	41.2	42	49.3	24	51.9	48	92.1	53	109.8	59
Thallium	0.5	mg/kg	<	<	<	<	<	<	<	<	<	<
Tin	0.5	mg/kg	<	1.2	<	1.3	<	2.2	<	2.4	<	2.1
Titanium	0.3	mg/kg	109.9	260	84.6	190	41.5	110	43.7	84	54.9	75
Vanadium	0.1	mg/kg	15.4	29	22.6	22	10.9	25	14.6	29	19.0	26
Zinc	0.1	mg/kg	274.6	220	225.4	97	72.6	65	153.4	100	199.5	110

Table A1.7: Dome Sediment - Comparison of Simultaneously Extracted Metals to Total Metals

Component	MDL	Units	D3-4-S SEM	D3-4-S Tot	D3-5-S SEM	D3-5-S Tot	D3-6-S SEM	D3-6-S Tot	D3-7-S SEM	D3-7-S Tot	D4-1-S SEM	D4-1-S Tot
Aluminum	2	mg/kg	2983.7	5000	2293.4	6500	1897.0	5600	2052.3	6500	4613.7	6400
Barium	0.1	mg/kg	29.8	23	22.2	20	19.0	18	16.1	15	42.7	24
Beryllium	0.1	mg/kg	<	<	<	<	<	<	<	<	<	<
Boron	1	mg/kg	26.7	<	29.9	<	20.2	<	12.8	<	35.0	<
Cadmium	0.05	mg/kg	<	0.25	<	0.24	<	0.24	<	0.2	<	0.37
Chromium	0.1	mg/kg	19.5	56	13.9	70	12.6	61	14.4	68	15.4	33
Cobalt	0.2	mg/kg	31.9	49	9.7	45	14.5	38	19.4	43	18.8	23
Copper	0.1	mg/kg	288.1	730	<	780	94.9	700	310.6	650	393.0	270
Iron	0.2	mg/kg	41186.9	28000	29211.5	34000	30376.5	31000	28865.1	35000	29071.9	21000
Lead	0.4	mg/kg	<	12	<	13	<	14	<	12	<	19
Manganese	0.1	mg/kg	1544.3	810	1182.2	870	1328.8	900	1165.5	990	812.2	500
Molybdenum	0.1	mg/kg	<	7.3	<	5.1	<	4.9	<	5.1	<	2.4
Nickel	0.2	mg/kg	390.9	260	145.9	240	196.0	230	199.7	220	230.7	140
Silver	0.1	mg/kg	<	5.1	<	3.1	<	2.7	<	2.6	<	0.73
Strontium	0.1	mg/kg	68.9	59	58.4	57	58.2	61	51.6	55	64.9	35
Thallium	0.5	mg/kg	<	<	<	<	<	<	<	<	<	<
Tin	0.5	mg/kg	<	3	<	3.9	<	8.8	<	1.1	<	3.3
Titanium	0.3	mg/kg	44.2	61	41.7	97	36.0	79	30.0	68	102.5	230
Vanadium	0.1	mg/kg	15.4	23	11.8	28	10.8	25	11.1	28	16.2	21
Zinc	0.1	mg/kg	113.1	64	111.2	100	120.1	88	105.3	94	256.2	130

Table A1.7: Dome Sediment - Comparison of Simultaneously Extracted Metals to Total Metals

Component	MDL	Units	D4-4S SEM	D4-4S Tot	D4-7S SEM	D4-7S Tot	D4-5S SEM	D4-5S Tot	D4-2S SEM	D4-2S Tot	D4-3S SEM	D4-3S Tot
Aluminum	2	mg/kg	1983.3	8300	1427.6	9600	5360.0	9200	5115.2	8400	4290.9	11000
Barium	0.1	mg/kg	21.8	34	16.9	33	61.1	23	60.8	43	37.0	38
Beryllium	0.1	mg/kg	<	0.6	<	0.2	<	0.2	<	0.3	<	0.4
Boron	1	mg/kg	18.8		14.3		112.8		38.5		29.5	
Cadmium	0.05	mg/kg	<	0.5	<	0.6	<	0.5	<	0.6	<	0.4
Chromium	0.1	mg/kg	6.7	38	7.0	46	16.9	45	16.3	39	11.3	50
Cobalt	0.2	mg/kg	9.1	30	9.7	33	29.2	32	25.2	26	12.3	21
Copper	0.1	mg/kg	121.0	370	108.9	380	225.7	560	274.3	310	193.1	260
Iron	0.2	mg/kg	15811.6	23000	11865.8	29000	56465.0	30000	38579.5	23000	19324.4	25000
Lead	0.4	mg/kg	<	19	<	20	<	22	<	20	<	15
Manganese	0.1	mg/kg	571.8	690	460.0	830	2164.2	800	1483.6	740	515.2	580
Molybdenum	0.1	mg/kg	<	3.5	<	3.6	<	3.9	<	2.8	<	2
Nickel	0.2	mg/kg	100.8	160	75.0	170	253.9	160	244.6	150	96.5	110
Silver	0.1	mg/kg	<	1.2	<	1.3	<	1.5	<	1.1	<	0.7
Strontium	0.1	mg/kg	32.9	44	26.6	50	131.7	43	81.6	44	38.1	37
Thallium	0.5	mg/kg	<	<	<	<	<	<	<	<	<	<
Tin	0.5	mg/kg	<	2	<	1.5	<	1.9	<	1.2	<	0.9
Titanium	0.3	mg/kg	43.7	180	29.0	180	122.2	160	103.8	190	80.5	260
Vanadium	0.1	mg/kg	7.1	25	5.8	29	20.7	28	16.3	25	12.3	31
Zinc	0.1	mg/kg	141.1	170	106.4	190	498.2	210	326.1	170	139.4	150

Table A1.7: Dome Sediment - Comparison of Simultaneously Extracted Metals to Total Metals

Component	MDL	Units	D4-6S SEM	D4-6S Tot
Aluminum	2	mg/kg	2709.6	8500
Barium	0.1	mg/kg	30.1	29
Beryllium	0.1	mg/kg	<	0.2
Boron	1	mg/kg	47.7	
Cadmium	0.05	mg/kg	<	0.6
Chromium	0.1	mg/kg	9.0	44
Cobalt	0.2	mg/kg	13.0	29
Copper	0.1	mg/kg	65.2	410
Iron	0.2	mg/kg	24606.8	27000
Lead	0.4	mg/kg	<	22
Manganese	0.1	mg/kg	954.0	780
Molybdenum	0.1	mg/kg	<	3.9
Nickel	0.2	mg/kg	125.4	150
Silver	0.1	mg/kg	<	1.7
Strontium	0.1	mg/kg	50.2	46
Thallium	0.5	mg/kg	<	<
Tin	0.5	mg/kg	<	2.2
Titanium	0.3	mg/kg	65.2	150
Vanadium	0.1	mg/kg	9.0	27
Zinc	0.1	mg/kg	195.6	190

Table A1.8: Dome Water Toxicity QA/QC

Organism	MSD (%)	Control Mortality (%)	Control CV (%)	Reference toxicant CV[3] (%)	Reference toxicant Endpoint[3]	Warning Limits (Mean ± 2 std.dev.)	Control Limits (Mean ± 3 std.dev.)
Ceriodaphnia dubia							
P-E-1	-[1]	0	23	13	1700	1170 - 1980	963 - 2180
P-E-2	-	0	21	13	1590	1170 - 1970	965 - 2170
P-E-3	-	0	43	14	1390	1100 - 1940	896 - 2150
Fathead Minnow							
P-E-1	-	8	5.3	20	1610	672 - 1600	440 - 1830
P-E-2	-	3	4.3	18	1100	705 - 1490	510 - 1680
P-E-3	16	3	4.2	-	1360	698 - 1480	501 - 1680
Selenastrum capricornutum							
M-E-1	11	na[2]	10	35[4]	11.4	7.6 - 41.3	-0.8 - 49.7
M-E-2	20	na	17	40	46.2	5.2 - 49	-5.8 - 59.9
M-E-3	22	na	12	42	35.4	4.6 - 55.4	-8.0 - 68.1

[1] - = MSD (minimum significant difference) value not available from the statistical methods used.

[2] na = Not applicable for the corresponding test.

[3] Based on IC50 for *Ceriodaphnia dubia* and Fathead Minnow and IC25 for *Selenastrum capricornutum*.

[4] The high CV values associated with the algae test are largely the result of the recent adaptation of the test by Beak. As a result, the control chart for this test is not as established as those for other reference toxicant tests. It is expected that after more points are added to the control chart, the CV will be reduced to a level consistent with the Ceriodaphnia and fathead minnow reference toxicant tests (approximately 20%). Higher variability with the Selenastrum test may also be attributed to the reference toxicant, zinc sulphate, which does not provide as consistent results as do salts, such as sodium chloride and potassium chloride. Variability associated with the reference toxicant test is considered to be a function of issues specific to the reference testing, such as the toxicant, and is not representative of the effluent test results. During the CANMET project, three Selenastrum tests were conducted in parallel, one for each mine site. Results of each pair of tests were within each other's confidence limits, even though different dilution waters were used. The average difference between IC50s for each pair was 16%, indicating a high degree of precision.

Table A1.9: Dome Sediment Toxicity QA/QC

Control Statistics

Organism	Control Mortality (%)	Control CV (%)
Chironomus riparius	6 - 14	6 - 11
Hyalella azteca	2 - 20	0 - 11

Chironomus riparius Re-Tests

	D3-2	D3-2 re-test	**DQA (%)**
Survival ± SD	80 ± 12	84 ± 11	**4.88**
CV (%)	15	14	
Mean dw/org ± SD (mg)	0.75 ± 0.19	0.65 ± 0.04	**14.29**
CV (%)	26	7	

Hyalella azteca Re-Tests

	D1B	D1B re-test	**DQA (%)**	D3-1	D3-1 re-test	**DQA (%)**
Survival ± SD	84 ± 15	74 ± 6	**12.66**	52 ± 31	42 ± 16	**21.28**
CV (%)	18	7		60	39	
Mean dw/org ± SD (mg)	0.14 ± 0.03	0.14 ± .02	**0.00**	0.10 ± .01	0.09 ± .01	**10.53**
CV (%)	24	17		11	16	

CERTIFICATE OF ACCREDITATION

CERTIFICAT D'ACCRÉDITATION

Zenon Environmental Inc.

ZENON ENVIRONMENTAL LABORATORIES INC. – BURLINGTON

5555 North Service Road, Burlington, ON

having been assessed by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc., under the authority of the Standards Council of Canada (SCC), and found to comply with the requirements of the ISO/IEC Guide 25, the conditions established by the SCC and the CAEAL proficiency testing program, is hereby recognized as an

ACCREDITED ENVIRONMENTAL LABORATORY

for specific tests or types of tests listed in the scope of accreditation approved by the Standards Council of Canada.

ACLAE

CAEAL

ayant été soumis à une évaluation par l'Association canadienne des laboratoires d'analyse environnementale (ACLAE) Inc., sous l'autorité du Conseil canadien des normes (CCN), et ayant été trouvé conforme aux prescriptions du Guide ISO/CEI 25, aux conditions établies par le CCN et au programme d'essais d'aptitude de l'ACLAE, est de fait reconnu comme

LABORATOIRE DE L'ENVIRONNEMENT ACCRÉDITÉ

pour des essais ou types d'essais déterminés inscrits dans la portée d'accréditation approuvée par le Conseil canadien des normes.

Accredited Laboratory No.
No de laboratoire accrédité : 197

Accreditation Date
Date d'accréditation: 1995-03-06

Issued on
Émis ce : 1995-03-06

Expiry date
Date d'expiration : 1998-03-06

Richard Lafontaine

President, SCC / Président, CCN

Assessment performed according to the *General Requirements for the Accreditation of Calibration and Testing Laboratories*, CAN-P-4 (ISO/IEC Guide 25), *Requirements for the Competence of Environmental Analytical Laboratories*, CAN/CSA-Z753 and the *Conditions for the Accreditation of Calibration and Testing Laboratories*, CAN-P-1515.
The scope of accreditation is available from the accredited laboratory or SCC.

Évaluation effectuée conformément aux *Prescriptions générales concernant la compétence des laboratoires d'étalonnage et d'essais*, CAN-P-4 (Guide ISO/CEI 25), aux *Exigences visant les compétences des laboratoires de l'environnement*, CAN/CSA-Z753 et aux *Conditions d'accréditation des laboratoires d'étalonnage et d'essais*, CAN-P-1515.
La portée d'accréditation est disponible auprès du laboratoire accrédité ou du CCN.

CERTIFICATE OF ACCREDITATION

CERTIFICAT D'ACCRÉDITATION

Beak Consultants Ltd.
ECOTOXICITY LABORATORY
14 Abacus Road, Brampton, ON

having been assessed by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc., under the authority of the Standards Council of Canada (SCC), and found to comply with the requirements of the ISO/IEC Guide 25, the conditions established by the SCC and the CAEAL proficiency testing program, is hereby recognized as an

ACCREDITED ENVIRONMENTAL LABORATORY

for specific tests or types of tests listed in the scope of accreditation approved by the Standards Council of Canada.

ACLAE
CAEAL

ayant été soumis à une évaluation par l'Association canadienne des laboratoires d'analyse environnementale (ACLAE) Inc., sous l'autorité du Conseil canadien des normes (CCN), et ayant été trouvé conforme aux prescriptions du Guide ISO/CEI 25, aux conditions établies par le CCN et au programme d'essais d'aptitude de l'ACLAE, est de fait reconnu comme

LABORATOIRE DE L'ENVIRONNEMENT ACCRÉDITÉ

pour des essais ou types d'essais déterminés inscrits dans la portée d'accréditation approuvée par le Conseil canadien des normes.

Accredited Laboratory No.
No de laboratoire accrédité : 168

Accreditation Date
Date d'accréditation: 1995-03-06

Issued on
Émis ce : 1995-03-06

Expiry date
Date d'expiration : 1999-03-06

Richard Lafontaine
President, SCC / Président, CCN

Assessment performed according to the *General Requirements for the Accreditation of Calibration and Testing Laboratories*, CAN-P-4 (ISO/IEC Guide 25), *Requirements for the Competence of Environmental Analytical Laboratories*, CAN/CSA-Z753 and the *Conditions for the Accreditation of Calibration and Testing Laboratories*, CAN-P-1515.
The scope of accreditation is available from the accredited laboratory or SCC.

Évaluation effectuée conformément aux *Prescriptions générales concernant la compétence des laboratoires d'étalonnage et d'essais*, CAN-P-4 (Guide ISO/CEI 25), aux *Exigences visant les compétences des laboratoires de l'environnement*, CAN/CSA-Z753 et aux *Conditions d'accréditation des laboratoires d'étalonnage et d'essais*, CAN-P-1515.
La portée d'accréditation est disponible auprès du laboratoire accrédité ou du CCN.

CERTIFICATE OF ACCREDITATION

CERTIFICAT D'ACCRÉDITATION

CAEAL 1996 ACLAE

CAEAL 1997 ACLAE

Beak Consultants Ltd.

ECOTOXICOLOGY LABORATORY

455 Boul. Fenelon, Suite 104, Dorval, Québec

having been assessed by the Canadian Association for Environmental Analytical Laboratories (CAEAL) Inc., under the authority of the Standards Council of Canada (SCC), and found to comply with the requirements of the ISO/IEC Guide 25, the conditions established by the SCC and the CAEAL proficiency testing program, is hereby recognized as an

ACCREDITED ENVIRONMENTAL LABORATORY

for specific tests or types of tests listed in the scope of accreditation approved by the Standards Council of Canada.

ACLAE

CAEAL

ayant été soumis à une évaluation par l'Association canadienne des laboratoires d'analyse environnementale (ACLAE) Inc., sous l'autorité du Conseil canadien des normes (CCN), et ayant été trouvé conforme aux prescriptions du Guide ISO/CEI 25, aux conditions établies par le CCN et au programme d'essais d'aptitude de l'ACLAE, est de fait reconnu comme

LABORATOIRE DE L'ENVIRONNEMENT ACCRÉDITÉ

pour des essais ou types d'essais déterminés inscrits dans la portée d'accréditation approuvée par le Conseil canadien des normes.

Accredited Laboratory No.
No de laboratoire accrédité : 227

Accreditation Date
Date d'accréditation: 1996-02-15

Issued on
Émis ce : 1996-02-15

Expiry date
Date d'expiration : 2000-02-15

President, SCC / Président, CCN

Assessment performed according to the *General Requirements for the Accreditation of Calibration and Testing Laboratories*, CAN-P-4 (ISO/IEC Guide 25), *Requirements for the Competence of Environmental Analytical Laboratories*, CAN/CSA-Z753 and the *Conditions for the Accreditation of Calibration and Testing Laboratories*, CAN-P-1515. The scope of accreditation is available from the accredited laboratory or SCC.

Évaluation effectuée conformément aux *Prescriptions générales concernant la compétence des laboratoires d'étalonnage et d'essais*, CAN-P-4 (Guide ISO/CEI 25), *Exigences visant les compétences des laboratoires de l'environnement*, CAN/CSA-Z753 et les *Conditions d'accréditation des laboratoires d'étalonnage et d'essais*, CAN-P-1515. La portée d'accréditation est disponible auprès du laboratoire accrédité ou du CCN.

N° 108

CERTIFICAT D'ACCRÉDITATION
DE LABORATOIRE D'ANALYSE ENVIRONNEMENTALE

ENVIRONNEMENT
ET FAUNE
QUÉBEC

Champ d'accréditation : Toxicologie de l'eau

Détenteur : LES CONSULTANTS BEAK LTÉE

Adresse : 455, boulevard Fénelon, bureau 104
Dorval (Québec) H9S 5T8

N° de laboratoire : 428

Service à la clientèle externe Oui [X] Non [ ]

Selon les dispositions de l'article 118.6 de la Loi sur la qualité de l'environnement (L.R.Q., chap. Q-2) et conformément aux normes et exigences d'accréditation incluant celles du Guide ISO/CEI 25, le détenteur de ce certificat est habilité à réaliser les analyses déterminées dans les domaines ci-dessous :

Domaine	Date d'entrée en vigueur	Date d'échéance
191	1997-07-02	1998-07-01

Le présent certificat, valide pour la période indiquée, est soumis aux règles et procédures établies et demeure la propriété du ministère de l'Environnement et de la Faune,

Québec, le 7 août 19 97

Le ministre de l'Environnement et de la Faune

Québec

APPENDIX 2

Field Notes

Table A2.1: Station Coordinates and Field Chemistry Measurements, Dome Mine Site

Station I.D.	Latitude [1]	Longitude [2]	Depth (m)	Temperature (°C)	D.O. (mg/L)	pH (units)	Conductivity (µs/cm)
D1-1	NM[3]	NM	surface	12.5	8.7	8.14	310
D1-2	NM	NM	surface	12.5	8.7	8.14	310
D1-3	NM	NM	surface	12.5	8.7	8.14	310
D1-4	NM	NM	surface	12.5	8.8	8.18	307
D1B-1	48°26'39"	81°16'46.8"	1	13.0	5.9	8.14	310
D1B-2	48°26'39.6"	81°16'46.2"	1	13.0	5.9	8.14	310
D1B-3	48°26'40.2"	81°16'45.6"	1	13.0	5.9	8.14	310
D2-1	48°26'37.2"	81°16'6"	0.7	14.5	4.8	7.34	635
D2-2	48°26'37.8"	81°16'6.6"	0.7	14.5	4.8	7.34	635
D2-3	48°26'38.4"	81°16'7.2"	0.7	14.5	4.8	7.34	635
D2-4	48°26'42"	81°16'11.4"	0.7	14.5	4.8	7.34	635
D2-7	48°26'42"	81°16'11.4"	0.7	14.5	4.8	7.34	635
D3-1	48°27'28.2"	81°13'30.6"	1.2	14.5	5.5	7.40	803
D3-2	48°27'28.2"	81°13'28.8"	1.2	14.5	5.5	7.40	803
D3-3	48°27'31.2"	81°13'28.8"	1.2	14.5	5.5	7.40	803
D3-4	48°27'32.4"	81°13'28.2"	1.2	14.5	5.5	7.40	803
D3-5	48°27'34.8"	81°13'24"	1.2	14.5	5.5	7.40	803
D3-6	48°27'34.8"	81°13'22.8"	1.2	14.5	5.5	7.40	803
D3-7	48°27'36"	81°13'22.2"	1.2	14.5	5.5	7.40	803
D4-1	48°28'30"	81°12'29.4"	1	13.5	5.4	7.64	1,287
D4-2	48°28'25.2"	81°12'6.6"	1	13.5	5.4	7.64	1,287
D4-3	48°28'25.8"	81°12'6"	1	13.5	5.4	7.64	1,287
D4-4	48°28'25.8"	81°12'3.6"	1	13.5	5.4	7.64	1,287
D4-5	48°28'26.4"	81°12'1.8"	1	13.5	5.4	7.64	1,287
D4-6	48°28'26.4"	81°12'00"	1	13.5	5.4	7.64	1,287
D4-7	48°28'27"	81°11'58.8"	1	13.5	5.4	7.64	1,287
D5-1	NM	NM	surface	11.0	9.7	8.58	721
D5-2	NM	NM	surface	11.0	9.2	8.60	715
D5-3	NM	NM	surface	11.0	9.2	8.60	715
D5-4	NM	NM	surface	11.0	9.2	8.60	715

[1] Latitude - measurements are in degrees North

[2] Longitude - measurements are in degrees West

[3] NM - Not Measured

APPENDIX 3

Water Chemistry

Table A3.1: Water Quality at Dome Mine Site

Parameter	LOQ	Units	D1-1 Dissolved	D1-1 Dissolved Replicate	D1-2 Total	D1-2 Dissolved	D1-3 Total	D1-3 Dissolved	D1-4 Total
Acidity(as CaCO3)	1	mg/L	-	-	8	-	6	-	20
Alkalinity(as CaCO3)	1	mg/L	-	-	105	-	96	-	93
Aluminum	0.005	mg/L	0.013	-	0.027	0.018	0.016	0.014	0.016
Ammonia(as N)	0.05	mg/L	-	-	0.09	-	0.08	-	0.1
Anion Sum	na	meq/L	-	-	2.99	-	2.82	-	2.74
Antimony	0.0005	mg/L	nd	-	nd	nd	nd	nd	nd
Arsenic	0.002	mg/L	0.002	-	0.002	0.002	0.002	0.002	0.002
Barium	0.005	mg/L	0.008	-	0.008	0.008	0.008	0.008	0.008
Beryllium	0.005	mg/L	nd	-	nd	nd	nd	-	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	-	-	104	-	95	-	93
Bismuth	0.002	mg/L	nd	-	nd	nd	nd	nd	nd
Boron	0.005	mg/L	nd	nd	0.071	nd	0.025	nd	0.011
Cadmium	0.00005	mg/L	nd	-	nd	0.00007	nd	nd	nd
Calcium	0.1	mg/L	35.6	36.1	35.2	36.3	36	35.9	34.2
Carbonate(as CaCO3, calculated)	1	mg/L	-	-	1	-	1	-	nd
Cation Sum	na	meq/L	-	-	3.1	-	3.08	-	3.07
Chloride	1	mg/L	-	-	26	-	26	-	26
Chromium	0.0005	mg/L	nd	-	0.0006	nd	0.0007	nd	0.0008
Cobalt	0.0002	mg/L	nd	-	nd	nd	nd	nd	nd
Colour	5	TCU	-	-	15	-	15	-	17
Conductivity - @25øC	1	us/cm	-	-	275	-	276	-	275
Copper	0.0003	mg/L	0.0007	-	0.001	0.0009	0.0008	0.0007	0.0007
Cyanates	0.5	mg/L	-	-	nd	-	nd	-	nd
Cyanide, Free	0.002	mg/L	-	-	nd	-	nd	-	nd
Cyanide, Total	0.002	mg/L	-	-	nd	-	nd	-	nd
Cyanide, weak acid dissociable	0.002	mg/L	-	-	-	-	nd	-	nd
Dissolved Inorganic Carbon(as C)	0.2	mg/L	24.5	24.2	-	23.7	-	24.2	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	7	6.7	-	6.4	-	6.1	-
Hardness(as CaCO3)	0.1	mg/L	119	-	-	121	-	120	-
Ion Balance	0.01	%	1.84	-	-	1.81	-	4.48	-
Iron	0.02	mg/L	nd	-	0.06	nd	0.06	nd	0.07
Langelier Index at 20øC	na	na	-	-	0.15	-	0.179	-	-0.185
Langelier Index at 4øC	na	na	-	-	-0.25	-	-0.221	-	-0.585
Lead	0.0001	mg/L	0.0002	-	0.0001	0.0002	nd	0.0002	nd
Magnesium	0.1	mg/L	7.2	7.3	6.8	7.4	6.9	7.3	6.6
Manganese	0.0005	mg/L	0.0013	-	0.0042	0.0013	0.0042	0.0012	0.0045
Mercury	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd
Molybdenum	0.0001	mg/L	nd	-	nd	0.0002	nd	nd	nd
Nickel	0.001	mg/L	0.002	-	0.002	0.002	0.002	0.002	0.002
Nitrate(as N)	0.05	mg/L	-	-	nd	-	nd	-	nd
Nitrite(as N)	0.01	mg/L	-	-	nd	-	nd	-	nd
Orthophosphate(as P)	0.01	mg/L	-	-	nd	-	nd	-	nd
pH	0.1	Units	-	-	8	-	8.1	-	7.7
Phosphorus	0.1	mg/L	nd	nd	nd	nd	nd	nd	nd
Phosphorus, Total	0.01	mg/L	0.01	0.02	-	0.01	-	0.01	-
Potassium	0.5	mg/L	nd	nd	0.6	nd	nd	0.5	nd
Reactive Silica(SiO2)	0.5	mg/L	-	-	2.1	-	2.1	-	2.1
Saturation pH at 20øC	na	units	-	-	7.87	-	7.91	-	7.93
Saturation pH at 4øC	na	units	-	-	8.27	-	8.31	-	8.33
Selenium	0.002	mg/L	nd	-	nd	nd	nd	nd	nd
Silver	0.00005	mg/L	nd	-	nd	nd	nd	nd	nd
Sodium	0.1	mg/L	15.2	15.4	15.7	15.4	16	15.4	15.2
Strontium	0.005	mg/L	0.049	-	0.049	0.047	0.048	0.047	0.049
Sulphate	2	mg/L	-	-	8	-	8	-	8
Thallium	0.0001	mg/L	nd	-	nd	nd	nd	nd	nd
Tin	0.002	mg/L	nd	-	nd	nd	nd	nd	nd
Titanium	0.002	mg/L	nd	-	nd	nd	nd	nd	nd
Total Dissolved Solids(Calculated)	1	mg/L	162	-	-	158	-	153	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	-	-	0.27	-	0.3	-	0.3
Total Suspended Solids	1	mg/L	-	-	nd	-	nd	-	2
Turbidity	0.1	NTU	-	-	0.5	-	0.6	-	0.5
Uranium	0.0001	mg/L	nd	-	nd	nd	nd	nd	nd
Vanadium	0.002	mg/L	nd	-	nd	nd	nd	nd	nd
Zinc	0.001	mg/L	nd	-	0.001	0.002	0.002	nd	0.001
Fluoride	0.02	mg/L	-	-	0.05	-	0.18	-	0.03

Table A3.1: Water Quality at Dome Mine Site

Parameter	LOQ	Units	D1-4 Dissolved	D1B-1 Total	D1B-1 Dissolved	D1B-2 Total	D1B-2 Dissolved	D1B-3 Total	D1B-3 Dissolved
Acidity(as CaCO3)	1	mg/L	-	16	-	10	-	20	-
Alkalinity(as CaCO3)	1	mg/L	-	167	-	158	-	164	-
Aluminum	0.005	mg/L	0.019	0.028	0.005	0.017	0.008	0.034	0.008
Ammonia(as N)	0.05	mg/L	-	0.09	-	0.1	-	0.05	-
Anion Sum	na	meq/L	-	3.92	-	3.83	-	3.95	-
Antimony	0.0005	mg/L	nd	nd	nd	nd	nd	nd	nd
Arsenic	0.002	mg/L	0.002	0.017	0.013	0.016	0.013	0.019	0.015
Barium	0.005	mg/L	0.008	0.015	0.015	0.014	0.015	0.015	0.015
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	-	166	-	157	-	163	-
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd
Boron	0.005	mg/L	nd	nd	0.01	0.168	0.007	0.317	nd
Cadmium	0.00005	mg/L	nd	nd	nd	nd	nd	nd	nd
Calcium	0.1	mg/L	35.9	52.5	53.6	52.9	53.6	52.3	53.5
Carbonate(as CaCO3, calculated)	1	mg/L	-	1	-	1	-	nd	-
Cation Sum	na	meq/L	-	4.21	-	4.22	-	4.19	-
Chloride	1	mg/L	-	17	-	21	-	20	-
Chromium	0.0005	mg/L	nd	0.0006	nd	0.0006	0.0005	0.0008	nd
Cobalt	0.0002	mg/L	nd	0.0004	0.0002	0.0004	0.0003	0.0005	0.0003
Colour	5	TCU	-	34	-	32	-	32	-
Conductivity - @25øC	1	us/cm	-	365	-	360	-	364	-
Copper	0.0003	mg/L	0.001	0.0005	0.0003	0.0006	0.0004	0.0005	nd
Cyanates	0.5	mg/L	-	nd	-	nd	-	nd	-
Cyanide, Free	0.002	mg/L	-	nd	-	nd	-	nd	-
Cyanide, Total	0.002	mg/L	-	nd	-	nd	-	nd	-
Cyanide, weak acid dissociable	0.002	mg/L	-	nd	-	nd	-	nd	-
Dissolved Inorganic Carbon(as C)	0.2	mg/L	24	-	35	-	35	-	32
Dissolved Organic Carbon(DOC)	0.5	mg/L	6.3	-	7	-	6.9	-	6.8
Hardness(as CaCO3)	0.1	mg/L	120	-	182	-	182	-	182
Ion Balance	0.01	%	5.73	-	3.65	-	4.85	-	2.97
Iron	0.02	mg/L	nd	0.32	0.04	0.28	0.05	0.31	0.05
Langelier Index at 20øC	na	na	-	0.433	-	0.32	-	0.215	-
Langelier Index at 4øC	na	na	-	0.034	-	-0.08	-	-0.185	-
Lead	0.0001	mg/L	0.0002	0.0003	0.0002	0.0003	0.0002	0.0004	0.0002
Magnesium	0.1	mg/L	7.3	11	11.7	11	11.8	10.9	11.8
Manganese	0.0005	mg/L	0.001	0.0575	0.0359	0.0425	0.0314	0.047	0.0342
Mercury	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd
Molybdenum	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd
Nickel	0.001	mg/L	0.002	0.004	0.004	0.005	0.004	0.005	0.004
Nitrate(as N)	0.05	mg/L	-	nd	-	nd	-	nd	-
Nitrite(as N)	0.01	mg/L	-	nd	-	nd	-	nd	-
Orthophosphate(as P)	0.01	mg/L	-	nd	-	nd	-	nd	-
pH	0.1	Units	-	7.9	-	7.9	-	7.7	-
Phosphorus	0.1	mg/L	nd	nd	nd	nd	nd	nd	nd
Phosphorus, Total	0.01	mg/L	0.01	-	0.03	-	0.03	-	0.02
Potassium	0.5	mg/L	nd	0.6	1.1	0.7	1.3	nd	0.6
Reactive Silica(SiO2)	0.5	mg/L	-	9.2	-	9.2	-	9.3	-
Saturation pH at 20øC	na	units	-	7.51	-	7.53	-	7.52	-
Saturation pH at 4øC	na	units	-	7.91	-	7.93	-	7.92	-
Selenium	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd
Silver	0.00005	mg/L	nd	nd	nd	nd	nd	nd	nd
Sodium	0.1	mg/L	15.3	12.4	12.3	12.9	12.2	13.1	12.2
Strontium	0.005	mg/L	0.046	0.07	0.066	0.069	0.066	0.07	0.065
Sulphate	2	mg/L	-	4	-	4	-	5	-
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd
Titanium	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd
Total Dissolved Solids(Calculated)	1	mg/L	150	-	210	-	208	-	211
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	-	0.47	-	0.39	-	0.37	-
Total Suspended Solids	1	mg/L	-	6	-	4	-	10	-
Turbidity	0.1	NTU	-	1.6	-	1	-	1.7	-
Uranium	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd
Vanadium	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd
Zinc	0.001	mg/L	0.008	0.002	0.001	0.002	0.001	0.001	0.001
Fluoride	0.02	mg/L	-	0.02	-	0.03	-	0.02	-

Table A3.1: Water Quality at Dome Mine Site

Parameter	LOQ	Units	D2-1 Total	D2-1 Dissolved	D2-3 Total	D2-3 Dissolved	D2-7 Total	D2-7 Dissolved	D3-1 Total
Acidity(as CaCO3)	1	mg/L	18	-	28	-	34	-	34
Alkalinity(as CaCO3)	1	mg/L	188	-	225	-	230	-	193
Aluminum	0.005	mg/L	0.009	nd	0.009	nd	0.008	0.008	0.006
Ammonia(as N)	0.05	mg/L	0.7	-	0.56	-	nd	-	0.12
Anion Sum	na	meq/L	6.02	-	6.84	-	6.91	-	13.1
Antimony	0.0005	mg/L	0.0007	nd	0.0006	nd	nd	nd	0.0018
Arsenic	0.002	mg/L	0.076	0.041	0.07	0.043	0.059	0.038	0.015
Barium	0.005	mg/L	0.019	0.019	0.02	0.02	0.018	0.019	0.035
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	187	-	224	-	229	-	192
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd
Boron	0.005	mg/L	0.009	0.013	0.006	0.01	nd	0.008	0.142
Cadmium	0.00005	mg/L	nd	nd	nd	nd	nd	nd	nd
Calcium	0.1	mg/L	80.3	81.7	79.5	81	80.5	81.7	120
Carbonate(as CaCO3, calculated)	1	mg/L	nd	-	1	-	nd	-	nd
Cation Sum	na	meq/L	6.82	-	6.76	-	6.78	-	13.9
Chloride	1	mg/L	42	-	43	-	43	-	59
Chromium	0.0005	mg/L	0.0007	nd	0.0007	0.0006	0.0006	nd	0.0008
Cobalt	0.0002	mg/L	0.0018	0.0015	0.0017	0.0015	0.0016	0.0015	0.0149
Colour	5	TCU	32	-	34	-	34	-	34
Conductivity - @25øC	1	us/cm	584	-	585	-	588	-	1180
Copper	0.0003	mg/L	0.0029	0.0032	0.0017	0.0014	0.0028	0.0026	0.0125
Cyanates	0.5	mg/L	nd	-	nd	-	nd	-	nd
Cyanide, Free	0.002	mg/L	nd	-	nd	-	nd	-	nd
Cyanide, Total	0.002	mg/L	nd	-	nd	-	nd	-	nd
Cyanide, weak acid dissociable	0.002	mg/L	0.003	-	nd	-	0.003	-	nd
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	47	-	44	-	45	-
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	7.3	-	7.2	-	7.7	-
Hardness(as CaCO3)	0.1	mg/L	-	284	-	280	-	284	-
Ion Balance	0.01	%	-	6.22	-	0.57	-	0.91	-
Iron	0.02	mg/L	0.58	0.09	0.5	0.09	0.44	0.08	0.15
Langelier Index at 20øC	na	na	0.461	-	0.502	-	0.415	-	0.462
Langelier Index at 4øC	na	na	0.061	-	0.102	-	0.015	-	0.062
Lead	0.0001	mg/L	0.0002	0.0001	0.0002	0.0001	0.0001	0.0002	0.0001
Magnesium	0.1	mg/L	18.1	19.5	17.5	18.9	18	19.4	31.9
Manganese	0.0005	mg/L	0.262	0.252	0.175	0.209	0.143	0.15	0.0648
Mercury	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd
Molybdenum	0.0001	mg/L	0.0006	0.0004	0.0005	0.0003	0.0005	0.0003	0.0077
Nickel	0.001	mg/L	0.009	0.009	0.009	0.01	0.009	0.01	0.048
Nitrate(as N)	0.05	mg/L	0.09	-	0.05	-	nd	-	8.1
Nitrite(as N)	0.01	mg/L	nd	-	nd	-	nd	-	nd
Orthophosphate(as P)	0.01	mg/L	nd	-	nd	-	nd	-	nd
pH	0.1	Units	7.8	-	7.7	-	7.6	-	7.6
Phosphorus	0.1	mg/L	nd	nd	nd	nd	nd	nd	nd
Phosphorus, Total	0.01	mg/L	-	0.02	-	0.02	-	0.03	-
Potassium	0.5	mg/L	1.4	1.4	1.6	0.7	1	1.3	29.8
Reactive Silica(SiO2)	0.5	mg/L	8.5	-	8.9	-	8.5	-	2.9
Saturation pH at 20øC	na	units	7.29	-	7.22	-	7.2	-	7.14
Saturation pH at 4øC	na	units	7.69	-	7.62	-	7.6	-	7.54
Selenium	0.002	mg/L	nd	nd	nd	nd	nd	nd	0.002
Silver	0.00005	mg/L	nd	nd	nd	nd	nd	nd	nd
Sodium	0.1	mg/L	24.7	24.3	25.6	25.4	25.1	24.8	92.1
Strontium	0.005	mg/L	0.117	0.115	0.115	0.116	0.112	0.114	0.381
Sulphate	2	mg/L	51	-	54	-	53	-	334
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd
Titanium	0.002	mg/L	nd	nd	nd	nd	nd	nd	0.006
Total Dissolved Solids(Calculated)	1	mg/L	-	343	-	368	-	370	-
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.45	-	0.44	-	0.54	-	0.93
Total Suspended Solids	1	mg/L	1	-	3	-	4	-	5
Turbidity	0.1	NTU	0.8	-	0.9	-	0.9	-	0.9
Uranium	0.0001	mg/L	0.0002	0.0001	0.0002	0.0001	0.0001	0.0001	0.0006
Vanadium	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd
Zinc	0.001	mg/L	0.004	0.004	0.003	0.003	0.005	0.004	0.004
Fluoride	0.02	mg/L	0.05	-	0.37	-	0.11	-	0.14

Table A3.1: Water Quality at Dome Mine Site

Parameter	LOQ	Units	D3-1 Dissolved	D3-2 Total	D3-2 Dissolved	D3-3 Total	D3-3 Dissolved	D4-7 Total	D4-7 Dissolved
Acidity(as CaCO3)	1	mg/L	-	22	-	20	-	14	-
Alkalinity(as CaCO3)	1	mg/L	-	208	-	217	-	212	-
Aluminum	0.005	mg/L	nd	nd	nd	0.006	0.006	0.018	0.006
Ammonia(as N)	0.05	mg/L	-	0.16	-	nd	-	0.11	-
Anion Sum	na	meq/L	-	8.08	-	8.31	-	12.9	-
Antimony	0.0005	mg/L	0.0018	0.0009	0.0005	0.0009	0.0005	0.0009	0.0005
Arsenic	0.002	mg/L	0.012	0.021	0.018	0.021	0.019	0.005	0.005
Barium	0.005	mg/L	0.033	0.013	0.013	0.013	0.014	0.027	0.028
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	-	207	-	216	-	210	-
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd
Boron	0.005	mg/L	0.132	0.101	0.099	0.148	0.099	0.752	0.612
Cadmium	0.00005	mg/L	nd	nd	nd	nd	nd	0.00005	0.00008
Calcium	0.1	mg/L	124	84.6	86.4	83.1	87.4	134	140
Carbonate(as CaCO3, calculated)	1	mg/L	-	1	-	1	-	2	-
Cation Sum	na	meq/L	-	8.81	-	8.9	-	13.2	-
Chloride	1	mg/L	-	30	-	31	-	42	-
Chromium	0.0005	mg/L	0.0008	0.001	0.0006	0.001	0.0007	0.0008	0.0007
Cobalt	0.0002	mg/L	0.0132	0.006	0.0051	0.0059	0.0053	0.003	0.0027
Colour	5	TCU	-	34	-	34	-	34	-
Conductivity - @25øC	1	us/cm	-	755	-	755	-	1070	-
Copper	0.0003	mg/L	0.0104	0.0248	0.0212	0.0198	0.0172	0.0093	0.0084
Cyanates	0.5	mg/L	-	nd	-	nd	-	nd	-
Cyanide, Free	0.002	mg/L	-	nd	-	nd	-	nd	-
Cyanide, Total	0.002	mg/L	-	nd	-	nd	-	nd	-
Cyanide, weak acid dissociable	0.002	mg/L	-	nd	-	nd	-	nd	-
Dissolved Inorganic Carbon(as C)	0.2	mg/L	45	-	51	-	48	-	48
Dissolved Organic Carbon(DOC)	0.5	mg/L	6.9	-	8	-	8.1	-	7.5
Hardness(as CaCO3)	0.1	mg/L	453	-	327	-	331	-	532
Ion Balance	0.01	%	2.95	-	4.31	-	3.44	-	1.17
Iron	0.02	mg/L	nd	0.15	nd	0.17	nd	0.17	0.02
Langelier Index at 20øC	na	na	-	0.555	-	0.637	-	0.978	-
Langelier Index at 4øC	na	na	-	0.155	-	0.237	-	0.578	-
Lead	0.0001	mg/L	0.0003	nd	0.0002	nd	0.0002	0.0002	0.0002
Magnesium	0.1	mg/L	34.9	25	27	24.6	27.3	40.2	44.3
Manganese	0.0005	mg/L	0.0497	0.0908	0.0663	0.0961	0.0846	0.0196	0.018
Mercury	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd
Molybdenum	0.0001	mg/L	0.0069	0.0073	0.0063	0.0072	0.0062	0.0072	0.0066
Nickel	0.001	mg/L	0.041	0.033	0.029	0.03	0.026	0.033	0.029
Nitrate(as N)	0.05	mg/L	-	0.83	-	0.89	-	3.27	-
Nitrite(as N)	0.01	mg/L	-	nd	-	nd	-	nd	-
Orthophosphate(as P)	0.01	mg/L	-	nd	-	nd	-	nd	-
pH	0.1	Units	-	7.8	-	7.9	-	8	-
Phosphorus	0.1	mg/L	nd	nd	nd	nd	nd	nd	nd
Phosphorus, Total	0.01	mg/L	0.01	-	0.02	-	0.03	-	0.02
Potassium	0.5	mg/L	30.5	12.2	12.5	11.8	12.2	12.1	12.7
Reactive Silica(SiO2)	0.5	mg/L	-	2.8	-	3	-	1.9	-
Saturation pH at 20øC	na	units	-	7.24	-	7.21	-	7.04	-
Saturation pH at 4øC	na	units	-	7.64	-	7.61	-	7.44	-
Selenium	0.002	mg/L	0.002	nd	nd	nd	nd	nd	nd
Silver	0.00005	mg/L	nd	0.00011	nd	0.00008	nd	nd	nd
Sodium	0.1	mg/L	92.1	45.7	44.7	44.8	45.5	50.9	51.3
Strontium	0.005	mg/L	0.374	0.252	0.24	0.246	0.24	0.591	0.603
Sulphate	2	mg/L	-	146	-	146	-	348	-
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd
Titanium	0.002	mg/L	0.004	0.003	0.002	0.003	0.002	0.007	0.005
Total Dissolved Solids(Calculated)	1	mg/L	829	-	477	-	486	-	781
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	-	0.49	-	0.57	-	0.83	-
Total Suspended Solids	1	mg/L	-	2	-	4	-	4	-
Turbidity	0.1	NTU	-	0.4	-	3.6	-	0.7	-
Uranium	0.0001	mg/L	0.0005	0.0003	0.0002	0.0003	0.0002	0.0007	0.0006
Vanadium	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd
Zinc	0.001	mg/L	0.003	0.003	0.001	0.003	0.002	0.018	0.005
Fluoride	0.02	mg/L	-	0.06	-	0.04	-	nd	-

Table A3.1: Water Quality at Dome Mine Site

Parameter	LOQ	Units	D4B-1 Total	D4B-1 Total Replicate	D4B-1 Dissolved	D4B-1 Dissolved Replicate	D4B-2 Total	D4B-2 Total field dup	D4B-2 Dissolved
Acidity(as CaCO3)	1	mg/L	8	6	-	-	2	12	-
Alkalinity(as CaCO3)	1	mg/L	215	222	-	-	181	230	-
Aluminum	0.005	mg/L	nd	-	nd	-	0.008	0.007	0.006
Ammonia(as N)	0.05	mg/L	nd	nd	-	-	0.05	0.12	-
Anion Sum	na	meq/L	14.3	-	-	-	13.2	14.7	-
Antimony	0.0005	mg/L	0.0019	-	0.002	-	0.0016	0.0022	0.0017
Arsenic	0.002	mg/L	0.011	-	0.011	-	0.011	0.011	0.009
Barium	0.005	mg/L	0.031	-	0.032	-	0.032	0.032	0.034
Beryllium	0.005	mg/L	nd	-	nd	-	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	212	-	-	-	178	228	-
Bismuth	0.002	mg/L	nd	-	nd	-	nd	nd	nd
Boron	0.005	mg/L	0.092	0.105	0.102	0.1	0.123	0.079	0.096
Cadmium	0.00005	mg/L	nd	-	0.00008	-	nd	nd	nd
Calcium	0.1	mg/L	155	153	158	160	147	143	149
Carbonate(as CaCO3, calculated)	1	mg/L	3	-	-	-	3	2	-
Cation Sum	na	meq/L	14.8	-	-	-	14.2	14.3	-
Chloride	1	mg/L	47	46	-	-	47	51	-
Chromium	0.0005	mg/L	0.0008	-	nd	-	0.0009	0.0008	0.0006
Cobalt	0.0002	mg/L	0.0054	-	0.0048	-	0.0053	0.0053	0.0049
Colour	5	TCU	13	13	-	-	13	13	-
Conductivity - @25øC	1	us/cm	1220	1220	-	-	1190	1190	-
Copper	0.0003	mg/L	0.0156	-	0.0114	-	0.0103	0.0102	0.0091
Cyanates	0.5	mg/L	nd	nd	-	-	nd	nd	-
Cyanide, Free	0.002	mg/L	nd	nd	-	-	nd	nd	-
Cyanide, Total	0.002	mg/L	nd	nd	-	-	nd	nd	-
Cyanide, weak acid dissociable	0.002	mg/L	nd	-	-	-	nd	nd	-
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	-	48	49	-	-	46
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	-	6.4	5.8	-	-	6.1
Hardness(as CaCO3)	0.1	mg/L	-	-	582	-	-	-	545
Ion Balance	0.01	%	-	-	1.9	-	-	-	3.61
Iron	0.02	mg/L	0.11	-	nd	-	0.23	0.23	0.02
Langelier Index at 20øC	na	na	1.17	-	-	-	1.15	1.06	-
Langelier Index at 4øC	na	na	0.77	-	-	-	0.753	0.659	-
Lead	0.0001	mg/L	nd	-	0.0001	-	nd	nd	0.0001
Magnesium	0.1	mg/L	42.4	41.7	45.7	46	39.7	38.4	42.1
Manganese	0.0005	mg/L	0.0197	-	0.0186	-	0.112	0.109	0.128
Mercury	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd
Molybdenum	0.0001	mg/L	0.0135	-	0.0124	-	0.012	0.0121	0.0111
Nickel	0.001	mg/L	0.069	-	0.063	-	0.066	0.067	0.063
Nitrate(as N)	0.05	mg/L	8.06	8	-	-	6.54	7.12	-
Nitrite(as N)	0.01	mg/L	nd	nd	-	-	nd	nd	-
Orthophosphate(as P)	0.01	mg/L	nd	nd	-	-	nd	nd	-
pH	0.1	Units	8.2	8.2	-	-	8.2	8	-
Phosphorus	0.1	mg/L	nd	nd	nd	nd	nd	nd	nd
Phosphorus, Total	0.01	mg/L	-	-	0.02	0.02	-	-	0.01
Potassium	0.5	mg/L	20.2	19.9	19.9	20.5	20.5	19.8	20
Reactive Silica(SiO2)	0.5	mg/L	1.8	1.8	-	-	2.6	2.5	-
Saturation pH at 20øC	na	units	6.99	-	-	-	7.09	6.98	-
Saturation pH at 4øC	na	units	7.39	-	-	-	7.49	7.38	-
Selenium	0.002	mg/L	0.002	-	0.002	-	nd	0.002	nd
Silver	0.00005	mg/L	nd	-	nd	-	nd	nd	nd
Sodium	0.1	mg/L	63.9	63.1	61.5	63.1	66.1	63.2	63.7
Strontium	0.005	mg/L	0.489	-	0.496	-	0.449	0.446	0.465
Sulphate	2	mg/L	389	na	-	-	374	392	-
Thallium	0.0001	mg/L	nd	-	nd	-	nd	nd	nd
Tin	0.002	mg/L	nd	-	nd	-	nd	nd	nd
Titanium	0.002	mg/L	0.007	-	0.006	-	0.007	0.007	0.006
Total Dissolved Solids(Calculated)	1	mg/L	-	-	887	-	-	-	836
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.91	0.79	-	-	0.79	0.81	-
Total Suspended Solids	1	mg/L	2	2	-	-	3	3	-
Turbidity	0.1	NTU	0.4	0.4	-	-	0.4	0.5	-
Uranium	0.0001	mg/L	0.0014	-	0.0012	-	0.0012	0.0012	0.001
Vanadium	0.002	mg/L	nd	-	nd	-	nd	nd	nd
Zinc	0.001	mg/L	0.008	-	0.01	-	0.008	0.008	0.007
Fluoride	0.02	mg/L	nd!(0.10)	nd!(0.10)	-	-	nd	1.97	-

Table A3.1: Water Quality at Dome Mine Site

Parameter	LOQ	Units	D4B-2 Dissolved field dup	D5-1 Total	D5-1 Dissolved	D5-2 Total	D5-2 Dissolved	D5-3 Total	D5-3 Dissolved
Acidity(as CaCO3)	1	mg/L	-	4	-	nd	-	nd	-
Alkalinity(as CaCO3)	1	mg/L	-	104	-	96	-	103	-
Aluminum	0.005	mg/L	nd	0.012	0.01	0.011	0.007	0.023	0.007
Ammonia(as N)	0.05	mg/L	-	0.08	-	0.07	-	nd	-
Anion Sum	na	meq/L	-	6.76	-	6.61	-	11.1	-
Antimony	0.0005	mg/L	0.0018	0.0014	0.001	0.0011	0.001	0.001	0.0013
Arsenic	0.002	mg/L	0.009	0.008	0.008	0.008	0.008	0.008	0.008
Barium	0.005	mg/L	0.034	0.012	0.013	0.012	0.012	0.012	0.012
Beryllium	0.005	mg/L	nd	nd	nd	nd	nd	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	-	103	-	94	-	101	-
Bismuth	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd
Boron	0.005	mg/L	0.095	0.326	0.223	0.215	0.222	0.202	0.22
Cadmium	0.00005	mg/L	0.00006	nd	nd	nd	nd	nd	nd
Calcium	0.1	mg/L	151	62.8	65.9	61.3	65.5	68.2	75
Carbonate(as CaCO3, calculated)	1	mg/L	-	1	-	2	-	2	-
Cation Sum	na	meq/L	-	7.25	-	7.21	-	8.14	-
Chloride	1	mg/L	-	39	-	39	-	40	-
Chromium	0.0005	mg/L	0.0005	0.0008	0.0006	0.0008	0.0005	0.0008	nd
Cobalt	0.0002	mg/L	0.0049	0.0194	0.0187	0.0195	0.0192	0.019	0.0188
Colour	5	TCU	-	11	-	9	-	12	-
Conductivity - @25øC	1	us/cm	-	649	-	645	-	645	-
Copper	0.0003	mg/L	0.0091	0.0094	0.0083	0.0094	0.0086	0.0099	0.0083
Cyanates	0.5	mg/L	-	nd	-	nd	-	nd	-
Cyanide, Free	0.002	mg/L	-	nd	-	nd	-	nd	-
Cyanide, Total	0.002	mg/L	-	nd	-	nd	-	nd	-
Cyanide, weak acid dissociable	0.002	mg/L	-	nd	-	nd	-	nd	-
Dissolved Inorganic Carbon(as C)	0.2	mg/L	48	-	24.2	-	24.1	-	23.9
Dissolved Organic Carbon(DOC)	0.5	mg/L	5.7	-	6.2	-	6.4	-	6.1
Hardness(as CaCO3)	0.1	mg/L	552	-	242	-	240	-	273
Ion Balance	0.01	%	1.39	-	3.54	-	4.37	-	15.5
Iron	0.02	mg/L	0.02	0.09	nd	0.08	nd	0.1	nd
Langelier Index at 20øC	na	na	-	0.472	-	0.655	-	0.67	-
Langelier Index at 4øC	na	na	-	0.072	-	0.255	-	0.27	-
Lead	0.0001	mg/L	nd	0.0001	0.0001	0.0002	0.0001	0.0002	0.0002
Magnesium	0.1	mg/L	42.7	16.9	18.7	16.5	18.6	18.1	20.9
Manganese	0.0005	mg/L	0.102	0.0162	0.0077	0.0145	0.007	0.014	0.0062
Mercury	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd
Molybdenum	0.0001	mg/L	0.0115	0.0067	0.0062	0.0066	0.0062	0.0062	0.0062
Nickel	0.001	mg/L	0.064	0.023	0.021	0.022	0.021	0.022	0.02
Nitrate(as N)	0.05	mg/L	-	0.79	-	0.79	-	58.4	-
Nitrite(as N)	0.01	mg/L	-	nd	-	nd	-	nd	-
Orthophosphate(as P)	0.01	mg/L	-	nd	-	nd	-	nd	-
pH	0.1	Units	-	8.1	-	8.3	-	8.3	-
Phosphorus	0.1	mg/L	nd	nd	nd	nd	nd	nd	nd
Phosphorus, Total	0.01	mg/L	0.02	-	0.02	-	0.04	-	0.02
Potassium	0.5	mg/L	19.9	11.5	11.7	11.3	11.6	11.1	11.5
Reactive Silica(SiO2)	0.5	mg/L	-	0.6	-	0.6	-	0.5	-
Saturation pH at 20øC	na	units	-	7.65	-	7.69	-	7.62	-
Saturation pH at 4øC	na	units	-	8.05	-	8.09	-	8.02	-
Selenium	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd
Silver	0.00005	mg/L	nd	nd	nd	nd	nd	nd	nd
Sodium	0.1	mg/L	63.1	49.1	48.6	47.3	48.5	48.4	54.7
Strontium	0.005	mg/L	0.474	0.237	0.242	0.238	0.241	0.227	0.24
Sulphate	2	mg/L	-	170	-	170	-	182	-
Thallium	0.0001	mg/L	nd	nd	nd	nd	nd	nd	nd
Tin	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd
Titanium	0.002	mg/L	0.006	0.004	0.003	0.004	0.003	0.004	0.003
Total Dissolved Solids(Calculated)	1	mg/L	891	-	420	-	415	-	705
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	-	0.67	-	0.59	-	0.67	-
Total Suspended Solids	1	mg/L	-	1	-	3	-	4	-
Turbidity	0.1	NTU	-	0.8	-	0.9	-	1.1	-
Uranium	0.0001	mg/L	0.0011	0.0002	nd	0.0001	nd	nd	nd
Vanadium	0.002	mg/L	nd	nd	nd	nd	nd	nd	nd
Zinc	0.001	mg/L	0.007	0.003	0.002	0.004	0.002	0.003	0.002
Fluoride	0.02	mg/L	-	0.03	-	0.04	-	0.07	-

Table A3.1: Water Quality at Dome Mine Site

Parameter	LOQ	Units	D5-4 Total	D5-4 Dissolved
Acidity(as CaCO3)	1	mg/L	nd	-
Alkalinity(as CaCO3)	1	mg/L	106	-
Aluminum	0.005	mg/L	0.02	0.006
Ammonia(as N)	0.05	mg/L	0.35	-
Anion Sum	na	meq/L	11.8	-
Antimony	0.0005	mg/L	0.001	0.001
Arsenic	0.002	mg/L	0.009	0.008
Barium	0.005	mg/L	0.012	0.012
Beryllium	0.005	mg/L	nd	nd
Bicarbonate(as CaCO3, calculated)	1	mg/L	104	-
Bismuth	0.002	mg/L	nd	nd
Boron	0.005	mg/L	0.229	0.222
Cadmium	0.00005	mg/L	nd	nd
Calcium	0.1	mg/L	72.6	75.6
Carbonate(as CaCO3, calculated)	1	mg/L	2	-
Cation Sum	na	meq/L	8.21	-
Chloride	1	mg/L	40	-
Chromium	0.0005	mg/L	0.0009	nd
Cobalt	0.0002	mg/L	0.0201	0.0189
Colour	5	TCU	12	-
Conductivity - @25øC	1	us/cm	646	-
Copper	0.0003	mg/L	0.0103	0.0082
Cyanates	0.5	mg/L	nd	-
Cyanide, Free	0.002	mg/L	nd	-
Cyanide, Total	0.002	mg/L	nd	-
Cyanide, weak acid dissociable	0.002	mg/L	nd	-
Dissolved Inorganic Carbon(as C)	0.2	mg/L	-	23.5
Dissolved Organic Carbon(DOC)	0.5	mg/L	-	6.5
Hardness(as CaCO3)	0.1	mg/L	-	277
Ion Balance	0.01	%	-	17.9
Iron	0.02	mg/L	0.1	nd
Langelier Index at 20øC	na	na	0.683	-
Langelier Index at 4øC	na	na	0.283	-
Lead	0.0001	mg/L	0.0002	0.0001
Magnesium	0.1	mg/L	19.9	21.4
Manganese	0.0005	mg/L	0.0152	0.0053
Mercury	0.0001	mg/L	nd	nd
Molybdenum	0.0001	mg/L	0.0065	0.0061
Nickel	0.001	mg/L	0.023	0.02
Nitrate(as N)	0.05	mg/L	65.9	-
Nitrite(as N)	0.01	mg/L	nd	-
Orthophosphate(as P)	0.01	mg/L	nd	-
pH	0.1	Units	8.3	-
Phosphorus	0.1	mg/L	nd	nd
Phosphorus, Total	0.01	mg/L	-	0.02
Potassium	0.5	mg/L	10.9	12
Reactive Silica(SiO2)	0.5	mg/L	0.5	-
Saturation pH at 20øC	na	units	7.61	-
Saturation pH at 4øC	na	units	8.01	-
Selenium	0.002	mg/L	nd	nd
Silver	0.00005	mg/L	nd	nd
Sodium	0.1	mg/L	51.4	54
Strontium	0.005	mg/L	0.24	0.242
Sulphate	2	mg/L	186	-
Thallium	0.0001	mg/L	nd	nd
Tin	0.002	mg/L	nd	nd
Titanium	0.002	mg/L	0.004	0.003
Total Dissolved Solids(Calculated)	1	mg/L	-	745
Total Kjeldahl Nitrogen(as N)	0.05	mg/L	0.61	-
Total Suspended Solids	1	mg/L	7	-
Turbidity	0.1	NTU	1.3	-
Uranium	0.0001	mg/L	0.0001	nd
Vanadium	0.002	mg/L	nd	nd
Zinc	0.001	mg/L	0.003	0.002
Fluoride	0.02	mg/L	0.08	-

Table A3.2: LABORATORY METHODS AND BOTTLE/PRESERVATIVE PROCEDURES USED IN WATER SAMPLE ANALYSIS (as provided by Philip Analytical Services)

Parameters	Method	Bottle Requirement	Preservative Type	Max. Holding Time
Acidity	Standard Methods (17th ed.) No. 2310B U.S. EPA Method No. 305.1	250 ml Bottle Glass	no preservative	14 days
Alkalinity	Standard Methods (17th ed.) No. 2320	250 ml Bottle Glass	no preservative	14 days
RCAP Calculations Total Dissolved Solids(Calculated) Hardness(as CaCO3) Bicarbonate(as CaCO3, calculated) Carbonate(as CaCO3, calculated) Cation Sum Anion Sum Ion Balance	MDS Internal Reference Method			
Colour	U.S. EPA Method No. 110.3(Modified) (Reference-Std Methods(17th)2120CMod)	100 ml Bottle Glass	no preservative	48 hours
Specific Conductance	U.S EPA Method No. 120.1	100 ml Bottle Glass	no preservative	28 days
Manual Conventionals for RCP(pH,Turb,Conduct,Color) pH Turbidity	U.S. EPA Method No. 150.1, 120.1, 180.1 and 110.3	250 ml Bottle HDPE	no preservative	
Hardness	U.S. EPA Method No. 130.2	250 ml Bottle Glass	no preservative	6 months
Ion Balance		250 ml Bottle HDPE	HNO3 to pH < 2	14 days
pH, Hydrogen Ion Activity	U.S. EPA Method No. 150.1	100 ml Bottle Glass	no preservative	
Total dissolved Solids	U.S. EPA Method No. 160.1	1 L Bottle Glass	no preservative	7 days
Total Suspended Solids	U.S. EPA Method No. 160.2	500 ml Bottle Glass	no preservative	7 days
Turbidity, UltraViolet	U.S. EPA Method No. 180.1	100 ml Bottle Glass	no preservative	48 hours
RCAP MS Package, 8 Element ICPAES Scan B, Fe, P, Zn, Ca, Mg, K, Na	U.S. EPA Method No. 200.7	125 ml Bottle HDPE 250 ml Bottle HDPE	HNO3 to pH < 2 no preservative	
ICP-MS 25 Element Scan, Clean Water Package Al, Sb, As, Ba, Be, Bi, Cd, Cr, Co, Cu, Pb, Mn, Mo, Ni, Se, As, Sr, Th, Sn, Ti, U, V, B, Fe, Zn	U.S. EPA Method No. 200.8(Modification)	250 ml Bottle HDPE 125 ml Bottle HDPE	no preservative HNO3 to pH < 2	
Alkalinity for RCAP Packages 30, 50 and MS	U.S. EPA Method No. 310.2	250 ml Bottle HDPE	no preservative	14 days
Anions for RCAP 50 and MS(Cl,NO2,NO3,o-PO4 & SO4)	U.S. EPA Method No. 300.0 or U.S. EPA Method No. 350.1, 354.1, 353.1, 365.1 and 375.4.	250 ml Bottle HDPE	no preservative	48 hours
Dissolved Organic Carbon, as Carbon for RCAP	MOE Method No. ROM - 102ACE(Modified)	100 ml Bottle Glass	no preservative	3 days
Ammonia for RCAP Packages 30, 50 and MS	ASTM Method No. D1426-79 C Refer - Method No. 1100106 Issue 122289	100 ml Bottle Glass 250 ml Bottle HDPE	H2SO4 to pH < 2 no preservative	28 days
Organic Nitrogen(TKN - NH3)	U.S. EPA Method No. 350.1 U.S. EPA Method No. 351.1	250 ml Bottle Glass	H2SO4 to pH < 2	28 days
Mercury, Cold Vapour AA	U.S. EPA SW846 Method No. 7470A Standard Methods(18th ed.) No. 3112B	100 ml Bottle Glass	HNO3 to pH < 2 + 5% K2CR207	7 days

APPENDIX 4

Sediment Chemistry, Sediment Toxicity and Effluent Toxicity

Table A4.1: Total Metals in Sediment Samples from Dome Mine Site

Component	MDL	Units	D1B-1-S	D1B-1-S Replicate	D1B-2-S	D1B-3-S	D2-1-S
ICP/MS - HNO3-H2O2							
Aluminum	1	mg/kg	4500	-	2700	2900	7900
Antimony	0.2	"	0.7	-	0.3	<	<
Arsenic	0.5	"	1100	-	77	36	240
Barium	0.5	"	22	-	25	26	36
Beryllium	0.2	"	<	-	<	<	<
Bismuth	0.5	"	<	-	<	<	0.6
Boron	2.5	"	<	-	<	<	<
Cadmium	0.05	"	0.24	-	0.47	0.4	0.36
Chromium	0.6	"	150	-	29	14	47
Cobalt	0.2	"	33	-	5.8	4	22
Copper	0.2	"	58	-	12	10	290
Iron	20	"	18000	-	6000	5000	27000
Lead	0.1	"	59	-	16	11	18
Manganese	1	"	420	-	130	110	830
Molybdenum	0.2	"	0.6	-	0.3	0.3	6.1
Nickel	0.5	"	250	-	32	13	49
Selenium	1	"	3.2	-	2.2	3.2	2.1
Silver	0.05	"	0.21	-	0.09	0.08	0.45
Strontium	0.5	"	41	-	16	18	37
Thallium	0.2	"	<	-	<	<	<
Tin	0.2	"	2.7	-	2.3	3.4	2.6
Titanium	0.3	"	63	-	120	150	230
Vanadium	1	"	17	-	7.4	7.4	29
Zinc	1	"	78	-	50	64	240
Calcium	20	mg/kg	30900	-	9702.5	12147.5	31500
Magnesium	20	"	30325	-	5515	4970	13850
pH (20 DEG C)			7.3	7.3	6.25	6.58	7.04
Loss on Ignition	0.1	(%)	13	-	14	17	7.4
Coarse Gravel (>4.8mm)	0.1	"	<	-	<	<	<
Fine Gravel (2.0-4.8mm)	0.1	"	0.5	-	3.3	2.2	2.3
V. Coarse Sand (1.0-2.0mm)	0.1	"	0.5	-	0.9	0.6	1.6
Coarse Sand (0.50-1.0mm)	0.1	"	<0.4	-	4.3	0.4	3.3
Med. Sand (0.25-0.50mm)	0.1	"	3.5	-	4.3	3.6	7.7
Fine Sand (0.10-0.25mm)	0.1	"	7.3	-	7.3	6.6	8.3
V. Fine Sand (0.050-0.10mm)	0.1	"	16	-	15	18	8.6
Silt (0.002-0.050mm)	0.1	"	55	-	47	51	51
Clay (<0.002mm)	0.1	"	17	-	18	18	17
Mercury	0.04	mg/kg	0.11	-	0.06	0.06	0.15
TOC(Solid)	0.1	(%)	4.6	-	5.5	6	2.6
Bulk Density (g/mL)			0.40	-	0.31	0.30	0.57
Sediment Moisture (%)			67.6	-	73.2	74.4	56.6
Munsell Number			2.5Y 2.5/1	-	2.5Y 2.5/1	2.5Y 2.5/1	GLEY N2.5/
Munsell Colour			Black	-	Black	Black	Black

Table A4.1: Total Metals in Sediment Samples from Dome Mine Site

Component	MDL	Units	D2-2-S	D2-3-S	D2-3-S Replicate	D2-4-S	D3-1-S
ICP/MS - HNO3-H2O2							
Aluminum	1	mg/kg	6900	8100	-	6300	6300
Antimony	0.2	"	<	<	-	<	0.2
Arsenic	0.5	"	210	200	-	300	180
Barium	0.5	"	36	41	-	33	19
Beryllium	0.2	"	0.2	<	-	<	<
Bismuth	0.5	"	<	<	-	<	<
Boron	2.5	"	<	<	-	<	<
Cadmium	0.05	"	0.29	0.44	-	0.52	0.2
Chromium	0.6	"	40	52	-	61	59
Cobalt	0.2	"	19	20	-	16	41
Copper	0.2	"	260	320	-	140	390
Iron	20	"	22000	26000	-	17000	30000
Lead	0.1	"	16	21	-	18	7.5
Manganese	1	"	780	830	-	290	870
Molybdenum	0.2	"	4.5	6.1	-	2.2	5.3
Nickel	0.5	"	43	52	-	61	220
Selenium	1	"	2.4	1.7	-	1.8	1.2
Silver	0.05	"	0.33	0.42	-	0.17	1.7
Strontium	0.5	"	33	42	-	24	48
Thallium	0.2	"	<	<	-	<	<
Tin	0.2	"	2	1.2	-	1.3	2.2
Titanium	0.3	"	250	260	-	190	110
Vanadium	1	"	25	29	-	22	25
Zinc	1	"	190	220	-	97	65
Calcium	20	mg/kg	27050	34550	-	19100	31575
Magnesium	20	"	12265	16082.5	-	11305	24337.5
pH (20 DEG C)			7.1	7.1	-	6.72	7.3
Loss on Ignition	0.1	(%)	7.5	9.1	-	17	7.9
Coarse Gravel (>4.8mm)	0.1	"	<	<	-	<	<
Fine Gravel (2.0-4.8mm)	0.1	"	4.3	8.9	-	14	4.4
V. Coarse Sand (1.0-2.0mm)	0.1	"	1	2.8	-	2.7	0.8
Coarse Sand (0.50-1.0mm)	0.1	"	2.1	7.8	-	5.6	2.1
Med. Sand (0.25-0.50mm)	0.1	"	7.1	11	-	24	4.5
Fine Sand (0.10-0.25mm)	0.1	"	7.9	6.5	-	31	3.6
V. Fine Sand (0.050-0.10mm)	0.1	"	22	7.7	-	23	12
Silt (0.002-0.050mm)	0.1	"	36	46	-	NA	63
Clay (<0.002mm)	0.1	"	20	9.5	-	NA	9.4
Mercury	0.04	mg/kg	0.09	0.15	0.13	0.12	0.12
TOC(Solid)	0.1	(%)	2.2	2.9	-	6.9	2.1
Bulk Density (g/mL)			0.61	0.58	-	0.31	0.56
Sediment Moisture (%)			55.5	57.0	-	73.5	58.4
Munsell Number			GLEY N2.5/	GLEY N2.5/	-	GLEY N2.5/	GLEY N2.5/
Munsell Colour			Black	Black	-	Black	Black

Table A4.1: Total Metals in Sediment Samples from Dome Mine Site

Component	MDL	Units	D3-1-S Replicate	D3-1-S field dup	D3-1-S field dup Replicate	D3-2-S	D3-3-S
ICP/MS - HNO3-H2O2							
Aluminum	1	mg/kg	-	6600	5700	6800	6900
Antimony	0.2	"	-	0.6	0.4	0.2	0.7
Arsenic	0.5	"	-	160	140	270	290
Barium	0.5	"	-	18	18	16	21
Beryllium	0.2	"	-	<	<	<	<
Bismuth	0.5	"	-	<	<	<	<
Boron	2.5	"	-	<	<	<	4.9
Cadmium	0.05	"	-	0.19	0.17	0.19	0.23
Chromium	0.6	"	-	64	55	72	64
Cobalt	0.2	"	-	36	33	44	39
Copper	0.2	"	-	320	290	610	660
Iron	20	"	-	31000	28000	37000	37000
Lead	0.1	"	-	9.2	15	8.9	10
Manganese	1	"	-	890	820	1200	1100
Molybdenum	0.2	"	-	4.5	4.6	3.8	4.9
Nickel	0.5	"	-	180	170	240	230
Selenium	1	"	-	3.2	2.3	3.4	2.2
Silver	0.05	"	-	1.3	1.3	1.4	2.4
Strontium	0.5	"	-	51	51	53	59
Thallium	0.2	"	-	<	<	<	<
Tin	0.2	"	-	8.3	10	2.4	2.1
Titanium	0.3	"	-	120	100	84	75
Vanadium	1	"	-	27	23	29	26
Zinc	1	"	-	61	54	100	110
Calcium	20	mg/kg	-	31250	31025	34425	36700
Magnesium	20	"	-	23920	23692.5	25775	26725
pH (20 DEG C)			-	7.12	-	7.41	7.33
Loss on Ignition	0.1	(%)	5.9	5.2	-	4.8	4.8
Coarse Gravel (>4.8mm)	0.1	"	-	<	-	<	<
Fine Gravel (2.0-4.8mm)	0.1	"	-	5.5	-	11	3.5
V. Coarse Sand (1.0-2.0mm)	0.1	"	-	0.9	-	1.9	0.5
Coarse Sand (0.50-1.0mm)	0.1	"	-	1	-	2.2	0.8
Med. Sand (0.25-0.50mm)	0.1	"	-	2.9	-	3.8	3.4
Fine Sand (0.10-0.25mm)	0.1	"	-	2.9	-	5.8	5.9
V. Fine Sand (0.050-0.10mm)	0.1	"	-	1.6	-	21	19
Silt (0.002-0.050mm)	0.1	"	-	51	-	47	56
Clay (<0.002mm)	0.1	"	-	34	-	7.6	12
Mercury	0.04	mg/kg	-	0.11	-	0.14	0.12
TOC(Solid)	0.1	(%)	-	1.8	-	2.2	2.2
Bulk Density (g/mL)			-	-	-	0.50	0.47
Sediment Moisture (%)			-	-	-	61.6	63.4
Munsell Number			-	-	-	GLEY N2.5/	GLEY N2.5/
Munsell Colour			-	-	-	Black	Black

Table A4.1: Total Metals in Sediment Samples from Dome Mine Site

Component	MDL	Units	D3-3-S Replicate	D3-4-S	D3-4-S Replicate	D3-5-S	D3-6-S
ICP/MS - HNO3-H2O2							
Aluminum	1	mg/kg	6200	5000	-	6500	5600
Antimony	0.2	"	0.4	0.7	-	0.3	0.3
Arsenic	0.5	"	270	280	-	290	250
Barium	0.5	"	20	23	-	20	18
Beryllium	0.2	"	<	<	-	<	<
Bismuth	0.5	"	<	<	-	<	<
Boron	2.5	"	5	<	-	<	<
Cadmium	0.05	"	0.25	0.25	-	0.24	0.24
Chromium	0.6	"	57	56	-	70	61
Cobalt	0.2	"	36	49	-	45	38
Copper	0.2	"	610	730	-	780	700
Iron	20	"	34000	28000	-	34000	31000
Lead	0.1	"	10	12	-	13	14
Manganese	1	"	1000	810	-	870	900
Molybdenum	0.2	"	4.7	7.3	-	5.1	4.9
Nickel	0.5	"	220	260	-	240	230
Selenium	1	"	1.3	2.7	-	2.5	2.1
Silver	0.05	"	2.2	5.1	-	3.1	2.7
Strontium	0.5	"	56	59	-	57	61
Thallium	0.2	"	<	<	-	<	<
Tin	0.2	"	2.2	3	-	3.9	8.8
Titanium	0.3	"	69	61	-	97	79
Vanadium	1	"	24	23	-	28	25
Zinc	1	"	97	64	-	100	88
Calcium	20	mg/kg	36175	33525	-	36225	37975
Magnesium	20	"	26250	26425	-	26750	27075
pH (20 DEG C)			-	7.01	7.01	7.38	7.3
Loss on Ignition	0.1	(%)	-	6.9	-	15	4.9
Coarse Gravel (>4.8mm)	0.1	"	-	<	-	<	<
Fine Gravel (2.0-4.8mm)	0.1	"	-	2.8	-	2.1	4.9
V. Coarse Sand (1.0-2.0mm)	0.1	"	-	0.2	-	0.3	0.7
Coarse Sand (0.50-1.0mm)	0.1	"	-	2.3	-	0.8	1
Med. Sand (0.25-0.50mm)	0.1	"	-	7.4	-	9.8	2.8
Fine Sand (0.10-0.25mm)	0.1	"	-	11	-	16	3.9
V. Fine Sand (0.050-0.10mm)	0.1	"	-	11	-	7.7	7.6
Silt (0.002-0.050mm)	0.1	"	-	51	-	47	56
Clay (<0.002mm)	0.1	"	-	15	-	17	24
Mercury	0.04	mg/kg	-	0.12	-	0.11	0.11
TOC(Solid)	0.1	(%)	-	2.5	-	2.5	2.4
Bulk Density (g/mL)			-	0.34	-	0.41	0.48
Sediment Moisture (%)			-	71.8	-	67.2	62.4
Munsell Number			-	GLEY N2.5/	-	GLEY N2.5/	GLEY N2.5/
Munsell Colour			-	Black	-	Black	Black

Table A4.1: Total Metals in Sediment Samples from Dome Mine Site

Component	MDL	Units	D3-7-S	D4-1-S	D4-1-S Replicate	D4-4S	D4-4S Replicate
ICP/MS - HNO3-H2O2							
Aluminum	1	mg/kg	6500	6400	-	8300	-
Antimony	0.2	"	0.2	0.3	-	0.6	-
Arsenic	0.5	"	290	55	-	74	-
Barium	0.5	"	15	24	-	34	-
Beryllium	0.2	"	<	<	-	0.6	-
Bismuth	0.5	"	<	<	-	<	-
Boron	2.5	"	<	<	-		-
Cadmium	0.05	"	0.2	0.37	-	0.5	
Chromium	0.6	"	68	33	-	38	-
Cobalt	0.2	"	43	23	-	30	-
Copper	0.2	"	650	270	-	370	-
Iron	20	"	35000	21000	-	23000	-
Lead	0.1	"	12	19	-	19	-
Manganese	1	"	990	500	-	690	-
Molybdenum	0.2	"	5.1	2.4	-	3.5	-
Nickel	0.5	"	220	140	-	160	-
Selenium	1	"	2.9	2.1	-	2.1	-
Silver	0.05	"	2.6	0.73	-	1.2	-
Strontium	0.5	"	55	35	-	44	-
Thallium	0.2	"	<	<	-	<	-
Tin	0.2	"	1.1	3.3	-	2	-
Titanium	0.3	"	68	230	-	180	-
Vanadium	1	"	28	21	-	25	-
Zinc	1	"	94	130	-	170	-
Calcium	20	mg/kg	37525	14927.5	-	19567.5	-
Magnesium	20	"	26825	10455	-	15170	-
pH (20 DEG C)			7.21	6.93	-		
Loss on Ignition	0.1	(%)	5	8.1	-	10	10
Coarse Gravel (>4.8mm)	0.1	"	<	<	-	<	-
Fine Gravel (2.0-4.8mm)	0.1	"	2.6	2.9	-	1.9	-
V. Coarse Sand (1.0-2.0mm)	0.1	"	0.6	0.9	-	0.6	-
Coarse Sand (0.50-1.0mm)	0.1	"	0.8	3.7	-	0.7	-
Med. Sand (0.25-0.50mm)	0.1	"	3.7	9.9	-	2.4	-
Fine Sand (0.10-0.25mm)	0.1	"	3.5	9.6	-	2.8	-
V. Fine Sand (0.050-0.10mm)	0.1	"	5.1	11	-	5.1	-
Silt (0.002-0.050mm)	0.1	"	58	27	-	59	-
Clay (<0.002mm)	0.1	"	26	35	-	28	-
Mercury	0.04	mg/kg	0.14	0.71	0.69	1.2	1.1
TOC(Solid)	0.1	(%)	2.2	3	-	3.1	-
Bulk Density (g/mL)			0.56	0.53	-	0.60	-
Sediment Moisture (%)			59.1	59.3	-	55.4	-
Munsell Number			GLEY N2.5/	GLEY N2.5/	-	GLEY N2.5/	-
Munsell Colour			Black	Black	-	Black	-

Table A4.1: Total Metals in Sediment Samples from Dome Mine Site

Component	MDL	Units	D4-7S	D4-5S	D4-2S	D4-2S Replicate	D4-2BS field dup of D4-2S
ICP/MS - HNO3-H2O2							
Aluminum	1	mg/kg	9600	9200	8400	8900	7700
Antimony	0.2	"	0.3	0.2	0.3	0.2	0.2
Arsenic	0.5	"	86	98	72	73	65
Barium	0.5	"	33	23	43	42	33
Beryllium	0.2	"	0.2	0.2	0.3	0.2	0.5
Bismuth	0.5	"	<	<	<	<	<
Boron	2.5	"					
Cadmium	0.05	"	0.6	0.5	0.6	0.6	0.5
Chromium	0.6	"	46	45	39	42	37
Cobalt	0.2	"	33	32	26	27	24
Copper	0.2	"	380	560	310	320	280
Iron	20	"	29000	30000	23000	25000	22000
Lead	0.1	"	20	22	20	21	17
Manganese	1	"	830	800	740	770	680
Molybdenum	0.2	"	3.6	3.9	2.8	2.9	2.2
Nickel	0.5	"	170	160	150	150	140
Selenium	1	"	1.5	2.1	2.3	2.1	1.3
Silver	0.05	"	1.3	1.5	1.1	1.1	0.8
Strontium	0.5	"	50	43	44	46	38
Thallium	0.2	"	<	<	<	<	<
Tin	0.2	"	1.5	1.9	1.2	1.1	0.9
Titanium	0.3	"	180	160	190	210	180
Vanadium	1	"	29	28	25	26	23
Zinc	1	"	190	210	170	170	160
Calcium	20	mg/kg	21185	21367.5	19075	18460	17937.5
Magnesium	20	"	17687.5	17390	15302.5	14822.5	14407.5
pH (20 DEG C)							
Loss on Ignition	0.1	(%)	11	11	9.9	-	9.8
Coarse Gravel (>4.8mm)	0.1	"	<	<	<	-	<
Fine Gravel (2.0-4.8mm)	0.1	"	4.8	3.8	0.6	-	0.8
V. Coarse Sand (1.0-2.0mm)	0.1	"	1.2	1.2	0.4	-	0.6
Coarse Sand (0.50-1.0mm)	0.1	"	1.6	1.6	1.5	-	2.3
Med. Sand (0.25-0.50mm)	0.1	"	2.5	4.1	2.2	-	3.4
Fine Sand (0.10-0.25mm)	0.1	"	2.2	4.6	5.4	-	2.7
V. Fine Sand (0.050-0.10mm)	0.1	"	1.9	3.1	6	-	16
Silt (0.002-0.050mm)	0.1	"	45	44	41	-	40
Clay (<0.002mm)	0.1	"	41	38	43	-	35
Mercury	0.04	mg/kg	1.2	1.4	1.2	-	1.1
TOC(Solid)	0.1	(%)	2.7	2.4	3	-	2.8
Bulk Density (g/mL)			0.53	0.64	0.68	-	-
Sediment Moisture (%)			59.6	53.1	52.6	-	-
Munsell Number			GLEY N2.5/	GLEY N2.5/	GLEY N2.5/	-	-
Munsell Colour			Black	Black	Black	-	-

Table A4.1: Total Metals in Sediment Samples from Dome Mine Site

Component	MDL	Units	D4-3S	D4-6S
ICP/MS - HNO3-H2O2				
Aluminum	1	mg/kg	11000	8500
Antimony	0.2	"	0.2	0.4
Arsenic	0.5	"	59	80
Barium	0.5	"	38	29
Beryllium	0.2	"	0.4	0.2
Bismuth	0.5	"	<	<
Boron	2.5	"		
Cadmium	0.05	"	0.4	0.6
Chromium	0.6	"	50	44
Cobalt	0.2	"	21	29
Copper	0.2	"	260	410
Iron	20	"	25000	27000
Lead	0.1	"	15	22
Manganese	1	"	580	780
Molybdenum	0.2	"	2	3.9
Nickel	0.5	"	110	150
Selenium	1	"	2.3	1.2
Silver	0.05	"	0.7	1.7
Strontium	0.5	"	37	46
Thallium	0.2	"	<	<
Tin	0.2	"	0.9	2.2
Titanium	0.3	"	260	150
Vanadium	1	"	31	27
Zinc	1	"	150	190
Calcium	20	mg/kg	11500	21185
Magnesium	20	"	10707.5	17545
pH (20 DEG C)				
Loss on Ignition	0.1	(%)	9.6	10
Coarse Gravel (>4.8mm)	0.1	"	<	<
Fine Gravel (2.0-4.8mm)	0.1	"	3.9	2.6
V. Coarse Sand (1.0-2.0mm)	0.1	"	1.1	0.7
Coarse Sand (0.50-1.0mm)	0.1	"	2	1.7
Med. Sand (0.25-0.50mm)	0.1	"	2.3	2.4
Fine Sand (0.10-0.25mm)	0.1	"	2.2	2.5
V. Fine Sand (0.050-0.10mm)	0.1	"	4.9	5.9
Silt (0.002-0.050mm)	0.1	"	73	77
Clay (<0.002mm)	0.1	"	10	7.2
Mercury	0.04	mg/kg	0.99	1.2
TOC(Solid)	0.1	(%)	3.4	3
Bulk Density (g/mL)			0.76	0.64
Sediment Moisture (%)			48.6	53.8
Munsell Number			5Y 2.5/1	GLEY N2.5/
Munsell Colour			Black	Black

Table A4.2: Results of Partial Extraction Analysis on Sediment Samples from Dome Mine Site

	Client ID:		D1B-1	D1B-2	D1B-3	D2-1
Component	**MDL**	**Units**				
NH2OH-HCl						
Aluminum (ext.)	1	mg/kg	358	289	276	317
Antimony (ext.)	0.2	"	<	<	<	<
Arsenic (ext.)	0.5	"	344	27	10	152
Barium (ext.)	0.5	"	12	12	10	21
Beryllium (ext.)	0.2	"	<	<	<	<
Bismuth (ext.)	0.5	"	<	<	<	<
Cadmium (ext.)	0.05	"	0.10	0.14	0.01	0.16
Chromium (ext.)	0.6	"	10.1	2.6	2.4	4.5
Cobalt (ext.)	0.2	"	23.1	1.0	0.5	6.0
Copper (ext.)	0.2	"	0.7	0.1	0.096	2.1
Iron (ext.)	20	"	6500	1500	860	6600
Lead (ext.)	0.1	"	19.2	2.4	0.4	6.9
Manganese (ext.)	1	"	360	104	74	541
Molybdenum (ext.)	0.2	"	<	<	<	<
Nickel (ext.)	0.5	"	157	6.864	1.7	16
Selenium (ext.)	1	"	<	<	<	<
Silver (ext.)	0.05	"	<	<	<	<
Strontium (ext.)	0.5	"	23	7.598	7.5	19
Thallium (ext.)	0.2	"	<	<	<	<
Tin (ext.)	0.2	"	<	<	<	<
Titanium (ext.)	0.3	"	0.3	3.6	0.6	0.7
Vanadium (ext.)	1	"	6.3	4.4	5.1	6.9
Zinc (ext.)	1	"	49	21	9.8	130
Calcium	20	mg/kg	30900	8616	11858	28680
Magnesium	20	"	15070	2986	4056	6936

Table A4.2: Results of Partial Extraction Analysis on Sediment Samples from Dome Mine Site

Component	MDL	Units	D2-2	D2-3	D2-4	D3-1
	Client ID:		D2-2	D2-3	D2-4	D3-1
NH2OH-HCl						
Aluminum (ext.)	1	mg/kg	290	442	291	308
Antimony (ext.)	0.2	"	<	<	<	<
Arsenic (ext.)	0.5	"	147	167	173	108
Barium (ext.)	0.5	"	22	23	18	16
Beryllium (ext.)	0.2	"	<	<	<	<
Bismuth (ext.)	0.5	"	<	<	<	<
Cadmium (ext.)	0.05	"	0.15	0.21	0.18	0.13
Chromium (ext.)	0.6	"	3.9	5.2	2.9	6.3
Cobalt (ext.)	0.2	"	5.8	5.7	2.7	9.7
Copper (ext.)	0.2	"	2.1	2.3	0.4	4.2
Iron (ext.)	20	"	6100	7300	4900	10000
Lead (ext.)	0.1	"	6.7	8.7	3.0	3.8
Manganese (ext.)	1	"	609	739	193	615
Molybdenum (ext.)	0.2	"	<	<	<	0.5
Nickel (ext.)	0.5	"	14	19	15	101
Selenium (ext.)	1	"	<	<	<	<
Silver (ext.)	0.05	"	<	<	<	<
Strontium (ext.)	0.5	"	19	28	15	26
Thallium (ext.)	0.2	"	<	<	<	<
Tin (ext.)	0.2	"	<	<	<	<
Titanium (ext.)	0.3	"	0.6	0.8	0.3	2.1
Vanadium (ext.)	1	"	6.7	8.2	5.0	6.7
Zinc (ext.)	1	"	113	161	42	33
Calcium	20	mg/kg	27840	38420	19488	33640
Magnesium	20	"	6382	7860	5928	15002

Table A4.2: Results of Partial Extraction Analysis on Sediment Samples from Dome Mine Site

Component	MDL	Units	D3B-1 field dup of D3-1	D3B-1 field dup of D3-1 Replicate	D3-2	D3-3
	Client ID:					
NH2OH-HCl						
Aluminum (ext.)	1	mg/kg	268	243	253	239
Antimony (ext.)	0.2	"	<	<	0.2	<
Arsenic (ext.)	0.5	"	81	73	137	149
Barium (ext.)	0.5	"	11	11	13	15
Beryllium (ext.)	0.2	"	<	<	<	<
Bismuth (ext.)	0.5	"	<	<	<	<
Cadmium (ext.)	0.05	"	0.10	0.09	0.11	0.10
Chromium (ext.)	0.6	"	6.1	5.7	5.7	5.8
Cobalt (ext.)	0.2	"	9.2	8.3	7.9	7.6
Copper (ext.)	0.2	"	4.8	4.7	3.8	4.3
Iron (ext.)	20	"	9300	8400	10000	11000
Lead (ext.)	0.1	"	2.6	2.6	4.0	4.1
Manganese (ext.)	1	"	552	499	652	802
Molybdenum (ext.)	0.2	"	0.3	0.3	0.3	0.2
Nickel (ext.)	0.5	"	81	72	96	105
Selenium (ext.)	1	"	<	<	<	<
Silver (ext.)	0.05	"	<	<	<	<
Strontium (ext.)	0.5	"	20	19	23	24
Thallium (ext.)	0.2	"	<	<	<	<
Tin (ext.)	0.2	"	<	<	<	<
Titanium (ext.)	0.3	"	0.4	0.4	0.3	0.3
Vanadium (ext.)	1	"	6.7	6.1	6.8	6.2
Zinc (ext.)	1	"	28	25	52	50
Calcium	20	mg/kg	30220	32220	33580	37820
Magnesium	20	"	13628	14464	14836	16702

Table A4.2: Results of Partial Extraction Analysis on Sediment Samples from Dome Mine Site

	Client ID:		D3-4	D3-4	D3-5	D3-6
Component	**MDL**	**Units**		Replicate		
NH2OH-HCl						
Aluminum (ext.)	1	mg/kg	280	255	320	249
Antimony (ext.)	0.2	"	0.2	<	<	0.2
Arsenic (ext.)	0.5	"	227	213	209	161
Barium (ext.)	0.5	"	15	15	13	11
Beryllium (ext.)	0.2	"	<	<	<	0.4
Bismuth (ext.)	0.5	"	<	<	<	<
Cadmium (ext.)	0.05	"	0.12	0.12	0.14	0.12
Chromium (ext.)	0.6	"	5.9	5.5	6.7	5.9
Cobalt (ext.)	0.2	"	18.0	17.6	10.9	8.3
Copper (ext.)	0.2	"	7.5	6.5	5.1	3.6
Iron (ext.)	20	"	13000	18000	12000	11000
Lead (ext.)	0.1	"	3.9	4.0	5.6	4.8
Manganese (ext.)	1	"	683	642	667	649
Molybdenum (ext.)	0.2	"	0.5	0.4	0.3	0.3
Nickel (ext.)	0.5	"	180	171	128	115
Selenium (ext.)	1	"	<	<	<	<
Silver (ext.)	0.05	"	<	<	<	<
Strontium (ext.)	0.5	"	21	21	26	24
Thallium (ext.)	0.2	"	<	<	<	<
Tin (ext.)	0.2	"	<	<	<	<
Titanium (ext.)	0.3	"	0.3	<	0.4	0.6
Vanadium (ext.)	1	"	7.6	6.9	8.0	6.9
Zinc (ext.)	1	"	54	42	69	59
Calcium	20	mg/kg	31820	32260	35300	38640
Magnesium	20	"	14218	14450	15624	16696

Table A4.2: Results of Partial Extraction Analysis on Sediment Samples from Dome Mine Site

	Client ID:		D3-7	D4-1	D4-2	D4-2B field dup of D4-2
Component	**MDL**	**Units**				
NH2OH-HCl						
Aluminum (ext.)	1	mg/kg	263	273	334	298
Antimony (ext.)	0.2	"	<	<	<	<
Arsenic (ext.)	0.5	"	169	29	31	32
Barium (ext.)	0.5	"	10	13	17	16
Beryllium (ext.)	0.2	"	<	<	<	<
Bismuth (ext.)	0.5	"	<	<	<	<
Cadmium (ext.)	0.05	"	0.11	0.22	0.22	0.20
Chromium (ext.)	0.6	"	6.5	3.4	4.3	3.9
Cobalt (ext.)	0.2	"	12.8	5.9	7.8	6.9
Copper (ext.)	0.2	"	5.6	3.8	3.7	3.1
Iron (ext.)	20	"	11000	5500	6800	6500
Lead (ext.)	0.1	"	5.5	5.9	6.9	6.3
Manganese (ext.)	1	"	665	297	434	410
Molybdenum (ext.)	0.2	"	0.3	<	<	<
Nickel (ext.)	0.5	"	117	61	64	58
Selenium (ext.)	1	"	<	<	<	<
Silver (ext.)	0.05	"	<	<	<	<
Strontium (ext.)	0.5	"	23	24	22	24
Thallium (ext.)	0.2	"	<	<	<	<
Tin (ext.)	0.2	"	<	<	<	<
Titanium (ext.)	0.3	"	0.3	0.5	0.6	0.6
Vanadium (ext.)	1	"	7.0	5.5	6.0	6.0
Zinc (ext.)	1	"	60	70	77	71
Calcium	20	mg/kg	41540	15572	17432	17040
Magnesium	20	"	17402	4964	7070	6612

Table A4.2: Results of Partial Extraction Analysis on Sediment Samples from Dome Mine Site

	Client ID:		D4-3	D4-3	D4-4	D4-5
Component	**MDL**	**Units**		Replicate		
NH2OH-HCl						
Aluminum (ext.)	1	mg/kg	411	433	391	342
Antimony (ext.)	0.2	"	<	<	<	<
Arsenic (ext.)	0.5	"	26	26	30	39
Barium (ext.)	0.5	"	15	15	20	12
Beryllium (ext.)	0.2	"	0.3	<	0.3	<
Bismuth (ext.)	0.5	"	<	<	<	<
Cadmium (ext.)	0.05	"	0.17	0.17	0.25	0.25
Chromium (ext.)	0.6	"	4.2	4.3	4.9	5.1
Cobalt (ext.)	0.2	"	6.7	6.9	8.8	7.9
Copper (ext.)	0.2	"	4.1	4.4	3.8	3.4
Iron (ext.)	20	"	6100	6200	7400	8600
Lead (ext.)	0.1	"	4.0	3.7	7.1	9.4
Manganese (ext.)	1	"	319	325	445	437
Molybdenum (ext.)	0.2	"	<	<	0.2	0.2
Nickel (ext.)	0.5	"	41	41	78	60
Selenium (ext.)	1	"	<	<	<	<
Silver (ext.)	0.05	"	<	<	<	<
Strontium (ext.)	0.5	"	20	19	24	27
Thallium (ext.)	0.2	"	<	<	<	<
Tin (ext.)	0.2	"	<	<	<	<
Titanium (ext.)	0.3	"	1.0	1.4	0.7	0.4
Vanadium (ext.)	1	"	7.1	7.2	6.8	7.0
Zinc (ext.)	1	"	59	61	99	106
Calcium	20	mg/kg	10280	10134	17978	21800
Magnesium	20	"	3884	3798	7420	8962

Table A4.2: Results of Partial Extraction Analysis on Sediment Samples from Dome Mine Site

		Client ID:	D4-6	D4-7
Component	**MDL**	**Units**		
NH2OH-HCl				
Aluminum (ext.)	1	mg/kg	276	315
Antimony (ext.)	0.2	"	<	<
Arsenic (ext.)	0.5	"	27	35
Barium (ext.)	0.5	"	13	17
Beryllium (ext.)	0.2	"	<	<
Bismuth (ext.)	0.5	"	<	<
Cadmium (ext.)	0.05	"	0.21	0.27
Chromium (ext.)	0.6	"	4.0	4.2
Cobalt (ext.)	0.2	"	6.0	8.7
Copper (ext.)	0.2	"	4.2	3.6
Iron (ext.)	20	"	7200	7600
Lead (ext.)	0.1	"	7.9	8.6
Manganese (ext.)	1	"	413	465
Molybdenum (ext.)	0.2	"	0.2	0.2
Nickel (ext.)	0.5	"	53	73
Selenium (ext.)	1	"	<	<
Silver (ext.)	0.05	"	<	<
Strontium (ext.)	0.5	"	24	30
Thallium (ext.)	0.2	"	<	<
Tin (ext.)	0.2	"	<	<
Titanium (ext.)	0.3	"	0.5	0.5
Vanadium (ext.)	1	"	5.6	6.0
Zinc (ext.)	1	"	70	92
Calcium	20	mg/kg	20940	22740
Magnesium	20	"	8746	9470

Table A4.3: Results of AVS/SEM Analysis Conducted on Sediment Samples from Dome Mine Site

Component	MDL	Units	D1B-1-S	D1B-2-S	D1B-3-S	D2-1-S	D2-2-S	D2-3-S	D2-4-S
Aluminum	2	umol/g	99.7	80.3	129.8	125.1	187.6	169.0	250.8
Barium	0.1	umol/g	0.2	0.2	0.3	0.3	0.4	0.3	0.5
Beryllium	0.1	umol/g	<	<	<	<	<	<	<
Boron	1	umol/g	1.4	1.7	2.3	1.5	2.9	3.3	3.1
Cadmium	0.05	umol/g	<	<	<	<	<	<	<
Calcium	7	umol/g	1725.7	283.1	572.5	800.4	1225.4	1028.2	1195.6
Chromium	0.1	umol/g	0.7	0.1	0.1	0.2	0.3	0.3	0.5
Cobalt	0.2	umol/g	0.8	<	<	0.2	0.3	0.2	0.2
Copper	0.1	umol/g	<	<	<	2.4	1.9	1.7	1.0
Iron	0.2	umol/g	533.7	77.6	127.7	346.9	501.0	374.2	530.4
Lead	0.4	umol/g	<	<	<	<	<	<	<
Magnesium	3	umol/g	1103.7	114.7	259.6	328.0	448.1	386.9	574.6
Manganese	0.1	umol/g	17.5	3.2	3.5	16.1	27.5	18.0	10.8
Molybdenum	0.1	umol/g	<	<	<	<	<	<	<
Nickel	0.2	umol/g	7.4	0.5	0.3	0.6	1.4	0.7	1.7
Potassium	10	umol/g	<	<	<	<	<	<	<
Silver	0.1	umol/g	<	<	<	<	<	<	<
Sodium	6	umol/g	<	<	5.3	6.5	10.5	9.6	15.3
Strontium	0.1	umol/g	0.7	0.2	0.3	0.4	0.6	0.5	0.6
Sulphur	3	umol/g	13.5	6.1	8.3	6.9	12.9	8.9	15.8
Thallium	0.5	umol/g	<	<	<	<	<	<	<
Tin	0.5	umol/g	<	<	<	<	<	<	<
Titanium	0.3	umol/g	0.9	0.8	1.3	1.6	2.7	2.3	1.8
Vanadium	0.1	umol/g	0.2	<	0.2	0.3	0.4	0.3	0.4
Zinc	0.1	umol/g	2.4	0.9	2.6	4.1	5.5	4.2	3.4
Zirconium	0.5	umol/g	<	<	<	<	<	<	<
Sum of SEM (Cd/Cu/Ni/Pb/Zn)	0.1		9.7	1.4	2.9	7.2	8.9	6.6	6.1
AV Sulphide	0.1		142.0	7.9	42.1	74.1	19.0	50.7	227.0
SEM/AVS Ratio	0.1		0.07	0.18	0.07	0.10	0.47	0.13	0.03

Table A4.3: Results of AVS/SEM Analysis Conducted on Sediment Samples from Dome Mine Site

Component	MDL	Units	D3-1-S	D3-1-S field dup	D3-2-S	D3-3-S	D3-3-S Replicate	D3-4-S	D3-5-S
		Client ID:							
Aluminum	2	umol/g	88.4	92.3	108.1	144.3	96.2	110.6	85.0
Barium	0.1	umol/g	0.2	0.2	0.2	0.3	0.3	0.2	0.2
Beryllium	0.1	umol/g	<	<	<	<	<	<	<
Boron	1	umol/g	1.3	2.7	2.5	3.5	8.2	2.5	2.8
Cadmium	0.05	umol/g	<	<	<	<	<	<	<
Calcium	7	umol/g	983.0	1035.6	1722.7	2016.9	1543.8	1309.1	1127.0
Chromium	0.1	umol/g	0.3	0.3	0.4	0.5	0.3	0.4	0.3
Cobalt	0.2	umol/g	0.3	0.3	0.3	0.4	0.5	0.5	0.2
Copper	0.1	umol/g	6.1	3.9	<	2.7	<	4.5	<
Iron	0.2	umol/g	492.4	510.1	811.2	1001.6	769.1	737.5	523.1
Lead	0.4	umol/g	<	<	<	<	<	<	<
Magnesium	3	umol/g	710.9	747.2	1194.3	1405.6	1035.7	953.3	772.7
Manganese	0.1	umol/g	19.8	20.5	37.7	50.9	40.0	28.1	21.5
Molybdenum	0.1	umol/g	<	<	<	<	<	<	<
Nickel	0.2	umol/g	3.1	2.6	3.9	6.5	4.6	6.7	2.5
Potassium	10	umol/g	<	<	<	<	<	<	<
Silver	0.1	umol/g	<	<	<	<	<	<	<
Sodium	6	umol/g	10.4	11.1	16.7	20.4	20.0	20.6	13.3
Strontium	0.1	umol/g	0.6	0.6	1.1	1.3	0.9	0.8	0.7
Sulphur	3	umol/g	12.4	17.9	167.3	23.0	18.7	13.8	34.6
Thallium	0.5	umol/g	<	<	<	<	<	<	<
Tin	0.5	umol/g	<	<	<	<	<	<	<
Titanium	0.3	umol/g	0.9	0.9	0.9	1.1	0.9	0.9	0.9
Vanadium	0.1	umol/g	0.2	0.2	0.3	0.4	0.3	0.3	0.2
Zinc	0.1	umol/g	1.1	1.0	2.3	3.1	2.3	1.7	1.7
Zirconium	0.5	umol/g	<	<	<	<	<	<	<
Sum of SEM (Cd/Cu/Ni/Pb/Zn)	0.1		10.3	7.5	6.3	12.2	6.9	12.9	4.2
AV Sulphide	0.1		135.0	97.5	52.0	42.0	49.0	250.0	63.1
SEM/AVS Ratio	0.1		0.08	0.08	0.12	0.29	0.14	0.05	0.07

Table A4.3: Results of AVS/SEM Analysis Conducted on Sediment Samples from Dome Mine Site

Component	MDL	Units	*Client ID:* D3-6-S	D3-6-S Replicate	D3-7-S	D4-1-S	D4-4S	D4-4S Replicate	D4-7S
Aluminum	2	umol/g	70.3	103.1	76.1	171.0	73.5	57.3	52.9
Barium	0.1	umol/g	0.1	0.2	0.1	0.3	0.2	0.2	0.1
Beryllium	0.1	umol/g	<	<	<	<	<	<	<
Boron	1	umol/g	1.9	2.0	1.2	3.2	1.7	1.9	1.3
Cadmium	0.05	umol/g	<	<	<	<	<	<	<
Calcium	7	umol/g	1183.2	1325.2	1051.7	767.4	461.3	503.2	404.5
Chromium	0.1	umol/g	0.2	0.3	0.3	0.3	0.1	0.1	0.1
Cobalt	0.2	umol/g	0.2	0.3	0.3	0.3	0.2	0.1	0.2
Copper	0.1	umol/g	1.5	0.8	4.9	6.2	1.9	0.1	1.7
Iron	0.2	umol/g	543.9	634.6	516.9	520.6	283.1	271.1	212.5
Lead	0.4	umol/g	<	<	<	<	<	<	<
Magnesium	3	umol/g	796.8	937.5	719.5	380.0	274.1	274.1	224.2
Manganese	0.1	umol/g	24.2	26.5	21.2	14.8	10.4	11.0	8.4
Molybdenum	0.1	umol/g	<	<	<	<	<	<	<
Nickel	0.2	umol/g	3.3	3.9	3.4	3.9	1.7	1.7	1.3
Potassium	10	umol/g	<	<	<	<	<	<	<
Silver	0.1	umol/g	<	<	<	<	<	<	<
Sodium	6	umol/g	11.8	10.7	8.4	14.5	7.9	8.6	8.1
Strontium	0.1	umol/g	0.7	0.7	0.6	0.7	0.4	0.4	0.3
Sulphur	3	umol/g	27.6	25.6	16.6	16.8	7.9	62.8	3.5
Thallium	0.5	umol/g	<	<	<	<	<	<	<
Tin	0.5	umol/g	<	<	<	<	<	<	<
Titanium	0.3	umol/g	0.8	0.9	0.6	2.1	0.9	0.9	0.6
Vanadium	0.1	umol/g	0.2	0.3	0.2	0.3	0.1	0.1	0.1
Zinc	0.1	umol/g	1.8	1.9	1.6	3.9	2.2	2.1	1.6
Zirconium	0.5	umol/g	<	<	<	<	<	<	<
Sum of SEM (Cd/Cu/Ni/Pb/Zn)	0.1		6.7	6.6	9.9	14.0	5.8	3.9	4.6
AV Sulphide	0.1		174.0	180.0	110.0	25.9	37.3	20.4	47.9
SEM/AVS Ratio	0.1		0.04	0.04	0.09	0.54	0.15	0.19	0.10

Table A4.3: Results of AVS/SEM Analysis Conducted on Sediment Samples from Dome Mine Site

Component	MDL	Units	*Client ID:* D4-5S	D4-2S	D4-2S field dup	D4-3S	D4-6S
Aluminum	2	umol/g	198.7	189.6	145.2	159.0	100.4
Barium	0.1	umol/g	0.4	0.4	0.3	0.3	0.2
Beryllium	0.1	umol/g	<	<	<	<	<
Boron	1	umol/g	10.4	3.6	3.9	2.7	4.4
Cadmium	0.05	umol/g	<	<	<	<	<
Calcium	7	umol/g	1900.3	1128.2	651.5	374.7	738.6
Chromium	0.1	umol/g	0.3	0.3	0.3	0.2	0.2
Cobalt	0.2	umol/g	0.5	0.4	0.2	0.2	0.2
Copper	0.1	umol/g	3.6	4.3	1.3	3.0	1.0
Iron	0.2	umol/g	1011.1	690.8	440.9	346.0	440.6
Lead	0.4	umol/g	<	<	<	<	<
Magnesium	3	umol/g	1115.2	631.9	409.4	198.8	446.3
Manganese	0.1	umol/g	39.4	27.0	16.5	9.4	17.4
Molybdenum	0.1	umol/g	<	<	<	<	<
Nickel	0.2	umol/g	4.3	4.2	2.4	1.6	2.1
Potassium	10	umol/g	<	<	<	<	<
Silver	0.1	umol/g	<	<	<	<	<
Sodium	6	umol/g	28.2	20.3	13.3	13.5	13.1
Strontium	0.1	umol/g	1.5	0.9	0.5	0.4	0.6
Sulphur	3	umol/g	26.7	11.8	148.6	7.0	171.9
Thallium	0.5	umol/g	<	<	<	<	<
Tin	0.5	umol/g	<	<	<	<	<
Titanium	0.3	umol/g	2.6	2.2	1.8	1.7	1.4
Vanadium	0.1	umol/g	0.4	0.3	0.2	0.2	0.2
Zinc	0.1	umol/g	7.6	5.0	2.9	2.1	3.0
Zirconium	0.5	umol/g	<	<	<	<	<
Sum of SEM (Cd/Cu/Ni/Pb/Zn)	0.1		15.5	13.5	6.7	6.8	6.2
AV Sulphide	0.1		94.6	186.0	19.6	46.2	59.7
SEM/AVS Ratio	0.1		0.16	0.07	0.34	0.15	0.10

beak
international
incorporée

Carré Dorval
455 Boul. Fénélon
Suite 104
Dorval, Québec
Canada H9S 5T8

Tel (514) 631-5544
Fax (514) 631-5588

CERTIFICATE OF ANALYSIS

Client: BEAK (Brampton)
Adresse: 14 Abacus rd
Brampton, On L6T 5B7
Contact: D. Farara/P. McKee
Project N° : 20776.230
Type of sample: Sediment
Collected by: BEAK (Brampton)
Method of transport: Federal Express

Final Test Results: Growth and Survival using the freshwater midgefly larvae *Chironomus riparius*

Client sample number	BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
D1B-1-S	0466CRSD	48* ± 4	9	0.73 ± 0.18	25	5 Nov.
D1B-2-S	0467CRSD	52* ± 4	9	1.06 ± 0.12	12	5 Nov.
D1B-3-S	0468CRSD	64* ± 6	9	0.93 ± 0.17	18	5 Nov.
D2-1-S	0469CRSD	58* ± 4	8	1.00 ± 0.11	11	5 Nov.
D2-2-S	0470CRSD	56* ± 6	10	1.2 ± 0.19	17	5 Nov.
D2-3-S	0471CRSD	64* ± 6	9	1.09 ± 0.14	13	5 Nov.
D2-4-S	0472CRSD	82 ± 20	25	0.67* ± 0.12	18	5 Nov.
D3-1-S	0473CRSD	56* ± 6	10	1.14 ± 0.32	28	5 Nov.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth

Protocol: EPS1/RM/xx, January 1997.

*: indicates that the growth or survival was significantly less that the growth or survival of the biological control ($p<0.05$ or $p<0.01$ for the Student T test).

The statistical analyses were performed using the Tukey, Steels Many-one rank or Student T test (when there was 0 variance). The computer programs used were Toxstat®3.4 and excel 4.0.

19-jan-98

Approved by:

L Savoy

Laura Savoy, BA. DEC. Appl. Écol.
Laboratory Coordinator

beak international incorporée

Carré Dorval
455 Boul. Fénélon
Suite 104
Dorval, Québec
Canada H9S 5T8

Tel (514) 631-5544
Fax (514) 631-5588

CERTIFICATE OF ANALYSIS

Client: BEAK (Brampton)
Adresse: 14 Abacus rd
Brampton, On L6T 5B7

Contact: D. Farara/P. McKee
Project N° : 20776.230
Type of sample: Sediment
Collected by: BEAK (Brampton)
Method of transport: Federal Express

Final Test Results: Growth and Survival using the freshwater midgefly larvae *Chironomus riparius*

Client sample number	BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
D3-2-S	0474CRSD	80 ± 12	15	0.75 ± 0.19	26	29 Oct.
D3-3-S	0475CRSD	78 ± 4	6	0.77 ±.18	23	29 Oct.
D3-4-S	0476CRSD	86 ± 9	10	0.78 ± 0.14	18	29 Oct.
D3-5-S	0477CRSD	80 ± 8	10	0.79 ± 0.19	24	29 Oct.
D3-6-S	0478CRSD	80 ± 10	12	0.9 ± 0.18	20	29 Oct.
D3-7-S	0479CRSD	78 ± 18	23	1.05 ± 0.21	20	29 Oct.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth

Protocol: EPS1/RM/xx, January 1997.

*: indicates that the growth or survival was significantly less that the growth or survival of the biological control ($p<0.05$ or $p<0.01$ for the Student T test).

The statistical analyses were performed using the Tukey, Steels Many-one rank or Student T test (when there was 0 variance). The computer programs used were Toxstat®3.4 and excel 4.0.

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Approved by:

L Savoy

Laura Savoy, BA. DEC. Appl. Ecol.
Laboratory Coordinator

beak international incorporée

Carré Dorval
455 Boul. Fénélon
Suite 104
Dorval, Québec
Canada H9S 5T8

Tel (514) 631-5544
Fax (514) 631-5588

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Type of sample: Sediment
Collected by: BEAK (Brampton)
Method of transport: Federal Express

Final Test Results: Growth and Survival using the freshwater midgefly larvae *Chironomus riparius*

Client sample number	BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
D4-1-S	0480CRSD	78 ± 4	6	1.04 ± 0.23	23	29 Oct.
D4-2-S	0481CRSD	70 ± 7	10	1.07 ± 0.17	16	29 Oct.
D4-3-S	0482CRSD	34* ± 6	16	0.36* ± 0.06	16	1 Nov.
D4-4-S	0483CRSD	68 ± 4	7	0.62* ± 0.07	11	1 Nov.
D4-5-S	0484CRSD	30* ± 10	33	0.41* ± 0.07	16	1 Nov.
D4-6-S	0485CRSD	86 ± 13	16	0.73 ± 0.06	8	1 Nov.
D4-7-S	0486CRSD	74 ± 6	7	0.72 ± 0.11	15	1 Nov.

1. s.d. Standard deviation
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3. C.V. Coefficient of variation: growth

Protocol: EPS1/RM/xx, January 1997.
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The statistical analyses were performed using the Tukey, Steels Many-one rank or Student T test (when there was 0 variance). The computer programs used were Toxstat®3.4 and excel 4.0.

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Approved by:

Laura Savoy, BA. DEC. Appl. Ecol.
Laboratory Coordinator

beak international incorporée

Carré Dorval
455 Boul. Fénélon
Suite 104
Dorval, Québec
Canada H9S 5T8

Tel (514) 631-5544
Fax (514) 631-5588

CERTIFICATE OF ANALYSIS

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Adresse: 14 Abacus rd
Brampton, On L6T 5B7

Contact: D. Farara/P. McKee
Project N° : 20776.230
Type of sample: Sediment
Collected by: BEAK (Brampton)
Method of transport: Federal Express

Final Test Results: Growth and Survival using the freshwater midgefly larvae *Chironomus riparius*

BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
Biological control	76 ± 6	7	0.85 ± 0.05	6	4 Oct.
Biological control	78 ± 4	6	0.97 ± 0.09	9	22 Oct.
Biological control	90 ± 10	11	0.8 ± 0.11	14	23 Oct.
Biological control	84 ± 6	6	0.98 ± 0.08	8	29 Oct.
Biological control	84 ± 6	6	0.63 ± 0.12	19	31 Oct.
Biological control	76 ± 5	7	0.82 ± 0.09	11	1 Nov.
Biological control	78 ± 4	6	1.07 ± 0.12	11	5 Nov.
Biological control	90 ± 0	0	0.67 ± 0.05	7	6 Nov.
Biological control	76 ± 6	7	0.78 ± 0.03	4	7 Nov.
Biological control	94 ± 9	10	0.75 ± 0.05	6	14 Nov.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth

Protocol: EPS1/RM/xx, January 1997.

19-jan-98

Approved by:

L Savoy

Laura Savoy, BA. DEC. Appl. Écol.
Laboratory Coordinator

beak international incorporée

Carré Dorval
455 Boul. Fénélon
Suite 104
Dorval, Québec
Canada H9S 5T8

Tel (514) 631-5544
Fax (514) 631-5588

CERTIFICATE OF ANALYSIS

Client:	BEAK (Brampton)
Adresse:	14 Abacus rd Brampton, On L6T 5B7
Contact:	D. Farara/P. McKee
Project N° :	20776.230
Type of sample:	Sediment
Collected by:	BEAK (Brampton)
Method of transport:	Federal Express

Final Test Results: Growth and Survival using the freshwater amphipod *Hyalella azteca*

Client sample number	BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
D1B-1-S	0466HASD	24* ± 6	23	0.11* ± 0.02	22	15 Oct.
D1B-2-S	0467HASD	84 ± 15	18	0.14* ± 0.03	24	15 Oct.
D1B-3-S	0468HASD	80 ± 7	9	0.16* ± 0.04	23	15 Oct.
D2-1-S	0469HASD	68* ± 4	7	0.29 ± 0.07	24	15 Oct.
D2-2-S	0470HASD	60* ± 10	17	0.19* ± 0.06	32	15 Oct.
D2-3-S	0471HASD	64* ± 9	14	0.19* ± 0.06	32	15 Oct.
D2-4-S	0472HASD	66* ± 9	14	0.21 ± 0.05	22	15 Oct.
D3-1-S	0473HASD	52* ± 31	60	0.10* ± 0.01	11	15 Oct.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth

Protocol: EPS1/RM/xx, December 1996.

*: indicates that the growth or survival was significantly less that the growth or survival of the biological control ($p<0.05$ or $p<0.01$ for the Student T test).

The statistical analyses were performed using the Tukey, Steels many-one rank or Student T test (when there was 0 variance). The computer programs used were Toxstat®3.4 and excel 4.0.

19-jan-98

Approved by:

Laura Savoy, BA. DEC. Appl. Ecol.
Laboratory Coordinator

beak international incorporée

Carré Dorval
455 Boul. Fénélon
Suite 104
Dorval, Québec
Canada H9S 5T8

Tel (514) 631-5544
Fax (514) 631-5588

CERTIFICATE OF ANALYSIS

Client: BEAK (Brampton)
Adresse: 14 Abacus rd
Brampton, On L6T 5B7

Contact: D. Farara/P. McKee
Project N° : 20776.230
Type of sample: Sediment
Collected by: BEAK (Brampton)
Method of transport: Federal Express

Final Test Results: Growth and Survival using the freshwater amphipod *Hyalella azteca*

Client sample number	BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
D3-2-S	0474HASD	54* ± 6	10	0.09* ± 0.05	62	17 Oct.
D3-3-S	0475HASD	52* ± 4	9	0.21 ± 0.04	20	17 Oct.
D3-4-S	0476HASD	14* ± 15	108	0.14* ± 0.04	29	17 Oct.
D3-5-S	0477HASD	48* ± 13	27	0.09* ± 0.03	37	17 Oct.
D3-6-S	0478HASD	56* ± 6	10	0.1* ± 0.02	18	17 Oct.
D3-7-S	0479HASD	34* ± 6	16	0.17* ± 0.03	18	25 Oct.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth

Protocol: EPS1/RM/xx, December 1996.

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Approved by:

Laura Savoy, BA. DEC. Appl. Ecol.
Laboratory Coordinator

beak international incorporée

Carré Dorval
455 Boul. Fénélon
Suite 104
Dorval, Québec
Canada H9S 5T8
Tel (514) 631-5544
Fax (514) 631-5588

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Adresse: 14 Abacus rd
Brampton, On L6T 5B7
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Project N° : 20776.230
Type of sample: Sediment
Collected by: BEAK (Brampton)
Method of transport: Federal Express

Final Test Results: Growth and Survival using the freshwater amphipod *Hyalella azteca*

Client sample number	BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
D4-1-S	0480HASD	72* ± 11	15	0.18* ± 0.04	20	25 Oct.
D4-2-S	0481HASD	64* ± 6	9	0.19* ± 0.02	12	25 Oct.
D4-3-S	0482HASD	82 ± 8	10	0.2 ± 0.12	57	25 Oct.
D4-4-S	0483HASD	68* ± 4	7	0.2* ± 0.03	17	25 Oct.
D4-5-S	0484HASD	42* ± 4	11	0.14* ± 0.02	15	25 Oct.
D4-6-S	0485HASD	68* ± 4	7	0.2* ± 0.04	19	25 Oct.
D4-7-S	0486HASD	66* ± 6	8	0.14* ± 0.02	15	25 Oct.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth

Protocol: EPS1/RM/xx, December 1996.
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Approved by:

L Savoy

Laura Savoy, BA. DEC. Appl. Ecol.
Laboratory Coordinator

beak international incorporée

Carré Dorval
455 Boul. Fénélon
Suite 104
Dorval, Québec
Canada H9S 5T8

Tel (514) 631-5544
Fax (514) 631-5588

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Brampton, On L6T 5B7

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Project N° : 20776.230
Type of sample: Sediment
Collected by: BEAK (Brampton)
Method of transport: Federal Express

Final Test Results: Growth and Survival using the freshwater amphipod *Hyalella azteca*

BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
Biological control	96 ± 6	6	0.25 ± 0.04	14	12 Sept.
Biological control	88 ± 8	10	0.26 ± 0.02	9	19 Sept.
Biological control	98 ± 4	5	0.26 ± 0.06	25	25 Sept.
Biological control	92 ± 8	9	0.24 ± 0.04	16	15 Oct.
Biological control	88 ± 8	10	0.26 ± 0.02	8	17 Oct.
Biological control	86 ± 6	6	0.26 ± 0.01	4	25 Oct.
Biological control	80 ± 0	0	0.3 ± 0.12	41	30 Oct.
Biological control	98 ± 11	11	0.41 ± 0.06	15	5 Nov.
Biological control	84 ± 6	6	0.28 ± 0.02	7	19 Nov.
Biological control	88 ± 4	5	0.25 ± 0.04	15	20 Nov.
Biological control	80 ± 0	0	0.25 ± 0.04	16	21 Nov.
Biological control (QAQC test)	80 ± 0	0	0.25 ± 0.02	7	28 Nov.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth

Protocol: EPS1/RM/xx, December 1996.

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Approved by:

Laura Savoy, BA. DEC. Appl. Ecol.
Laboratory Coordinator

Sample	Received[1]	Characteristics	Treatment	Beginning of test	End of test
MN6-S	18/09/97	Silt / clay composition	Homogeneisation	19/09/97[2] 23/10/97[3]	03/10/97[2] 02/11/97[3]
MN7-S	18/09/97	Silt / clay composition	Homogeneisation	25/09/97[2] 23/10/97[3]	09/10/97[2] 02/11/97[3]
MN8-S	18/09/97	Silt / clay composition	Homogeneisation	25/09/97[2] 23/10/97[3]	09/10/97[2] 02/11/97[3]
MN9-S	18/09/97	Silt / clay composition	Homogeneisation	25/09/97[2] 23/10/97[3]	09/10/97[2] 02/11/97[3]
MN10-S	18/09/97	Silt / clay composition	Homogeneisation	25/09/97[2] 23/10/97[3]	09/10/97[2] 02/11/97[3]
D1B-1-S	10/10/97	Silt / clay composition	Homogeneisation	15/10/97[2] 05/11/97[3]	29/10/97[2] 15/11/97[3]
D1B-2-S	10/10/97	Silt / clay composition	Homogeneisation	15/10/97[2] 05/11/97[3]	29/10/97[2] 15/11/97[3]
D1B-3-S	10/10/97	Silt / clay composition	Homogeneisation	15/10/97[2] 05/11/97[3]	29/10/97[2] 15/11/97[3]
D2-1-S	10/10/97	Silt / clay composition	Homogeneisation	15/10/97[2] 05/11/97[3]	29/10/97[2] 15/11/97[3]
D2-2-S	10/10/97	Silt / clay composition	Homogeneisation	15/10/97[2] 05/11/97[3]	29/10/97[2] 15/11/97[3]
D2-3-S	10/10/97	Silt / clay composition, odour	Homogeneisation	15/10/97[2] 05/11/97[3]	29/10/97[2] 15/11/97[3]
D2-4-S	10/10/97	Silt / clay composition, odour	Homogeneisation	15/10/97[2] 05/11/97[3]	29/10/97[2] 15/11/97[3]
D3-1-S	10/10/97	Silt / clay composition	Homogeneisation	15/10/97[2] 05/11/97[3]	29/10/97[2] 15/11/97[3]
D3-2-S	10/10/97	Silt / clay composition	Homogeneisation	17/10/97[2] 29/10/97[3]	31/10/97[2] 08/11/97[3]
D3-3-S	10/10/97	Silt / clay composition	Homogeneisation	17/10/97[2] 29/10/97[3]	31/10/97[2] 08/11/97[3]
D3-4-S	10/10/97	Silt / clay composition	Homogeneisation	17/10/97[2] 29/10/97[3]	31/10/97[2] 08/11/97[3]
D3-5-S	10/10/97	Silt / clay composition	Homogeneisation	17/10/97[2] 29/10/97[3]	31/10/97[2] 08/11/97[3]
D3-6-S	10/10/97	Silt / clay composition,	Homogeneisation	17/10/97[2] 29/10/97[3]	31/10/97[2] 08/11/97[3]
D3-7-S	10/10/97	Silt / clay composition, surface of sediment is orange	Homogeneisation	25/10/97[2] 29/10/97[3]	08/11/97[2] 08/11/97[3]

Sample	Received[1]	Characteristics	Treatment	Beginning of test	End of test
D4-1-S	10/10/97	Silt / clay composition	Homogeneisation	25/10/97[2] 29/10/97[3]	08/11/97[2] 08/11/97[3]
D4-2-S	16/10/97	Silt / clay composition	Homogeneisation	25/10/97[2] 29/10/97[3]	08/11/97[2] 08/11/97[3]
D4-5-S	16/10/97	Silt / clay composition	Homogeneisation	25/10/97[2] 01/11/97[3]	08/11/97[2] 11/11/97[3]
D4-6-S	16/10/97	Silt / clay composition	Homogeneisation	25/10/97[2] 01/11/97[3]	08/11/97[2] 11/11/97[3]
D4-7-S	16/10/97	Silt / clay composition	Homogeneisation	25/10/97[2] 01/11/97[3]	08/11/97[2] 11/11/97[3]
MMS4-3	29/10/97	Silt / clay composition	Homogeneisation	05/11/97[2] 01/11/97[3]	19/11/97[2] 11/11/97[3]
MMS1-2	29/10/97	silt / clay composition, organic matter	Homogeneisation	30/10/97[2] 31/11/97[3]	13/11/97[2] 10/11/97[3]
MMSR2-1	29/10/97	silt / clay composition, organic matter	Homogeneisation	30/10/97[2] 31/11/97[3]	13/11/97[2] 10/11/97[3]
MMS1-3	29/10/97	silt / clay composition	Homogeneisation	30/10/97[2] 31/11/97[3]	13/11/97[2] 10/11/97[3]
MMS3-1	29/10/97	silt / clay composition, organic matter	Homogeneisation	05/11/97[2] 31/10/97[3]	19/10/97[2] 10/11/97[3]
MMS3-2	29/10/97	silt / clay composition, organic matter	Homogeneisation	05/11/97[2] 06/11/97[3]	19/11/97[2] 16/11/97[3]
MMSR1-3	29/10/97	silt / clay composition, organic matter	Homogeneisation	05/11/97[2] 06/11/97[3]	19/11/97[2] 16/11/97[3]
MMS4-1	29/10/97	silt / clay composition, organic matter	Homogeneisation	05/11/97[2] 06/11/97[3]	19/11/97[2] 16/11/97[3]
MMS4-2	29/10/97	silt / clay composition, organic matter	Homogeneisation	19/11/97[2] 06/11/97[3]	03/11/97[2] 16/11/97[3]
MMSR1-1	29/10/97	silt / clay composition, organic matter	Homogeneisation	19/11/97[2] 07/11/97[3]	03/11/97[2] 17/11/97[3]
MMS2-1	29/10/97	silt / clay composition, organic matter	Homogeneisation	19/11/97[2] 07/11/97[3]	03/11/97[2] 17/11/97[3]
MMS2-2	29/10/97	silt / clay composition, organic matter	Homogeneisation	30/10/97[2] 31/11/97[3]	13/11/97[2] 10/11/97[3]

Conditions and procedures for whole sediment testing with the freshwater midgefly larvae *Chironomus riparius*

Conditions and procedures	Env. Canada 1997[1]	BEAK International inc.
Test type	14 days, static or twice daily renewal	14 days, static
Water renewal	Static: none, except if evaporation occurs.	Static: none, except if evaporation occurs.
Overlying water	Dechlorinated culture water, uncontaminated ground water	Culture water originating from the city of Dorval aquaduct, and dechlorinated by a system devised by BEAK Dorval. Overlying surface water is aerated for 24 hrs prior to the start of tests.
Control sediment	Natural sediment exempt from natural or artifical contaminants, previously tested to ensure adequate growth and survival.	Natural sediment collected from Long Point (Lake Erie, ON) exempt from contaminants, provided by CCIW, Burlington, ON
Organisms	*Chironomus riparius*, ≤48hrs old, 10 organisms per beaker	*Chironomus riparius*, ≤48hrs old, 10 organisms per beaker
Test beakers	300 mL glass beakers, with covers	300 mL glass beakers, with covers
Volume of sediment (wet)	100 mL	100 mL
Volume of overlying water	175 mL	175 mL
Number of replicates	A minimum of 5 field replicates, and 1 to 5 replicates for each field replicate	5 replicates per sample
Temperature	daily average: 23±1°C instant: 23±3°C	23±1°C: Temperature of water bath taken daily, temperature of 1 replicate from each sample taken 3 times/wk
Lighting and photoperiod	• fluorescent tubes that provide 500-1000 lux • photoperiode: 16 h light-8 h dark	• fluorescent tubes that provide 630-1000 lux • photoperiode: 16 h light-8 h dark

1: Conditions and procedures recommended by: Environment Canada. January 1997. Test for growth and survival in sediment using larvae of freshwater midges (*Chironomus tentans* or *Chironomus riparius*)-Preview to Final Manuscript. Environmental protection series biological test method. Method Development and Application Section, Environmental Technology Centre, Environment Canada, Ottawa. 102p.

Conditions and procedures	Env. Canada 1997[1]	BEAK International inc.
Aeration	static: continuous aeration (2 - 3 bubbles /sec in all beakers)	static: continuous aeration (2 - 3 bubbles /sec in all beakers)
Feeding regime	Fish food flakes (Tetrafin™ or Nutrafin™ : 4 times/week, 15 mg (dry weight) in a 3.75 mL suspension/beaker or daily with 6.0 mg (dry weight) in a 1.5 mL suspension/beaker .	Fish food flakes (Nutrafin™) : 4 times/week, 15 mg (dry weight) in a 3.75 mL suspension/beaker.
Observations	Optional: number of organisms observed at the sediment surface, general behaviour (daily or less frequently).	Daily observations of each beaker, if organisms are observed, it is noted.
Parameters: overlying water	• DO and temperature: ≥3 times/week for each sample • pH, hardness or alkalinity, conductivity and ammonia: Day 0 and Day 14 in at least one replicate for each sample	• DO and temperature: 3 times/week for each sample • pH, hardness or alkalinity, conductivity and ammonia: Day 0 and Day 14 in at least one replicate for each sample
Test endpoint	Growth and survival: mean % survival and mean dry weight/organism for each sample	Growth and survival: mean % survival and mean dry weight/organism for each sample
Test validity	Test invalid if the mean survival in the control is less than 70% and/or if the mean dry weight per organisms is less than 0.5 mg.	Test invalid if the mean survival in the control is less than 70% and/or if the mean dry weight per organisms is less than 0.5 mg.
Reference toxicant	Water only 96 hrs test using $CuSO_4$, $CdCl_2$, KCl or NaCl . Minimum of five concentrations and a control, with 3 replicates.	Water only 96 hrs test using $CuSO_4$, $CdCl_2$, KCl or NaCl . Minimum of five concentrations and a control, with 3 replicates. • Reference toxicant: $CuSO_4$ • Geometric mean and standard deviation: CL_{50}: 0,19 ppm (0.04) Coefficient of variation: 22%

1: Test conditions and prodedures recommended by Environment Canada. January 1997. Test for growth and survival in sediment using larvae of freshwater midges (*Chironomus tentans* or *Chironomus riparius*)- Preview to Final Manuscript. Environmental protection series biological test method. Method Development and Application Section, Environmental Technology Centre, Environment Canada, Ottawa. 102p.

Quality Control Test Results: Growth and Survival using the freshwater midgefly larvae *Chironomus riparius*

Client sample number	BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V.[3] (%)	Date of test (1997)
D3-2-S	0474CRSD	80 ± 12	15	0.75 ± 0.19	26	29 Oct.
MMS4-3	0492CRSD	28* ± 18	64	0.69 ± 0.2	29	1 Nov.
MMS3-2	0497CRSD	80 ± 10	12	0.69 ± 0.07	10	1 Nov.
MMSR1-3	0498CRSD	42* ± 4	11	0.44* ± 0.06	14	1 Nov.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth

Protocol: EPS1/RM/xx, January 1997.

*: indicates that the growth or survival was significantly less that the growth or survival of the biological control ($p<0.05$ or $p<0.01$ for the Student T test).

The statistical analyses were performed using the Tukey, Steels Many-one rank or Student T test (when there was 0 variance). The computer programs used were Toxstat®3.4 and excel 4.0.

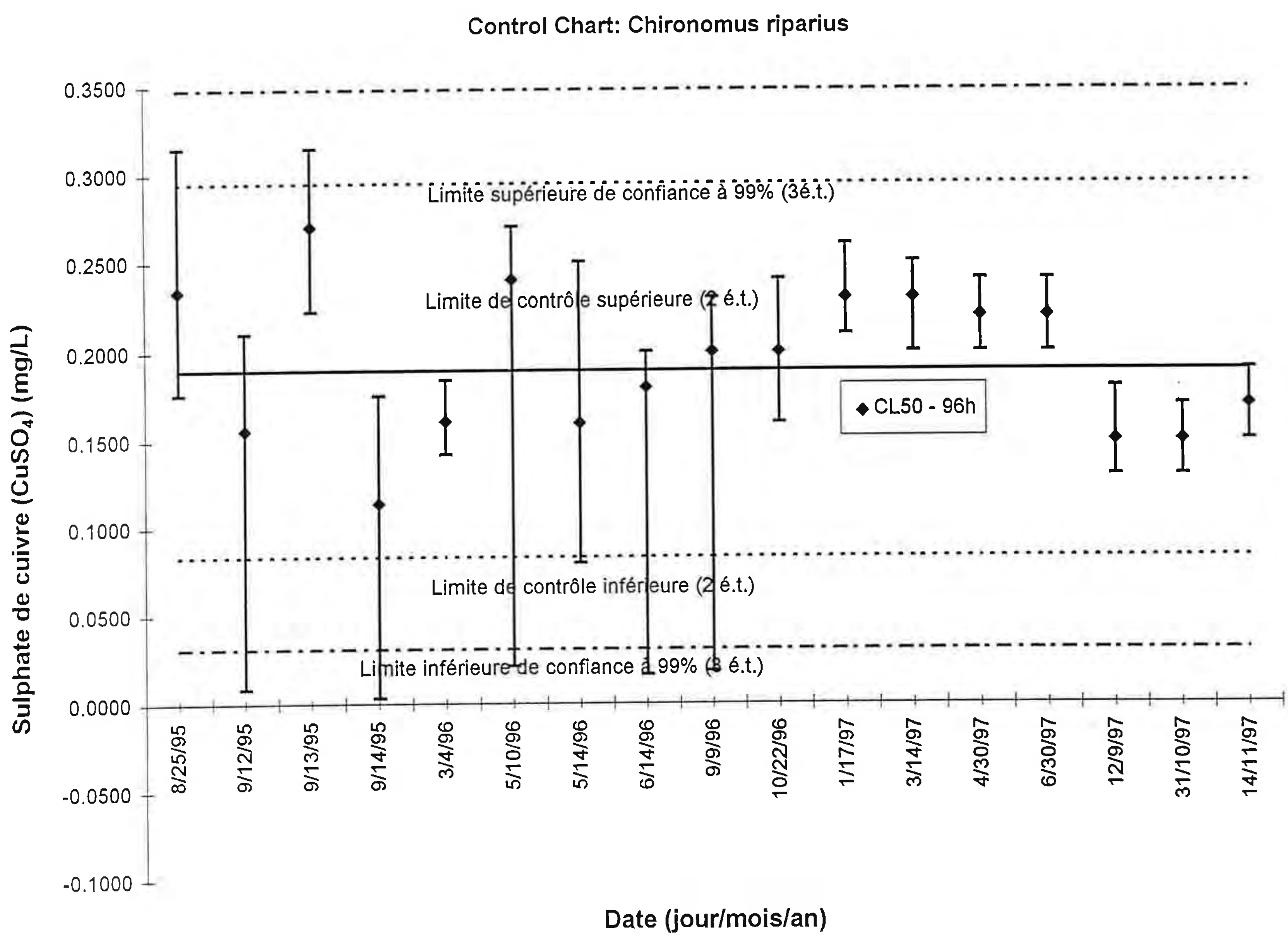
Quality control:

Sample **D3-2-S** was re-tested on the 14 Novemberr 1997 (duplicate):
Survival (%): 84 ± 11, C.V.(%): 14
Growth (mg/organism): 0.65 ± 0.04, C.V. (%): 7

Sample **MMS4-3** was re-tested on the 06 November and 14 November 1997 (triplicate):
Survival (%): 46* ± 6, C.V.(%): 12
Growth (mg/organism): 0.20* ± 0.12, C.V. (%): 59
Survival (%): 66* ± 6, C.V.(%): 8
Growth (mg/organism): 0.44*± 0.16, C.V. (%): 35
Quality control results were variable, results for this sample should be interpreted with caution.

Sample **MMSR1-3** was re-tested on the 14 November 1997):
Survival (%): 54* ± 6, C.V.(%): 10
Growth (mg/organism): 0.23*± 0.09, C.V. (%): 41

Sample **MMS3-2** was re-tested on the 06 November 1997
Survival (%): 48* ± 4, C.V.(%): 9
Growth (mg/organism): 0.20* ± 0.08, C.V.(%): 38
Quality control results were variable, results for this sample should be interpreted with caution.



Control Chart: Chironomus riparius
Sulphate de cuivre ($CuSO_4$) (mg/L)
0.3500
0.3000
0.2500
0.2000
0.1500
0.1000
0.0500
0.0000
-0.0500
-0.1000
Limite supérieure de confiance à 99% (3é.t.)
Limite de contrôle supérieure (2 é.t.)
Limite de contrôle inférieure (2 é.t.)
Limite inférieure de confiance à 99% (3 é.t.)
◆ CL50 - 96h
8/25/95
9/12/95
9/13/95
9/14/95
3/4/96
5/10/96
5/14/96
6/14/96
9/9/96
10/22/96
1/17/97
3/14/97
4/30/97
6/30/97
12/9/97
31/10/97
14/11/97
Date (jour/mois/an)

Conditions and procedures for whole sediment testing with the freshwater amphipod *Hyalella azteca*

Conditions and procedures	Env. Canada 1996[1]	BEAK International inc.
Test	14 days, static or twice daily renewal	14 days, static
Water renewal	Static: none, except if evaporation occurs	Static: none, except if evaporation occurs
Surface water	Dechlorinated culture water, uncontaminated ground water	Culture water originating from the city of Dorval aquaduct, and dechlorinated by a system devised by BEAK Dorval. Overlying surface water is aerated for 24 hrs prior to the start of tests.
Control sediment	Natural sediment exempt from natural or artifical contaminants, previously tested to ensure adequate growth and survival .	Natural sediment collected from Long Point (Lake Erie, ON) exempt from contaminants, provided by CCIW, Burlington, ON.
Organisms	*Hyalella azteca*, 2-9 days	*Hyalella azteca*, 2-9 days
Test beakers	300 mL glass beakers, with covers	300 mL glass beakers, with covers
Volume of sediment (wet)	100 mL	100 mL
Volume of overlying water	175 mL	175 mL
Number of replicates	A minimum of 5 field replicates, and 1 to 5 replicates for each field replicate	5 replicates per sample
Temperature	daily average: 23±1°C instant: 23±3°C	23±1°C: Temperature of water bath taken daily, temperature of 1 replicate from each sample taken 3 times/wk
Lighting and photoperiod	• fluorescent tubes that provide 500-1000 lux • photoperiode: 16 h light-8 h dark	• fluorescent tubes that provide 630-1000 lux • photoperiode: 16 h light-8 h dark
Aeration	static: continuous aeration (2 - 3 bubbles /sec in all beakers)	static: continuous aeration (2 - 3 bubbles /sec in all beakers)

1: Test conditions and procedures recommended by: Environnement Canada. December 1996. Test for growth and survival in sediment using larvae of freshwater amphipod (*Hyalella azteca*)-Preview to Final Manuscript. Environmental protection series biological test method. Method Development and Application Section, Environmental Technology Centre, Environment Canada, Ottawa. 102p.

Conditions and procedures	Env. Canada 1996[1]	BEAK International inc.
Feeding regime	Fish food flakes (Tetrafin™ or Nutrafin™ : 4 times/week, 15 mg (dry weight) in a 3.75 ml suspension/beaker or daily with 6.0 mg (dry weight) in a 1.5 ml suspension/beaker .	Fish food flakes (Nutrafin™) : 4 times/week, 15 mg (dry weight) in a 3.75 ml suspension/beaker.
Observations	Optional: number of organisms observed at the sediment surface, general behaviour (daily or less frequently).	Daily observations of each beaker, if organisms are observed, it is noted..
Parameters: overlying water	• DO and temperature: ≥3 timestimes/week for each sample • pH, hardness or alkalinity, conductivity and ammonia: Day 0 and Day 14 in at least one replicate for each sample.	• DO and temperature: 3 timestimes/week for each sample • pH, hardness or alkalinity, conductivity and ammonia: Day 0 and Day 14 in at least one replicate for each sample.
Test endpoint	Growth and survival: mean % survival and mean dry weight/organism for each sample.	Growth and survival: mean % survival and mean dry weight/organism for each sample.
Test validity	Test invalid if the mean survival in the controls is less than 80%, or if the mean individual dry weight of the test organisms is less than 0.2 mg.	Test invalid if the mean survival in the controls is less than 80%, or if the mean individual dry weight of the test organisms is less than 0.2 mg.
Reference toxicant	Water only 96 hr test using $CuSO_4$, $CdCl_2$, KCl or NaCl . Minimum of five concentrations and a control, with 3 replicates.	Water only 96 hr test using $CuSO_4$ Five concentrations and a control, with 3 replicates. Test performed monthly. • reference toxicant: $CuSO_4$ • Geometric mean and standard deviation: CL_{50}: 0,31 ppm (0,06) *Coefficient of variation: 22%

1: Test conditions and procedures recommended by: Environnement Canada. December 1996. Test for growth and survival in sediment using larvae of freshwater amphipod (*Hyalella azteca*)-Preview to Final Manuscript. Environmental protection series biological test method. Method Development and Application Section, Environmental Technology Centre, Environment Canada, Ottawa. 102p.

Quality Control Test Results: Growth and Survival using the freshwater amphipod *Hyalella azteca*

Client sample number	BEAK sample number	Survival ± s. d[1] (%)	C.V.[2] (%)	Mean dry weight/org ± s.d[1] (mg)	C.V. [3] (%)	Date of test (1997)
MF6-S	0447HASD	24* ± 15	63	0.16* ± 0.05	34	19 Sept.
D1B-2-S	0467HASD	84 ± 15	18	0.14* ± 0.03	24	15 Oct.
D3-1-S	0473HASD	52* ± 31	60	0.10* ± 0.01	11	15 Oct.
MMS4-3	0492HASD	30* ± 27	91	0.27* ± 0.04	16	5 Nov.
MMS3-1	0496HASD	86 ± 11	13	0.16 ± 0.03	22	30 Oct.

1. s.d. Standard deviation
2. C.V. Coefficient of variation: survival
3. C.V. Coefficient of variation: growth

Protocol: EPS1/RM/xx, December 1996.
*: indicates that the growth or survival was significantly less that the growth or survival of the biological control (p<0.05 or p<0.01 for the Student T test).
The statistical analyses were performed using the Tukey, Steels many-one rank or Student T test (when there was 0 variance). The computer programs used were Toxstat®3.4 and excel 4.0.

Quality control:

Sample **MF6-S** was re-tested on the 28 November 1997 (duplicate):
Survival (%): 22* ± 20, C.V.(%): 93
Growth (mg/organism): 0.14* ± 0.03, C.V. (%): 18

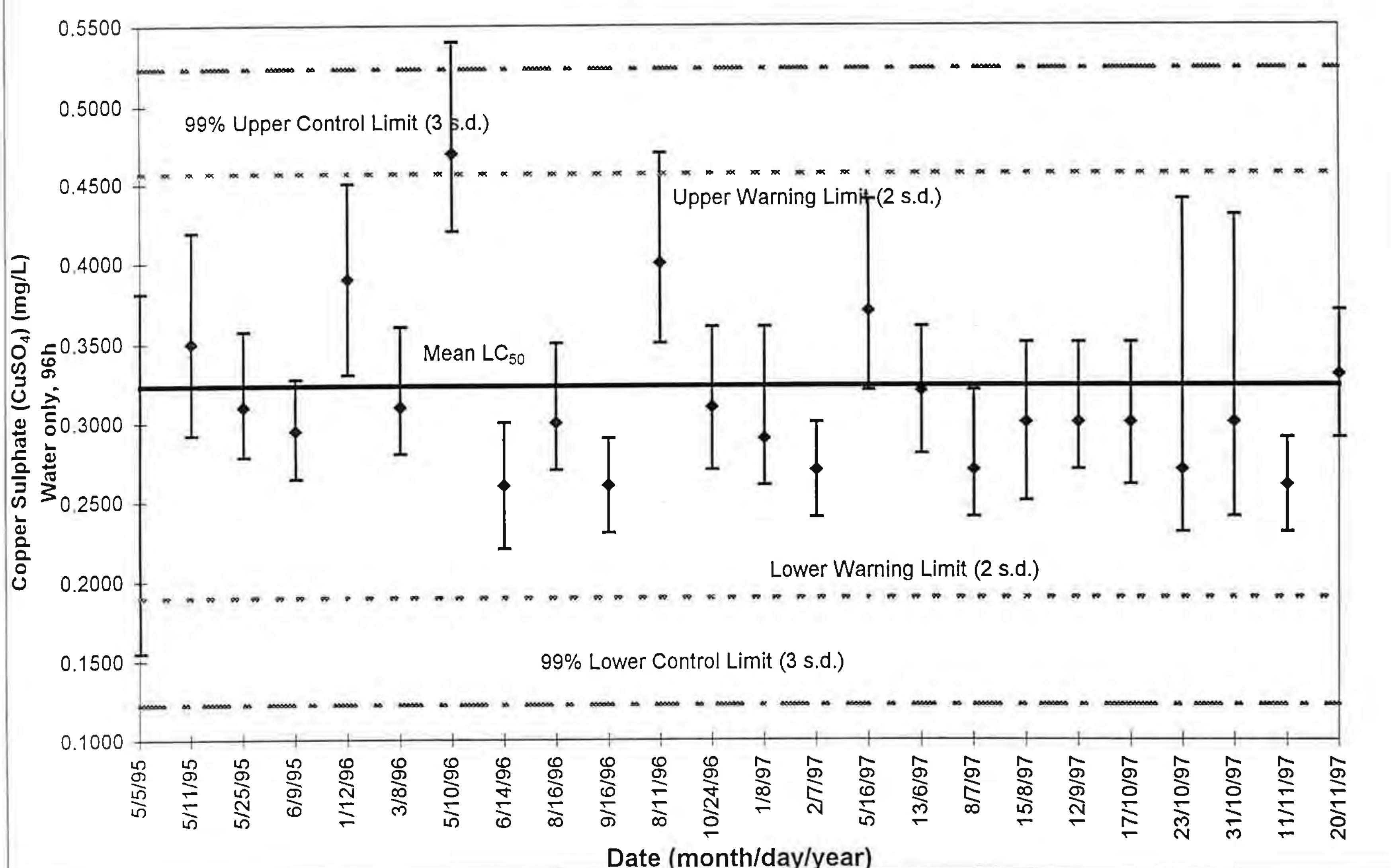
Sample **D1B-2-S** was re-tested on the 28 November 1997 (duplicate):
Survival (%): 74 ± 6, C.V.(%): 7
Growth (mg/organism): 0.14* ± 0.02, C.V. (%): 17

Sample **D3-1-S** was re-tested on the 28 November 1997 (duplicate):
Survival (%): 42* ± 16, C.V.(%): 39
Growth (mg/organism): 0.09* ± 0.01, C.V. (%): 16

Sample **MMS4-3** was re-tested on the 28 November 1997 (duplicate):
Survival (%): 16* ± 26, C.V.(%): 163
Growth (mg/organism): 0.09* ± 0.02, C.V. (%): 22

For the sample **MMS3-1**, a test was performed the 05 November 1997, but there was contamination (fungus observed on surface of sediment), so it was re-tested on the 28 November 1997:
Survival (%): 92 ± 13, C.V.(%): 14
Growth (mg/organism): 0.23 ± 0.03, C.V. (%): 15

BEAK International
Control Chart: *Hyalella azteca*



Tubifex Adult Survivorship: DOME MINE

	SITE	Mean	SD	CV	Classification
AETE 4	D1B-1	100.00	0.00	0.00	NON TOXIC
	D1B-2	100.00	0.00	0.00	NON TOXIC
	D1B-3	100.00	0.00	0.00	NON TOXIC
	D2-1	100.00	0.00	0.00	NON TOXIC
	D2-2	100.00	0.00	0.00	NON TOXIC
	D2-3	100.00	0.00	0.00	NON TOXIC
	D2-4	100.00	0.00	0.00	NON TOXIC
	LAB CONTROL	100.00	0.00	0.00	NON TOXIC
AETE 5	D3-1	100.00	0.00	0.00	NON TOXIC
	D3-2	100.00	0.00	0.00	NON TOXIC
	D3-3	100.00	0.00	0.00	NON TOXIC
	D3-4	100.00	0.00	0.00	NON TOXIC
	D3-5	100.00	0.00	0.00	NON TOXIC
	D3-6	100.00	0.00	0.00	NON TOXIC
	D3-7	100.00	0.00	0.00	NON TOXIC
	LAB CONTROL	100.00	0.00	0.00	NON TOXIC
AETE 6	D4-1	100.00	0.00	0.00	NON TOXIC
	D4-2	100.00	0.00	0.00	NON TOXIC
	D4-3	100.00	0.00	0.00	NON TOXIC
	D4-4	100.00	0.00	0.00	NON TOXIC
	D4-5	100.00	0.00	0.00	NON TOXIC
	D4-6	100.00	0.00	0.00	NON TOXIC
	D4-7	100.00	0.00	0.00	NON TOXIC
	LAB CONTROL	100.00	0.00	0.00	NON TOXIC
	Mean CV	0.00			
	CV Range	0.00			

Tubifex Cocoons/Adult: DOME MINE

	SITE	Mean	SD	CV	Classification
AETE 4	D1B-1	11.15	0.45	4.07	NON TOXIC
	D1B-2	10.75	0.53	4.93	NON TOXIC
	D1B-3	10.90	0.68	6.20	NON TOXIC
	D2-1	10.70	0.60	5.58	NON TOXIC
	D2-2	11.12	0.84	7.51	NON TOXIC
	D2-3	10.85	0.83	7.61	NON TOXIC
	D2-4	10.45	0.76	7.26	NON TOXIC
	LAB CONTROL	10.90	0.98	8.97	NON TOXIC
AETE 5	D3-1	11.25	0.35	3.14	NON TOXIC
	D3-2	10.90	0.55	5.03	NON TOXIC
	D3-3	10.70	0.33	3.05	NON TOXIC
	D3-4	11.00	0.92	8.35	NON TOXIC
	D3-5	10.50	1.84	17.50	NON TOXIC
	D3-6	10.05	0.98	9.70	NON TOXIC
	D3-7	11.25	1.41	12.57	NON TOXIC
	LAB CONTROL	10.95	0.54	4.95	NON TOXIC
AETE 6	D4-1	11.15	0.58	5.16	NON TOXIC
	D4-2	10.44	0.94	9.04	NON TOXIC
	D4-3	11.63	1.08	9.25	NON TOXIC
	D4-4	11.48	0.91	7.95	NON TOXIC
	D4-5	11.00	0.74	6.69	NON TOXIC
	D4-6	9.96	0.36	3.62	NON TOXIC
	D4-7	11.25	0.46	4.06	NON TOXIC
	LAB CONTROL	11.50	1.55	13.49	NON TOXIC

Mean CV 7.32

CV Range 3.05 - 17.50

Tubifex % Cocoons Hatched: DOME MINE

	SITE	Mean	SD	CV	Classification
AETE 4	D1B-1	52.31	5.69	10.87	NON TOXIC
	D1B-2	53.62	5.49	10.25	NON TOXIC
	D1B-3	48.46	3.87	7.99	NON TOXIC
	D2-1	53.20	3.19	6.00	NON TOXIC
	D2-2	48.50	2.55	5.26	NON TOXIC
	D2-3	49.34	7.80	15.82	NON TOXIC
	D2-4	53.43	5.32	9.96	NON TOXIC
	LAB CONTROL	52.93	6.47	12.20	NON TOXIC
AETE 5	D3-1	50.65	3.91	7.72	NON TOXIC
	D3-2	52.67	3.29	6.25	NON TOXIC
	D3-3	57.95	2.56	4.42	NON TOXIC
	D3-4	57.15	3.87	6.78	NON TOXIC
	D3-5	52.89	8.06	15.20	NON TOXIC
	D3-6	53.84	2.01	3.73	NON TOXIC
	D3-7	51.13	7.05	13.78	NON TOXIC
	LAB CONTROL	48.45	4.87	10.06	NON TOXIC
AETE 6	D4-1	54.36	4.79	8.82	NON TOXIC
	D4-2	49.27	5.80	11.77	NON TOXIC
	D4-3	48.28	7.20	14.92	NON TOXIC
	D4-4	56.67	7.82	13.80	NON TOXIC
	D4-5	49.85	11.01	22.08	NON TOXIC
	D4-6	59.80	2.93	4.91	NON TOXIC
	D4-7	51.66	2.37	4.60	NON TOXIC
	LAB CONTROL	53.96	3.66	6.79	NON TOXIC

Mean CV	9.75
CV Range	3.73 - 22.08

Tubifex Young/Adult: DOME MINE

	SITE	Mean	SD	CV	Classification
AETE 4	D1B-1	32.88	5.02	15.27	NON TOXIC
	D1B-2	32.50	5.16	15.88	NON TOXIC
	D1B-3	34.25	5.34	15.59	NON TOXIC
	D2-1	37.50	3.74	9.98	NON TOXIC
	D2-2	25.89	2.36	9.13	NON TOXIC
	D2-3	30.98	2.68	8.67	NON TOXIC
	D2-4	32.05	2.46	7.67	NON TOXIC
	LAB CONTROL	38.75	7.36	18.99	NON TOXIC
AETE 5	D3-1	29.25	5.17	17.66	NON TOXIC
	D3-2	29.65	3.79	12.78	NON TOXIC
	D3-3	25.35	7.35	29.00	NON TOXIC
	D3-4	37.55	5.06	13.48	NON TOXIC
	D3-5	16.45	1.19	7.24	NON TOXIC
	D3-6	26.20	3.61	13.78	NON TOXIC
	D3-7	27.95	4.52	16.17	NON TOXIC
	LAB CONTROL	33.50	3.60	10.74	NON TOXIC
AETE 6	D4-1	38.45	3.71	9.66	NON TOXIC
	D4-2	28.81	6.57	22.80	NON TOXIC
	D4-3	36.00	9.27	25.74	NON TOXIC
	D4-4	32.70	1.90	5.81	NON TOXIC
	D4-5	30.19	5.34	17.68	NON TOXIC
	D4-6	23.46	1.65	7.04	NON TOXIC
	D4-7	31.81	2.07	6.49	NON TOXIC
	LAB CONTROL	40.10	10.54	26.28	NON TOXIC

Mean CV 14.31

CV Range 6.49 - 29.00

beak international incorporated

14 Abacus Road
Brampton,Ontario
Canada L6T 5B7

Tel (905) 794-2325
Fax (905) 794-2338
1-800-361-BEAK (2325)

QUALITY ASSURANCE INFORMATION

Ceriodaphnia **Survival and Reproduction Test**

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 600 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	15ml per replicate, 10 replicates per concentration
Test Vessels:	25 ml disposable plastic containers
Test Organism:	*Ceriodaphnia dubia*
Organism Age:	< 24 hours, within 8 hours of each other
Organism Health:	no ephippia detected in culture, mortality in culture <20%

Protocol

Environment Canada. 1992. Biological Test Method: Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia* . EPS 1/RM/21.

Reference Toxicant Test # 9700562-0:

Chemical Used:	Sodium Chloride
Date of Test:	21-Jun-97
7-Day LC50:	2630 mg/L
Historical Warning Limits (LC50):	1180 - 2530
Historical Control Limits (LC50):	844 - 2870
7-Day IC50:	1700 mg/L
Historical Warning Limits (IC50):	1170 - 1980
Historical Control Limits (IC50):	963 - 2180

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using sodium chloride at least once per month and assesses the acceptability of the test results based on historical data, which are regularly updated on control charts.

Reference Test Commments:

The IC50, which estimates survival and reproduction effects, is within the established historical limits; however, the LC50 value, which measures survival alone, is above the historical warning limit. This may occur due to chance alone, once every 20 tests or may indicate a problem with the test system. An investigation revealed no anomalies in test system, cultures or technical performance and limits were recalculated using the latest data.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

Acronyms

LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable (when applied to the LOEC, means that no concentration tested exhibited an observable effect).
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different).

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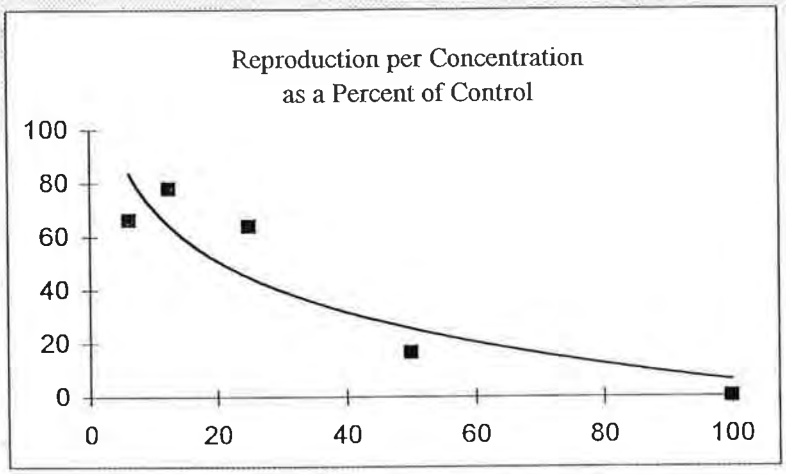
Ceriodaphnia dubia Survival and Reproduction Test

Biological Test Method EPS 1/RM/21

Client: Placer Dome
South Porcupine, Ontario

Sample: PD-R-B (P-E-1)
Sample Type: effluent
Test No.: 9700603-3
Date Sampled: 24-Jun-97
Date Initiated: 25-Jun-97
Time Initiated: 21:30
Initiated by: J. Schroeder



TEST DATA
Total Number of Neonates Produced per Adult After 7 Days of Testing

replicate	concentration (% v/v) 0	6.25	12.5	25	50	100
1	32	27	30	24	0	0
2	27	36	32	27	3	0
3	39	9	25	7	4	0
4	25	25	25	32	8	0
5	31	19	22	16	0	0
6	27	26	21	28	7	0
7	46	29	26	15	6	0
8	32	0	25	26	2	0
9	25	15	20	28	10	0
10	44	31	29	6	14	0
mean / conc.	32.8	21.7	25.5	20.9	5.4	0.0
mortality / 10 adults	0	2	0	0	3	10

Sample Appearance: clear,colourless

Initial Parameters:

DO (mg/L)	Conductivity (µmhos/cm)	Temperature (°C)	pH	Hardness (mg/L)	Alkalinity (mg/L)
8.2	957	25.2	8.61	230	90

Sample treatments: none

TEST RESULTS

	%v/v	95% CI	Method of Calculation	Notes
IC25	<6.25	na	Linear Interpolation,	
IC50	32.3	22.4 - 36.8	(Norberg-King, 1993)	
LC50	57.4	47.0 - 70.2	Spearman-Karber	

QUALITY ASSURANCE INFORMATION & COMMENTS

Associated QA/QC test: 9700562-0

Reported by: [signature]

Date: Jan. 16/98

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14 Abacus Road
Brampton,Ontario
Canada L6T 5B7

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QUALITY ASSURANCE INFORMATION: 7-Day Fathead Minnow Survival and Growth Test

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 500 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	500 ml per replicate, 2000 ml per concentration
Test Vessels:	500 ml disposable plastic containers
Test Organism:	*Pimephales promelas,*
Organism Source:	Aquatic Research Organisms, New Hampshire
Organism Age:	< 24 hours

Protocol

Environment Canada. 1992. Biological Test Method: Test of Larval Growth and Survival Using Fathead Minnows . Report EPS 1/RM/22.

Reference Toxicant Test # 9700599-0

Chemical Used:	Potassium Chloride
Date of Test:	21-Jun-97
7-Day LC50:	964 mg/L
Historical Warning Limits (LC50):	785 - 1050
Historical Control Limits (LC50):	720 - 1113
IC50:	1610 mg/L
Historical Warning Limits (IC50):	672 - 1600
Historical Control Limits (IC50):	440 - 1830

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using potassium chloride at least once per month and assesses the acceptability of the test results based on historical data, updated regularly on control charts.

Reference Test Comments:

The reference toxicant test results show that test reproducibility and sensitivity are within established control and warning limits (± 1%).
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

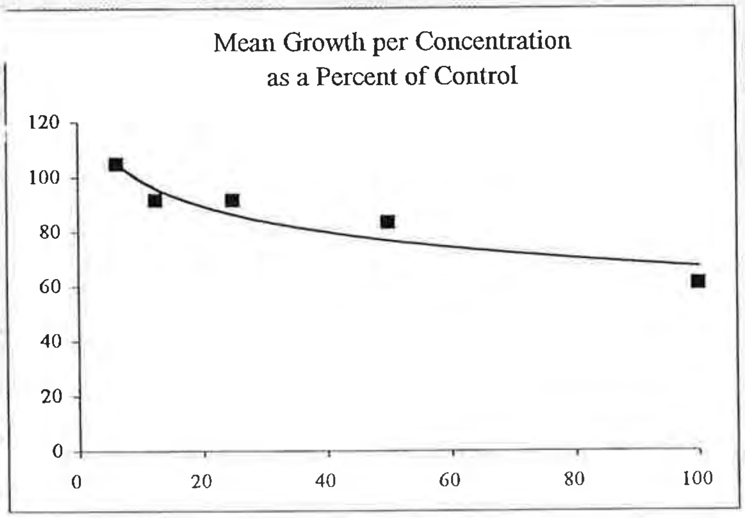
Acronyms

LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable (when applied to the LOEC, means that no concentration tested exhibited an observable effect)
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different.

beak

ᅳathead Minnow Survival and Growth Test
ological Test Method EPS 1/RM/22 *

Client:	Placer Dome South Porcupine, Ontario		
Sample:	PD-R-B (P-E-1)		
Sample Type:	effluent		
Test No.:	9700603-4	**Date Initiated:**	25-Jun-97
Date Sampled:	24-Jun-97	**Time Initiated:**	19:00
		Initiated by:	S. Stragier



TEST DATA

Mean Fish Weight per Replicate (mg)

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	1.090	1.052	0.981	0.966	0.862	0.606
2	1.092	1.162	0.950	0.910	0.967	0.746
3	1.065	1.132	0.853	0.926	0.806	0.624
4	0.974	1.070	1.072	1.051	0.880	0.587
mean / conc.	1.055	1.104	0.964	0.963	0.879	0.641

Survival per Replicate (total exposed per concentration = 40)

	concentration (% v/v)					
replicate	0**	6.25**	12.5	25	50	100
1	7	10	8	10	10	9
2	8	10	10	10	9	7
3	10	9	10	10	10	9
4	10	10	9	10	10	7
total survival	35	39	37	40	39	32
proportion	0.92	1.00	0.93	1.00	0.98	0.80

Sample Appearance: clear, colourless

Initial Parameters:

DO (mg/L)	8.2	Conductivity (µmhos/cm)	957	Temperature (°C)	25.2	pH	8.61	Hardness (mg/L)	230	Alkalinity (mg/L)	90

Sample treatments: none

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	64.5	44.1 - 80.4	Linear Interpolation, (Norberg-King, 1993)	Growth effects endpoint, surviving fish only.
IC50	>100	na		
LC50	>100	na	na	

QUALITY ASSURANCE / COMMENTS

Associated QA/QC test: 9700599-0

**38 organisms exposed in the control, 39 organisms exposed in the 6.25% concentration.

* Data analysis performed in accordance with EPS 1/RM/22 amendments November 1997.

Reported by: [signature] Date: Jan. 16/98

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14 Abacus Road
Brampton,Ontario
Canada L6T 5B7

Tel (905) 794-2325
Fax (905) 794-2338
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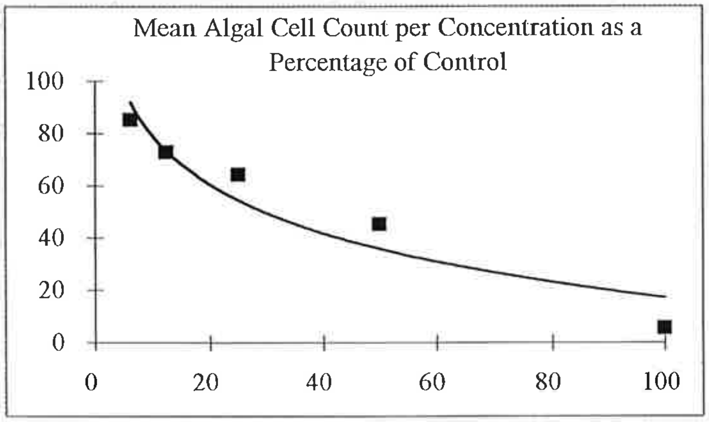
Algal Growth Inhibition Test

Biological Test Method EPS 1/RM/25

Client:	Beak		
Sample:	$ZnSO_4$		
Sample No.:	9700620-0	**Date Initiated:**	27-Jun-97
Date Sampled:	na	**Time Initiated:**	14:10
Time Sampled:	na	**Initiated by:**	R. Dorosz



TEST DATA

Mean Algal Cell Count (cells/ml = cell count x 10,000)

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	116	106	83	78	52	4
2	121	106	93	80	57	1
3	136	111	93	80	60	6
4	134	106	98	85	62	11
5	121	106	90	80	52	11
mean / conc.	125.6	107.0	91.4	80.6	56.6	6.6

TEST RESULTS

	% v/v	95% CI	Method of Calculation	MSD (%)	Notes
NOEC	0	na	Dunnett's	6	
LOEC	6.25	na			
TEC	<6.25	na			
IC25	11.4	7.97 - 18.4	Linear Interpolation, (Norberg-King, 1993)	na	
IC50	43.6	37.6 - 51.3			

QUALITY ASSURANCE / COMMENTS

t-test showed that growth in controls was significantly higher (11%) than in the QA/QC plate.
CV of control group = 15%

Reported by: [signature]

Date: Jan 16/98

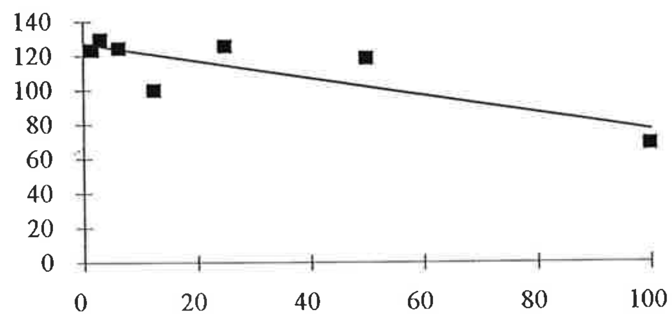
Algal Growth Inhibition Test
Biological Test Method EPS 1/RM/25

Client: Placer Dome
South Porcupine, Ontario

Sample: PD-R-B (P-E-1)

Sample No.:	9700603-5	**Date Initiated:**	27-Jun-97
Date Sampled:	24-Jun-97	**Time Initiated:**	11:20
Time Sampled:	11:00	**Initiated by:**	R. Dorosz

Mean Algal Cell Count per Concentration as a Percent of Control



TEST DATA
Mean Algal Cell Count Determined Via Absorbance (cells/ml = cell count x 10,000)

	concentration (% v/v)							
replicate	0	1.56	3.13	6.25	12.5	25	50	100
1	148	197	194	192	143	197	184	115
2	159	327	207	192	164	194	179	103
3	161	205	217	202	166	199	187	110
4	156	174	189	189	148	192	187	97
mean / conc.	156.1	191.8	202.0	193.8	155.5	195.7	184.2	106.4

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	80.9	62.7 - 98.1	Linear Interpolation, (Norberg-King, 1993)	
IC50	>100	na		

QUALITY ASSURANCE / COMMENTS

Associated QA/QC test: 9700620-0
CV of vertical control group = 4%; CV of entire control group = 10%
Replicate 2 of the 1.56% concentration was determined to be an outlier, using Grubb's test (p=0.05), and was excluded from data analysis.
The IC25/50 values were calculated using concentrations with mean cell counts less than or equal to that of the control, as recommended by the Environment Canada protocol.

Reported by: [signature] Date: Jan. 16/98

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14 Abacus Road
Brampton,Ontario
Canada L6T 5B7

Tel (905) 794-2325
Fax (905) 794-2338
1-800-361-BEAK (2325)

QUALITY ASSURANCE INFORMATION

***Ceriodaphnia* Survival and Reproduction Test**

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 600 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	15ml per replicate, 10 replicates per concentration
Test Vessels:	25 ml disposable plastic containers
Test Organism:	*Ceriodaphnia dubia*
Organism Age:	< 24 hours, within 8 hours of each other
Organism Health:	no ephippia detected in culture, mortality in culture <20%

Protocol

Environment Canada. 1992. Biological Test Method: Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia* . EPS 1/RM/21.

Reference Toxicant Test # 9700696-0

Chemical Used:	Sodium Chloride
Date of Test:	28-Jul-97
7-Day LC50:	1540 mg/L
Historical Warning Limits (LC50):	1170 - 2540
Historical Control Limits (LC50):	825 - 2880
7-Day IC50:	1590 mg/L
Historical Warning Limits (IC50):	1170 - 1970
Historical Control Limits (IC50):	965 - 2170

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using sodium chloride at least once per month and assesses the acceptability of the test results based on historical data, which are regularly updated on control charts.

Reference Test Commments:

The reference toxicant test results show that test reproducibility and sensitivity are within established limits.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

Acronyms

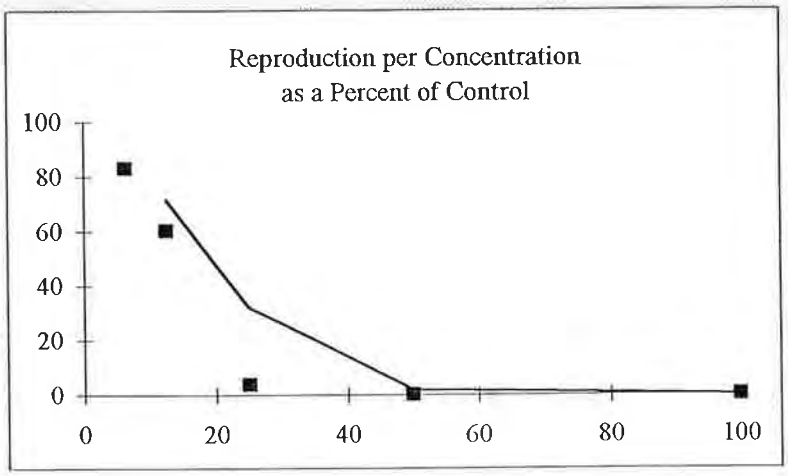
LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable (when applied to the LOEC, means that no concentration tested exhibited an observable effect)
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different).

Ceriodaphnia dubia Survival and Reproduction Test

Biological Test Method EPS 1/RM/21

Client: Placer Dome
South Porcupine, Ontario

Sample: PD-R-B (P-E-2)
Sample Type: effluent
Test No.: 9700710-3
Date Sampled: 29-Jul-97
Date Initiated: 31-Jul-97
Time Initiated: 12:30
Initiated by: E. Jonczyk



TEST DATA
Total Number of Neonates Produced per Adult After 6 Days of Testing

	concentration (% v/v)					
replicate	0	6.25	12.5	25	50	100
1	26	18	10	0	0	0
2	22	24	19	0	0	0
3	22	18	16	3	0	0
4	15	21	17	0	0	0
5	22	14	4	0	0	0
6	26	17	0	0	0	0
7	27	21	20	1	0	0
8	32	18	17	5	0	0
9	18	24	20	0	0	0
10	26	21	19	0	0	0
mean / conc.	23.6	19.6	14.2	0.9	0.0	0.0
mortality / 10 adults	0	0	2	10	10	10

Sample Appearance: clear,colourless
Initial Parameters:

DO (mg/L)	8.0	Conductivity (µmhos/cm)	972	Temperature (°C)	24.0	pH	8.24	Hardness (mg/L)	180	Alkalinity (mg/L)	90

Sample treatments: none

TEST RESULTS

	%v/v	95% CI	Method of Calculation	Notes
IC25	8.44	5.49 - 13.1	Linear Interpolation,	
IC50	14.8	11.1 - 17.5	(Norberg-King, 1993)	
LC50	15.4	12.9 - 18.3	Spearman-Karber	

QUALITY ASSURANCE INFORMATION & COMMENTS

Associated QA/QC test: 9700696-0

Reported by: [signature]

Date: Jan. 16/98

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Brampton,Ontario
Canada L6T 5B7

Tel (905) 794-2325
Fax (905) 794-2338
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QUALITY ASSURANCE INFORMATION: 7-Day Fathead Minnow Survival and Growth Test

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 500 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	500 ml per replicate, 2000 ml per concentration
Test Vessels:	500 ml disposable plastic containers
Test Organism:	*Pimephales promelas,*
Organism Source:	In House Culture
Organism Age:	< 24 hours

Protocol

Environment Canada. 1992. Biological Test Method: Test of Larval Growth and Survival Using Fathead Minnows . Report EPS 1/RM/22.

Reference Toxicant Test # 9700740-0

Chemical Used:	Potassium Chloride
Date of Test:	11-Aug-97
7-Day LC50:	868 mg/L
Historical Warning Limits (LC50):	771 - 1030
Historical Control Limits (LC50):	707 - 1090
IC50:	1100 mg/L
Historical Warning Limits (IC50):	705 - 1490
Historical Control Limits (IC50):	510 - 1680

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using potassium chloride at least once per month and assesses the acceptability of the test results based on historical data, updated regularly on control charts.

Reference Test Comments:

The reference toxicant test results show that test reproducibility and sensitivity are within established control and warning limits.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

Acronyms

LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable (when applied to the LOEC, means that no concentration tested exhibited an observable effect).
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different.

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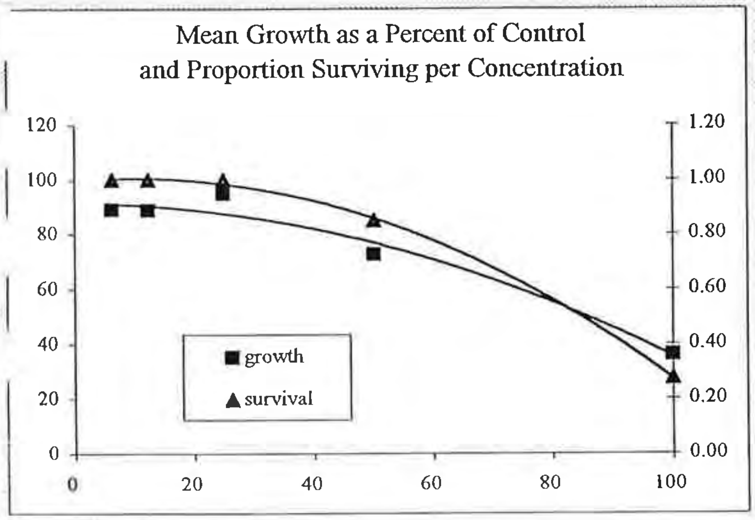
ıthead Minnow Survival and Growth Test
ological Test Method EPS 1/RM/22 *

Client:	Placer Dome South Porcupine, Ontario		
Sample:	PD-L-B		
Sample Type:	effluent		
Test No.:	9700710-1	Date Initiated:	30-Jul-97
Date Sampled:	29-Jul-97	Time Initiated:	14:30
		Initiated by:	R. Dorosz



TEST DATA

Mean Fish Weight per Replicate (mg)

replicate	concentration (% v/v) 0	6.25	12.5	25	50	100
1	0.932	0.850	0.764	0.887	0.649	0.225
2	0.847	0.790	0.845	0.833	0.623	0.320
3	0.873	0.799	0.714	0.816	0.696	0.370
4	0.914	0.734	0.840	0.843	0.623	0.370
mean / conc.	0.892	0.793	0.791	0.845	0.648	0.321

Survival per Replicate (total exposed per concentration = 40)

replicate	concentration (% v/v) 0	6.25	12.5	25	50	100
1	10	10	10	10	9	2
2	10	10	10	10	8	4
3	9	10	10	10	10	2
4	10	10	10	10	7	3
total survival	39	40	40	40	34	11
proportion	0.98	1.00	1.00	1.00	0.85	0.28

Sample Appearance: clear, colourless

Initial Parameters:

DO (mg/L)	8.2	Conductivity (µmhos/cm)	973	Temperature (°C)	21.3	pH	8.45	Hardness (mg/L)	180	Alkalinity (mg/L)	90

Sample treatments: none

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	46.8	38.2 - 56.8	Linear Interpolation, (Norberg-King, 1993)	Growth effects endpoint,
IC50	80.9	71.3 - 91.6		surviving fish only.
LC50	79.0	69.7 - 91.0	Probit	

QUALITY ASSURANCE / COMMENTS

Associated QA/QC test: 9700740-0

* Data analysis performed in accordance with EPS 1/RM/22 amendments November 1997.

Reported by: [signature]　　Date: Jan. 16/98

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Brampton,Ontario
Canada L6T 5B7

Tel (905) 794-2325
Fax (905) 794-2338
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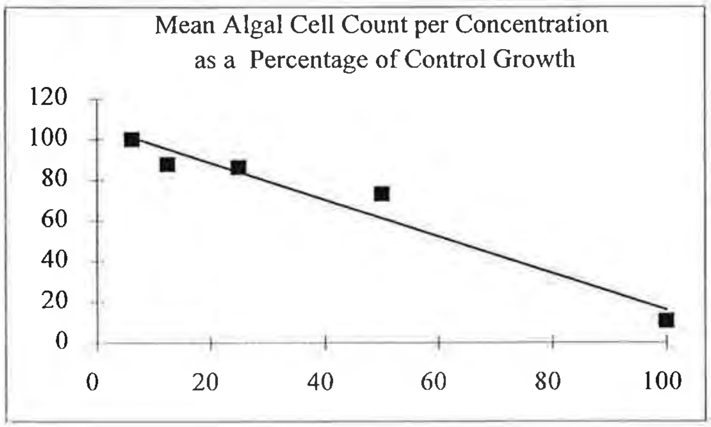
Algal Growth Inhibition Test

Biological Test Method EPS 1/RM/25

Client: Beak

Sample: $ZnSO_4$

Sample No.:	9700726-0	**Date Initiated:**	1-Aug-97
Date Sampled:	na	**Time Initiated:**	17:15
Time Sampled:	na	**Initiated by:**	E. Jonczyk



TEST DATA

Mean Algal Cell Count (cells/ml = cell count x 10,000)

	concentration (µg/L)					
replicate	0	6.25	12.5	25	50	100
1	99	107	96	99	96	951
2	124	115	102	93	77	6
3	118	118	102	102	88	14
4	115	107	96	93	63	11
5	99	107	91	91	212	17
mean / conc.	111.1	111.1	97.3	95.7	81.1	11.7

TEST RESULTS

	µg/L	95% CI	Method of Calculation	MSD (%)	Notes
NOEC	6.25	na	Bonferroni t-test	12	
LOEC	12.5	na			
TEC	8.84	na			
IC25	46.2	25.9 - 60.0	Linear Interpolation, (Norberg-King, 1993)	na	
IC50	68.4	55.3 - 75.4			

QUALITY ASSURANCE / COMMENTS

No significant difference was found between control growth and growth in the QA/QC plate.
CV of control group = 10%
5th and 1st data points from 50µl/L and 100µl/L, respectively were determined to be outliers (Grubb's test p=0.05) and therefore were excluded from analysis.
The IC25 and IC50 calculated in the latest test are outside the historic control limits. This may be expected to occur, due to chance alone, once every hundred test but may also indicate a problem within the test system.
A review of culture health, technical performance and test system revealed no anomalies. The control limits were recalculated using the latest results and the IC25 and IC50 are now within the new limits.

Reported by:

Date: Jan. 16/98

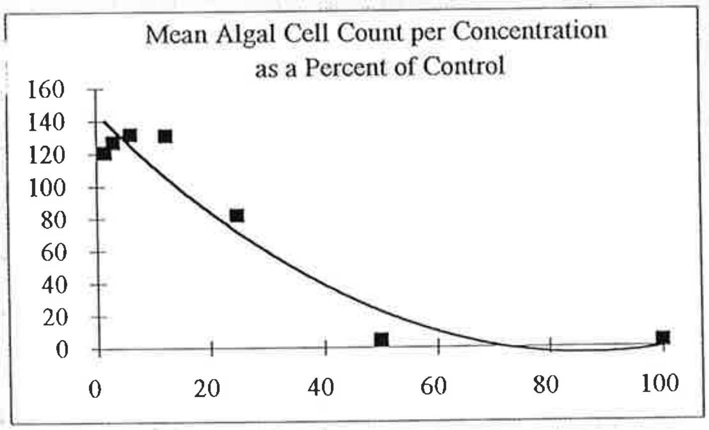
lgal Growth Inhibition Test

Biological Test Method EPS 1/RM/25

Client: Placer Dome
South Porcupine, Ontario

Sample: PD-R-B (P-E-2)

Sample No.: 9700710-5 **Date Initiated:** 1-Aug-97
Date Sampled: 29-Jul-97 **Time Initiated:** 16:30
Initiated by: E. Jonczyk



TEST DATA

Mean Algal Cell Count Determined Via Absorbance
(cells/ml = cell count x 10,000)

	concentration (% v/v)							
replicate	0	1.56	3.13	6.25	12.5	25	50	100
1	142	165	191	214	191	82	4	4
2	140	186	157	163	197	125	7	528
3	157	180	191	203	197	151	10	4
4	151	180	209	194	186	122	4	4
mean / conc.	147.5	177.7	187.0	193.5	192.8	120.2	6.6	4.4

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	27.1	10.6 - 33.4	Linear Interpolation, (Norberg-King, 1993)	
IC50	35.2	28.8 - 39.5		

QUALITY ASSURANCE / COMMENTS

Associated QA/QC test: 9700726-0
CV of vertical control group = 4%; CV of entire control group = 17%
Growth in the qa/qc plate was higher than growth in the control.
Concentrations with mean algal cell counts > mean control cell counts were excluded from the IC25 and IC50 determination, as recommended by the Environment Canada protocol.
Replicate 2 of the 100% concentration (528) was determined to be an outlier using Grubb's test (p=0.05), and was therefore excluded from analysis.

Reported by: [signature] Date: Jan. 16/98

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14 Abacus Road
Brampton,Ontario
Canada L6T 5B7

Tel (905) 794-2325
Fax (905) 794-2338
1-800-361-BEAK (2325)

QUALITY ASSURANCE INFORMATION

***Ceriodaphnia* Survival and Reproduction Test**

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 600 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	15ml per replicate, 10 replicates per concentration
Test Vessels:	25 ml disposable plastic containers
Test Organism:	*Ceriodaphnia dubia*
Organism Age:	< 24 hours, within 8 hours of each other
Organism Health:	no ephippia detected in culture, mortality in culture <20%

Protocol

Environment Canada. 1992. Biological Test Method: Test of Reproduction and Survival Using the Cladoceran *Ceriodaphnia dubia*. EPS 1/RM/21.

Reference Toxicant Test # 9701016-0

Chemical Used:	Sodium Chloride
Date of Test:	17-Oct-97
7-Day LC50:	2360 mg/L
Historical Warning Limits (LC50):	1150 - 2590
Historical Control Limits (LC50):	792 - 2940
8-Day IC50:	1390 mg/L
Historical Warning Limits (IC50):	1100 - 1940
Historical Control Limits (IC50):	896 - 2150

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using sodium chloride at least once per month and assesses the acceptability of the test results based on historical data, which are regularly updated on control charts.

Reference Test Commments:

The reference toxicant test results show that test reproducibility and sensitivity are within established limits.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

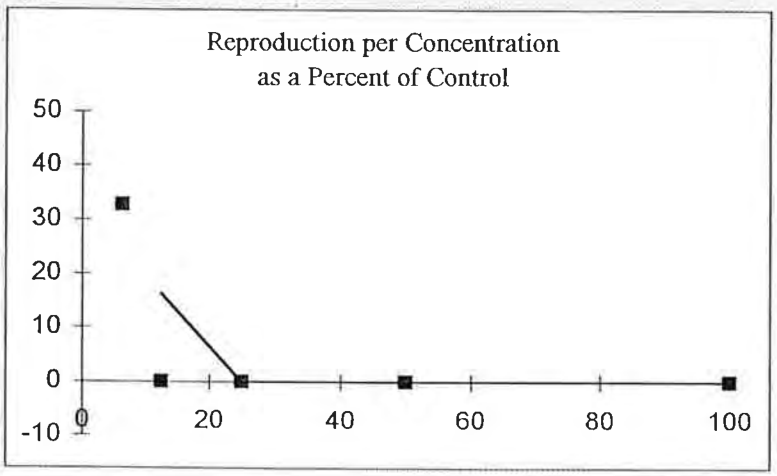
Acronyms

LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable (when applied to the LOEC, means that no concentration tested exhibited an observable effect).
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different).

Ceriodaphnia dubia Survival and Reproduction Test

Biological Test Method EPS 1/RM/21

Client:	Placer Dome South Porcupine, Ontario
Sample:	PD-R-B (P-E-3)
Sample Type:	effluent
Test No.:	9701083-4
Date Sampled:	20-Oct-97
Date Initiated:	23-Oct-97
Time Initiated:	15:15
Initiated by:	E. Jonczyk



TEST DATA

Total Number of Neonates Produced per Adult After 6 Days of Testing

replicate	concentration (% v/v) 0	6.25	12.5	25	50	100
1	26	9	0	0	0	0
2	20	0	0	0	0	0
3	16	0	0	0	0	0
4	5	0	0	0	0	0
5	14	0	0	0	0	0
6	9	3	0	0	0	0
7	23	0	0	0	0	0
8	32	17	0	0	0	0
9	24	20	0	0	0	0
10	21	13	0	0	0	0
mean / conc.	19.0	6.2	0.0	0.0	0.0	0.0
mortality / 10 adults	0	5	10	10	10	10

Sample Appearance: clear

Initial Parameters:

DO (mg/L)	Conductivity (µmhos/cm)	Temperature (°C)	pH	Hardness (mg/L)	Alkalinity (mg/L)
11.0	1100	24.1	8.37	200	90

Sample treatments: Sample was preaerated for 20 minutes on Days 0-1 prior to dilution.

TEST RESULTS

	%v/v	95% CI	Method of Calculation	Notes
IC25	<6.25	na	Linear Interpolation,	
IC50	<6.25	na	(Norberg-King, 1993)	
LC50	6.25	0 - 12.5	Binomial	

QUALITY ASSURANCE INFORMATION & COMMENTS

Associated QA/QC test: 9701016-0

Reported by: [signature] Date: Jan. 16/98

beak international incorporated

14 Abacus Road
Brampton,Ontario
Canada L6T 5B7

Tel (905) 794-2325
Fax (905) 794-2338
1-800-361-BEAK (2325)

QUALITY ASSURANCE INFORMATION:

7-Day Fathead Minnow Survival and Growth Test

Test Conditons

Test Type:	Static renewal
Test Temperature:	25±1°C
Lighting:	16 hours light/8 hours dark, < 500 lux
Dilution Water:	3/4 Reconstituted Water + 1/4 Dechlorinated Tap
Test Volume:	300 ml per replicate
Test Vessels:	420 ml disposable plastic containers
Test Organism:	*Pimephales promelas,*
Organism Source:	Aquatic Research Organisms, New Hampshire, U.S.A.
Organism Age:	< 24 hours

Protocol

Environment Canada. 1992. Biological Test Method: Test of Larval Growth and Survival Using Fathead Minnows . Report EPS 1/RM/22.
BEAK Reference: SOP FH - 4

Reference Toxicant Test # 9701162-0

Chemical Used:	Potassium Chloride
Date of Test:	23-Oct-97
7-Day LC50:	974 mg/L
Historical Warning Limits (LC50):	773 - 1030
Historical Control Limits (LC50):	710 - 1090
IC50:	1360 mg/L
Historical Warning Limits (IC50):	698 - 1480
Historical Control Limits (IC50):	501 - 1680

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using potassium chloride at least once per month and assesses the acceptability of the test results based on historical data, updated regularly on control charts.

Reference Test Comments:

The latest reference toxicant test results are within our established warning and control limits for our in-house culture, therefore, clarifying that organism response is normal.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

Acronyms

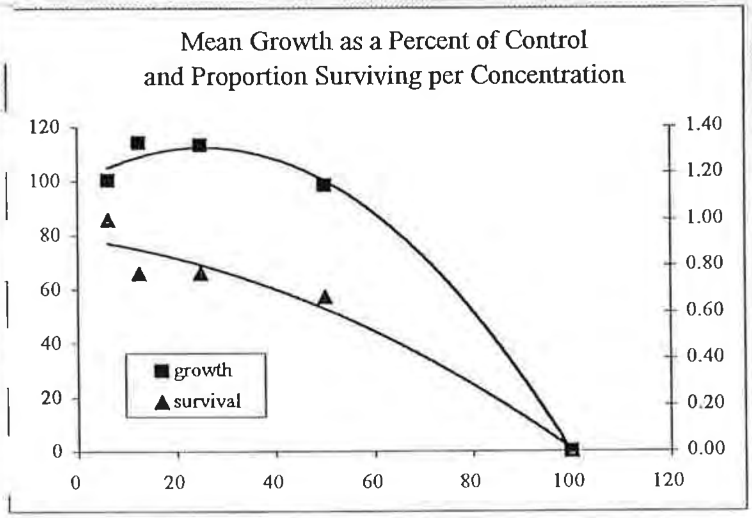
LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
na	not applicable
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different.

beak

[F]athead Minnow Survival and Growth Test
[B]iological Test Method EPS 1/RM/22 *

[C]lient: Placer Dome
South Porcupine, Ontario

[S]ample: PD-R-B (P-E-3)
Sample Type: effluent
Test No.: 9701083-5 **Date Initiated:** 23-Oct-97
[D]ate Sampled: 20-Oct-97 **Time Initiated:** 17:45
Initiated by: K. Elliot



TEST DATA

Mean Fish Weight per Replicate (mg)

replicate	concentration (% v/v) 0	6.25	12.5	25	50	100
1	0.841	0.763	0.851	1.010	0.757	0.000
2	0.866	0.842	0.992	0.938	0.877	0.000
3	0.796	0.901	1.015	0.884	0.826	0.000
mean / conc.	0.834	0.835	0.953	0.944	0.820	0.000

Survival per Replicate (total exposed per concentration = 30)

replicate	concentration (% v/v) 0**	6.25**	12.5	25	50	100
1	10	9	9	8	6	0
2	9	10	6	8	7	0
3	10	10	8	7	7	0
total survival	29	29	23	23	20	0
proportion	0.94	1.00	0.77	0.77	0.67	0.00

Sample Appearance: clear

Initial Parameters:

DO (mg/L)	11.0	Conductivity (µmhos/cm)	1100	Temperature (°C)	24.1	pH	8.37	Hardness (mg/L)	200	Alkalinity (mg/L)	90

Sample treatments: Sample was preaerated for 20 minutes on Days 0-1 prior to dilution.

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	>50	na	Linear Interpolation, (Norberg-King, 1993)	Growth effects endpoint,
IC50	>50	na		surviving fish only.
LC50	50.9	43.9 - 59.1	Moving Average	

QUALITY ASSURANCE / COMMENTS

Associated QA/QC test: 9701162-0

**31 organisms exposed in the control; 29 organisms exposed in the 6.25% concentration.

* Data analysis performed in accordance with EPS 1/RM/22 amendments November 1997.

Reported by: [signature] Date: Jan. 16/98

beak international incorporated

14 Abacus Road
Brampton,Ontario
Canada L6T 5B7

Tel (905) 794-2325
Fax (905) 794-2338
1-800-361-BEAK (2325)

QUALITY ASSURANCE INFORMATION:

72hr. Algal Growth Inhibition Test

Test Conditons

Test Temperature:	25±1°C
Lighting (lux intensity):	4000±10%
Dilution Water:	Filtered algal medium
Test Volume:	220 µL
Test Organism:	*Selenastrum capricornutum*
Organism Source:	In House Culture
Organism Age:	4-7 days (in exponential growth)
Initial Algal Innoculum:	10 000 cells/mL

Protocol

Environment Canada. 1992. Biological Test Method: Growth Inhibition Test Using the Freshwater Alga *Selenastrum capricornutum*. EPS 1/RM/21

Reference Toxicant Test # 9700997-0

Chemical Used:	Zinc Sulfate
Date of Test:	10-Oct-97
IC25:	35.4 µL/L
Historical Warning Limits (IC25):	4.6 - 55.4
Historical Control Limits (IC25):	-8.0 - 68.1
IC50:	49.8 µL/L
Historical Warning Limits (IC50):	22.6 - 76.8
Historical Control Limits (IC50):	9.0 - 90.4

Reference tests assess, under standardized conditions, the relative sensitivity of the culture and the precision and reliability of the data produced by the laboratory for that reference toxicant (Environment Canada, 1992). BEAK conducts a reference test using zinc sulfate at least once per month and assesses the acceptability of the test results based on historical data, updated regularly on control charts.

Reference Test Comments:

The reference toxicant test results show that test reproducibility and sensitivity are within established control and warning limits.
All reported data were cross-checked for errors and omissions.
Instruments used to monitor chemical and physical parameters were calibrated daily.

Acronyms

LC50	median lethal concentration (concentration that causes mortality in 50% of the test organisms)
NOEC	no observable effect concentration (highest concentration tested that exhibits no observable effect)
LOEC	lowest observable effect concentration (lowest concentration at which there is an observable effect)
IC25	inhibiton concentration (concentration at which response is impaired by 25%)
IC50	inhibiton concentration (concentration at which response is impaired by 50%)
MSD	minimum significant difference (difference between groups that is necessary to conclude that that they are significantly different.
na	not applicable

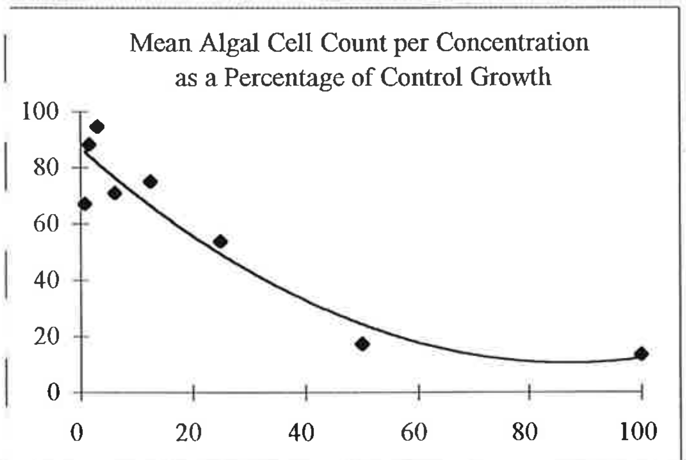
Algal Growth Inhibition Test

iological Test Method EPS 1/RM/25

Client: Placer Dome
South Porcupine, Ontario

Sample: PD-R-B (P-E-3)

Sample No.: 9701083-6 **Date Initiated:** 23-Oct-97
Date Sampled: 20-Oct-97 **Time Initiated:** 16:00
Initiated by: P. Trainor



TEST DATA

Mean Algal Cell Count (cells/ml = cell count x 10,000)

	concentration (% v/v)								
replicate	0	0.78	1.56	3.13	6.25	12.5	25	50	100
1	292	206	287	244	191	177	110	39	48
2	282	191	239	239	168	187	196	48	34
3	301	211	268	292	211	249	201	62	39
4	297	177	263	306	220	254	153	62	43
5	297	201	239	306	254	234	129	43	34
mean/conc.	293.7	197.2	259.3	277.4	208.6	220.1	158.0	50.9	39.5

TEST RESULTS

	% v/v	95% CI	Method of Calculation	Notes
IC25	5.64	3.99 - 19.9	Linear Interpolation, (Norberg-King, 1993)	
IC50	27.6	19.6 - 35.2		

QUALITY ASSURANCE / COMMENTS

Associated QA/QC test: 9700997-0
CV of vertical control group = 3%; CV of entire control group = 12%

Reported by: [signature] Date: Jan. 16/98

APPENDIX 5

Detailed Benthic Data and Chironomid Deformity Data

TABLE A5.1: Benthic Invertebrates from Dome Mine Site (densities expressed per 0.11 m^2)

Station	D1B			D2				D3			
Replicate	1	2	3	1	2	3	4	1	2	3	4
HYDROIDS											
P. Coelenterata											
Hydra	-	-	-	-	8	-	-	-	-	-	-
ROUNDWORMS											
P. Nematoda	-	32	16	40	80	88	488	40	8	28	28
FLATWORMS											
P. Platyhelminthes											
Cl. Turbellaria											
F. Tricladida	-	-	-	-	8	16	-	-	-	-	4
UNSEGMENTED WORMS											
P. Nemertea											
Prostoma	-	-	-	-	8	-	-	-	-	-	-
ANNELIDS											
P. Annelida											
WORMS											
Cl. Oligochaeta											
F. Enchytraeidae	-	-	-	8	-	-	8	-	-	-	-
F. Naididae											
Chaetogaster diaphanus	4	-	-	-	-	-	-	-	-	-	-
Dero nivea	4	-	-	64	191	64	24	4	-	28	50
Nais? pseudobtusa	-	-	-	-	-	-	-	-	-	-	-
Nais simplex	-	-	-	-	-	-	-	-	-	-	-
Nais variabilis	8	-	-	32	74	8	8	8	40	44	30
Ophidonais serpentina	-	-	-	-	-	-	-	-	-	-	-
Pristinella	-	-	-	-	-	-	-	-	-	-	-
Slavina appendiculata	-	-	-	-	-	-	8	-	-	-	-
F. Tubificidae											
Limnodrilus hoffmeisteri	-	-	-	-	-	8	-	-	-	-	-
immatures with hair chaeta	-	-	-	224	1543	392	56	60	44	4	180
immatures without hair ch	-	8	16	16	-	-	88	8	20	4	33
LEECHES											
Cl. Hirudinae											
F. Glossiphoniidae											
Glossiphonia complanata	-	-	-	-	-	-	-	-	-	-	-
F. Hirudinidae											
Haemopis grandis	-	-	-	1	-	-	-	-	-	-	-
F. Erpobdellidae											
Erpobdella punctata	-	-	-	-	-	-	12	-	-	-	-
Nephelopsis obscura	-	-	-	-	-	8	1	-	-	-	-
ARTHROPODS											
P. Arthropoda											
MITES											
Cl. Arachnida											
O. Hydracarina	12	24	24	136	184	184	120	-	48	40	36
HARPACTICOIDS											
O. Harpacticoida	-	24	16	-	-	8	48	-	4	-	-
SEED SHRIMPS											
Cl. Ostracoda	24	80	8	424	712	1568	1168	592	432	104	220
WATER SCUDS											

TABLE A5.1: Benthic Invertebrates from Dome Mine Site (densities expressed per 0.11 m^2)

Station	D1B			D2				D3			
Replicate	1	2	3	1	2	3	4	1	2	3	4
O. Amphipoda											
F. Hyalellidae											
Hyalella azteca	-	-	-	8	-	17	-	-	-	-	-
SPRINGTAILS											
Cl. Entognatha											
O. Collembola	-	-	-	8	16	-	-	-	-	-	-
INSECTS											
Cl. Insecta											
BEETLES											
O. Coleoptera											
F. Chrysomelidae											
Donacia	-	1	-	-	-	-	-	-	-	-	-
F. Elmidae											
Dubiraphia	-	-	-	-	-	-	-	-	-	-	-
F. Haliplidae											
Haliplus	-	-	-	8	16	32	-	-	-	-	-
MAYFLIES											
O. Ephemeroptera											
F. Baetidae											
Callibaetis	-	-	-	-	-	-	-	-	-	-	-
F. Caenidae											
Caenis	-	-	-	-	56	24	16	-	-	-	-
F. Leptophlebiidae											
Leptophlebia	-	-	-	-	-	-	-	-	-	-	-
indeterminate	-	-	-	-	24	16	-	-	-	-	-
ALDERFLIES											
O. Megaloptera											
F. Sialidae											
Sialis	-	-	-	-	-	-	-	-	-	-	-
O. Odonata											
DAMSELFLIES											
F. Coenagrionidae	-	-	-	8	-	-	-	-	-	-	-
Enallagma	-	-	-	-	-	-	-	-	-	-	-
DRAGONFLIES											
F. Corduliidae											
Cordulia	-	-	8	-	-	-	-	-	-	-	-
F. Libellulidae											
Libellula	-	-	-	-	-	-	-	-	-	-	-
BUGS											
O. Hemiptera											
F. Corixidae											
Hesperocorixa atopodonta	-	-	-	1	-	-	-	-	-	-	-
Sigara solensis	-	-	-	-	-	8	-	-	-	-	-
Sigara	-	-	-	-	-	8	-	-	-	-	-
CADDISFLIES											
O. Trichoptera											
F. Dipseudopsidae											
Phylocentropus	-	-	-	-	-	-	-	-	-	-	-
F. Hydroptilidae											
Hydroptila	-	-	-	-	-	-	-	-	-	-	-
Oxyethira	-	-	-	-	8	-	-	-	4	-	-
F. Leptoceridae											
Ceraclea	-	-	-	-	-	-	-	-	-	-	-

TABLE A5.1: Benthic Invertebrates from Dome Mine Site (densities expressed per 0.11 m^2)

Station	D1B			D2				D3			
Replicate	1	2	3	1	2	3	4	1	2	3	4
Nectopsyche	-	-	-	-	-	-	-	-	-	-	-
Oecetis	-	-	-	-	-	-	-	-	-	-	-
F. Limnephilidae											
Nemotaulius	-	-	-	-	-	-	-	-	-	-	-
F. Phryganeidae											
Phryganea	-	-	-	-	-	1	-	-	-	-	-
F. Polycentropodidae											
Polycentropus	-	-	-	-	-	-	-	-	-	-	-
TRUE FLIES											
O. Diptera											
pupae	-	-	-	-	8	-	-	-	-	-	-
BITING-MIDGE											
F. Ceratopogonidae											
Bezzia	-	8	-	8	8	8	56	-	-	-	-
Mallochohelea	-	-	-	-	-	-	-	-	-	-	-
Probezzia	-	-	-	-	8	-	24	-	-	-	-
Serromyia	4	-	16	8	8	32	176	-	-	-	-
PHANTOM MIDGE											
F. Chaoboridae											
Chaoborus flavicans	-	-	-	-	-	-	-	-	-	4	4
Chaoborus punctipennis	-	-	16	-	-	-	-	24	8	-	-
MIDGES											
F. Chironomidae											
S.F. Chironominae											
Chironomus	12	8	72	-	24	32	64	4	4	8	32
Cladopelma	504	88	144	56	88	200	2152	16	8	-	60
Cladotanytarsus	-	-	-	40	-	-	-	-	-	-	-
Cryptochironomus	16	16	8	8	-	-	-	-	-	-	-
Cryptotendipes	8	-	-	-	-	-	-	-	-	-	-
Dicrotendipes	4	8	8	48	176	344	40	12	12	4	20
Einfeldia	16	80	104	752	32	184	2848	-	4	-	28
Endochironomus	8	8	16	8	40	88	-	-	20	8	8
Glyptotendipes	-	-	-	-	-	32	-	-	-	-	-
Micropsectra	-	-	-	-	-	-	-	-	-	-	-
Microtendipes	-	-	-	-	-	-	-	-	-	-	-
Parachironomus	16	-	8	-	32	48	56	48	28	112	76
Paratanytarsus	-	-	16	32	72	16	-	-	4	8	-
Paratendipes	-	-	-	-	-	-	-	-	-	-	-
Phaenopsectra	-	-	-	-	8	-	-	12	4	4	-
Polypedilum	-	16	-	-	8	-	-	-	-	-	-
Rheotanytarsus	-	-	-	-	-	-	-	-	-	-	-
Tanytarsus	64	96	24	232	832	1136	344	20	4	8	28
Tribelos	-	-	-	-	-	-	-	-	-	-	-
S.F. Orthocladiinae											
Acricotopus	-	-	-	-	-	-	8	-	-	-	12
Brillia	-	-	-	-	-	-	-	-	-	-	-
Corynoneura	-	-	-	-	-	-	-	-	-	-	-
Cricotopus	-	-	-	-	8	40	232	-	-	12	8
Cricotopus/Orthocladius	-	-	-	-	-	-	-	-	-	-	-
Parakiefferiella	-	-	-	-	24	-	-	-	-	-	-
Psectrocladius	4	-	-	-	8	-	-	16	8	12	-
Zalutschia	-	-	16	-	16	-	-	-	-	-	-
S.F. Tanypodinae											
Ablabesmyia	4	-	-	80	112	120	16	-	-	-	-

TABLE A5.1: Benthic Invertebrates from Dome Mine Site (densities expressed per 0.11 m^2)

Station	D1B			D2				D3			
Replicate	1	2	3	1	2	3	4	1	2	3	4
Guttipelopia	4	-	-	-	24	104	48	-	-	-	-
Nilotanypus	-	-	-	-	-	-	-	-	-	-	-
Procladius	376	192	176	64	-	112	208	28	20	12	8
Tanypus	32	-	-	-	40	-	-	-	-	-	-
indeterminate	-	-	-	-	-	-	-	-	-	-	-
F. Tipulidae											
Rhabdomastix	-	-	-	-	-	-	8	-	-	-	-
MOLLUSCS											
P. Mollusca											
SNAILS											
Cl. Gastropoda											
F. Hydrobiidae											
Amnicola	-	-	-	-	-	-	-	-	-	-	-
F. Planorbidae											
Gyraulus deflectus	-	-	-	8	-	-	-	-	-	-	-
Gyraulus	-	-	-	48	136	136	-	-	-	-	-
Helisoma anceps	-	-	-	8	-	-	-	-	-	-	-
Promenetus exacuous	-	-	-	-	-	-	-	-	-	-	-
F. Physidae											
Physella	-	-	-	-	-	-	-	-	-	-	-
F. Valvatidae											
Valvata lewisi	-	-	-	-	-	-	8	-	-	-	-
Valvata tricarinata	-	-	-	-	-	-	-	-	-	-	-
CLAMS											
Cl. Pelecypoda											
F. Sphaeriidae											
Pisidium	-	-	16	-	16	32	56	-	-	-	-
Sphaerium rhomboideum	-	8	-	1	2	2	42	-	-	-	-
TOTAL NUMBER OF ORGANI	1124	697	728	2379	4658	5116	8431	892	724	444	865
TOTAL NUMBER OF TAXA	20	17	20	30	37	35	31	15	20	18	19

TABLE A5.1: Benthic Invertebrates from Dome Mine Site (densities expressed per 0.11 m^2)

Station	D3			D4						
Replicate	5	6	7	1	2	3	4	5	6	7
HYDROIDS										
P. Coelenterata										
Hydra	-	-	-	-	-	-	-	8	-	-
ROUNDWORMS										
P. Nematoda	12	16	112	592	496	144	540	296	210	380
FLATWORMS										
P. Platyhelminthes										
Cl. Turbellaria										
F. Tricladida	-	-	-	-	-	-	-	-	-	-
UNSEGMENTED WORMS										
P. Nemertea										
Prostoma	-	-	-	64	-	-	4	8	-	-
ANNELIDS										
P. Annelida										
WORMS										
Cl. Oligochaeta										
F. Enchytraeidae	-	-	-	-	-	8	-	8	-	-
F. Naididae										
Chaetogaster diaphanus	-	-	-	-	-	-	-	-	-	-
Dero nivea	40	12	4	-	8	24	28	28	20	-
Nais? pseudobtusa	-	-	-	-	-	8	-	-	-	-
Nais simplex	-	12	-	-	-	40	16	-	-	-
Nais variabilis	4	-	16	110	24	32	-	-	10	-
Ophidonais serpentina	-	-	-	32	-	8	-	-	-	-
Pristinella	-	-	-	-	-	-	-	-	10	-
Slavina appendiculata	-	-	-	-	-	-	-	-	-	-
F. Tubificidae										
Limnodrilus hoffmeisteri	-	-	-	-	16	-	-	-	-	120
immatures with hair chaeta	4	36	99	142	40	-	12	36	30	60
immatures without hair ch	12	88	53	691	304	8	44	679	490	1980
LEECHES										
Cl. Hirudinae										
F. Glossiphoniidae										
Glossiphonia complanata	-	-	-	-	8	1	-	-	10	1
F. Hirudinidae										
Haemopis grandis	-	-	-	-	-	-	-	-	-	-
F. Erpobdellidae										
Erpobdella punctata	-	1	-	-	-	-	-	-	-	-
Nephelopsis obscura	-	1	-	-	-	-	-	-	-	-
ARTHROPODS										
P. Arthropoda										
MITES										
Cl. Arachnida										
O. Hydracarina	72	-	56	464	48	208	224	288	170	370
HARPACTICOIDS										
O. Harpacticoida	-	-	-	-	208	32	-	-	-	10
SEED SHRIMPS										
Cl. Ostracoda	264	16	144	5728	1480	2800	3720	4280	3990	6280
WATER SCUDS										

TABLE A5.1: Benthic Invertebrates from Dome Mine Site (densities expressed per 0.11 m²)

Station	D3			D4						
Replicate	5	6	7	1	2	3	4	5	6	7
O. Amphipoda										
F. Hyalellidae										
Hyalella azteca	-	-	-	-	-	32	4	16	-	-
SPRINGTAILS										
Cl. Entognatha										
O. Collembola	-	-	-	-	-	-	-	-	-	-
<u>**INSECTS**</u>										
Cl. Insecta										
BEETLES										
O. Coleoptera										
F. Chrysomelidae										
Donacia	-	-	-	-	-	-	-	-	-	-
F. Elmidae										
Dubiraphia	-	-	-	-	-	8	-	-	-	-
F. Haliplidae										
Haliplus	-	-	-	-	-	-	-	-	-	-
MAYFLIES										
O. Ephemeroptera										
F. Baetidae										
Callibaetis	-	-	-	-	-	8	-	-	-	-
F. Caenidae										
Caenis	-	-	-	96	40	48	104	96	20	60
F. Leptophlebiidae										
Leptophlebia	-	-	-	16	-	-	-	-	-	-
indeterminate	-	-	-	-	-	-	-	-	-	10
ALDERFLIES										
O. Megaloptera										
F. Sialidae										
Sialis	-	-	-	-	-	-	4	-	31	50
O. Odonata										
DAMSELFLIES										
F. Coenagrionidae	-	-	-	-	-	-	-	-	-	10
Enallagma	-	-	-	-	-	-	-	-	-	-
DRAGONFLIES										
F. Corduliidae										
Cordulia	8	-	-	-	-	-	-	-	-	-
F. Libellulidae										
Libellula	-	-	4	-	-	-	-	-	-	-
BUGS										
O. Hemiptera										
F. Corixidae										
Hesperocorixa atopodonta	-	-	-	-	-	-	-	-	-	-
Sigara solensis	-	-	-	-	-	-	-	-	-	-
Sigara	-	-	-	-	-	-	-	-	-	-
CADDISFLIES										
O. Trichoptera										
F. Dipseudopsidae										
Phylocentropus	-	-	-	-	-	1	2	8	1	-
F. Hydroptilidae										
Hydroptila	-	-	-	-	-	24	12	16	-	10
Oxyethira	56	-	-	16	8	-	-	-	10	-
F. Leptoceridae										
Ceraclea	-	-	-	-	8	-	-	-	-	-

TABLE A5.1: Benthic Invertebrates from Dome Mine Site (densities expressed per 0.11 m^2)

Station	D3			D4						
Replicate	5	6	7	1	2	3	4	5	6	7
Nectopsyche	-	-	-	16	-	-	-	-	-	-
Oecetis	-	-	-	-	48	-	-	-	10	-
F. Limnephilidae										
Nemotaulius	-	-	-	-	-	1	-	-	-	-
F. Phryganeidae										
Phryganea	-	-	-	-	-	1	-	2	-	-
F. Polycentropodidae										
Polycentropus	-	-	-	-	8	24	8	-	-	-
TRUE FLIES										
O. Diptera										
pupae	-	-	-	-	-	-	4	-	-	-
BITING-MIDGE										
F. Ceratopogonidae										
Bezzia	4	4	4	16	24	8	-	-	20	-
Mallochohelea	-	-	-	48	160	176	160	104	120	120
Probezzia	-	-	-	-	-	24	12	8	-	-
Serromyia	-	-	-	-	-	-	-	-	-	-
PHANTOM MIDGE										
F. Chaoboridae										
Chaoborus flavicans	4	-	-	-	-	-	-	-	-	-
Chaoborus punctipennis	-	-	-	-	-	-	-	-	-	-
MIDGES										
F. Chironomidae										
S.F. Chironominae										
Chironomus	16	-	8	-	-	-	32	32	10	40
Cladopelma	4	76	8	-	-	-	-	-	-	-
Cladotanytarsus	-	-	-	-	48	-	92	40	250	-
Cryptochironomus	-	-	-	-	-	-	-	8	-	-
Cryptotendipes	-	-	-	-	-	-	-	-	-	-
Dicrotendipes	16	-	4	128	32	248	192	8	50	110
Einfeldia	-	-	-	-	-	-	-	-	-	-
Endochironomus	-	-	4	16	-	-	-	-	-	20
Glyptotendipes	-	-	-	-	-	-	-	-	-	-
Micropsectra	-	-	4	-	-	-	24	40	-	-
Microtendipes	-	-	-	-	-	-	-	-	-	-
Parachironomus	36	4	60	144	48	64	-	-	20	10
Paratanytarsus	20	-	-	864	352	1288	428	408	190	930
Paratendipes	-	-	-	16	-	208	112	-	30	10
Phaenopsectra	-	4	-	144	16	24	-	48	10	30
Polypedilum	-	-	-	-	8	96	24	16	20	70
Rheotanytarsus	-	-	-	-	-	-	-	40	-	-
Tanytarsus	20	-	-	1472	-	600	144	360	140	170
Tribelos	-	-	-	80	8	96	32	80	140	280
S.F. Orthocladiinae										
Acricotopus	4	-	4	-	-	-	-	-	-	-
Brillia	-	-	-	16	-	-	-	-	-	-
Corynoneura	-	-	-	-	8	-	-	-	-	10
Cricotopus	-	-	4	128	16	48	48	8	-	-
Cricotopus/Orthocladius	-	-	-	-	-	-	-	-	-	10
Parakiefferiella	-	-	-	-	-	-	-	-	-	-
Psectrocladius	24	28	4	256	72	504	168	48	-	10
Zalutschia	4	-	12	-	-	-	-	-	-	-
S.F. Tanypodinae										
Ablabesmyia	-	-	-	64	24	32	60	24	10	50

TABLE A5.1: Benthic Invertebrates from Dome Mine Site (densities expressed per 0.11 m^2)

Station	D3			D4						
Replicate	5	6	7	1	2	3	4	5	6	7
Guttipelopia	4	-	-	-	-	-	-	-	-	-
Nilotanypus	-	-	-	-	-	-	-	8	-	-
Procladius	36	24	24	48	184	624	140	168	260	80
Tanypus	-	8	-	-	-	-	-	-	-	-
indeterminate	-	-	-	-	-	-	-	8	-	-
F. Tipulidae										
Rhabdomastix	-	-	-	-	-	-	-	-	-	-
MOLLUSCS										
P. Mollusca										
SNAILS										
Cl. Gastropoda										
F. Hydrobiidae										
Amnicola	-	-	-	192	104	40	48	8	10	-
F. Planorbidae										
Gyraulus deflectus	-	-	-	-	-	-	-	-	-	-
Gyraulus	-	-	-	64	8	16	16	-	-	50
Helisoma anceps	-	-	-	-	8	-	-	8	30	-
Promenetus exacuous	-	-	-	-	-	8	-	-	-	10
F. Physidae										
Physella	-	-	-	16	-	-	4	-	-	11
F. Valvatidae										
Valvata lewisi	-	-	-	-	-	-	-	-	-	-
Valvata tricarinata	-	-	-	32	168	32	36	8	30	-
CLAMS										
Cl. Pelecypoda										
F. Sphaeriidae										
Pisidium	-	-	-	64	256	48	196	304	690	560
Sphaerium rhomboideum	-	-	-	-	-	-	-	-	-	-
TOTAL NUMBER OF ORGANI	664	330	628	11775	4288	7644	6694	7553	7042	11922
TOTAL NUMBER OF TAXA	22	15	20	32	34	41	34	37	32	33

Table A5.2: Summary of Chironomid Anomalies, Dome Mine Site

Station	# Chironomids per Sample	# Chironomids Examined	% Showing Anomalies	Genus showing Anomalies	Noted Anomalies
D1B-1	141	50	2	*Cladopelma*	centre of mentum broken.
D1B-2	44	18	0		no deformities noted.
D1B-3	48	21	0		no deformities noted.
D2-1	65	28	0		no deformities noted.
D2-2	58	23	4	*Endochironomus*	mentum teeth worn.
D2-3	84	29	7	*Chironomus* *Glyptotendipes*	mentum- right first and second lateral teeth worn. both apical mandibular teeth broken; right lateral teeth on mentum worn.
D2-4	450	51	2	*Cladopelma*	mentum- four left lateral teeth missing.
D3-1	13	13	0		no deformities noted.
D3-2	15	15	7	*Chironomus*	left apical mandibular tooth broken.
D3-3	29	14	0		no deformities noted.
D3-4	36	26	0		no deformities noted.
D3-5	14	14	7	*Chironomus*	mandible-left apical and first inner tooth broken.
D3-6	6	6	0		no deformities noted.
D3-7	20	20	0		no deformities noted.
D4-1	40	17	0		no deformities noted.
D4-2	35	19	0		no deformities noted.
D4-3	134	36	3		no deformities noted.
D4-4	140	59	0		no deformities noted.
D4-5	69	27	4	*Psectrocladius*	centre teeth on mentum worn.
D4-6	40	17	0		no deformities noted.
D4-7	56	21	14	*Chironomus* *Chironomus* *Chironomus*	median trifid tooth and toothlets worn. mandible- right apical tooth broken. median trifid tooth and right toothlet worn.

APPENDIX 6

Fish Data

Table A6.1: Metallothionein and Metal Concentrations in Yellow Perch Liver Tissue, Dome Mine Site

Station	Fish Number	ASSIGNED NUMBER	LIVER µg MT/g	Hg µg/g	Ag µg/g	Al µg/g	As µg/g	Ba µg/g	Cd µg/g	Co µg/g	Cr µg/g	Cu µg/g	Fe µg/g
D1	D1YP1												
	D1YP6	D1YP-1	282.5	0.066	0.005	4.745	< 0.050	< 0.151	0.098	19.384	< 0.151	11.509	209.989
	D1YP7	D1YP-2	182.0	0.049	0.004	5.629	< 0.049	< 0.146	0.124	4.823	< 0.146	5.677	167.892
	D1YP8	D1YP-3	172.9	0.064	0.003	3.713	< 0.050	< 0.149	0.110	3.015	< 0.149	5.198	212.393
	D1YP9	D1YP-4	248.1	0.061	0.004	2.341	< 0.056	< 0.167	0.109	1.633	< 0.167	5.211	180.560
	D1YP21		93.9	0.16	< 0.005	4.31	< 0.1	< 0.3	0.178	0.098	< 0.3	6.44	122
	D1YP22		20.9	0.164	< 0.007	6.41	< 0.2	< 0.4	0.217	0.204	< 0.4	4.47	243
	D1YP23		13.9	0.122	< 0.009	7.18	< 0.2	< 0.5	0.115	0.043	< 0.5	3.37	90.1
	D1YP25		122.0	0.128	< 0.009	7.41	< 0.2	< 0.5	0.207	0.263	< 0.5	5.87	214
D5	D5YP1		219.6	0.051	0.011	3.06	0.17	< 0.3	0.223	0.22	< 0.3	15.9	40.5
	D5YP2		107.1	0.035	0.013	5.68	< 0.2	< 0.4	0.065	0.122	< 0.4	4.79	56.4
	D5YP3		150.6	0.03	0.005	5.27	< 0.08	< 0.2	0.093	0.094	< 0.2	6.21	24.5
	D5YP4		394.3	0.028	0.005	2.28	0.08	< 0.2	0.125	0.133	< 0.2	13.9	48.6
	D5YP5		100.2	0.029	< 0.003	2.21	< 0.06	< 0.2	0.122	0.111	< 0.2	4.37	34.7
	D5YP6		395.0	0.031	0.006	2.64	0.07	< 0.1	0.068	0.093	0.13	15.6	48
	D5YP7		234.0	0.03	0.007	4.69	0.13	< 0.3	0.087	0.116	< 0.3	8.35	27.3
	D5YP8		59.5	0.027	< 0.006	4.94	< 0.2	< 0.3	0.1	0.153	< 0.3	3.08	88.9
	D5YP9		82.0	0.02	< 0.004	3.3	0.23	< 0.2	0.054	0.135	< 0.2	4.62	66.8
	D5YP10		185.9	0.072	0.004	2.4	0.1	< 0.2	0.101	0.152	< 0.2	7.6	75.2
	D5YP11		217.0	0.021	0.005	1.91	0.08	< 0.2	0.126	0.28	0.17	8.87	116
	D5YP12		271.4	0.051	0.005	4.29	0.08	< 0.2	0.152	0.165	< 0.2	11.6	84.6

Table A6.1: Metallothionein and Metal Concentrations in Yellow Perch Liver Tissue, Dome Mine Site

Station	Fish Number	ASSIGNED NUMBER	LIVER µg MT/g	Mo µg/g	Ni µg/g	Pb µg/g	Sb µg/g	Se µg/g	Tl µg/g	U µg/g	V µg/g	Zn µg/g
D1	D1YP1											
	D1YP6	D1YP-1	282.5	0.146	0.177	0.101	0.096	0.742			0.146	26.652
	D1YP7	D1YP-2	182.0	0.160	0.082	0.102	0.019	1.034			0.184	26.640
	D1YP8	D1YP-3	172.9	0.149	0.074	0.089	0.020	0.906			0.153	25.844
	D1YP9	D1YP-4	248.1	0.139	0.061	0.100	0.061	0.920			0.089	26.750
	D1YP21		93.9	0.16	< 0.05	0.26	< 0.025	1.24	0.019	< 0.005	0.172	32.6
	D1YP22		20.9	0.17	0.23	0.372	0.157	1.25	0.012	< 0.007	0.394	30.3
	D1YP23		13.9	0.17	0.18	0.533	0.096	1.12	0.015	< 0.009	0.156	34.5
	D1YP25		122.0	0.18	< 0.09	0.341	0.056	1.29	0.007	< 0.009	0.194	33.6
D5	D5YP1		219.6	0.23	0.39	0.207	0.088	1.17	0.003	< 0.005	0.112	32.3
	D5YP2		107.1	0.19	0.2	0.321	0.1	1.23	< 0.004	< 0.007	0.114	28
	D5YP3		150.6	0.18	0.1	0.222	0.024	0.95	< 0.002	< 0.004	0.087	26.8
	D5YP4		394.3	0.21	0.29	0.13	0.027	1.2	0.002	< 0.003	0.075	33.1
	D5YP5		100.2	0.17	0.16	0.13	< 0.02	1.04	0.002	< 0.003	0.088	26.1
	D5YP6		395.0	0.21	0.19	0.162	0.02	1.19	0.002	< 0.002	0.058	30.7
	D5YP7		234.0	0.19	0.19	0.387	0.036	0.99	< 0.003	< 0.005	0.095	28.9
	D5YP8		59.5	0.19	0.15	0.412	< 0.03	1.35	< 0.003	< 0.006	0.124	23.3
	D5YP9		82.0	0.2	0.15	0.266	0.268	1.44	< 0.002	< 0.004	0.053	25.1
	D5YP10		185.9	0.19	0.2	0.194	0.044	1.23	0.002	< 0.003	0.067	29.3
	D5YP11		217.0	0.19	0.25	0.125	0.226	0.93	0.002	< 0.003	0.056	30.2
	D5YP12		271.4	0.2	0.25	0.132	0.023	1.24	0.002	< 0.003	0.094	30.9

Table A6.2: Metallothionein and Metal Concentrations in Yellow Perch Kidney Tissue, Dome Mine Site

Station	Fish Number	ASSIGNED NUMBER	KIDNEY µg MT/g	Hg µg/g	Ag µg/g	Al µg/g	As µg/g	Ba µg/g	Cd µg/g	Co µg/g	Cr µg/g	Cu µg/g
D1	D1YP1											
	D1YP6	D1YP-1	402.7	0.139	0.062	14.450	< 0.630	< 1.574	0.375	1.244	2.141	15.489
	D1YP7	D1YP-2	121.9	0.073	0.016	8.176	< 0.305	< 0.763	0.164	0.583	< 0.763	9.945
	D1YP21		625.3	0.205	< 0.03	18.6	0.71	< 2	0.198	0.057	< 2	1.65
	D1YP22		499.4	0.373	0.121	43.2	< 2	< 3	0.321	0.176	< 3	2.45
	D1YP23		626.4	0.31	0.204	29.6	< 2	< 4	0.406	< 0.07	< 4	9.96
	D1YP25		207.4	0.148	0.031	15.5	0.43	< 1	0.537	0.066	< 1	3.21
D5	D5YP1		121.4	< 0.04	0.029	25	0.66	< 1	0.348	0.157	< 1	2.77
	D5YP2		134.9	< 0.08	0.052	28.1	< 0.8	< 2	0.128	0.135	< 2	2.23
	D5YP3		69.8	< 0.06	< 0.03	21.3	1.25	< 2	0.225	0.146	< 2	3.07
	D5YP4		76.3	< 0.04	< 0.02	27.6	0.91	< 1	0.263	0.193	< 1	2.83
	D5YP5		149.9	< 0.04	< 0.02	18.7	0.66	< 1	0.139	0.112	< 1	2.2
	D5YP6		131.6	< 0.02	< 0.01	8.88	0.25	< 0.5	0.044	0.103	0.55	1.37
	D5YP7		67.5	< 0.1	0.882	32.1	< 1	< 3	< 0.05	0.201	< 3	1.85
	D5YP8		75.9	< 0.06	0.221	10.2	0.76	< 2	0.255	0.129	< 2	2.45
	D5YP9		170.9	< 0.04	0.061	6.94	< 0.4	< 1	0.091	0.103	< 1	2.9
	D5YP10		98.8	0.056	0.051	13.4	0.4	< 0.5	0.193	0.145	< 0.5	1.73
	D5YP11		101.8	0.047	0.052	19.7	0.6	< 1	0.181	0.267	< 1	1.73
	D5YP12		100.6	0.065	0.028	10.7	0.98	< 0.5	0.31	0.148	< 0.5	2.31

Table A6.2: Metallothionein and Metal Concentrations in Yellow Perch Kidney Tissue, Dome Mine Site

Station	Fish Number	ASSIGNED NUMBER	KIDNEY µg MT/g	Fe µg/g	Mo µg/g	Ni µg/g	Pb µg/g	Sb µg/g	Se µg/g	Tl µg/g	U µg/g	V µg/g	Zn µg/g
D1	D1YP1												
	D1YP6	D1YP-1	402.7	124.352	< 0.315	1.407	1.247	0.236	1.042			0.227	192.352
	D1YP7	D1YP-2	121.9	92.127	< 0.153	0.259	0.418	0.110	0.635			0.156	117.142
	D1YP21		625.3	88.2	< 0.3	0.43	1.31	< 0.15	0.82	< 0.015	< 0.03	0.298	143
	D1YP22		499.4	109	< 0.6	< 0.06	3.78	< 0.3	1.49	< 0.03	< 0.06	0.612	163
	D1YP23		626.4	168	< 0.7	< 0.7	2.63	0.934	1.9	0.052	< 0.07	0.355	333
	D1YP25		207.4	97.6	< 0.2	0.24	1.12	5.04	0.9	0.058	< 0.02	0.139	158
D5	D5YP1		121.4	81.4	< 0.2	1.46	1.01	0.188	1.1	< 0.01	< 0.02	0.171	155
	D5YP2		134.9	76.6	< 0.4	0.77	1.69	0.544	1.13	< 0.02	< 0.04	0.34	141
	D5YP3		69.8	85.6	< 0.3	0.59	1.7	0.274	1.05	< 0.02	< 0.03	0.318	162
	D5YP4		76.3	96.6	< 0.2	2.46	1.18	< 0.1	1.19	< 0.01	< 0.02	0.228	145
	D5YP5		149.9	64.9	< 0.2	0.59	1.31	0.179	0.8	< 0.01	< 0.02	0.229	113
	D5YP6		131.6	82.6	< 0.1	1.08	0.887	1.6	1.03	0.006	< 0.01	0.142	70.7
	D5YP7		67.5	86.2	< 0.5	1.1	1.91	0.345	< 1	< 0.03	< 0.05	0.351	78.4
	D5YP8		75.9	78.3	< 0.3	0.5	1.16	< 0.2	1.29	< 0.02	< 0.03	0.198	218
	D5YP9		170.9	71.3	< 0.2	0.34	0.858	< 0.1	1.1	< 0.01	< 0.02	0.126	100
	D5YP10		98.8	63.7	0.11	0.7	0.706	0.183	0.95	< 0.005	< 0.01	0.135	113
	D5YP11		101.8	78.5	< 0.2	1.02	0.93	< 0.1	0.84	< 0.01	< 0.02	0.159	147
	D5YP12		100.6	66.8	0.15	0.7	0.622	< 0.05	0.82	< 0.005	< 0.01	0.133	177

Table A6.3: Metallothionein and Metal Concentrations in Yellow Perch Gill Tissue, Dome Mine Site

Station	Fish Number	ASSIGNED NUMBER	GILL µg MT/g	Hg µg/g	Ag µg/g	Al µg/g	As µg/g	Ba µg/g	Cd µg/g	Co µg/g	Cr µg/g	Cu µg/g
D1	D1YP6	D1YP-1	54.7	0.018	0.008	9.627	0.088	0.293	0.020	2.888	0.822	11.241
	D1YP7	D1YP-2	66.5	0.125	0.064	76.038	1.087	2.020	0.172	5.376	6.000	68.613
	D1YP8	D1YP-3	29.5	0.031	0.021	13.948	< 0.122	0.336	0.047	0.483	1.927	12.999
	D1YP9	D1YP-4	61.4	0.028	0.057	8.901	0.095	0.189	0.030	0.254	0.852	10.574
	D1YP21		98.0	0.107	< 0.02	16.3	< 0.4	< 1	< 0.02	0.033	< 1	1.13
	D1YP22		65.6	0.044	< 0.007	23.4	< 0.2	0.97	0.01	0.036	0.64	1.29
	D1YP23		201.2	0.054	< 0.01	9.48	< 0.2	0.52	0.014	0.016	0.71	0.87
	D1YP25		72.5	0.058	0.009	11.6	< 0.2	0.4	0.027	0.028	0.48	0.68
D5	D5YP1		39.0	0.015	0.007	16.2	< 0.1	0.29	0.015	0.099	0.31	1.04
	D5YP2		51.4	< 0.02	0.008	11.9	< 0.2	< 0.4	0.011	0.059	0.44	1
	D5YP3		36.7	0.016	0.018	38.5	< 0.2	< 0.4	0.013	0.082	0.63	1.65
	D5YP4		44.1	0.013	< 0.006	7.1	< 0.2	< 0.3	0.011	0.069	0.41	0.94
	D5YP5		23.7	0.014	0.005	17	0.1	0.24	0.013	0.08	0.28	2.68
	D5YP6		60.8	0.009	< 0.003	5.26	0.07	< 0.2	0.008	0.051	0.2	0.98
	D5YP7		38.8	0.019	< 0.008	13.6	0.17	0.57	0.015	0.203	0.44	1.65
	D5YP8		37.0	0.01	< 0.005	13.7	0.1	0.54	0.011	0.104	0.3	1.92
	D5YP9		69.8	< 0.02	< 0.01	22.6	< 0.2	1.46	0.021	0.083	0.61	2.38
	D5YP10		52.7	0.018	< 0.006	11.4	0.14	0.85	0.017	0.184	0.32	1.08
	D5YP11		20.9	0.013	< 0.006	14.3	0.13	0.78	0.014	0.259	0.41	1.4
	D5YP12		29.5	0.015	< 0.006	13.4	0.18	0.37	0.014	0.113	0.43	1.49

Table A6.3: Metallothionein and Metal Concentrations in Yellow Perch Gill Tissue, Dome Mine Site

Station	Fish Number	ASSIGNED NUMBER	GILL µg MT/g	Fe µg/g	Mo µg/g	Ni µg/g	Pb µg/g	Sb µg/g	Se µg/g	Tl µg/g	U µg/g	V µg/g	Zn µg/g
D1	D1YP6	D1YP-1	54.7	75.722	0.059	0.352	0.285	0.021	0.426			0.053	16.377
	D1YP7	D1YP-2	66.5	605.929	0.541	2.887	1.809	0.490	5.376			0.532	160.096
	D1YP8	D1YP-3	29.5	99.713	0.184	0.976	0.309	< 0.031	0.554			0.101	20.921
	D1YP9	D1YP-4	61.4	77.330	0.088	0.426	0.312	< 0.016	0.508			0.069	14.898
	D1YP21		98.0	89	< 0.2	< 0.2	1.01	0.179	0.87	< 0.01	< 0.02	< 0.1	23.4
	D1YP22		65.6	110	< 0.07	0.19	0.805	0.046	0.54	< 0.004	< 0.007	0.107	18.8
	D1YP23		201.2	51.7	< 0.1	0.13	0.769	0.082	0.77	< 0.005	< 0.01	0.098	20.4
	D1YP25		72.5	86.8	< 0.08	0.16	0.539	< 0.04	0.74	< 0.004	< 0.008	0.106	37.9
D5	D5YP1		39.0	48.2	< 0.05	0.42	0.425	0.039	0.56	< 0.003	< 0.005	0.075	15.9
	D5YP2		51.4	56.2	< 0.08	0.22	0.689	< 0.04	0.67	< 0.004	< 0.008	0.084	19
	D5YP3		36.7	75.5	< 0.07	0.43	0.759	0.104	0.65	< 0.004	< 0.007	0.091	16.6
	D5YP4		44.1	32.8	< 0.06	0.43	0.405	0.071	0.63	< 0.003	< 0.006	0.061	16.7
	D5YP5		23.7	70.5	< 0.04	0.46	0.465	0.037	0.59	< 0.002	< 0.004	0.082	16.1
	D5YP6		60.8	56	< 0.03	0.39	0.183	0.024	0.69	< 0.002	< 0.003	0.045	15.5
	D5YP7		38.8	59.7	< 0.08	1.35	0.678	0.048	0.46	< 0.004	< 0.008	0.126	20.3
	D5YP8		37.0	62	< 0.05	0.41	0.389	0.126	0.67	< 0.003	< 0.005	0.09	17.1
	D5YP9		69.8	74.8	< 0.1	0.38	0.582	< 0.05	0.67	< 0.005	< 0.01	0.122	20
	D5YP10		52.7	51.4	< 0.06	0.6	0.471	0.032	0.69	< 0.003	< 0.006	0.073	16.7
	D5YP11		20.9	55.8	< 0.06	0.97	0.342	0.101	0.7	< 0.003	< 0.006	0.078	20.9
	D5YP12		29.5	61.6	< 0.06	0.53	0.43	0.062	0.71	< 0.003	< 0.006	0.096	18.9

Table A6.4: Metal Concentrations in Yellow Perch Muscle Tissue, Dome Mine Site

Station	Fish Number	ASSIGNED NUMBER	Hg µg/g	Ag µg/g	Al µg/g	As µg/g	Ba µg/g	Cd µg/g	Co µg/g	Cr µg/g	Cu µg/g	Fe µg/g
D1	D1YP1											
	D1YP6	D1YP-1	0.118	< 0.001	0.73	0.04	< 0.05	0.006	0.005	< 0.05	0.18	1.92
	D1YP7	D1YP-2	0.232	< 0.001	0.47	0.03	< 0.05	0.002	0.003	< 0.05	0.18	2
	D1YP8	D1YP-3	0.137	< 0.001	0.61	0.05	< 0.05	0.002	0.002	< 0.05	0.24	1.88
	D1YP9	D1YP-4	0.116	< 0.001	0.64	0.07	< 0.05	0.003	0.003	< 0.05	0.12	1.86
	D1YP10		0.096	< 0.001	0.52	0.03	< 0.05	< 0.001	0.003	< 0.05	0.16	1.47
	D1YP11		0.154	< 0.001	0.53	0.05	< 0.05	0.001	0.002	< 0.05	0.1	1.77
	D1YP12		0.121	< 0.001	0.83	0.04	0.06	0.002	0.003	< 0.05	0.14	1.79
	D1YP13		0.143	< 0.001	0.51	0.04	< 0.05	0.001	0.002	< 0.05	0.12	1.87
	D1YP21		0.153	< 0.001	1.03	0.04	< 0.05	0.002	0.003	< 0.05	0.17	2.6
	D1YP22		0.176	< 0.001	0.45	0.04	< 0.05	< 0.001	0.003	< 0.05	0.12	1.19
	D1YP23		0.15	< 0.001	0.59	0.03	< 0.05	0.001	< 0.001	< 0.05	0.16	1.52
	D1YP25		0.333	< 0.001	0.48	< 0.02	< 0.05	0.002	0.003	< 0.05	0.21	1.94
D5	D5YP1		0.079	< 0.001	1.06	0.03	0.09	0.001	0.024	< 0.05	0.17	2.44
	D5YP2		0.051	< 0.001	0.67	0.03	< 0.05	0.001	0.006	0.06	0.24	2.44
	D5YP3		0.063	< 0.001	1.06	0.03	< 0.05	0.001	0.005	0.07	0.26	2.72
	D5YP4		0.037	< 0.001	0.83	0.04	< 0.05	0.002	0.009	0.06	0.19	2.23
	D5YP5		0.043	0.005	1.45	0.03	0.05	0.001	0.006	0.12	0.21	2.49
	D5YP6		0.047	0.005	1.42	0.03	0.06	< 0.001	0.005	0.06	0.18	1.55
	D5YP7		0.054	0.001	0.98	0.03	0.06	0.002	0.007	0.08	0.23	1.47
	D5YP8		0.06	< 0.001	0.77	0.02	< 0.05	0.001	0.009	0.06	0.27	2.21
	D5YP9		0.034	0.003	2.22	0.02	< 0.05	0.003	0.006	0.07	0.24	4.81
	D5YP10		0.08	< 0.001	1.04	0.03	< 0.05	0.002	0.009	< 0.05	0.19	2.34
	D5YP11		0.086	< 0.001	0.52	0.03	< 0.05	0.001	0.016	0.05	0.21	1.5
	D5YP12		0.089	< 0.001	1.02	0.04	< 0.05	0.002	0.011	< 0.05	0.24	2.03

Table A6.4: Metal Concentrations in Yellow Perch Muscle Tissue, Dome Mine Site

Station	Fish Number	ASSIGNED NUMBER	Mo µg/g	Ni µg/g	Pb µg/g	Sb µg/g	Se µg/g	Tl µg/g	U µg/g	V µg/g	Zn µg/g
D1	D1YP1										
	D1YP6	D1YP-1	< 0.01	0.01	0.067	< 0.005	0.27	0.002	< 0.001	< 0.005	3.56
	D1YP7	D1YP-2	< 0.01	< 0.01	0.062	< 0.005	0.17	0.001	< 0.001	0.005	4.84
	D1YP8	D1YP-3	< 0.01	< 0.01	0.031	< 0.005	0.28	0.002	< 0.001	0.008	5.43
	D1YP9	D1YP-4	< 0.01	0.01	0.046	0.027	0.26	0.002	< 0.001	0.005	3.74
	D1YP10		< 0.01	< 0.01	0.049	0.012	0.22	0.002	< 0.001	< 0.005	4.41
	D1YP11		< 0.01	< 0.01	0.044	0.021	0.21	0.001	< 0.001	0.006	3.53
	D1YP12		< 0.01	< 0.01	0.09	0.006	0.27	0.002	< 0.001	0.006	4.04
	D1YP13		< 0.01	< 0.01	0.059	< 0.005	0.25	0.002	< 0.001	< 0.005	3.81
	D1YP21		< 0.01	0.01	0.061	< 0.005	0.29	0.003	< 0.001	0.006	3.8
	D1YP22		< 0.01	< 0.01	0.054	< 0.005	0.22	0.002	< 0.001	0.007	3.74
	D1YP23		< 0.01	< 0.01	0.036	0.006	0.25	0.003	< 0.001	0.007	4.37
	D1YP25		< 0.01	< 0.01	0.079	< 0.005	0.36	0.001	< 0.001	< 0.005	5.17
D5	D5YP1		< 0.01	0.03	0.056	0.006	0.3	< 0.001	< 0.001	< 0.005	4.89
	D5YP2		< 0.01	0.02	0.074	< 0.005	0.4	< 0.001	< 0.001	0.005	4.98
	D5YP3		< 0.01	0.02	0.06	< 0.005	0.42	< 0.001	< 0.001	0.005	5.3
	D5YP4		< 0.01	0.04	0.14	0.006	0.41	< 0.001	< 0.001	0.005	4.26
	D5YP5		< 0.01	0.01	0.071	< 0.005	0.41	< 0.001	< 0.001	0.01	4.89
	D5YP6		< 0.01	0.03	0.064	< 0.005	0.34	0.001	< 0.001	0.01	4.32
	D5YP7		< 0.01	0.04	0.075	< 0.005	0.31	< 0.001	< 0.001	0.008	4.91
	D5YP8		< 0.01	0.01	0.05	0.036	0.35	0.001	< 0.001	0.01	5.83
	D5YP9		< 0.01	0.02	0.134	0.014	0.35	< 0.001	< 0.001	0.015	5.55
	D5YP10		< 0.01	0.02	0.064	0.011	0.34	< 0.001	< 0.001	0.01	4.06
	D5YP11		< 0.01	0.03	0.041	0.008	0.38	< 0.001	< 0.001	0.009	4.57
	D5YP12		< 0.01	0.03	0.064	< 0.005	0.37	< 0.001	< 0.001	0.011	5.57

Table A6.5: Metallothionein and Metal Concentrations in Pearl Dace Viscera, Dome Mine Site

Station	Fish Number	VISCERA µg MT/g	Hg µg/g	Ag µg/g	Al µg/g	As µg/g	Ba µg/g	Cd µg/g	Co µg/g	Cr µg/g	Cu µg/g	Fe µg/g
D1	D1PD1	181.3	0.009	0.036	3.214	0.179	0.576	0.020	0.221	0.212	7.550	31.232
	D1PD2	85.8	0.006	0.005	3.883	0.340	1.957	0.010	0.084	0.421	2.531	46.054
	D1PD3	108.9	0.018	0.011	7.758	3.066	1.870	0.054	0.573	1.441	18.367	278.117
	D1PD4	180.8	0.015	0.035	3.975	1.778	0.339	0.022	0.252	0.493	21.231	136.200
	D1PD5	153.3	< 0.006	0.017	6.832	1.159	1.655	0.030	0.310	0.512	12.008	84.870
	D1PD6	174.0	0.063	0.033	8.618	0.862	0.209	0.071	0.230	0.419	9.515	167.268
	D1PD7	122.7	0.039	0.050	1.263	0.394	0.120	0.020	0.087	0.210	13.833	112.766
	D1PD8	166.2	0.043	0.061	10.025	0.969	1.820	0.032	0.091	1.913	12.462	119.069
	D1PD9	197.5	0.019	0.044	9.919	0.650	0.964	0.030	0.221	0.560	11.412	104.170
D2	D2PD1	183.7	0.027	0.020	3.484	0.856	0.207	0.023	0.160	0.207	7.648	77.660
	D2PD2	60.1	0.018	0.029	5.198	3.944	< 0.306	0.019	0.205	0.336	5.748	153.802
	D2PD3	103.4	0.025	0.010	5.344	5.624	0.559	0.022	0.241	0.373	5.624	166.232
	D2PD4	116.2	0.040	0.020	5.015	1.104	< 0.459	0.035	0.394	< 0.459	7.706	109.776
	D2PD5	254.5	0.022	0.028	3.483	1.057	< 0.155	0.027	0.151	0.155	11.911	115.066
	D2PD6	153.8	0.027	0.037	5.655	1.039	0.238	0.032	0.135	0.357	9.227	108.342
	D2PD7	220.2	0.031	0.031	5.662	1.699	< 0.462	0.033	0.099	0.954	11.601	123.398
	D2PD8	214.3	0.061	0.066	18.644	3.286	< 0.768	0.046	0.839	0.768	15.603	167.700
	D2PD9	136.4	0.022	0.032	5.990	1.071	0.528	0.023	0.490	0.341	15.394	95.902
D3	D3PD1	237.4	0.018	0.390	6.405	0.241	< 0.457	0.059	0.217	< 0.457	53.677	113.758
	D3PD2	154.2	0.019	0.330	6.693	0.507	< 0.467	0.067	0.616	0.467	47.004	89.962
	D3PD3	155.6	0.003	0.045	3.678	2.915	1.318	0.038	0.265	0.184	16.305	128.111
	D3PD4	163.8	0.009	0.247	62.932	6.235	2.605	0.091	1.294	1.171	25.700	295.633
	D3PD5	127.3	0.003	0.165	8.004	2.512	0.859	0.059	0.552	0.184	35.879	158.849
	D3PD6	139.9	0.006	0.073	6.352	3.251	0.723	0.033	0.261	0.181	23.481	116.503
	D3PD7	163.3	< 0.003	0.137	6.961	2.258	1.695	0.026	0.430	0.212	28.147	78.388
	D3PD8	148.7	< 0.003	0.307	7.555	2.469	1.306	0.027	0.364	0.280	60.628	97.315
	D3PD9	137.3	0.009	0.345	12.323	2.298	1.548	0.031	0.239	0.387	30.659	122.636
D4	D4PD1	131.2	< 0.003	0.117	15.904	1.226	1.285	0.041	0.670	1.315	32.420	123.868
	D4PD2	114.2	< 0.003	0.050	10.621	0.776	2.537	0.030	0.235	0.502	30.387	66.970
	D4PD3	90.4	< 0.003	0.049	5.231	0.157	1.028	0.017	0.095	0.181	11.944	58.966
	D4PD4	90.3	< 0.003	0.028	9.592	0.390	2.234	0.035	0.094	0.268	9.383	58.981
	D4PD5	101.3	< 0.006	0.133	135.700	2.290	5.895	0.041	0.623	2.210	43.903	426.749
	D4PD6	136.8	< 0.003	0.064	6.515	0.390	1.903	0.029	0.348	0.419	20.673	56.440
	D4PD7	87.8	< 0.006	0.198	212.049	10.311	2.700	0.030	1.366	3.682	46.338	785.593
	D4PD8	58.3	< 0.006	0.059	5.919	0.409	1.797	0.031	0.229	0.496	15.867	89.251
	D4PD9	99.6	< 0.003	0.077	10.488	0.177	1.802	0.009	0.050	0.443	7.977	40.181

Table A6.5: Metallothionein and Metal Concentrations in Pearl Dace Viscera, Dome Mine Site

Station	Fish Number	VISCERA µg MT/g	Mo µg/g	Ni µg/g	Pb µg/g	Sb µg/g	Se µg/g	Tl µg/g	U µg/g	V µg/g	Zn µg/g
D1	D1PD1	181.3	0.079	0.139	0.061	0.006	0.321			0.018	17.526
	D1PD2	85.8	0.081	0.331	0.054	0.003	0.154			0.015	16.074
	D1PD3	108.9	0.343	1.128	0.086	0.009	0.659			0.058	21.802
	D1PD4	180.8	0.210	0.410	0.096	0.043	0.746			0.028	24.128
	D1PD5	153.3	0.175	0.442	0.102	0.033	0.635			0.033	27.658
	D1PD6	174.0	0.239	0.242	0.084	< 0.015	1.050			0.042	34.710
	D1PD7	122.7	0.171	0.069	0.090	0.084	0.809			< 0.012	22.132
	D1PD8	166.2	0.284	1.095	0.247	< 0.015	0.395			0.031	18.971
	D1PD9	197.5	0.183	0.308	0.134	< 0.016	0.821			0.037	29.479
D2	D2PD1	183.7	0.180	0.133	0.112	< 0.012	0.673			0.024	25.247
	D2PD2	60.1	0.153	0.147	0.165	0.208	0.547			< 0.031	22.872
	D2PD3	103.4	0.131	0.301	0.183	0.050	0.656			0.037	18.674
	D2PD4	116.2	0.190	0.150	0.239	< 0.046	0.764			0.046	22.903
	D2PD5	254.5	0.152	0.093	0.149	0.016	0.656			0.025	26.310
	D2PD6	153.8	0.161	0.202	0.247	0.021	0.658			0.033	27.026
	D2PD7	220.2	0.154	0.403	0.495	< 0.046	0.640			0.049	24.310
	D2PD8	214.3	0.264	0.768	0.624	0.968	0.906			0.101	33.171
	D2PD9	136.4	0.118	0.183	0.180	0.081	0.611			0.047	23.153
D3	D3PD1	237.4	0.198	0.250	0.281	0.073	1.653			0.055	21.135
	D3PD2	154.2	0.221	2.002	0.246	< 0.047	2.204			0.056	21.946
	D3PD3	155.6	0.230	0.782	0.070	0.046	1.542			0.018	28.289
	D3PD4	163.8	0.515	3.337	0.249	0.061	1.680			0.234	60.005
	D3PD5	127.3	0.233	3.067	0.074	0.021	1.527			0.040	23.674
	D3PD6	139.9	0.202	0.930	0.111	0.030	1.686			0.024	29.623
	D3PD7	163.3	0.230	0.950	0.115	0.036	1.522			0.027	31.476
	D3PD8	148.7	0.215	1.343	0.099	0.012	1.244			0.031	24.375
	D3PD9	137.3	0.292	0.860	0.182	0.030	1.935			0.054	45.244
D4	D4PD1	131.2	0.413	3.425	0.098	0.024	0.569			0.052	14.314
	D4PD2	114.2	0.254	1.006	0.080	0.091	0.693			0.038	28.470
	D4PD3	90.4	0.148	0.420	0.057	< 0.006	0.819			0.018	18.839
	D4PD4	90.3	0.182	1.206	0.387	0.039	0.602			0.033	24.337
	D4PD5	101.3	0.522	4.267	0.252	0.049	1.035			0.414	42.061
	D4PD6	136.8	0.239	0.742	0.087	0.013	1.632			0.026	25.995
	D4PD7	87.8	0.568	7.181	0.325	0.055	0.608			0.709	17.062
	D4PD8	58.3	0.242	0.555	0.161	0.077	1.441			0.028	34.399
	D4PD9	99.6	0.112	0.390	0.086	0.044	0.346			0.035	14.979

Table A6.6: Metallothionein and Metal Concentrations in Caged Yellow Perch Viscera, Dome Mine Site

Station	Fish Number	ASSIGNED NUMBER	VISCERA µg MT/g	Hg µg/g	Ag µg/g	Al µg/g	As µg/g	Ba µg/g	Cd µg/g	Co µg/g	Cr µg/g	Cu µg/g	Fe µg/g	Mo µg/g	Ni µg/g	Pb µg/g
D1	DIYP100CG	D1YP-101	40.6	< 0.036	0.021	14.277	< 0.142	< 0.355	0.085	0.163	3.338	2.166	103.703	0.142	1.776	0.419
		D1YP-201	38.8	< 0.047	0.019	20.897	< 0.189	< 0.473	0.085	0.199	12.481	2.704	117.250	0.284	5.390	0.444
	DIYP200CG	D1YP-301	69.1	< 0.051	0.031	16.509	< 0.205	< 0.513	0.072	0.133	5.845	1.620	95.363	0.205	2.666	0.297
		D1YP-401	37.9	< 0.044	0.018	10.467	< 0.177	< 0.444	0.044	0.089	4.790	1.215	78.062	0.177	2.306	0.293
	DIYP300CG	D1YP-501	37.3	< 0.033	0.013	9.286	< 0.134	< 0.334	0.047	0.067	3.006	1.122	61.461	0.134	1.136	0.234
		D1YP-601	70.8	< 0.054	0.011	17.698	< 0.217	< 0.543	0.087	0.065	5.103	1.292	62.974	0.109	2.172	0.380
	DIYP400CG	D1YP-701	49.3	< 0.041	0.008	14.094	< 0.164	< 0.410	0.057	0.074	3.278	1.188	65.554	0.082	1.721	0.385
		D1YP-801	67.9	< 0.032	< 0.006	5.349	< 0.127	< 0.318	0.038	0.025	1.401	0.866	39.480	0.064	0.573	0.204
	DIYP500CG	D1YP-901	84.4	< 0.056	0.011	13.905	< 0.222	< 0.556	0.067	0.067	2.781	1.001	57.845	< 0.111	1.335	0.356
		D1YP-1001	54.7	< 0.047	0.019	18.024	< 0.189	< 0.472	0.057	0.085	3.869	1.661	83.988	0.189	1.793	0.226
	DIYP600CG	D1YP-1101	81.0	< 0.048	< 0.010	28.695	< 0.192	< 0.480	0.019	0.749	0.480	7.399	39.347	< 0.096	0.096	0.326
D2	D2YP100CG	D2YP-101	55.2	< 0.021	0.025	10.621	< 0.085	< 0.212	0.038	0.072	3.314	1.517	63.302	0.297	1.869	0.200
		D2YP-201	32.9	< 0.018	< 0.004	2.767	< 0.073	< 0.182	0.015	0.131	< 0.182	1.343	15.653	< 0.036	< 0.036	0.120
	D2YP200CG	D2YP-301	19.7	< 0.035	< 0.007	7.478	< 0.138	< 0.346	0.028	0.388	0.623	3.573	30.467	0.138	0.277	0.222
		D2YP-401	32.0	< 0.018	< 0.004	5.050	< 0.070	< 0.175	0.025	0.719	0.421	9.925	31.214	0.105	0.210	0.102
	D2YP300CG	D2YP-501	54.5	< 0.031	< 0.006	6.195	< 0.125	< 0.313	0.031	0.175	< 0.313	4.142	35.666	0.063	0.125	0.138
		D2YP-601	65.4	< 0.021	< 0.004	3.434	< 0.083	< 0.207	0.021	0.885	< 0.207	8.358	28.962	0.041	0.083	0.124
	D2YP400CG	D2YP-701	25.8	< 0.036	< 0.007	4.738	< 0.146	< 0.364	0.022	0.270	< 0.364	3.594	31.346	0.073	0.073	0.204
		D2YP-801	54.7	< 0.013	< 0.003	1.494	< 0.052	< 0.131	0.018	0.225	< 0.131	2.170	23.852	0.052	0.052	0.045
	D2YP500CG	D2YP-901	36.4	< 0.036	< 0.007	2.811	< 0.144	< 0.360	0.029	0.173	< 0.360	3.849	36.039	0.072	0.072	0.173
D3	D3YP100CG	D3YP-101	68.0	< 0.031	< 0.006	3.245	< 0.125	< 0.312	0.031	0.356	< 0.312	4.449	36.814	0.062	0.125	0.237
		D3YP-201	76.1	< 0.042	< 0.008	3.811	< 0.169	< 0.423	0.034	0.398	< 0.423	6.182	44.883	0.085	0.085	0.229
	D3YP200CG	D3YP-301	62.9	< 0.026	< 0.005	2.078	< 0.104	< 0.260	0.021	0.151	0.312	2.478	27.536	0.104	0.156	0.068
		D3YP-401	42.3	< 0.037	< 0.007	3.213	< 0.149	< 0.374	0.030	0.149	< 0.374	2.503	42.594	0.075	0.149	0.142
	D3YP300CG	D3YP-501	35.5	< 0.030	< 0.006	6.007	< 0.119	< 0.297	0.024	0.327	< 0.297	4.865	44.605	0.059	0.119	0.161
		D3YP-601	53.7	< 0.040	< 0.008	2.468	< 0.159	< 0.398	0.024	0.127	< 0.398	2.635	38.212	0.080	0.080	0.127
	D3YP400CG	D3YP-701	52.3	< 0.034	< 0.007	11.662	< 0.136	< 0.341	0.041	0.232	0.546	3.806	56.607	0.136	0.273	0.355
		D3YP-801	19.3	< 0.030	< 0.006	4.717	< 0.121	< 0.302	0.024	0.169	0.665	3.308	41.127	0.121	0.302	0.127
	D3YP500CG	D3YP-901	46.9	< 0.030	< 0.006	5.155	< 0.119	< 0.296	0.024	0.184	0.415	2.981	46.812	0.119	0.178	0.089
D4	D4YP100CG	D4YP-101	62.8	< 0.030	< 0.006	3.520	< 0.121	< 0.303	0.055	0.115	< 0.303	2.713	38.232	0.061	0.182	0.109
		D4YP-201	52.6	< 0.025	< 0.005	2.380	< 0.099	< 0.248	0.040	0.183	< 0.248	4.387	33.711	0.099	0.099	0.084
	D4YP200CG	D4YP-301	45.5	< 0.029	< 0.006	2.243	< 0.115	< 0.288	0.029	0.322	0.345	3.565	36.800	0.058	0.115	0.069
		D4YP-401	42.3	< 0.038	< 0.008	3.041	< 0.152	< 0.380	0.038	0.220	< 0.380	4.675	41.810	0.076	0.152	0.144
	D4YP300CG	D4YP-501	81.7	< 0.037	< 0.007	3.443	< 0.147	< 0.366	0.037	0.227	< 0.366	3.018	49.812	0.073	0.147	0.132
		D4YP-601	65.2	< 0.036	< 0.007	3.180	< 0.145	< 0.361	0.036	0.137	< 0.361	2.125	41.196	< 0.072	0.072	0.108
	D4YP400CG	D4YP-701	64.7	< 0.033	< 0.007	3.064	< 0.130	< 0.326	0.046	0.156	< 0.326	2.822	43.021	0.065	0.130	0.111
		D4YP-801	45.1	< 0.041	0.033	7.309	< 0.164	< 0.411	0.033	0.189	< 0.411	2.135	36.133	< 0.082	0.082	0.189
	D4YP500CG	D4YP-901	56.0	< 0.051	0.010	9.739	< 0.203	< 0.507	0.051	0.852	< 0.507	4.859	49.707	0.101	0.304	0.254
D5	D5YP100CG	D5YP-101	48.9	< 0.032	0.006	5.922	< 0.126	< 0.315	0.044	0.592	< 0.315	4.782	39.062	0.063	0.315	0.239
		D5YP-201	57.6	< 0.034	< 0.007	8.006	< 0.137	< 0.342	0.048	0.144	< 0.342	2.313	49.269	0.068	0.274	0.185
	D5YP200CG	D5YP-301	41.8	< 0.032	0.006	8.917	< 0.129	< 0.323	0.032	0.084	< 0.323	2.281	50.402	0.065	0.129	0.162
		D5YP-401	42.0	< 0.026	< 0.005	3.566	< 0.105	< 0.262	0.031	0.105	< 0.262	2.522	40.904	0.105	0.105	0.073
	D5YP300CG	D5YP-501	30.4	< 0.037	< 0.007	8.896	< 0.148	< 0.371	0.037	0.089	< 0.371	2.165	53.377	0.074	0.222	0.111
		D5YP-601	34.2	< 0.039	< 0.008	8.172	< 0.157	< 0.393	0.039	0.126	0.707	2.742	55.788	0.157	0.393	0.149
	D5YP400CG	D5YP-701	56.4	< 0.032	< 0.006	20.929	0.192	0.320	0.064	0.301	0.832	5.844	76.805	0.128	0.768	0.275
		D5YP-801	51.8	< 0.030	< 0.006	3.472	< 0.120	< 0.299	0.030	0.269	0.419	3.856	41.908	0.120	0.239	0.102
	D5YP500CG	D5YP-901	88.6	< 0.033	< 0.007	12.671	< 0.133	< 0.333	0.040	0.180	0.534	3.981	52.017	0.133	0.467	0.207
		D5YP-1001	74.9	< 0.032	< 0.006	8.413	0.127	< 0.319	0.032	0.268	< 0.319	5.010	42.702	0.064	0.319	0.287
	D5YP600CG	D5YP-1101	76.0	< 0.033	< 0.007	8.105	< 0.133	< 0.332	0.033	0.146	< 0.332	2.259	35.876	0.066	0.133	0.226
		D5YP-1201	104.2	< 0.050	< 0.010	8.752	< 0.201	< 0.503	0.201	0.151	< 0.503	3.159	47.280	< 0.101	0.201	0.151
Control Fish	D6YP-1A		6.9	< 0.032	< 0.006	25.43	0.259	0.970	0.065	0.091	0.388	3.351	86.696	0.129	0.323	0.239
	D6YP-1B		62.4	< 0.030	< 0.006	11.31	< 0.122	0.790	0.049	0.103	0.304	5.947	40.130	0.122	0.182	0.176
	D6YP-1C		7.3	< 0.046	< 0.009	75.18	0.278	1.671	0.139	0.306	0.928	11.602	180.062	0.186	0.464	0.399

Table A6.6: Metallothionein and Metal Concentrations in Caged Yellow Perch Viscera, Dome Mine Site

Station	Fish Number	ASSIGNED NUMBER	VISCERA µg MT/g	Sb µg/g	Se µg/g	Ti µg/g	U µg/g	V µg/g	Zn µg/g
D1	DIYP100CG	D1YP-101	40.6	0.725	0.568	4.120		0.064	33.242
		D1YP-201	38.8	0.104	0.662	5.390		0.085	36.593
	DIYP200CG	D1YP-301	69.1	0.113	0.615	4.307		0.062	30.147
		D1YP-401	37.9	0.062	0.532	3.814		< 0.044	29.894
	DIYP300CG	D1YP-501	37.3	0.120	0.534	3.607		0.040	46.296
		D1YP-601	70.8	< 0.054	0.651	4.126		< 0.054	30.076
	DIYP400CG	D1YP-701	49.3	1.270	0.492	4.179		0.049	29.089
		D1YP-801	67.9	< 0.032	0.509	3.248		< 0.032	28.018
	DIYP500CG	D1YP-901	84.4	0.467	0.667	4.338		< 0.056	27.143
		D1YP-1001	54.7	0.717	0.661	4.813		< 0.047	32.840
	DIYP600CG	D1YP-1101	81.0	0.211	0.384	3.071		< 0.048	23.128
D2	D2YP100CG	D2YP-101	55.2	0.098	0.467	3.484		< 0.021	29.357
		D2YP-201	32.9	0.029	0.182	1.493		< 0.018	11.394
	D2YP200CG	D2YP-301	19.7	0.035	0.415	3.531		< 0.035	24.373
		D2YP-401	32.0	0.032	0.491	3.051		< 0.018	26.620
	D2YP300CG	D2YP-501	54.5	< 0.031	0.501	3.003		< 0.031	29.159
		D2YP-601	65.4	< 0.021	0.331	2.358		< 0.021	18.246
	D2YP400CG	D2YP-701	25.8	0.051	0.510	3.208		< 0.036	24.275
		D2YP-801	54.7	0.031	0.288	2.333		< 0.013	17.351
	D2YP500CG	D2YP-901	36.4	1.485	0.432	3.243		< 0.036	30.128
D3	D3YP100CG	D3YP-101	68.0	0.031	0.562	2.558		< 0.031	24.896
		D3YP-201	76.1	0.068	0.677	4.404		< 0.042	32.265
	D3YP200CG	D3YP-301	62.9	0.036	0.468	2.961		< 0.026	20.938
		D3YP-401	42.3	0.052	0.598	3.512		< 0.037	23.838
	D3YP300CG	D3YP-501	35.5	< 0.030	0.595	3.212		< 0.030	25.930
		D3YP-601	53.7	0.215	0.557	3.582		< 0.040	24.201
	D3YP400CG	D3YP-701	52.3	0.034	0.477	3.546		0.041	23.870
		D3YP-801	19.3	0.266	0.423	5.806		< 0.030	24.797
	D3YP500CG	D3YP-901	46.9	0.071	0.593	3.081		< 0.030	22.635
D4	D4YP100CG	D4YP-101	62.8	0.055	0.546	3.763		< 0.030	25.913
		D4YP-201	52.6	0.040	0.545	3.123		< 0.025	23.102
	D4YP200CG	D4YP-301	45.5	< 0.029	0.518	3.335		< 0.029	23.058
		D4YP-401	42.3	0.182	0.608	2.965		< 0.038	26.986
	D4YP300CG	D4YP-501	81.7	< 0.037	0.586	3.370		< 0.037	29.521
		D4YP-601	65.2	< 0.036	0.506	3.108		< 0.036	22.694
	D4YP400CG	D4YP-701	64.7	0.046	0.652	2.998		< 0.033	29.919
		D4YP-801	45.1	0.057	0.493	4.270		< 0.041	23.815
	D4YP500CG	D4YP-901	56.0	< 0.051	0.507	3.043		< 0.051	22.825
D5	D5YP100CG	D5YP-101	48.9	< 0.032	0.504	3.591		< 0.032	31.312
		D5YP-201	57.6	0.055	0.684	3.832		< 0.034	31.614
	D5YP200CG	D5YP-301	41.8	< 0.032	0.452	3.748		< 0.032	28.238
		D5YP-401	42.0	< 0.026	0.577	3.409		< 0.026	28.161
	D5YP300CG	D5YP-501	30.4	0.067	0.593	3.558		< 0.037	31.433
		D5YP-601	34.2	< 0.039	0.550	3.222		< 0.039	24.044
	D5YP400CG	D5YP-701	56.4	0.115	0.640	5.248		0.058	32.834
		D5YP-801	51.8	0.060	0.479	3.472		< 0.030	27.719
	D5YP500CG	D5YP-901	88.6	0.073	0.467	3.668		< 0.033	26.542
		D5YP-1001	74.9	0.038	0.382	2.804		< 0.032	19.375
	D5YP600CG	D5YP-1101	76.0	0.113	0.465	2.990		< 0.033	22.655
		D5YP-1201	104.2	0.091	0.604	3.722		< 0.050	25.853
Control Fish	D6YP-1A		6.9	0.045	0.518	4.011		0.039	25.232
	D6YP-1B		62.4	< 0.030	0.547	3.648		< 0.030	25.537
	D6YP-1C		7.3	0.798	0.464	6.776		0.186	25.339

Table A6.7: Biological Data of All Fish Sampled at Dome Mine Site

Station	Fish Number	Species	Sex	Age	Standard Length (cm)	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Gonad Weight (g)	Liver Weight (g)	Fecundity
D1	D1YP1	Yellow Perch	F	3	14.0	15.9	16.8	39.4	2.000	0.500	6563
	D1YP2	Yellow Perch	F	4	15.4	17.1	18.4	61.2	2.700	1.000	9030
	D1YP3	Yellow Perch	F	4	14.2	16.3	17.4	44.9	1.600	0.800	5193
	D1YP4	Yellow Perch	F	4	14.2	16.3	17.0	44.5	1.700	0.600	6066
	D1YP5	Yellow Perch	F	3	13.9	15.7	16.6	39.3	1.700	0.600	5940
	D1YP6	Yellow Perch	F	3	13.3	15.4	16.2	37.6	2.000	0.600	5467
	D1YP7	Yellow Perch	F	4	15.4	17.2	18.5	54.8	2.700	0.800	6840
	D1YP8	Yellow Perch	F	4	14.3	16.9	17.8	49.4	2.700	0.900	10170
	D1YP9	Yellow Perch	F	4	13.9	16.2	17.0	45.2	1.600	0.600	7010
	D1YP10	Yellow Perch	F	4	13.5	15.6	16.4	39.5	1.800	0.500	6780
	D1YP11	Yellow Perch	F	3	13.4	15.7	16.5	35.2	1.300	0.600	3923
	D1YP12	Yellow Perch	F	3	13.4	15.4	16.3	37.2	1.900	0.500	6314
	D1YP13	Yellow Perch	F	3	13.4	15.5	16.3	35.1	1.300	0.500	4200
	D1YP14	Yellow Perch	F	3	11.6	13.4	14.1	22.0	0.900	0.400	3600
	D1YP15	Yellow Perch	F	2	10.0	11.3	12.0	13.5	0.300	0.200	0
	D1YP16	Yellow Perch	M	3	10.0	12.2	13.4	20.1	1.800	0.100	
	D1YP17	Yellow Perch	M	2	9.3	10.3	11.4	13.1	1.100	<0.1	
	D1YP18	Yellow Perch	M	2	8.9	9.0	9.5	7.6	0.600	<0.1	
	D1YP19	Yellow Perch	F	3	13.9	15.8	16.5	49.9	2.500	0.740	6720
	D1YP20	Yellow Perch	F	3	13.8	15.6	16.5	41.2	1.600	0.690	5733
	D1YP21	Yellow Perch	F	3	14.6	16.6	17.2	45.6	2.300	0.690	5427
	D1YP22	Yellow Perch	F	4	14.4	16.2	17.0	43.2	1.900	0.630	5871
	D1YP23	Yellow Perch	F	3	13.2	14.9	15.7	30.0	1.300	0.500	3986
	D1YP24	Yellow Perch	F	3	13.0	14.9	15.6	39.0	2.530	0.456	7848
	D1YP25	Yellow Perch	F	3	13.3	15.0	15.9	32.9	2.070	0.618	
	D1YP26	Yellow Perch	M	2	8.7	9.8	10.3	10.1	0.618	0.174	
	D1YP27	Yellow Perch	M	2	9.8	11.1	11.6	14.6	1.248	0.136	
	D1YP28	Yellow Perch	I	3	13.1	14.7	15.5	34.1	-	0.328	
	D1YP29	Yellow Perch	M	4	16.5	18.8	19.5	72.2	5.014	0.800	
	D1YP30	Yellow Perch	M	2	8.8	9.8	10.4	10.4	0.612	0.266	
	D1YP31	Yellow Perch	M	2	8.8	9.8	10.4	9.9	0.594	0.226	
	D1YP32	Yellow Perch	M	2	9.5	10.0	10.6	11.3	0.774	0.210	
	D1YP33	Yellow Perch	M	2	8.7	9.6	10.2	10.6	0.692	0.228	
	D1YP34	Yellow Perch	M	2	8.8	9.6	10.3	10.2	0.712	0.174	
	D1YP35	Yellow Perch	M	2	8.9	9.9	10.5	10.8	0.972	0.236	
	D1YP36	Yellow Perch	M	2	9.8	11.0	11.5	14.2	0.920	0.348	
	D1YP37	Yellow Perch	M	2	9.1	10.0	10.6	11.0	0.808	0.230	
	D1YP38	Yellow Perch	M	2	9.5	10.5	11.3	12.6	1.016	0.296	
	D1YP39	Yellow Perch	M	2	9.0	9.9	10.5	11.8	0.802	0.220	
	D1YP40	Yellow Perch	M	2	10.2	11.4	12.0	14.2	1.270	0.238	
	D1YP41	Yellow Perch	M	2	9.2	10.3	10.8	11.7	0.964	0.160	
	D1YP42	Yellow Perch	M	3	11.2	12.3	13.0	22.6	1.810	0.404	
	D1PD1	Pearl Dace	F	NM	NM	11.3	NM	14.7	NM	NM	
	D1PD2	Pearl Dace	F	NM	NM	11.5	NM	15.4	NM	NM	
	D1PD3	Pearl Dace	F	NM	NM	11.1	NM	14.4	NM	NM	
	D1PD4	Pearl Dace	F	NM	NM	10.3	NM	10.9	NM	NM	
	D1PD5	Pearl Dace	F	NM	NM	11.1	NM	14.8	NM	NM	
	D1PD6	Pearl Dace	F	NM	NM	12.1	NM	16.6	NM	NM	
	D1PD7	Pearl Dace	F	NM	NM	10.3	NM	9.9	NM	NM	
	D1PD8	Pearl Dace	F	NM	NM	9.7	NM	9.6	NM	NM	
	D1PD9	Pearl Dace	F	NM	NM	10.5	NM	10.9	NM	NM	
D2	D2PD1	Pearl Dace	F	2	NM	11.0	NM	13.8	NM	NM	
	D2PD2	Pearl Dace	F	1	NM	9.1	NM	7.4	NM	NM	
	D2PD3	Pearl Dace	IM	NM	NM	8.4	NM	5.7	NM	NM	
	D2PD4	Pearl Dace	M	NM	NM	8.7	NM	7.2	NM	NM	
	D2PD5	Pearl Dace	F	1	NM	10.7	NM	12.7	NM	NM	
	D2PD6	Pearl Dace	F	1	NM	10.6	NM	11.4	NM	NM	
	D2PD7	Pearl Dace	F	NM	NM	8.6	NM	5.6	NM	NM	
	D2PD8	Pearl Dace	F	NM	NM	9.1	NM	7.0	NM	NM	
	D2PD9	Pearl Dace	F	NM	NM	8.5	NM	5.3	NM	NM	

Table A6.7: Biological Data of All Fish Sampled at Dome Mine Site

Station	Fish Number	Species	Sex	Age	Standard Length (cm)	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Gonad Weight (g)	Liver Weight (g)	Fecundity
D2	D2PD10	Pearl Dace	F	NM	8.0	8.8	9.3	7.1	0.708	0.096	881
	D2PD11	Pearl Dace	M	2	8.0	9.0	9.4	6.1	0.036	0.0.92	
	D2PD12	Pearl Dace	F	NM	8.0	8.8	9.3	5.9	0.552	0.128	1073
	D2PD13	Pearl Dace	M	1	6.2	6.9	7.4	3.1	0.062	0.072	
	D2PD14	Pearl Dace	M	NM	7.2	8.1	8.6	4.4	0.050	0.098	
	D2PD15	Pearl Dace	M	NM	7.7	8.6	9.2	6.0	0.110	0.180	
	D2PD16	Pearl Dace	F	NM	7.4	8.2	8.8	4.9	0.330	0.130	705
	D2PD17	Pearl Dace	M	NM	7.2	8.0	8.6	5.4	0.084	0.142	
	D2PD18	Pearl Dace	M	NM	7.3	8.1	8.7	5.0	0.098	0.096	
	D2PD19	Pearl Dace	F	1	6.6	7.3	7.8	4.0	0.222	0.088	554
	D2PD20	Pearl Dace	F	NM	7.1	7.9	8.4	4.7	0.376	0.092	811
	D2PD21	Pearl Dace	F	NM	7.0	7.8	8.4	5.2	0.492	0.118	895
	D2PD22	Pearl Dace	F	1	7.3	8.1	8.6	4.7	0.336	0.082	
	D2PD23	Pearl Dace	F	NM	7.2	7.9	8.6	4.6	0.054	0.108	884
	D2PD24	Pearl Dace	M	NM	6.8	7.5	8.0	3.8	0.040	0.068	
	D2PD25	Pearl Dace	M	NM	6.9	7.6	8.2	4.0	0.064	0.088	
	D2PD26	Pearl Dace	M	NM	6.8	7.7	8.2	4.2	0.030	0.112	
	D2PD27	Pearl Dace	F	1	7.7	8.0	8.5	4.9	0.398	0.132	509
	D2PD28	Pearl Dace	M	2	7.2	8.0	8.6	4.9	0.086	0.118	
	D2PD29	Pearl Dace	M	NM	6.7	7.5	8.0	4.0	0.078	0.102	
	D2PD30	Pearl Dace	M	NM	7.0	7.8	8.4	4.5	0.116	0.102	
	D2PD31	Pearl Dace	M	NM	6.7	7.0	8.1	4.1	0.070	0.110	
	D2PD32	Pearl Dace	F	NM	7.0	7.8	8.4	4.0	0.326	0.115	686
	D2PD33	Pearl Dace	M	NM	6.8	7.5	8.1	4.0	0.030	0.108	
	D2PD34	Pearl Dace	M	NM	6.5	7.3	7.8	3.6	0.070	0.102	
	D2PD35	Pearl Dace	M	NM	6.9	7.6	8.1	4.1	0.070	0.126	
	D2PD36	Pearl Dace	F	NM	7.0	7.7	8.2	4.6	0.380	0.154	807
	D2PD37	Pearl Dace	M	1	6.8	7.6	8.2	4.7	0.100	0.116	
	D2PD38	Pearl Dace	M	NM	7.1	7.9	8.4	4.7	0.126	0.124	
	D2PD39	Pearl Dace	M	1	6.5	7.3	7.7	3.5	0.074	0.082	
	D2PD40	Pearl Dace	F	1	6.2	6.9	7.4	3.3	0.242	0.124	439
	D2PD41	Pearl Dace	F	1	7.5	8.3	8.8	5.6	0.404	0.116	1306
	D2PD42	Pearl Dace	F	NM	7.6	8.4	8.9	5.4	0.446	0.132	1656
	D2PD43	Pearl Dace	F	1	9.2	10.2	11.0	10.7	1.020	0.284	2006
	D2PD44	Pearl Dace	F	NM	8.1	8.9	9.4	6.5	0.654	0.178	1404
	D2PD45	Pearl Dace	F	NM	7.8	8.5	9.1	6.3	0.538	0.186	1294
	D2PD46	Pearl Dace	F	NM	8.0	8.8	9.4	6.8	0.676	0.300	1516
	D2PD47	Pearl Dace	F	NM	8.2	9.1	9.6	7.3	0.792	0.186	1800
	D2PD48	Pearl Dace	F	1	7.4	8.2	8.7	4.7	0.412	0.120	1607
	D2PD49	Pearl Dace	F	NM	7.5	8.3	8.8	5.6	0.560	0.102	1362
D3	D3PD1	Pearl Dace	F	NM	NM	8.8	NM	5.1	NM	NM	
	D3PD2	Pearl Dace	F	NM	NM	7.8	NM	4.5	NM	NM	
	D3PD3	Pearl Dace	F	1	NM	14.2	NM	22.2	NM	NM	
	D3PD4	Pearl Dace	F	NM	NM	10.2	NM	10.1	NM	NM	
	D3PD5	Pearl Dace	F	1	NM	13.0	NM	20.7	NM	NM	
	D3PD6	Pearl Dace	F	NM	NM	11.4	NM	16.2	NM	NM	
	D3PD7	Pearl Dace	F	1	NM	12.2	NM	19.2	NM	NM	
	D3PD8	Pearl Dace	F	NM	NM	11.1	NM	12.6	NM	NM	
	D3PD9	Pearl Dace	F	1	NM	11.4	NM	13.8	NM	NM	
	D3PD10	Pearl Dace	M	NM	9.3	10.3	10.9	9.2	0.216	0.288	
	D3PD11	Pearl Dace	M	NM	9.6	10.1	11.4	12.4	0.272	0.234	
	D3PD12	Pearl Dace	M	NM	8.0	8.9	9.5	7.3	0.128	0.156	
	D3PD13	Pearl Dace	F	NM	8.6	9.5	10.0	8.9	0.772	0.198	1389
	D3PD14	Pearl Dace	F	1	10.5	11.4	12.2	15.2	1.796	0.340	2635
	D3PD15	Pearl Dace	F	1	10.0	10.9	11.6	13.6	1.408	0.402	2427
	D3PD16	Pearl Dace	F	NM	9.7	10.7	11.3	12.5	1.362	0.386	2262
	D3PD17	Pearl Dace	F	NM	9.5	10.5	11.2	11.8	1.174	0.282	2160
	D3PD18	Pearl Dace	M	NM	9.1	10.0	10.6	10.1	0.196	0.230	
	D3PD19	Pearl Dace	F	NM	8.8	9.8	10.4	10.0	1.064	0.276	1850
	D3PD20	Pearl Dace	M	2	9.0	9.9	10.6	9.2	0.116	0.232	
	D3PD21	Pearl Dace	F	NM	9.4	10.3	10.9	11.2	0.872	0.332	1686
	D3PD22	Pearl Dace	M	1	8.7	9.7	10.5	9.1	0.130	0.174	

Table A6.7: Biological Data of All Fish Sampled at Dome Mine Site

Station	Fish Number	Species	Sex	Age	Standard Length (cm)	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Gonad Weight (g)	Liver Weight (g)	Fecundity
D3	D3PD23	Pearl Dace	F	NM	9.2	10.0	10.7	12.1	1.252	0.384	1318
	D3PD24	Pearl Dace	F	1	7.9	8.7	9.3	6.4	0.404	0.172	814
	D3PD25	Pearl Dace	F	NM	8.8	9.7	10.3	8.0	0.532	0.158	1442
	D3PD26	Pearl Dace	M	NM	9.2	10.1	10.9	9.0	0.078	0.198	
	D3PD27	Pearl Dace	F	1	9.6	10.6	11.3	11.3	1.044	0.190	1587
	D3PD28	Pearl Dace	M	1	7.5	8.4	8.9	5.7	0.082	0.138	
	D3PD29	Pearl Dace	F	NM	8.7	9.1	9.7	7.8	0.516	0.192	1106
	D3PD30	Pearl Dace	M	NM	8.6	9.5	10.3	7.8	0.172	0.190	
	D3PD31	Pearl Dace	M	NM	8.6	9.4	10.0	8.2	0.118	0.158	
	D3PD32	Pearl Dace	F	NM	7.9	8.7	9.3	6.4	0.334	0.148	1671
	D3PD33	Pearl Dace	M	1	8.1	9.1	9.7	8.2	0.146	0.176	
	D3PD34	Pearl Dace	M	NM	8.3	9.2	9.8	7.3	0.124	0.092	
	D3PD35	Pearl Dace	F	NM	8.3	9.2	9.8	8.7	0.776	0.328	1492
	D3PD36	Pearl Dace	F	NM	7.9	8.8	9.4	6.9	0.408	0.134	974
	D3PD37	Pearl Dace	M	NM	8.1	9.0	9.5	7.6	0.118	0.134	
	D3PD38	Pearl Dace	M	NM	8.5	9.5	10.2	8.0	0.102	0.134	
	D3PD39	Pearl Dace	F	1	7.2	8.0	8.6	5.1	0.308	0.160	936
	D3PD40	Pearl Dace	M	1	8.2	9.2	10.8	7.4	0.116	0.150	
	D3PD41	Pearl Dace	M	1	8.1	8.9	9.5	7.2	0.212	0.230	
	D3PD42	Pearl Dace	F	NM	8.5	9.4	10.1	8.1	0.646	0.212	1641
	D3PD43	Pearl Dace	F	1	7.9	8.7	9.2	6.5	0.392	0.186	742
	D3PD44	Pearl Dace	F	NM	8.0	8.8	9.4	6.2	0.432	0.134	1277
	D3PD45	Pearl Dace	M	NM	8.3	9.1	9.9	8.0	0.140	0.196	
	D3PD46	Pearl Dace	F	NM	8.3	9.1	9.8	7.0	0.414	0.150	1011
	D3PD47	Pearl Dace	M	NM	8.4	9.2	9.9	8.4	0.122	0.216	
	D3PD48	Pearl Dace	M	NM	7.6	8.0	8.5	5.1	0.068	0.130	
	D3PD49	Pearl Dace	M	NM	8.0	9.0	9.6	6.3	0.146	0.120	
D4	D4PD1	Pearl Dace	F	2	NM	10.7	NM	12.7	NM	NM	
	D4PD2	Pearl Dace	F	2	NM	12.2	NM	19.9	NM	NM	
	D4PD3	Pearl Dace	F	2	NM	10.9	NM	13.1	NM	NM	
	D4PD4	Pearl Dace	F	1	NM	11.1	NM	16.0	NM	NM	
	D4PD5	Pearl Dace	F	2	NM	10.6	NM	13.2	NM	NM	
	D4PD6	Pearl Dace	F	NM	NM	10.2	NM	11.8	NM	NM	
	D4PD7	Pearl Dace	M	NM	NM	9.2	NM	8.3	NM	NM	
	D4PD8	Pearl Dace	F	NM	NM	10.1	NM	12.0	NM	NM	
	D4PD9	Pearl Dace	F	NM	NM	9.6	NM	9.7	NM	NM	
	D4PD10	Pearl Dace	F	NM	8.8	9.7	10.3	7.9	0.468	0.134	1913
	D4PD11	Pearl Dace	F	NM	8.7	9.6	10.3	9.4	0.898	0.134	2500
	D4PD12	Pearl Dace	F	NM	10.3	11.4	12.2	14.7	1.652	0.436	2992
	D4PD13	Pearl Dace	F	NM	9.2	10.2	10.9	10.8	0.968	0.262	2518
	D4PD14	Pearl Dace	M	NM	8.1	9.0	9.6	6.7	0.130	0.136	
	D4PD15	Pearl Dace	F	1	8.4	9.2	9.9	6.3	0.484	0.066	1959
	D4PD16	Pearl Dace	F	NM	8.6	9.5	10.1	8.7	0.788	0.288	1440
	D4PD17	Pearl Dace	F	NM	8.3	9.2	9.8	9.3	0.948	0.274	1844
	D4PD18	Pearl Dace	F	1	7.4	8.2	8.8	5.8	0.446	0.156	1590
	D4PD19	Pearl Dace	M	NM	7.7	8.5	9.1	6.5	0.096	0.150	
	D4PD20	Pearl Dace	M	NM	7.1	7.9	8.5	4.6	0.102	0.112	
	D4PD22	Pearl Dace	F	NM	7.3	8.1	8.8	5.9	0.314	0.130	1792
	D4PD23	Pearl Dace	F	NM	7.8	8.6	9.2	6.4	0.398	0.170	1348
	D4PD24	Pearl Dace	F	NM	7.4	8.2	8.8	6.2	0.578	0.180	2015
	D4PD25	Pearl Dace	M	2	7.9	8.9	9.5	6.7	0.182	0.136	
	D4PD26	Pearl Dace	F	NM	7.3	8.1	8.6	5.5	0.286	0.148	1420
	D4PD27	Pearl Dace	F	NM	7.9	8.7	9.4	6.9	0.460	0.192	1433
	D4PD28	Pearl Dace	M	NM	7.0	7.8	8.3	4.9	0.076	0.090	
	D4PD29	Pearl Dace	M	NM	7.8	8.5	9.2	6.8	0.100	0.180	
	D4PD30	Pearl Dace	M	NM	7.3	8.0	8.6	5.5	0.102	0.096	
	D4PD31	Pearl Dace	F	1	6.2	6.8	7.3	3.0	0.140	0.094	422
	D4PD32	Pearl Dace	M	NM	7.3	8.0	8.6	5.1	0.062	0.112	
	D4PD33	Pearl Dace	M	NM	6.8	7.6	8.1	4.1	0.078	0.068	
	D4PD34	Pearl Dace	F	NM	7.8	8.7	9.3	6.4	0.498	0.134	1413
	D4PD35	Pearl Dace	M	NM	6.2	7.0	7.4	3.0	0.018	0.044	
	D4PD36	Pearl Dace	F	NM	10.5	11.3	12.2	15.8	1.368	0.312	2162

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Station	Fish Number	Species	Sex	Age	Standard Length (cm)	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Gonad Weight (g)	Liver Weight (g)	Fecundity
D4	D4PD37	Pearl Dace	F	NM	9.0	10.0	10.6	10.0	0.828	0.206	2111
	D4PD38	Pearl Dace	F	NM	10.3	11.2	12.0	16.2	1.438	0.272	3191
	D4PD39	Pearl Dace	F	2	8.6	9.5	10.2	9.1	0.814	0.196	1888
	D4PD40	Pearl Dace	F	NM	8.8	9.6	10.4	10.4	0.794	0.338	2117
	D4PD41	Pearl Dace	M	NM	8.3	9.2	9.8	8.0	0.132	0.226	
	D4PD42	Pearl Dace	F	1	6.9	7.6	8.2	4.7	0.260	0.142	
	D4PD43	Pearl Dace	M	NM	7.6	8.3	9.0	6.6	0.100	0.184	
	D4PD44	Pearl Dace	F	1	7.7	8.4	9.0	7.0	-	-	
	D4PD45	Pearl Dace	M	NM	7.3	8.1	8.7	5.4	0.130	0.116	
	D4PD46	Pearl Dace	M	2	6.8	7.5	8.0	4.0	0.066	0.086	
	D4PD47	Pearl Dace	M	NM	8.8	9.7	10.5	8.2	0.162	0.158	
	D4PD48	Pearl Dace	M	2	6.3	7.0	7.5	3.0	0.048	0.070	
	D4PD49	Pearl Dace	M	1	6.5	7.3	7.8	4.2	0.082	0.088	
	D4PD50	Pearl Dace	M	1	8.1	8.9	9.5	6.9	0.142	0.082	
	D4PD51	Pearl Dace	M	NM	6.7	7.6	8.1	4.1	0.076	0.074	
	D4PD52	Pearl Dace	M	NM	6.6	7.4	7.8	4.3	0.062	0.084	
D5	D5YP1	Yellow Perch	M	4	13.7	15.8	16.7	48.5	2.350	0.524	
	D5YP2	Yellow Perch	M	3	12.5	14.3	15.1	34.3	2.040	0.536	
	D5YP3	Yellow Perch	F	3	12.1	15.0	15.9	38.4	1.740	0.638	7078
	D5YP4	Yellow Perch	F	4	14.4	16.2	17.2	51.1	1.820	0.770	6900
	D5YP5	Yellow Perch	F	3	14.3	16.3	17.2	52.1	1.720	0.732	7200
	D5YP6	Yellow Perch	F	4	15.7	17.8	18.6	70.9	2.750	0.998	7380
	D5YP7	Yellow Perch	F	3	12.4	13.9	14.6	33.4	1.300	0.514	3200
	D5YP8	Yellow Perch	M	3	13.1	14.6	15.6	39.9	2.390	0.542	
	D5YP9	Yellow Perch	M	3	13.4	14.8	15.7	42.1	2.270	0.636	
	D5YP10	Yellow Perch	F	3	14.4	16.2	17.0	49.1	1.950	0.770	6268
	D5YP11	Yellow Perch	F	3	13.8	15.7	16.7	46.8	1.940	0.740	6820
	D5YP12	Yellow Perch	F	3	14.3	16.2	17.2	50.6	1.940	0.758	5775
	D5YP13	Yellow Perch	F	3	13.6	15.3	16.1	45.1	2.050	0.948	5640
	D5YP14	Yellow Perch	F	4	16.7	18.8	19.6	91.8	4.390	1.592	12900
	D5YP15	Yellow Perch	F	3	13.7	15.3	16.3	46.0	1.600	1.022	5760
	D5YP16	Yellow Perch	M	3	13.9	15.8	16.7	48.0	2.570	0.508	
	D5YP17	Yellow Perch	M	3	12.0	13.6	14.5	29.6	1.670	0.294	
	D5YP18	Yellow Perch	F	3	12.9	14.6	15.5	36.2	1.340	0.512	9250
	D5YP19	Yellow Perch	F	3	12.3	14.0	14.5	31.6	1.320	0.492	4104
	D5YP20	Yellow Perch	F	3	13.5	15.2	16.0	39.4	1.340	0.448	3687
	D5YP21	Yellow Perch	F	3	12.6	14.5	15.2	35.9	1.300	0.544	5685
	D5YP22	Yellow Perch	F	3	12.3	14.0	14.5	32.4	0.840	0.434	2850
	D5YP23	Yellow Perch	F	2	11.4	12.9	13.6	23.4	0.880	0.424	3700
	D5YP24	Yellow Perch	F	3	11.7	13.5	14.3	28.1	1.150	0.404	3042
	D5YP25	Yellow Perch	M	2	11.4	12.9	13.6	25.8	1.370	0.398	
	D5YP26	Yellow Perch	M	2	11.1	12.7	13.2	23.1	1.210	0.368	
	D5YP27	Yellow Perch	F	2	10.6	12.1	12.7	20.5	0.742	0.398	2500
	D5YP28	Yellow Perch	F	4	15.3	17.6	18.4	72.0	2.778	1.162	
	D5YP29	Yellow Perch	M	3	12.8	14.5	15.4	39.6	1.910	0.848	
	D5YP30	Yellow Perch	M	3	11.9	13.6	14.4	31.0	1.852	0.540	
	D5YP31	Yellow Perch	M	3	13.5	15.4	16.3	45.2	2.870	0.446	
	D5YP32	Yellow Perch	M	3	13.1	14.7	15.6	41.6	1.896	0.772	
	D5YP33	Yellow Perch	M	3	12.8	14.4	15.4	38.1	2.384	0.554	
	D5YP34	Yellow Perch	M	3	13.4	15.5	16.3	47.1	2.668	0.558	
	D5YP35	Yellow Perch	M	3	12.3	14.2	14.9	38.2	2.270	0.674	
	D5YP36	Yellow Perch	M	3	13.2	15.1	15.8	39.4	2.140	0.602	
	D5YP37	Yellow Perch	M	3	12.4	14.0	14.8	35.0	1.920	0.536	
	D5YP38	Yellow Perch	M	2	8.3	9.4	9.9	10.7	0.540	0.162	
	D5YP39	Yellow Perch	M	2	8.6	9.8	10.4	11.3	0.710	0.226	
	D5YP40	Yellow Perch	M	2	8.7	10.0	10.7	13.1	0.682	0.320	
CAGED FISH											
D1	DIYP100CG	Yellow Perch	NM	NM	A	4.8	NM	1.0			
		Yellow Perch	NM	NM	B	6.1	NM	2.1			
	DIYP200CG	Yellow Perch	NM	NM	A	4.3	NM	0.7			
		Yellow Perch	NM	NM	B	4.6	NM	1.0			

Table A6.7: Biological Data of All Fish Sampled at Dome Mine Site

Station	Fish Number	Species	Sex	Age	Standard Length (cm)	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Gonad Weight (g)	Liver Weight (g)	Fecundity
D1	DIYP300CG	Yellow Perch	NM	NM	A	5.4	NM	1.5			
		Yellow Perch	NM	NM	B	5.7	NM	1.7			
	DIYP400CG	Yellow Perch	NM	NM	A	4.4	NM	0.7			
		Yellow Perch	NM	NM	B	5.6	NM	1.7			
	DIYP500CG	Yellow Perch	NM	NM	A	4.8	NM	0.9			
		Yellow Perch	NM	NM	B	5.5	NM	1.7			
	DIYP600CG	Yellow Perch	NM	NM	A	6.3	NM	2.5			
		Yellow Perch	NM	NM	B	5.0	NM	1.1			
	DIYP700CG	Yellow Perch	NM	NM	A	5.6	NM	1.9			
		Yellow Perch	NM	NM	B	5.4	NM	1.5			
	DIYP800CG	Yellow Perch	NM	NM	A	4.5	NM	0.8			
		Yellow Perch	NM	NM	B	5.0	NM	1.1			
	DIYP900CG	Yellow Perch	NM	NM	A	6.4	NM	2.7			
		Yellow Perch	NM	NM	B	5.6	NM	1.7			
	DIYP1000CG	Yellow Perch	NM	NM	A	5.0	NM	1.2			
		Yellow Perch	NM	NM	B	5.1	NM	1.5			
	D1YP1100CG	Yellow Perch	NM	NM	A	5.9	NM	2.0			
		Yellow Perch	NM	NM	B	5.8	NM	1.3			
	DIYP1200CG	Yellow Perch	NM	NM	A	5.0	NM	1.1			
		Yellow Perch	NM	NM	B	6.2	NM	2.5			
D2	D2YP100CG	Yellow Perch	NM	NM	A	5.9	NM	2.4			
		Yellow Perch	NM	NM	B	7.1	NM	4.0			
	D2YP200CG	Yellow Perch	NM	NM	A	7.6	NM	4.4			
		Yellow Perch	NM	NM	B	7.4	NM	4.7			
	D2YP300CG	Yellow Perch	NM	NM	A	6.9	NM	3.5			
		Yellow Perch	NM	NM	B	5.4	NM	1.7			
	D2YP400CG	Yellow Perch	NM	NM	A	5.9	NM	2.1			
		Yellow Perch	NM	NM	B	7.8	NM	5.1			
	D2YP500CG	Yellow Perch	NM	NM	A	5.8	NM	1.9			
		Yellow Perch	NM	NM	B	6.7	NM	3.1			
	D2YP600CG	Yellow Perch	NM	NM	A	5.9	NM	2.3			
		Yellow Perch	NM	NM	B	6.7	NM	3.1			
	D2YP700CG	Yellow Perch	NM	NM	A	4.9	NM	1.3			
		Yellow Perch	NM	NM	B	7.2	NM	4.0			
	D2YP800CG	Yellow Perch	NM	NM	A	6.3	NM	2.7			
		Yellow Perch	NM	NM	B	6.9	NM	3.7			
	D2YP900CG	Yellow Perch	NM	NM	A	5.5	NM	1.7			
		Yellow Perch	NM	NM	B	6.1	NM	2.4			
D3	D3YP100CG	Yellow Perch	NM	NM	A	6.0	NM	3.1			
		Yellow Perch	NM	NM	B	6.0	NM	2.3			
	D3YP200CG	Yellow Perch	NM	NM	A	6.2	NM	2.2			
		Yellow Perch	NM	NM	B	5.7	NM	1.9			
	D3YP300CG	Yellow Perch	NM	NM	A	6.5	NM	2.7			
		Yellow Perch	NM	NM	B	6.5	NM	2.8			
	D3YP400CG	Yellow Perch	NM	NM	A	6.7	NM	2.7			
		Yellow Perch	NM	NM	B	5.0	NM	1.1			
	D3YP500CG	Yellow Perch	NM	NM	A	6.3	NM	3.0			
		Yellow Perch	NM	NM	B	5.9	NM	2.1			
	D3YP600CG	Yellow Perch	NM	NM	A	6.2	NM	2.4			
		Yellow Perch	NM	NM	B	5.6	NM	2.0			
	D3YP700CG	Yellow Perch	NM	NM	A	5.7	NM	2.4			
		Yellow Perch	NM	NM	B	5.8	NM	1.8			
	D3YP800CG	Yellow Perch	NM	NM	A	6.4	NM	3.0			
		Yellow Perch	NM	NM	B	4.9	NM	1.5			
	D3YP900CG	Yellow Perch	NM	NM	A	5.6	NM	1.7			
		Yellow Perch	NM	NM	B	5.7	NM	2.6			
	D3YP1000CG	Yellow Perch	NM	NM	A	5.7	NM	1.7			
		Yellow Perch	NM	NM	B	7.1	NM	3.7			
	D3YP1100CG	Yellow Perch	NM	NM	A	6.3	NM	3.0			
		Yellow Perch	NM	NM	B	6.0	NM	2.5			

Table A6.7: Biological Data of All Fish Sampled at Dome Mine Site

Station	Fish Number	Species	Sex	Age	Standard Length (cm)	Fork Length (cm)	Total Length (cm)	Whole Weight (g)	Gonad Weight (g)	Liver Weight (g)	Fecundity
D4	D4YP100CG	Yellow Perch	NM	NM	A	5.5	NM	1.5			
		Yellow Perch	NM	NM	B	5.5	NM	1.6			
	D4YP200CG	Yellow Perch	NM	NM	A	5.7	NM	1.7			
		Yellow Perch	NM	NM	B	7.1	NM	3.6			
	D4YP300CG	Yellow Perch	NM	NM	A	6.6	NM	3.0			
		Yellow Perch	NM	NM	B	6.8	NM	3.2			
	D4YP400CG	Yellow Perch	NM	NM	A	7.1	NM	3.7			
		Yellow Perch	NM	NM	B	5.1	NM	1.4			
	D4YP500CG	Yellow Perch	NM	NM	A	5.8	NM	1.6			
		Yellow Perch	NM	NM	B	5.9	NM	2.2			
	D4YP600CG	Yellow Perch	NM	NM	A	6.2	NM	2.5			
		Yellow Perch	NM	NM	B	4.5	NM	0.8			
	D4YP700CG	Yellow Perch	NM	NM	A	4.5	NM	0.8			
		Yellow Perch	NM	NM	B	6.8	NM	3.4			
	D4YP800CG	Yellow Perch	NM	NM	A	4.7	NM	1.1			
		Yellow Perch	NM	NM	B	5.5	NM	1.8			
	D4YP900CG	Yellow Perch	NM	NM	A	4.9	NM	1.2			
		Yellow Perch	NM	NM	B	5.2	NM	1.5			
D5	D5YP100CG	Yellow Perch	NM	NM	A	6.6	NM	3.0			
		Yellow Perch	NM	NM	B	6.4	NM	2.9			
	D5YP200CG	Yellow Perch	NM	NM	A	5.9	NM	2.1			
		Yellow Perch	NM	NM	B	6.0	NM	2.3			
	D5YP300CG	Yellow Perch	NM	NM	A	6.5	NM	2.9			
		Yellow Perch	NM	NM	B	5.6	NM	1.9			
	D5YP400CG	Yellow Perch	NM	NM	A	7.0	NM	3.6			
		Yellow Perch	NM	NM	B	5.9	NM	2.0			
	D5YP500CG	Yellow Perch	NM	NM	A	4.3	NM	0.6			
		Yellow Perch	NM	NM	B	7.2	NM	4.0			
	D5YP600CG	Yellow Perch	NM	NM	A	4.9	NM	1.1			
		Yellow Perch	NM	NM	B	6.3	NM	2.5			
	D5YP700CG	Yellow Perch	NM	NM	A	6.5	NM	3.0			
		Yellow Perch	NM	NM	B	5.4	NM	1.5			
	D5YP800CG	Yellow Perch	NM	NM	A	6.2	NM	2.9			
		Yellow Perch	NM	NM	B	5.8	NM	2.0			
	D5YP900CG	Yellow Perch	NM	NM	A	5.9	NM	2.0			
		Yellow Perch	NM	NM	B	4.9	NM	1.2			
	D5YP1000CG	Yellow Perch	NM	NM	A	5.5	NM	1.9			
		Yellow Perch	NM	NM	B	5.6	NM	2.1			
	D5YP1100CG	Yellow Perch	NM	NM	A	5.5	NM	1.7			
		Yellow Perch	NM	NM	B	5.5	NM	1.8			
	D5YP1200CG	Yellow Perch	NM	NM	A	4.2	NM	0.9			
		Yellow Perch	NM	NM	B	6.2	NM	2.3			
Control Fish	D6YP1	Yellow Perch	NM	NM	NM	6.2	NM	2.6			
		Yellow Perch	NM	NM	NM	6.3	NM	2.7			
		Yellow Perch	NM	NM	NM	5.2	NM	1.6			
	D6YP2	Yellow Perch	NM	NM	NM	7.2	NM	3.5			
		Yellow Perch	NM	NM	NM	7.0	NM	3.5			
		Yellow Perch	NM	NM	NM	6.6	NM	3.2			
	D6YP3	Yellow Perch	NM	NM	NM	5.7	NM	2.1			
		Yellow Perch	NM	NM	NM	5.8	NM	1.8			
		Yellow Perch	NM	NM	NM	5.8	NM	2.0			

APPENDIX 7

Figures and Tables Illustrating Hypothesis Testing Results

Dome: Hypothesis 1

Sediment Toxicity: comparison of endpoints as tools
Note: of all sediment endpoints measured, only *Hyalella* mortality and growth shows significant mine related variation.

Tool: *Chironomus* and *Hyalella* mortality comparison

Source	SS	df	MS	F Ratio	P
Among Reach	0.651	2	0.326	0.325	0.724
Among Tools	11.116	1	11.116	11.115	**0.002**
Reach*Tool	13.174	2	6.587	6.586	**0.004**
Within Reach (Error)	36.004	36	1.000		

Tool: *Chironomus* Growth and *Hyalella* Growth Comparison

Source	SS	df	MS	F Ratio	P
Among Reach	0.204	2	0.102	1.711	0.195
Among Tools	0.893	1	0.893	14.948	**4.44E-04**
Reach*Tool	0.177	2	0.088	1.480	0.241
Within Reach (Error)	2.150	36	0.060		

Dome Mines - Hypothesis 2

Table A7.1: Summary of Analysis of Metals in Yellow perch Tissues

Metal	Tissue	Reference vs Exposure	Metal	Tissue	Reference vs Exposure
Aluminum	Muscle	*1	Lead	Muscle	-1
	Gill	-E		Gill	-2
	Liver	*2		Liver	-E
	Kidney	-E		Kidney	-2
Antimony	Muscle	-E	Mercury	Muscle	*2
	Gill	-E		Gill	*2
	Liver	-1		Liver	*2
	Kidney	-2		Kidney	*2
Arsenic	Muscle	-2	Metallotionein	Gill	*2
	Gill	-2		Liver	-1
	Liver	-1 (<D.L. in Ref.)		Kidney	*2
	Kidney	-1			
Barium	Muscle	-E	Molybdenum	Muscle	-E
	Gill	-2		Gill	-2 (<D.L. in Exp.)
	Liver	<D.L.		Liver	*1
	Kidney	<D.L.		Kidney	<D.L.
Cadmium	Muscle	-2	Nickel	Muscle	-1 (<D.L. in Ref.)
	Gill	-2		Gill	-E
	Liver	-2		Liver	*1
	Kidney	*2		Kidney	*1
Chromium	Muscle	-1 (<D.L. in Ref.)	Selenium	Muscle	*1
	Gill	*2		Gill	-2
	Liver	<D.L.		Liver	-1
	Kidney	<D.L.		Kidney	-2
Cobalt	Muscle	*1	Silver	Muscle	-1 (<D.L. in Ref.)
	Gill	-2		Gill	*2
	Liver	*2		Liver	-1
	Kidney	-2		Kidney	-2
Copper	Muscle	*1	Vanadium	Muscle	*1
	Gill	*2		Gill	-2
	Liver	-1		Liver	*2
	Kidney	*2		Kidney	-2
Iron	Muscle	*1	Zinc	Muscle	*1
	Gill	*2		Gill	-2
	Liver	*2		Liver	-E
	Kidney	*2		Kidney	-2

- not significant at $\alpha = 0.05$
* significant at $\alpha = 0.05$
E - Equal in exposure and reference areas
1 - higher in Exposure
2 - higher in reference
<D.L. = Less than analytical detection limit

Dome Mines - Hypothesis 2

Table A7.2: Summary of Analysis of Metals in Pearl Dace Viscera

Metal	Reference vs Exposure	Ranking of Areas (high to low)
Aluminum	*	D4 D3 D1/2
Antimony	-	D3 D4 D1/2
Arsenic	-	D3 D1/2 D4
Barium	*	D4 D3 D1/2
Cadmium	*	D3 D1/2 D4
Chromium	-	D4 D1/2 D3
Cobalt	-	D3 D4 D1/2
Copper	*	D3 D4 D1/2
Iron	-	Equal
Metallothionein	*	D3 D1/2 D4
Molybdenum	*	D4 D3 D1/2
Nickel	*	D4 D3 D1/2
Lead	-	D1/2 D4 D3
Selenium	*	D3 D4 D1/2
Silver	*	D3 D4 D1/2
Vanadium	-	D4 D3 D1/2
Zinc	-	D3 D1/2=D4

- not significant at $\alpha = 0.05$
* significant at $\alpha = 0.05$
Note: Differences among stations determined from multiple range tests

Dome Mines - Hypothesis 2

Table A7.3: Summary of Analysis of Metals in Caged Yellow perch Viscera

Metal	Reference vs Exposure	Homogeneous subgroups (high to low)
Aluminum	*	D5 D2 D5 D1 D3 D4 D2
Antimony	*	No Homogeneous subgroups
Arsenic	-	<D.L.
Barium	-	<D.L.
Cadmium	*	D4 D5 D1 D2 D3 D4 D5
Chromium	-	<D.L.
Cobalt	-	-
Copper	*	D2 D3 D4 D5 D1
Iron	*	D1 D5 D3 D4 D4 D3 D2
Molybdenum	-	-
Nickel	*	D1 D5 D2 D3 D4
Lead	*	D1 D5 D3 D2 D4
Selenium	*	D1 D4 D3 D5 D2
Silver	-	<D.L.
Zinc	*	D1 D5 D4 D3 D5 D4 D3 D2
Metallothionein	-	-
Molar Sum CdCuZn	-	-

- not significant at $\alpha = 0.05$
* significant at $\alpha = 0.05$
Note: Differences among stations determined from multiple range tests

Dome- Hypothesis 2

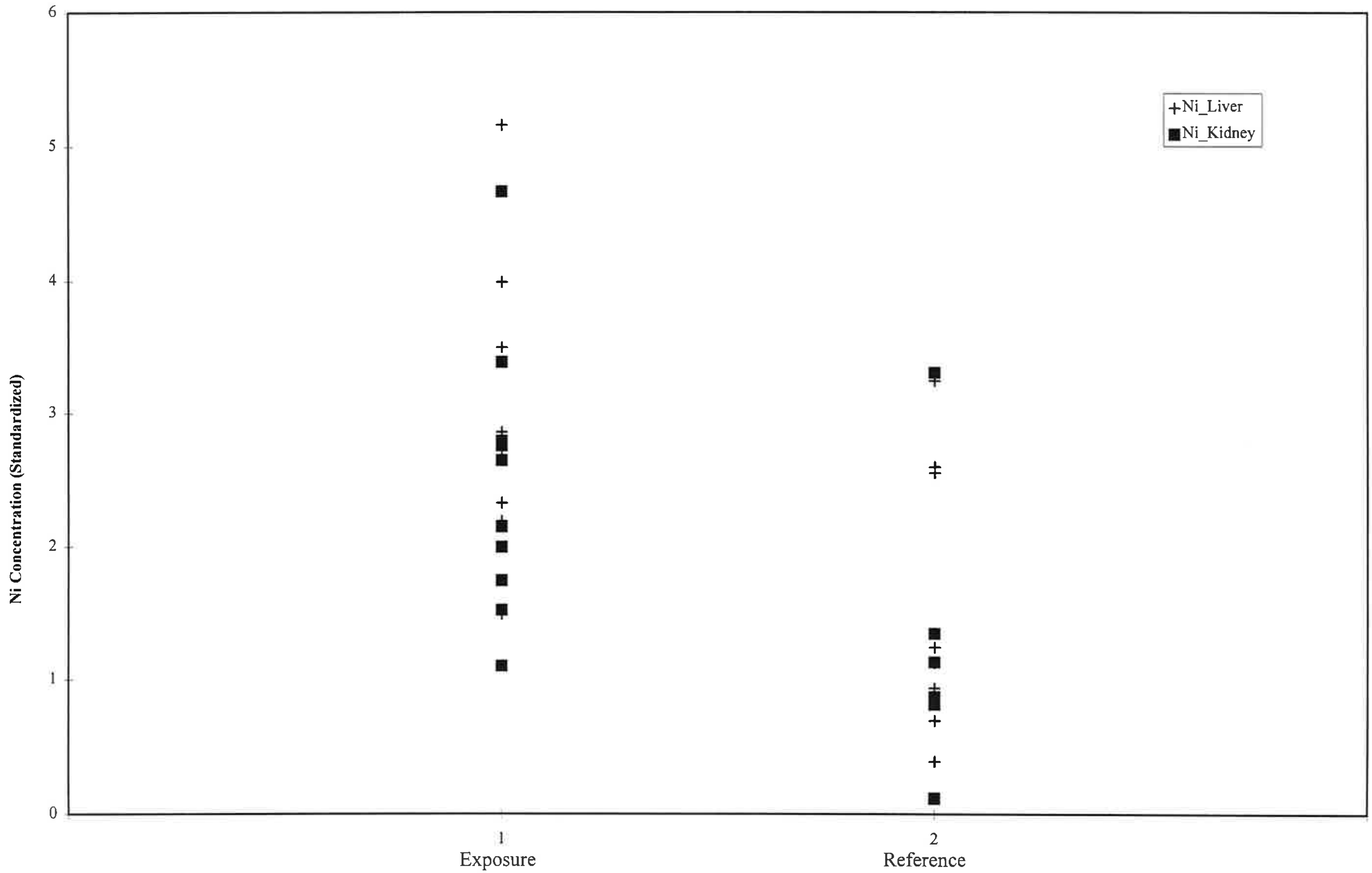
Comparison of organ tissues for concentrations of metals

Yellow perch

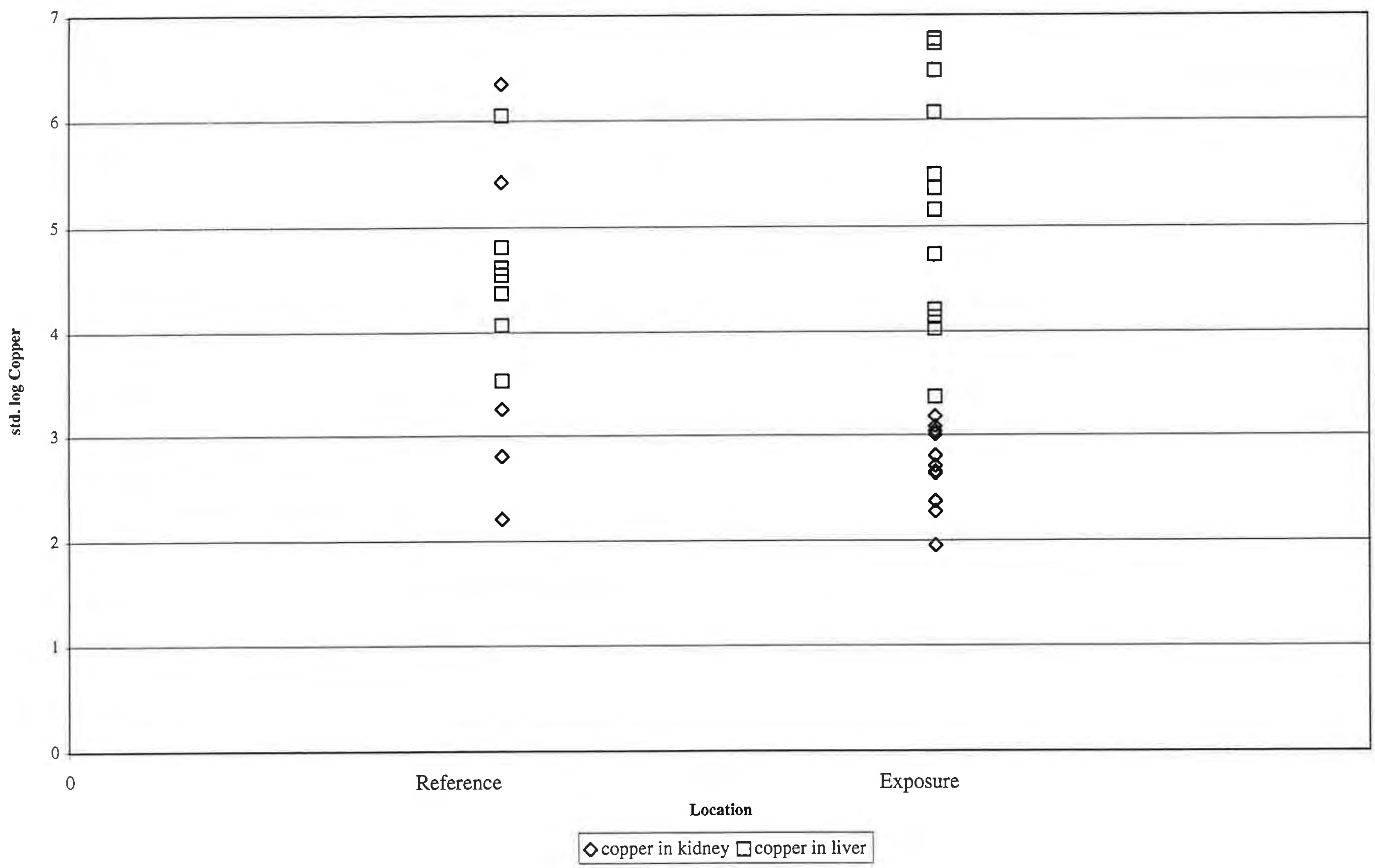
Tool: nickel in Kidney and Liver

Source	SS	df	MS	F Ratio	P
Among Area	13.368	1	13.368	13.367	**8.57E-04**
Among Tools	1.835	1	1.835	1.835	0.184
Area*Tool	0.136	1	0.136	0.136	0.714
Within Reach (Error)	34.002	34	1.000		

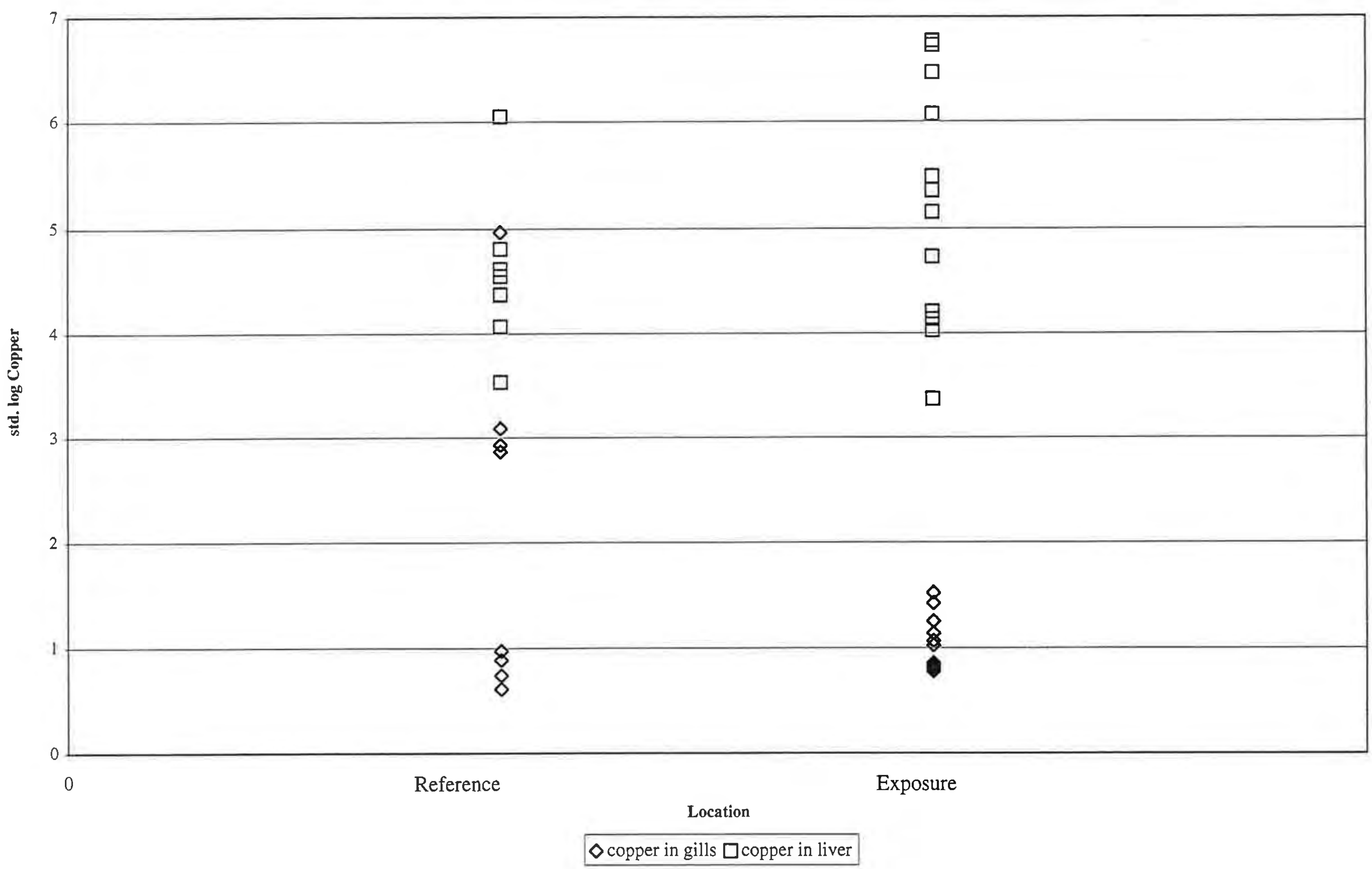
Nickel Concentrations in Yellow perch Liver and Kidney Tissues



Dome Mine - Copper in Kidney and Liver of Wild Yellow Perch



Dome Mine - Copper in Gills and Liver of Wild Yellow Perch



Dome: Hypothesis 3

Comparison of metallothionein in different organ tissues of wild Yellow Perch

Tool: metallothionein in gills and kidneys of Wild Yellow Perch

Source	SS	df	MS	F Ratio	P
Among Reach	52.83210	1	52.83210	52.832	**0.000000**
Among Tools	35.42390	1	35.42390	35.424	**0.000001**
Reach*Tool	4.34512	1	4.34512	4.345	**0.044698**
Error	33.99997	34	1.00000		

Tool: metallothionein in gills and livers of Wild Yellow Perch

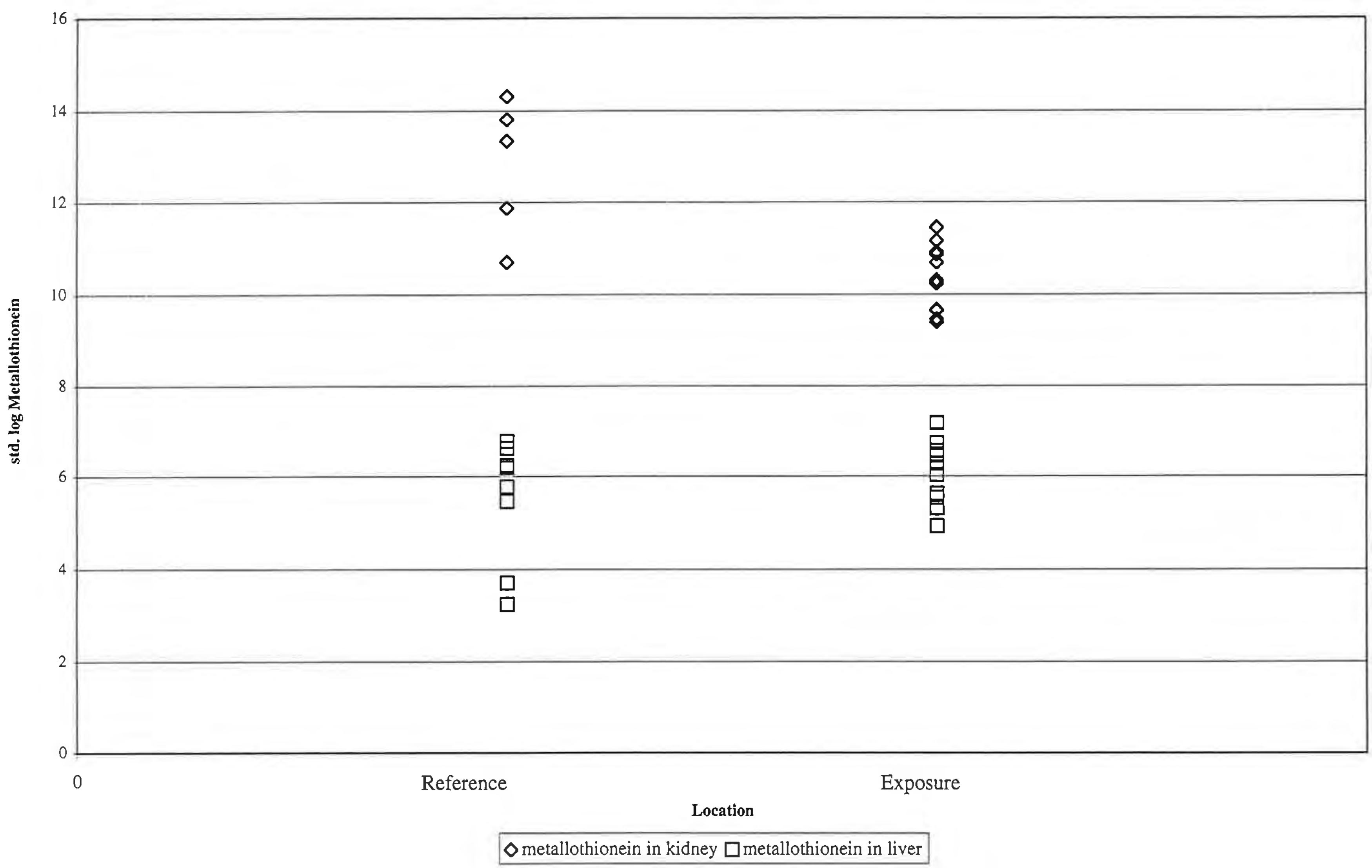
Source	SS	df	MS	F Ratio	P
Among Reach	110.36800	1	110.36800	110.367	**0.000000**
Among Tools	0.93535	1	0.93535	0.935	0.339931
Reach*Tool	9.54144	1	9.54144	9.541	**0.003858**
Error	36.00020	36	1.00001		

Tool: metallothionein in kidneys and livers of Wild Yellow Perch

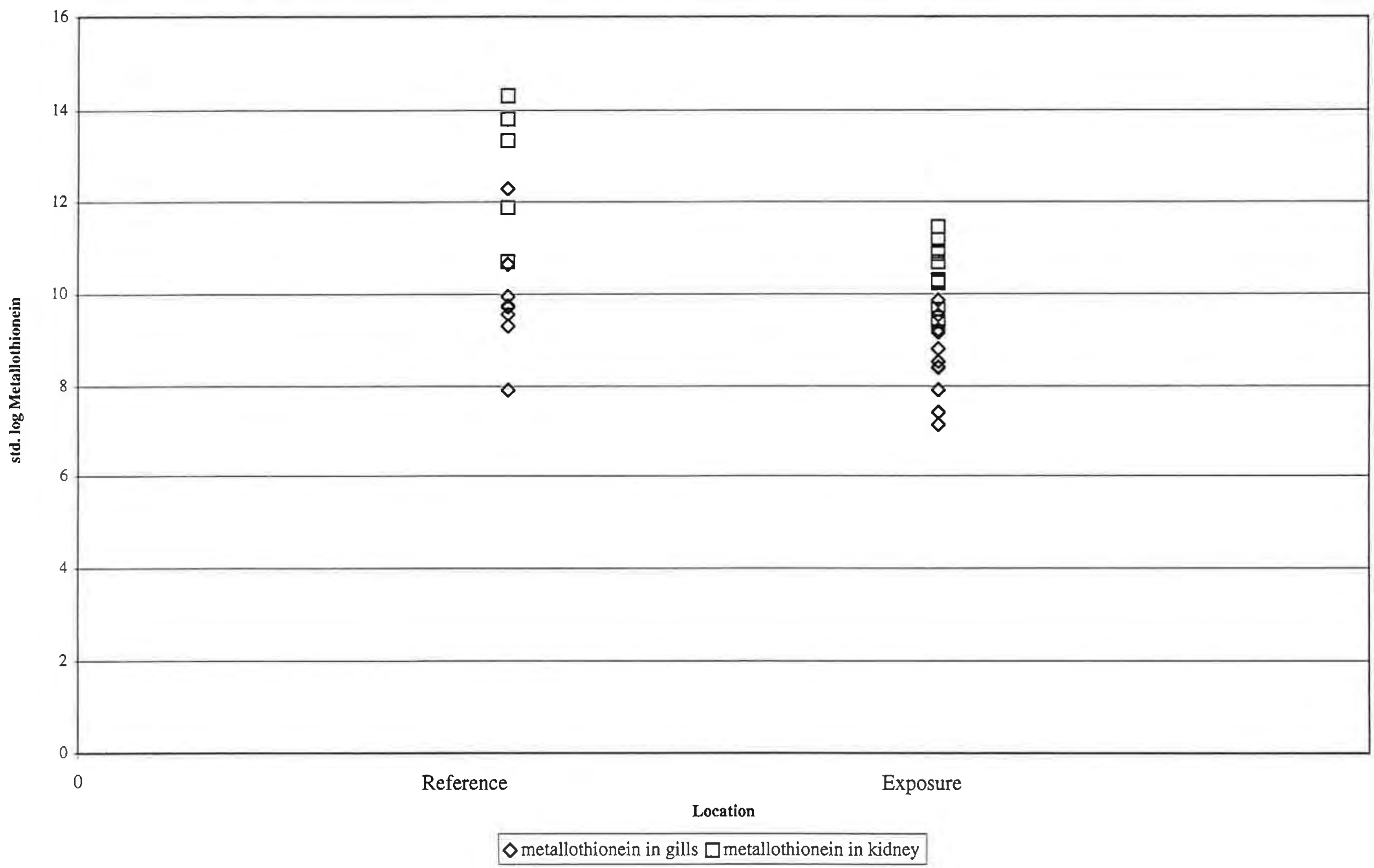
Source	SS	df	MS	F Ratio	P
Among Reach	298.78163	1	298.78163	298.782	**0.000000**
Among Tools	9.03980	1	9.03980	9.040	**0.004940**
Reach*Tool	25.29760	1	25.29760	25.298	**0.000016**
Error	34.00000	34	1.00000		

Dome Mine - Metallothionein in Gills and Liver of Wild Yellow Perch
14
12
10
8
6
4
2
0
std. log Metallothionein
0
Reference
Exposure
Location
metallothionein in gills
metallothionein in liver

Dome Mine - Metallothionein in Kidney and Liver of Wild Yellow Perch



Dome Mine - Metallothionein in Gills and Kidney of Wild Yellow Perch



Dome: Hypothesis 4

Comparison of metallothionein and metal concentrations in tissues - adult yellow perch

Tool: cadmium/metallothionein in livers of Adult Yellow Perch

Source	SS	df	MS	F Ratio	P
Among Reach	0.01418	1	0.01418	0.014	0.905880
Among Tools	82.53940	1	82.53940	82.539	**0.000000**
Reach*Tool	5.02120	1	5.02120	5.021	**0.031300**
Error	36.00000	36	1.00000		

Tool: copper/metallothionein in livers of Adult Yellow Perch

Source	SS	df	MS	F Ratio	P
Among Reach	4.35301	1	4.35301	4.353	**0.044089**
Among Tools	8.95020	1	8.95020	8.950	**0.004984**
Reach*Tool	0.00125	1	0.00125	0.001	0.971982
Error	36.00000	36	1.00000		

Tool: lead/metallothionein in livers of Adult Yellow Perch

Source	SS	df	MS	F Ratio	P
Among Reach	0.93744	1	0.93744	0.937	0.339396
Among Tools	144.97900	1	144.97900	144.979	**0.000000**
Reach*Tool	1.33060	1	1.33060	1.331	0.256300
Error	36.00000	36	1.00000		

Tool: zinc/metallothionein in livers of Adult Yellow Perch

Source	SS	df	MS	F Ratio	P
Among Reach	0.42869	1	0.42869	0.429	0.516794
Among Tools	6390.20000	1	6390.20000	6390.200	**0.000000**
Reach*Tool	2.15211	1	2.15211	2.152	0.151057
Error	36.00000	36	1.00000		

Tool: nickel/metallothionein in liver of Adult Yellow Perch

Source	SS	df	MS	F Ratio	P
Among Reach	9.301	1	9.301	9.130	**0.004679**
Among Tools	105.661	1	105.661	103.714	**0.000000**
Reach*Tool	1.176	1	1.176	1.154	**0.289996**
Error	35.657	35	1.019		

Tool: molybdenum/metallothionein in liver of Adult Yellow Perch

Source	SS	df	MS	F Ratio	P
Among Reach	22.193	1	22.193	21.784	**0.000044**
Among Tools	487.034	1	487.034	478.060	**0.000000**
Reach*Tool	7.538	1	7.538	7.399	**0.010092**
Error	35.657	35	1.019		

Tool: cadmium/metallothionein in gills of Adult Yellow Perch

Source	SS	df	MS	F Ratio	P
Among Reach	10.64750	1	10.64750	10.648	**0.002418**
Among Tools	678.05000	1	678.05000	678.050	**0.000000**
Reach*Tool	0.62880	1	0.62880	0.629	0.432991
Error	36.00000	36	1.00000		

Tool: copper/metallothionein in gills of Adult Yellow Perch

Source	SS	df	MS	F Ratio	P
Among Reach	13.64840	1	13.64840	13.648	**0.000728**
Among Tools	560.29300	1	560.29300	560.293	**0.000000**
Reach*Tool	0.13079	1	0.13079	0.131	0.719731
Error	36.00000	36	1.00000		

Tool: lead/metallothionein in gills of Adult Yellow Perch

Source	SS	df	MS	F Ratio	P
Among Reach	9.29990	1	9.29990	9.300	**0.004281**
Among Tools	449.31800	1	449.31800	449.318	**0.000000**
Reach*Tool	1.01292	1	1.01292	1.013	0.320921
Error	36.00000	36	1.00000		

Tool: zinc/metallothionein in gills of Adult Yellow Perch

Source	SS	df	MS	F Ratio	P
Among Reach	11.22380	1	11.22380	11.224	**0.001906**
Among Tools	68.13700	1	68.13700	68.137	**0.000000**
Reach*Tool	0.49818	1	0.49818	0.498	0.484844
Error	36.00000	36	1.00000		

Tool: cadmium/metallothionein in kidneys of Adult Yellow Perch

Source	SS	df	MS	F Ratio	P
Among Reach	31.84300	1	31.84300	31.843	**0.000003**
Among Tools	696.21500	1	696.21500	696.215	**0.000000**
Reach*Tool	4.20708	1	4.20708	4.207	**0.048518**
Error	32.00000	32	1.00000		

Tool: copper/metallothionein in kidneys of Adult Yellow Perch

Source	SS	df	MS	F Ratio	P
Among Reach	36.92870	1	36.92870	36.929	**0.000001**
Among Tools	542.98400	1	542.98400	542.984	**0.000000**
Reach*Tool	2.61544	1	2.61544	2.615	0.115645
Error	32.00000	32	1.00000		

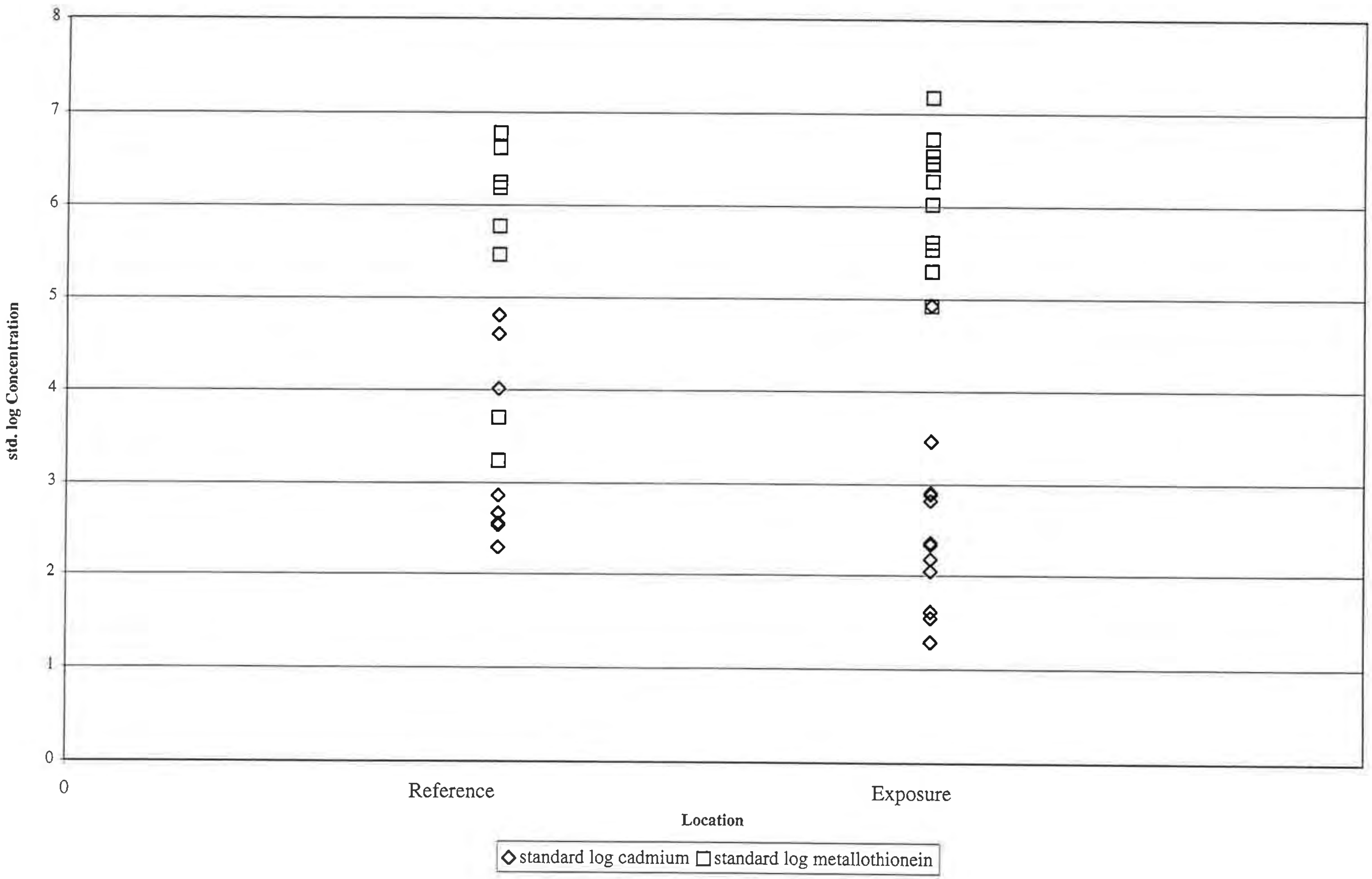
Tool: lead/metallothionein in kidneys of Adult Yellow Perch

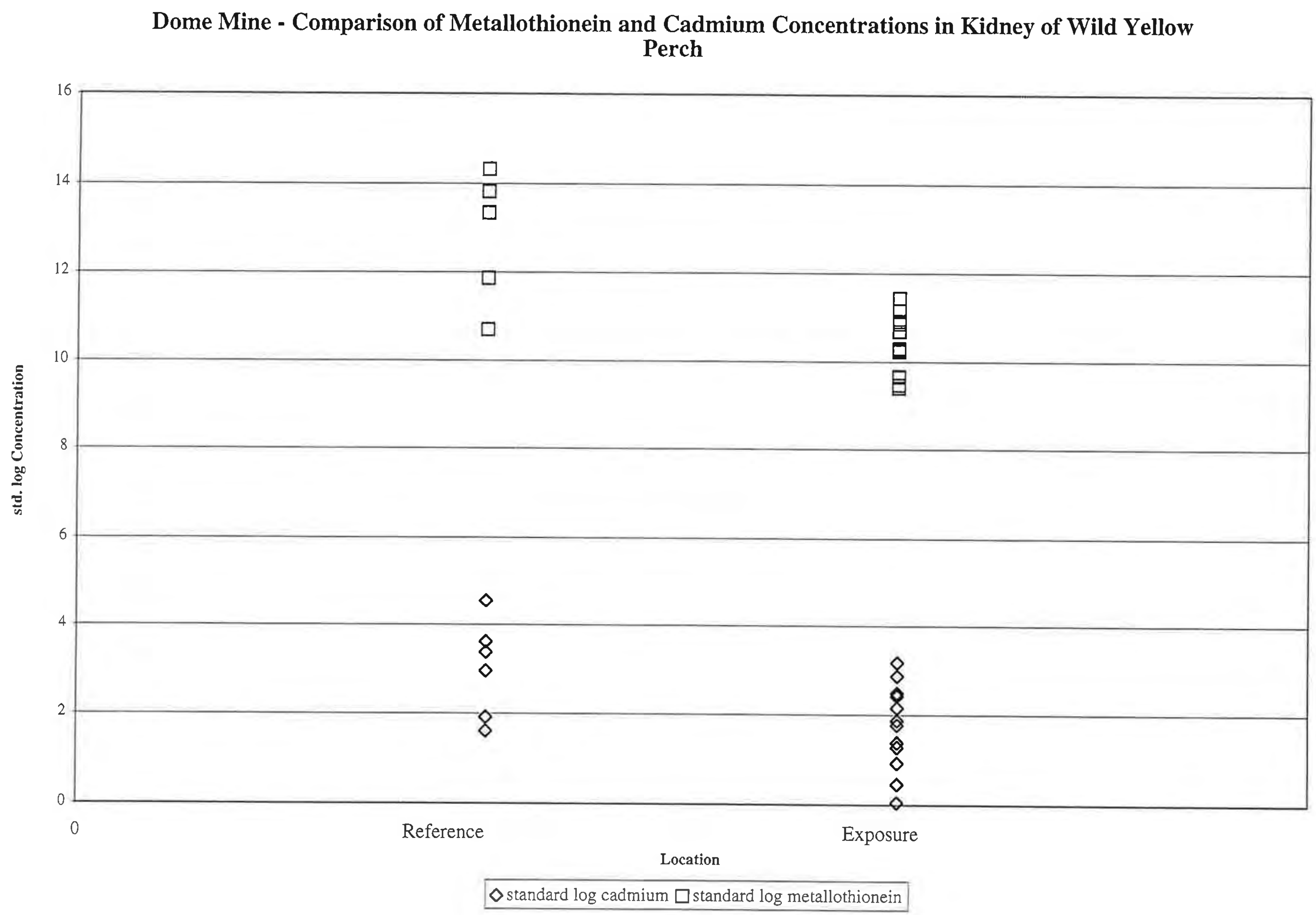
Source	SS	df	MS	F Ratio	P
Among Reach	22.34880	1	22.34880	22.349	**0.000044**
Among Tools	611.04500	1	611.04500	611.045	**0.000000**
Reach*Tool	8.80120	1	8.80120	8.801	**0.005655**
Error	32.00000	32	1.00000		

Tool: zinc/metallothionein in kidneys of Adult Yellow Perch

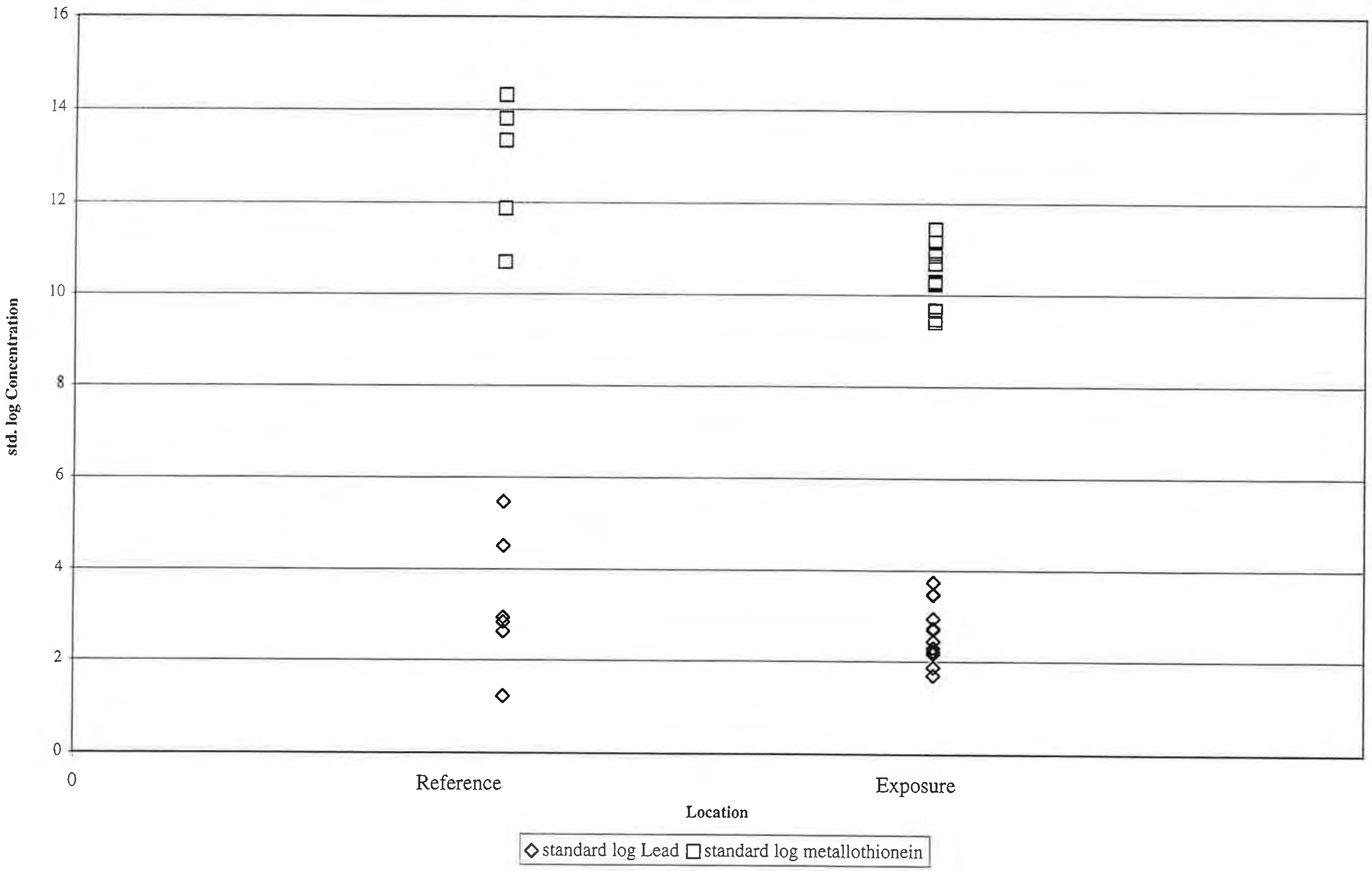
Source	SS	df	MS	F Ratio	P
Among Reach	26.00610	1	26.00610	26.006	**0.000015**
Among Tools	80.32420	1	80.32420	80.324	**0.000000**
Reach*Tool	6.73149	1	6.73149	6.731	**0.014175**
Error	32.00000	32	1.00000		

Dome Mine - Comparison of Metallothionein and Cadmium Concentrations in Liver of Wild Yellow Perch

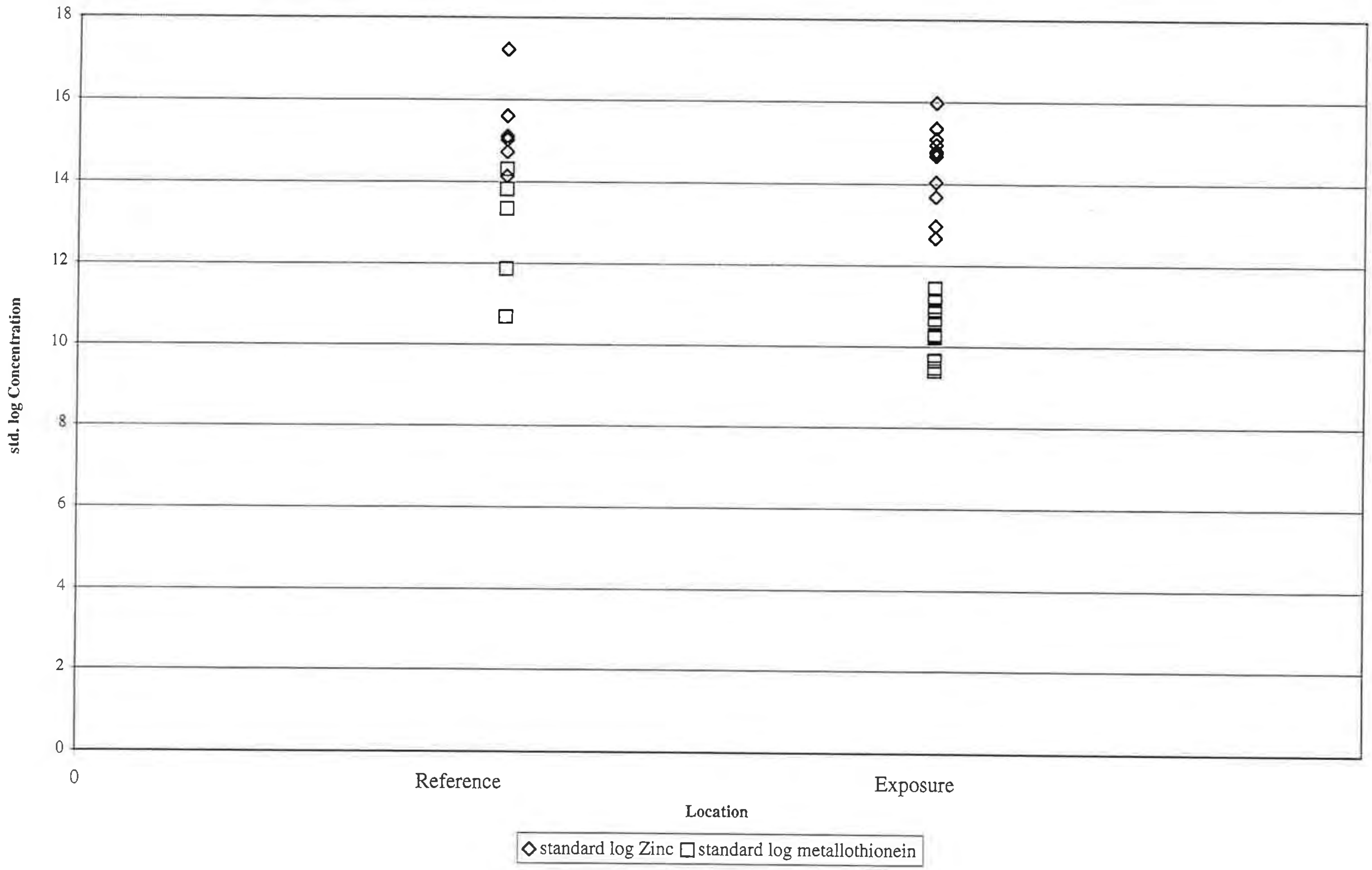


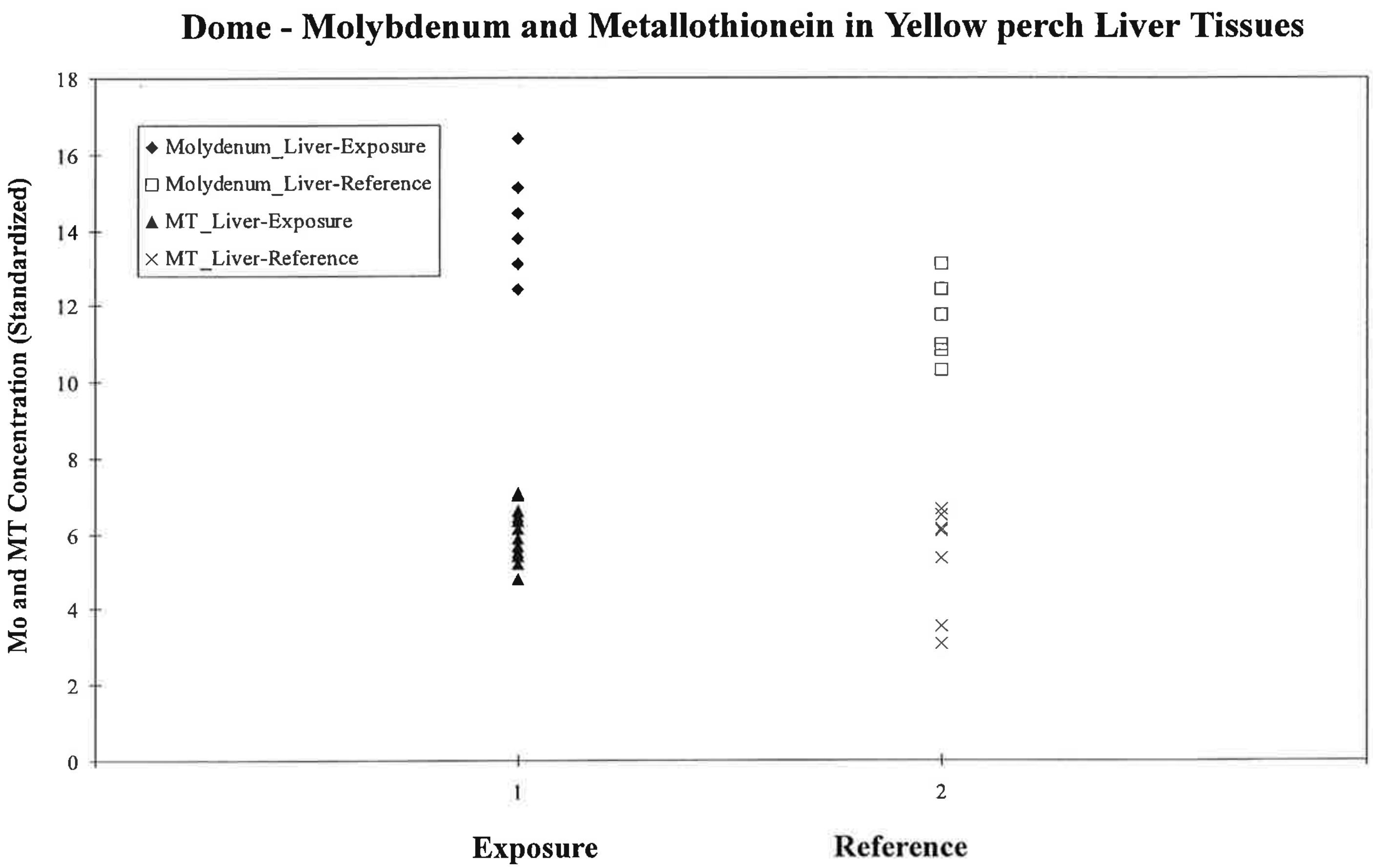

Dome Mine - Comparison of Metallothionein and Cadmium Concentrations in Kidney of Wild Yellow Perch
std. log Concentration
16
14
12
10
8
6
4
2
0
0
Reference
Exposure
Location
standard log cadmium
standard log metallothionein

Dome Mine - Comparison of Metallothionein and Lead Concentrations in Kidney of Wild Yellow Perch

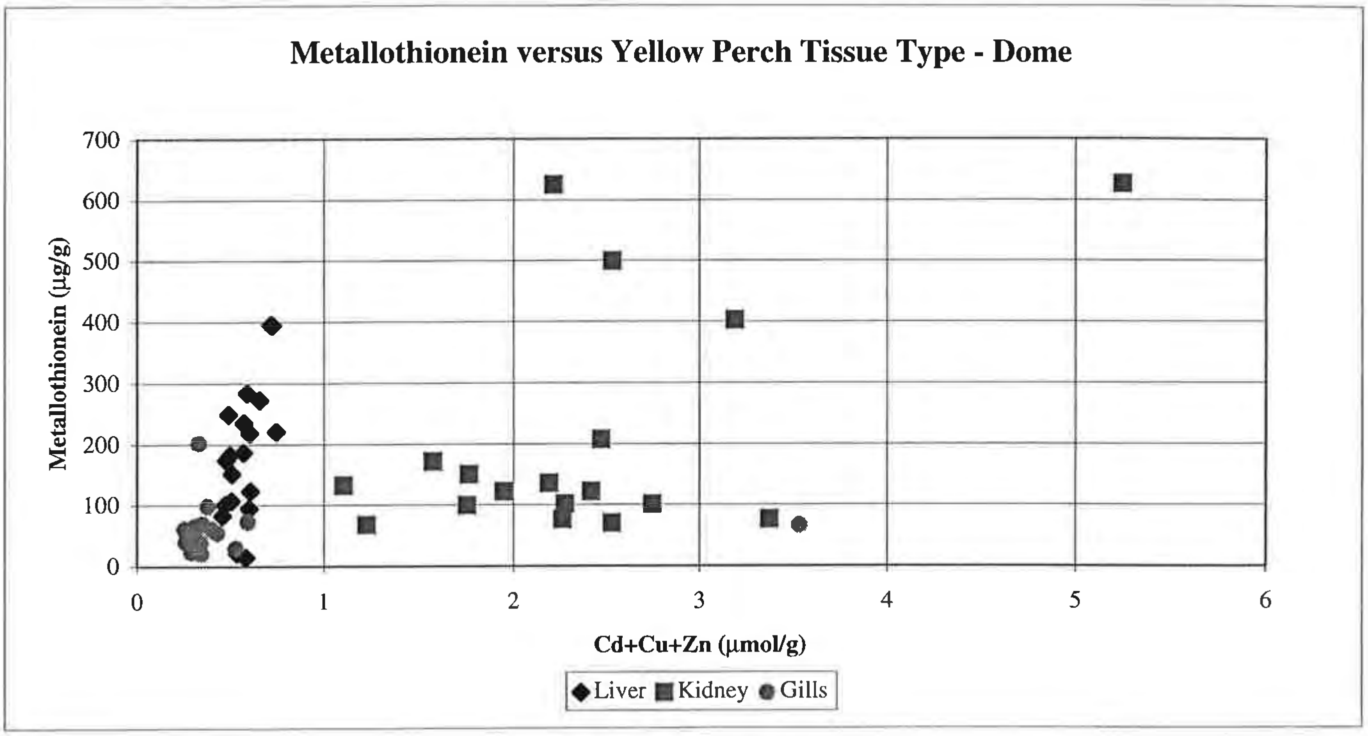


Dome Mine - Comparison of Metallothionein and Zinc Concentrations in Kidney of Wild Yellow Perch

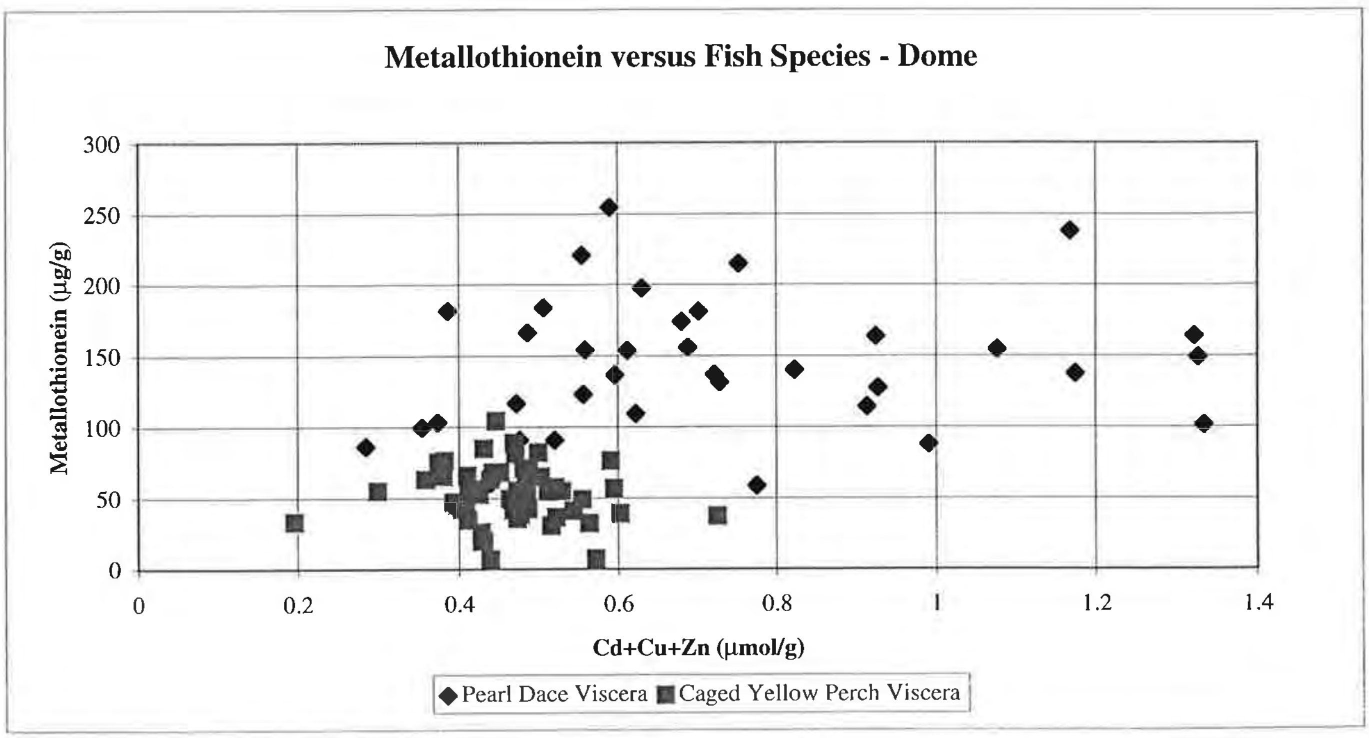




Dome - Molybdenum and Metallothionein in Yellow perch Liver Tissues
Molydenum_Liver-Exposure
Molydenum_Liver-Reference
MT_Liver-Exposure
MT_Liver-Reference
Mo and MT Concentration (Standardized)
0
2
4
6
8
10
12
14
16
18
1
2
Exposure
Reference



Metallothionein versus Yellow Perch Tissue Type - Dome
Metallothionein (µg/g)
0
100
200
300
400
500
600
700
0
1
2
3
4
5
6
Cd+Cu+Zn (µmol/g)
Liver
Kidney
Gills



Metallothionein versus Fish Species - Dome
Metallothionein (µg/g)
0
50
100
150
200
250
300
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Cd+Cu+Zn (µmol/g)
Pearl Dace Viscera
Caged Yellow Perch Viscera

Dome: Hypothesis 4

Comparison of metallotheinein and metal concentrations in tissues

Pearl dace

Tool: silver/metallotheinein in Viscera of Pearl dace

Source	SS	df	MS	F Ratio	P
Among Reach	36.562	2	18.281	18.281	**4.81E-07**
Among Tools	3296.578	1	3296.578	3296.615	**4.56E-58**
Reach*Tool	28.148	2	14.074	14.074	**8.11E-06**
Within Reach (Error)	65.999	66	1.000		

Tool: aluminum/metallotheinein in Viscera of Pearl dace

Source	SS	df	MS	F Ratio	P
Among Reach	1.959	2	0.980	0.980	0.381
Among Tools	2970.556	1	2970.556	2972.574	**1.29E-56**
Reach*Tool	21.184	2	10.592	10.599	**1.02E-04**
Within Reach (Error)	65.955	66	0.999		

Tool: cadmium/metallotheinein in Viscera of Pearl dace

Source	SS	df	MS	F Ratio	P
Among Reach	16.365	2	8.183	8.183	**6.69E-04**
Among Tools	3060.604	1	3060.604	3060.542	**5.04E-57**
Reach*Tool	5.570	2	2.785	2.785	0.069
Within Reach (Error)	66.001	66	1.000		

Tool: copper/metallotheinein in Viscera of Pearl dace

Source	SS	df	MS	F Ratio	P
Among Reach	20.169	2	10.084	10.084	**1.51E-04**
Among Tools	1791.754	1	1791.754	1791.669	**1.47E-49**
Reach*Tool	26.171	2	13.086	13.085	**1.63E-05**
Within Reach (Error)	66.003	66	1.000		

Tool: molybdenum/metallotheinein in Viscera of Pearl dace

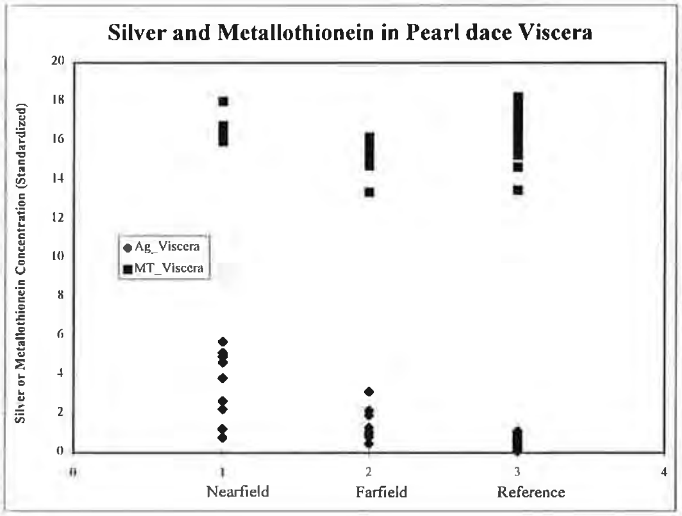
Source	SS	df	MS	F Ratio	P
Among Reach	3.856	2	1.928	1.928	0.154
Among Tools	2914.081	1	2914.081	2913.852	**2.46E-56**
Reach*Tool	17.760	2	8.880	8.879	**3.85E-04**
Within Reach (Error)	66.005	66	1.000		

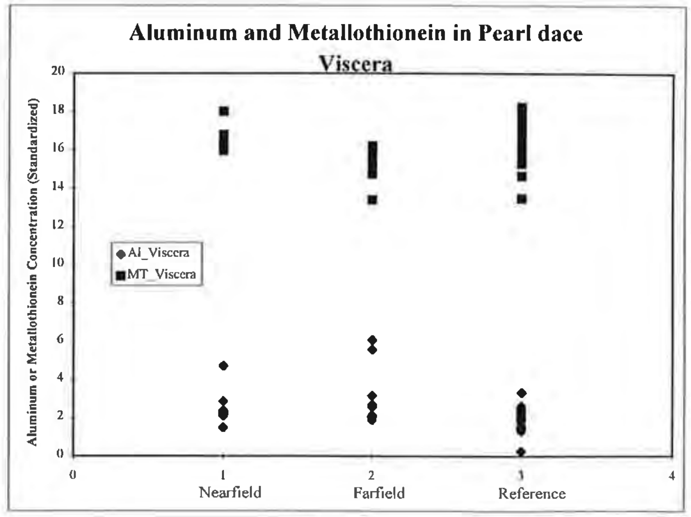
Tool: nickel/metallotheinein in Viscera of Pearl dace

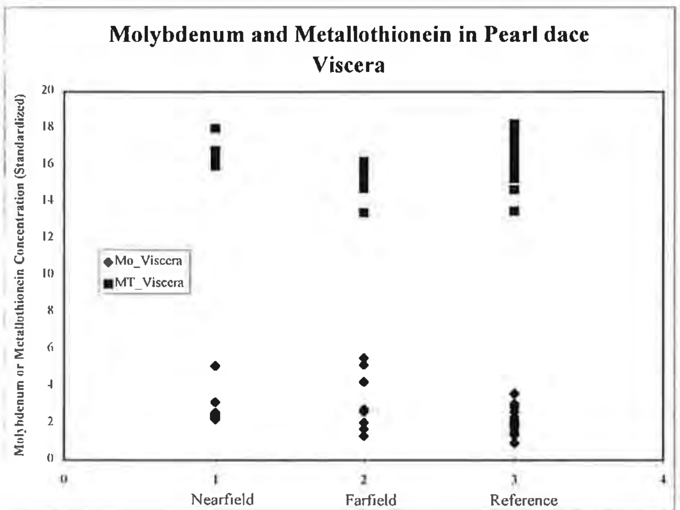
Source	SS	df	MS	F Ratio	P
Among Reach	7.423	2	3.712	3.712	**0.030**
Among Tools	3345.232	1	3345.232	3345.395	**2.84E-58**
Reach*Tool	25.849	2	12.924	12.925	**1.83E-05**
Within Reach (Error)	65.997	66	1.000		

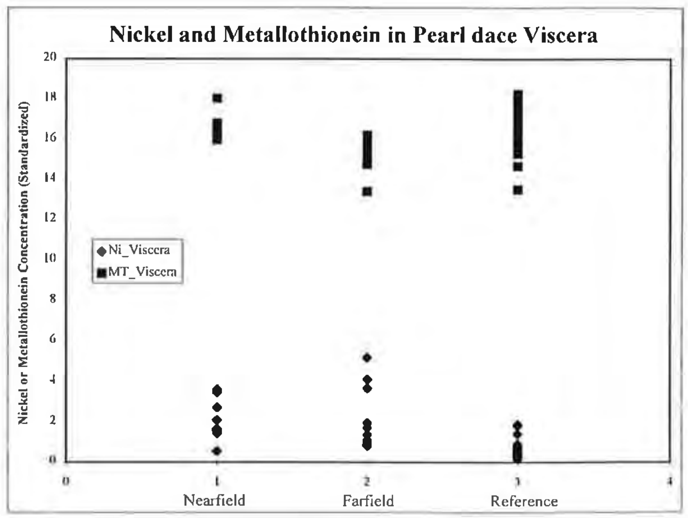
Tool: selenium/metallotheinein in Viscera of Pearl dace

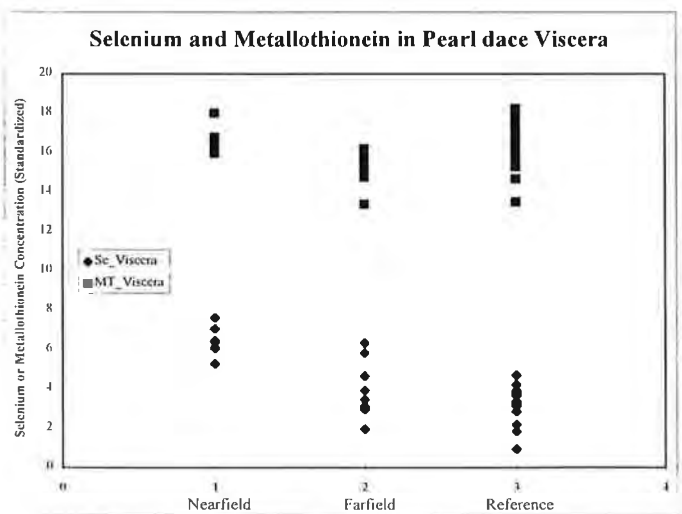
Source	SS	df	MS	F Ratio	P
Among Reach	44.151	2	22.075	22.075	**4.56E-08**
Among Tools	2161.485	1	2161.485	2161.417	**3.67E-52**
Reach*Tool	30.220	2	15.110	15.110	**3.96E-06**
Within Reach (Error)	66.002	66	1.000		


Silver and Metallothionein in Pearl dace Viscera
Silver or Metallothionein Concentration (Standardized)
Ag_Viscera
MT_Viscera
Nearfield
Farfield
Reference

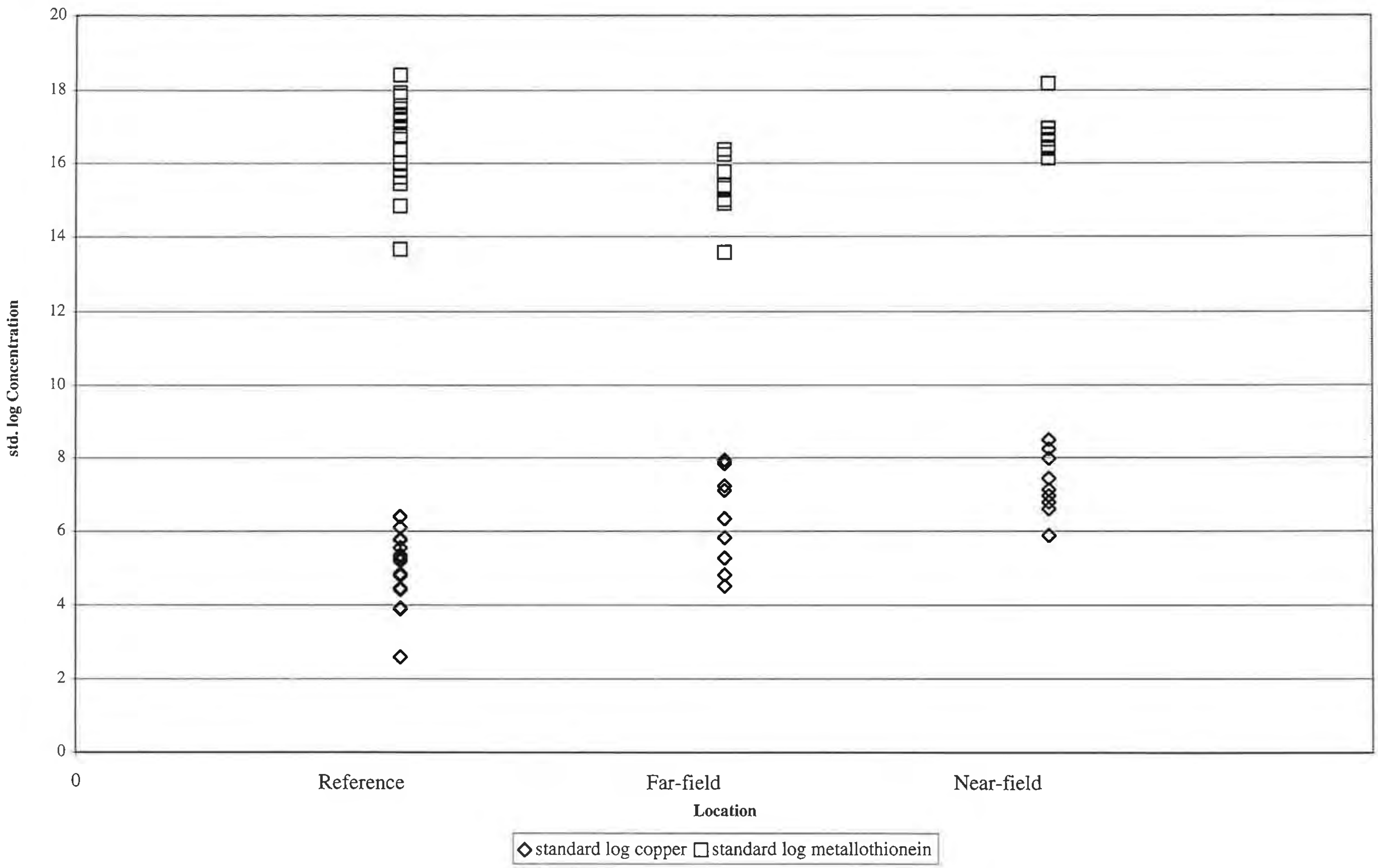

Aluminum and Metallothionein in Pearl dace Viscera
Aluminum or Metallothionein Concentration (Standardized)
Al_Viscera
MT_Viscera
Nearfield
Farfield
Reference


Molybdenum and Metallothionein in Pearl dace Viscera
Molybdenum or Metallothionein Concentration (Standardized)
Mo_Viscera
MT_Viscera
Nearfield
Farfield
Reference

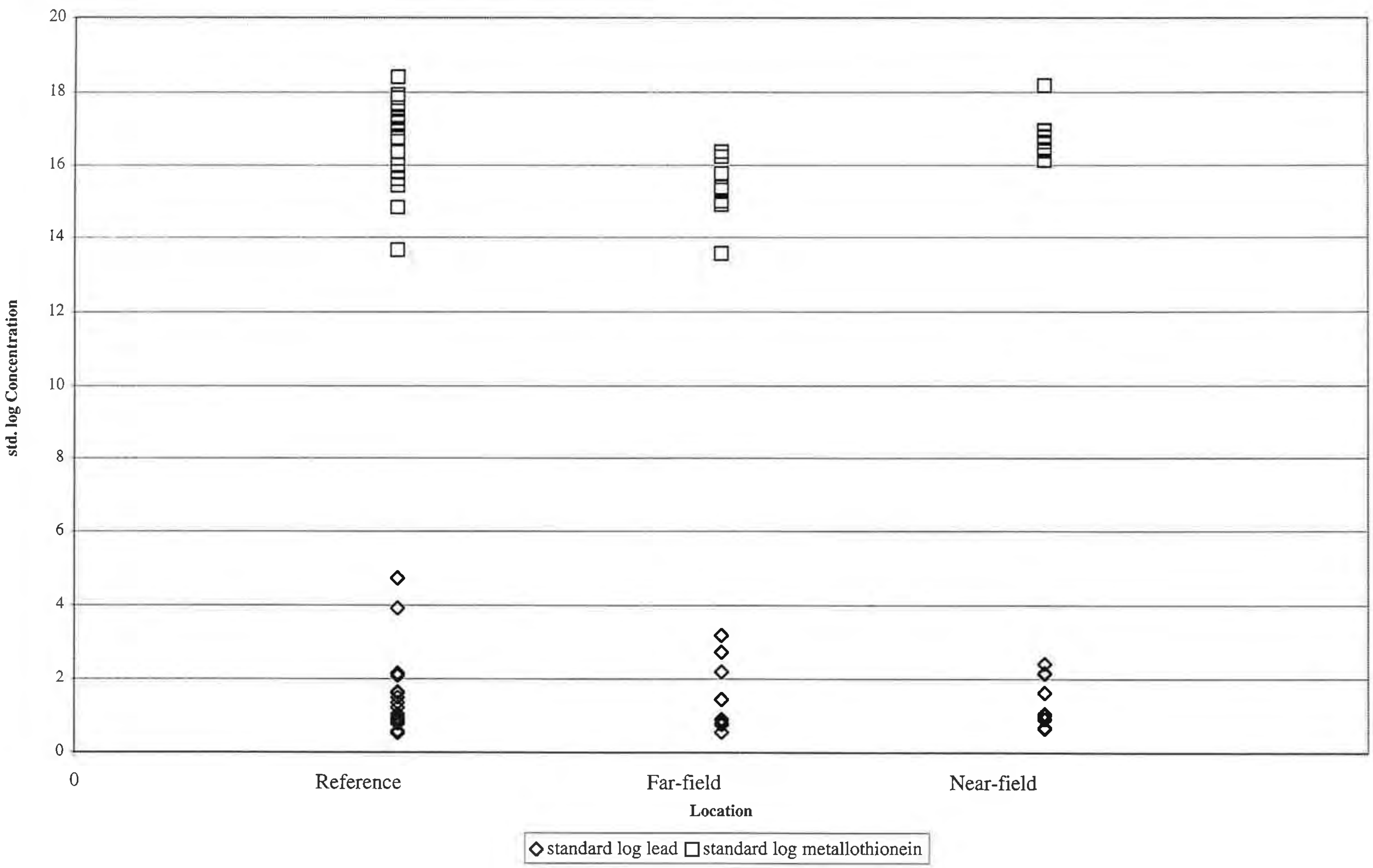

Nickel and Metallothionein in Pearl dace Viscera
Nickel or Metallothionein Concentration (Standardized)
Ni_Viscera
MT_Viscera
Nearfield
Farfield
Reference


Selenium and Metallothionein in Pearl dace Viscera
Selenium or Metallothionein Concentration (Standardized)
Se_Viscera
MT_Viscera
Nearfield
Farfield
Reference

Dome Mine - Comparison of Metallothionein and Copper Concentrations in Viscera of Wild Pearl Dace



Dome Mine - Comparison of Metallothionein and Lead Concentrations in Viscera of Wild Pearl Dace



Dome Mines - Hypothesis 4

Comparison of metallothionein and metal concentrations in Viscera of caged Yellow perch

Tool: selenium/metallothionein in Viscera of caged Yellow perch

Source	SS	df	MS	F Ratio	P
Among Reach	20.117	4	5.029	4.996	**0.001**
Among Tools	384.876	1	384.876	382.358	**5.68E-34**
Reach*Tool	6.204	4	1.551	1.541	0.197
Within Reach (Error)	89.586	89	1.007		

Tool: molybdenum/metallothionein in Viscera of caged Yellow perch

Source	SS	df	MS	F Ratio	P
Among Reach	5.799	4	1.450	1.440	0.227
Among Tools	2010.801	1	2010.801	1997.629	**9.29E-63**
Reach*Tool	5.588	4	1.397	1.388	0.245
Within Reach (Error)	89.587	89	1.007		

Tool: aluminum/metallothionein in Viscera of caged Yellow perch

Source	SS	df	MS	F Ratio	P
Among Reach	32.445	4	8.111	8.058	**1.36E-05**
Among Tools	1372.984	1	1372.984	1364.030	**9.25E-56**
Reach*Tool	21.437	4	5.359	5.324	**6.85E-04**
Within Reach (Error)	89.584	89	1.007		

Tool: cadmium/metallothionein in Viscera of caged Yellow perch

Source	SS	df	MS	F Ratio	P
Among Reach	14.249	4	3.562	3.538	**0.010**
Among Tools	2127.858	1	2127.858	2113.636	**8.35E-64**
Reach*Tool	3.287	4	0.822	0.816	0.518
Within Reach (Error)	89.599	89	1.007		

Tool: copper/metallothionein in Viscera of caged Yellow perch

Source	SS	df	MS	F Ratio	P
Among Reach	5.901	4	1.475	1.466	0.219
Among Tools	1250.882	1	1250.882	1242.687	**4.49E-54**
Reach*Tool	12.757	4	3.189	3.168	**0.018**
Within Reach (Error)	89.587	89	1.007		

Tool: lead/metallothionein in Viscera of caged Yellow perch

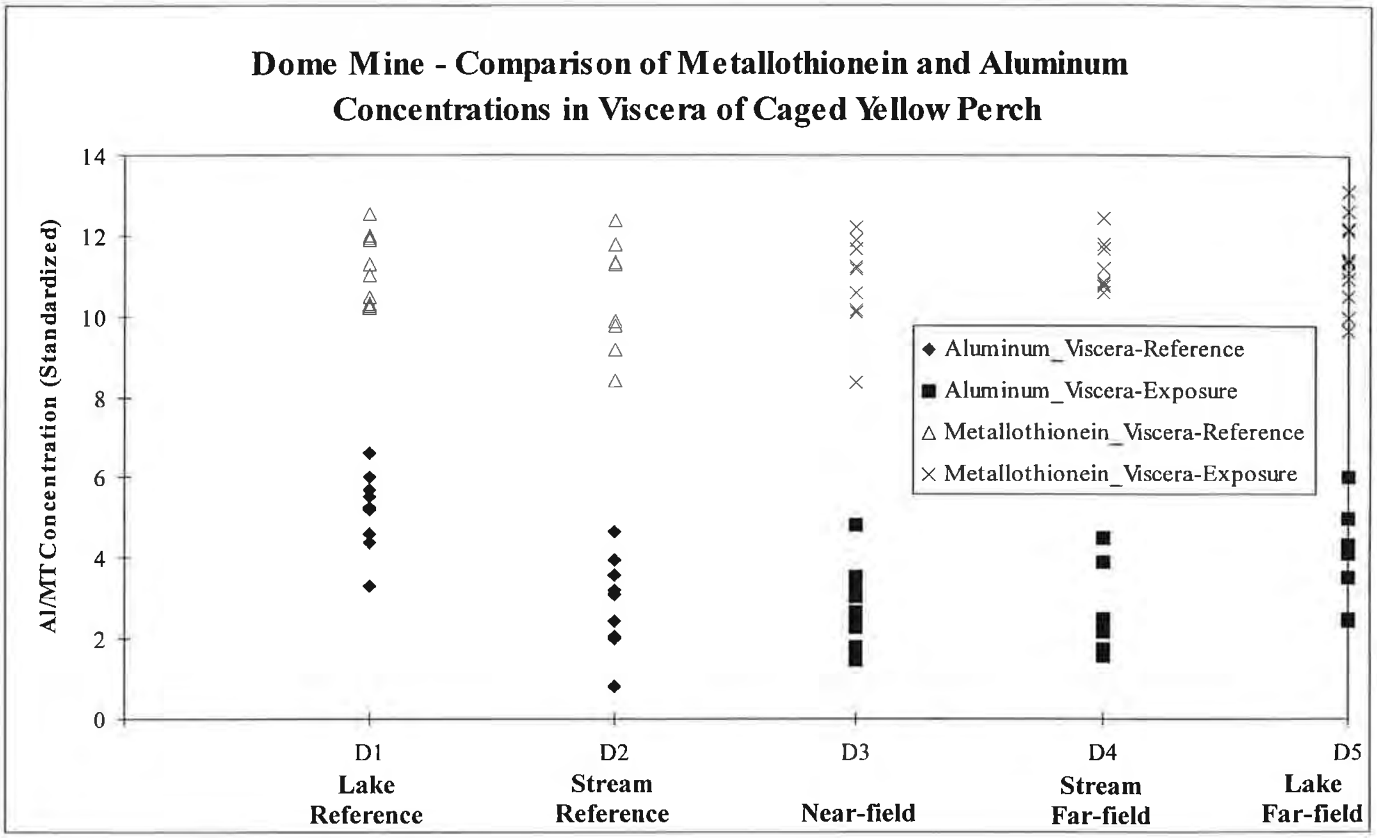
Source	SS	df	MS	F Ratio	P
Among Reach	27.568	4	6.892	6.847	**7.49E-05**
Among Tools	1607.015	1	1607.015	1596.580	**1.24E-58**
Reach*Tool	20.028	4	5.007	4.975	**0.001**
Within Reach (Error)	89.582	89	1.007		

Tool: zinc/metallothionein in Viscera of caged Yellow perch

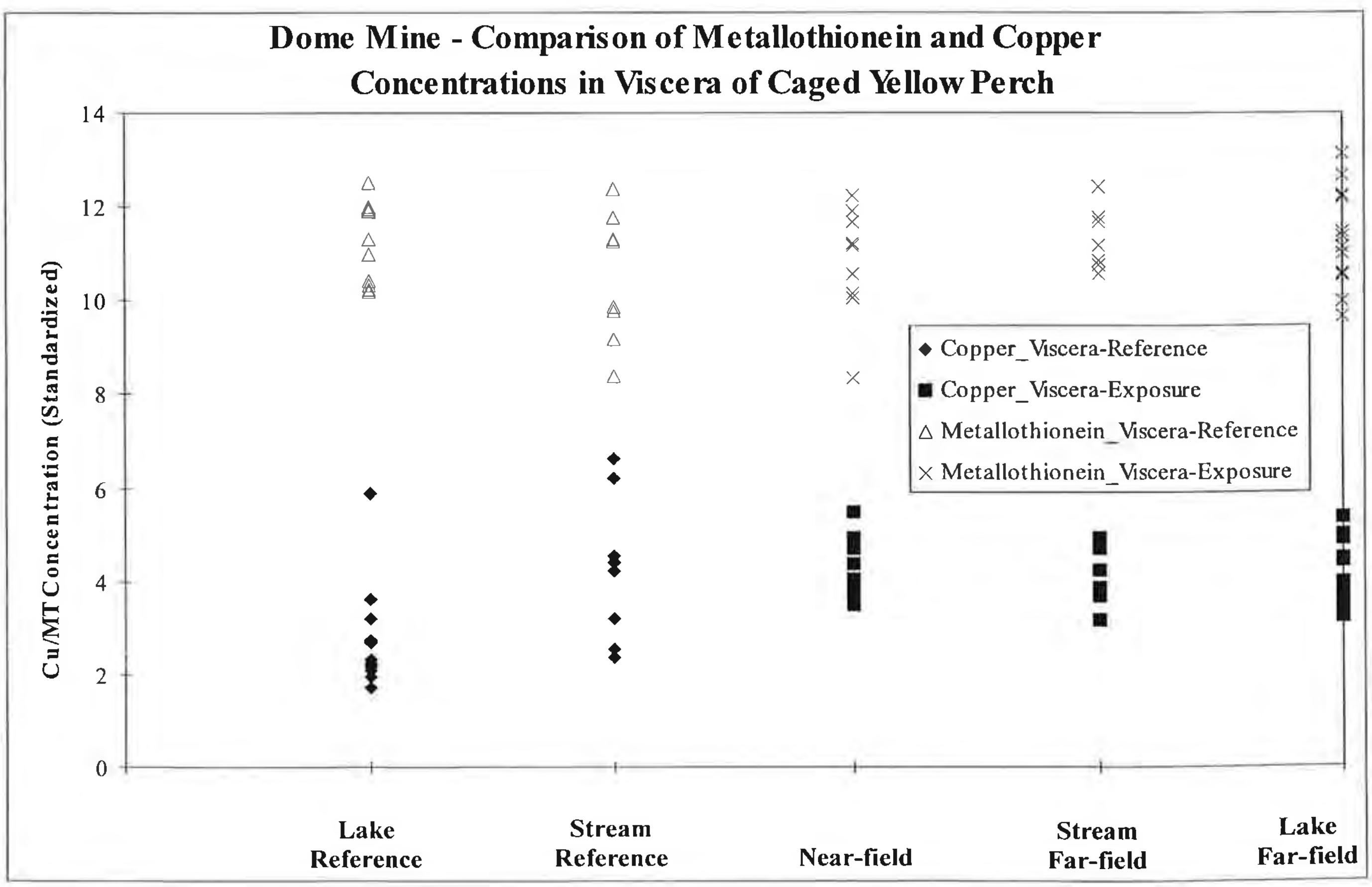
Source	SS	df	MS	F Ratio	P
Among Reach	14.696	4	3.674	3.650	**0.008**
Among Tools	898.607	1	898.607	892.772	**3.54E-48**
Reach*Tool	4.488	4	1.122	1.115	0.355
Within Reach (Error)	89.582	89	1.007		

Tool: nickel/metallothionein in Viscera of caged Yellow perch

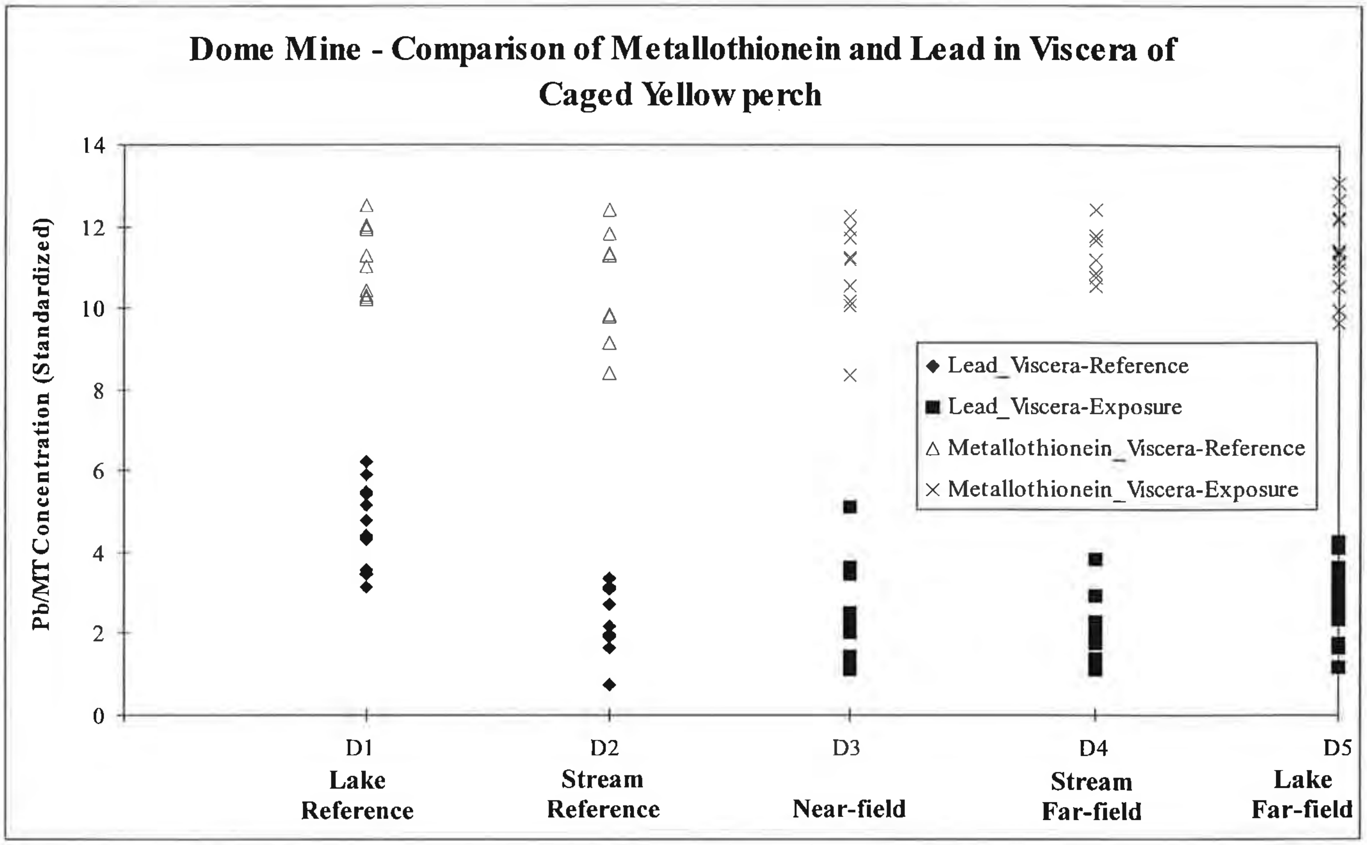
Source	SS	df	MS	F Ratio	P
Among Reach	43.001	4	10.750	10.681	**4.08E-07**
Among Tools	2307.442	1	2307.442	2292.668	**2.57E-65**
Reach*Tool	33.325	4	8.331	8.278	**1.01E-05**
Within Reach (Error)	89.574	89	1.006		



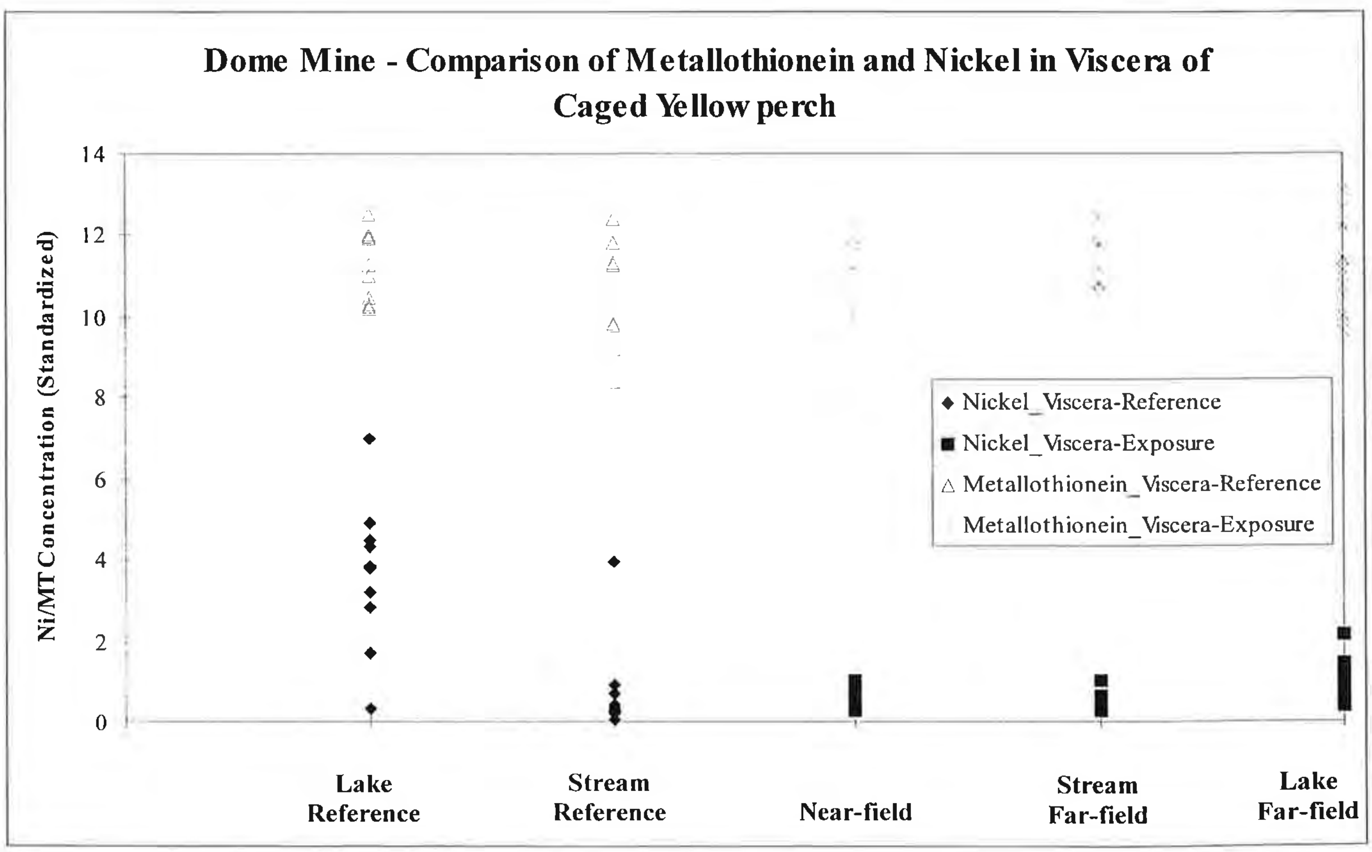
Dome Mine - Comparison of Metallothionein and Aluminum Concentrations in Viscera of Caged Yellow Perch
Al/MT Concentration (Standardized)
0
2
4
6
8
10
12
14
Aluminum_Viscera-Reference
Aluminum_Viscera-Exposure
Metallothionein_Viscera-Reference
Metallothionein_Viscera-Exposure
D1 Lake Reference
D2 Stream Reference
D3 Near-field
D4 Stream Far-field
D5 Lake Far-field



Dome Mine - Comparison of Metallothionein and Copper Concentrations in Viscera of Caged Yellow Perch
Cu/MT Concentration (Standardized)
0
2
4
6
8
10
12
14
Copper_Viscera-Reference
Copper_Viscera-Exposure
Metallothionein_Viscera-Reference
Metallothionein_Viscera-Exposure
Lake Reference
Stream Reference
Near-field
Stream Far-field
Lake Far-field



Dome Mine - Comparison of Metallothionein and Lead in Viscera of Caged Yellow perch
Pb/MT Concentration (Standardized)
0
2
4
6
8
10
12
14
D1
Lake Reference
D2
Stream Reference
D3
Near-field
D4
Stream Far-field
D5
Lake Far-field
Lead_Viscera-Reference
Lead_Viscera-Exposure
Metallothionein_Viscera-Reference
Metallothionein_Viscera-Exposure



Dome Mine - Comparison of Metallothionein and Nickel in Viscera of Caged Yellow perch
Ni/MT Concentration (Standardized)
0
2
4
6
8
10
12
14
Lake Reference
Stream Reference
Near-field
Stream Far-field
Lake Far-field
Nickel_Viscera-Reference
Nickel_Viscera-Exposure
Metallothionein_Viscera-Reference
Metallothionein_Viscera-Exposure

Dome: Hypothesis 6

Benthic Community Indices

Number of Taxa

Source	SS	df	MS	F Ratio	P
Among Reac	946.571	2	473.286	16.639	**8.09E-05**
Error	512.000	18	28.444		

EPT Taxa

Source	SS	df	MS	F Ratio	P
Among Reac	68.667	2	34.334	26.704	**4.11E-06**
Error	23.143	18	1.286		

number of Individuals (log)

Source	SS	df	MS	F Ratio	P
Among Reac	22.318	2	11.159	26.450	**4.38E-06**
Error	7.594	18	0.422		

% chironomids (asn)

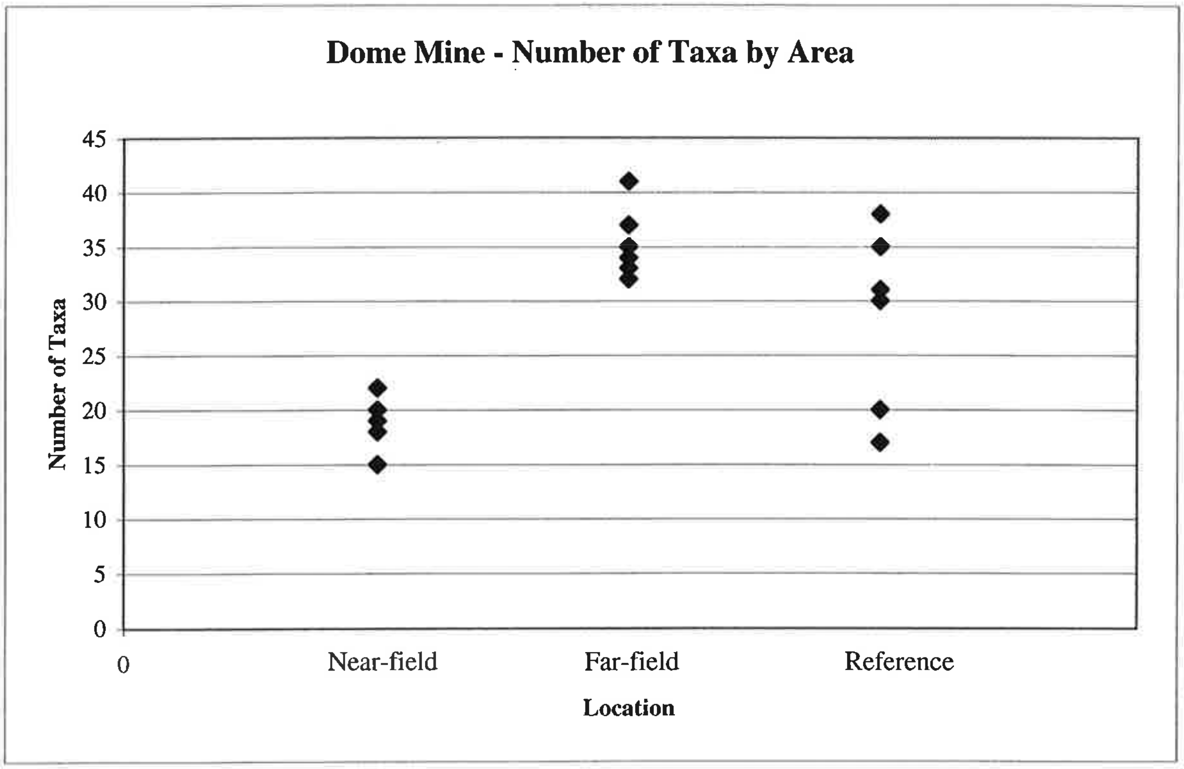
Source	SS	df	MS	F Ratio	P
Among Reac	0.863	2	0.432	13.894	**2.24E-04**
Error	0.559	18	0.031		

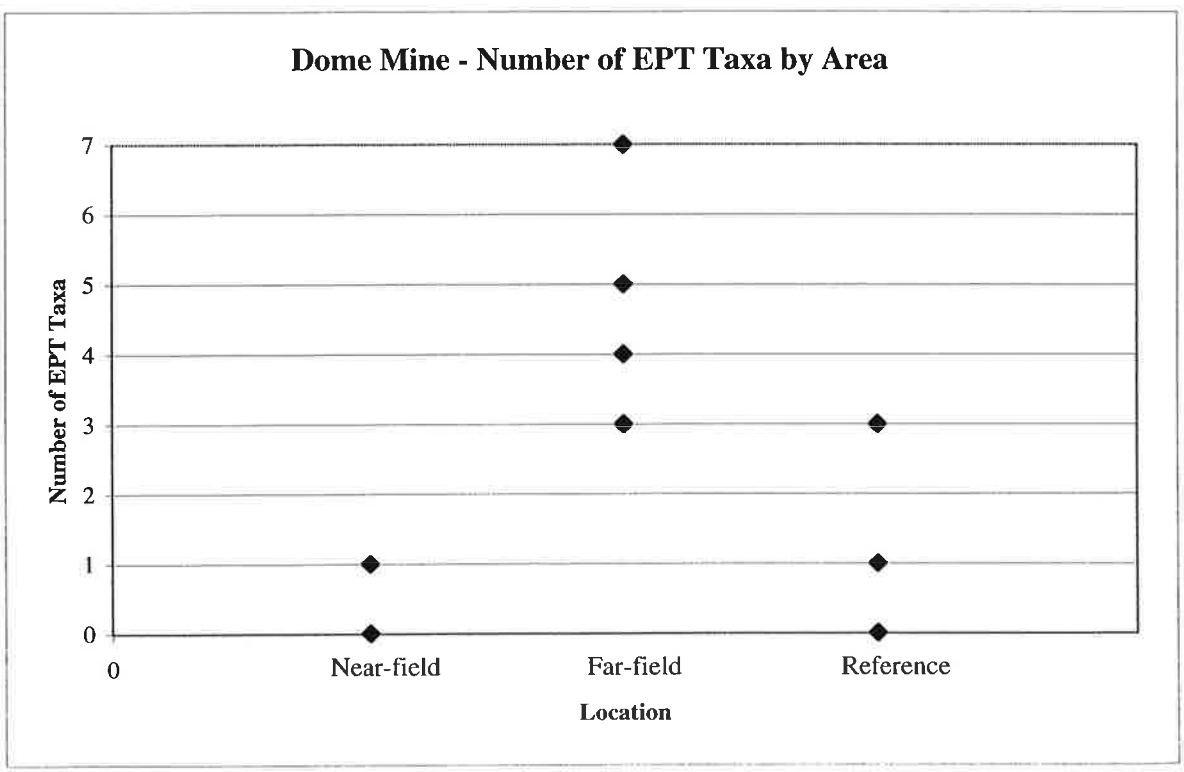
% Tanytarsus (asn)

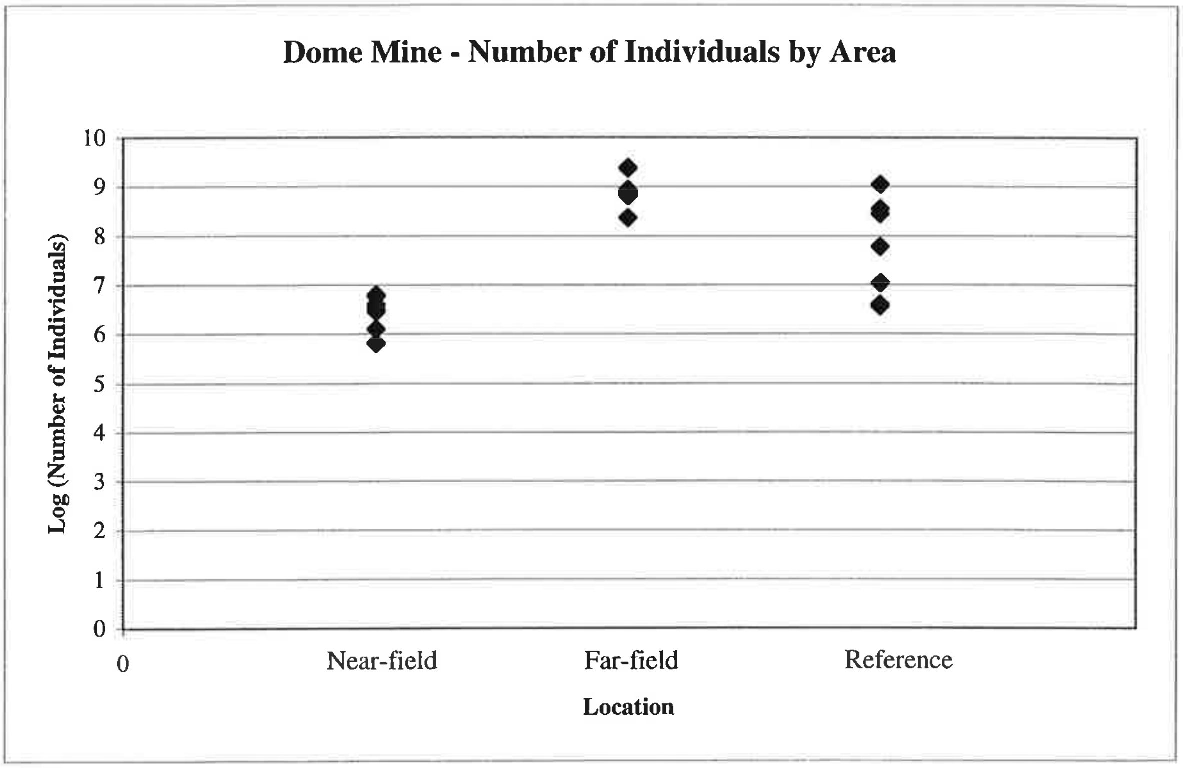
Source	SS	df	MS	F Ratio	P
Among Reac	0.173	2	0.086	7.579	**0.004**
Error	0.205	18	0.011		

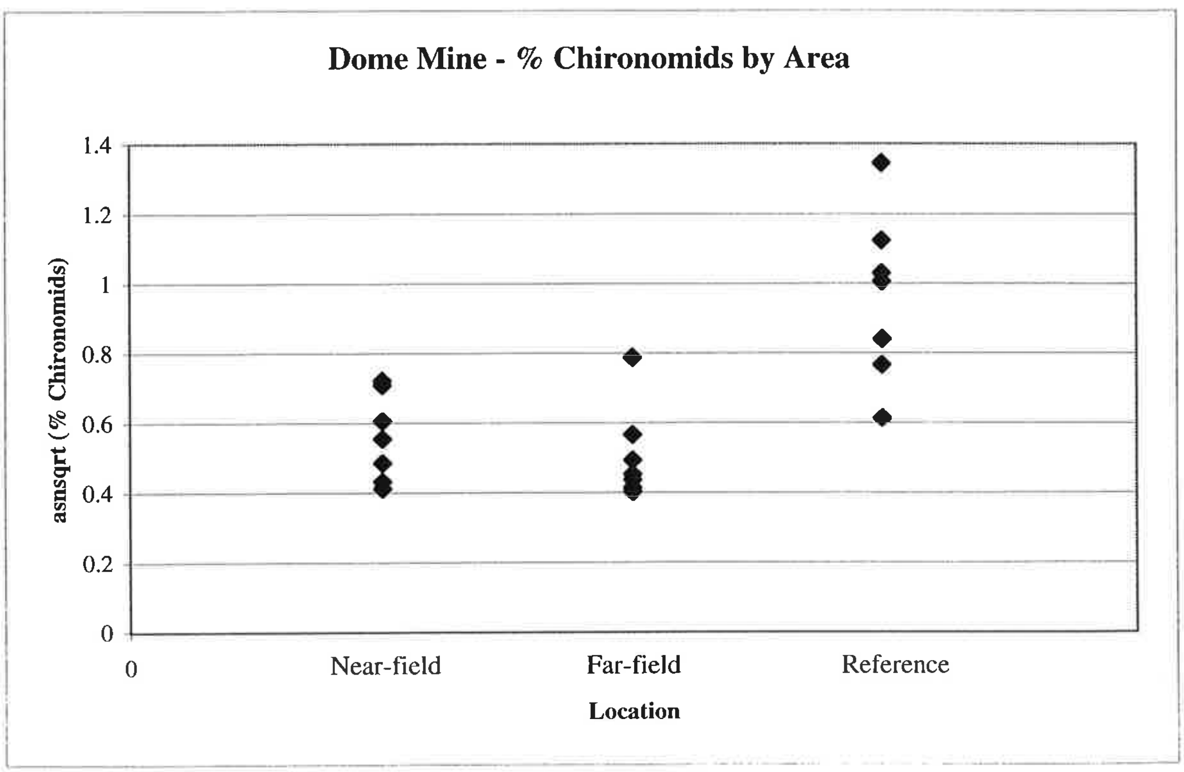
% Pisidium (asn)

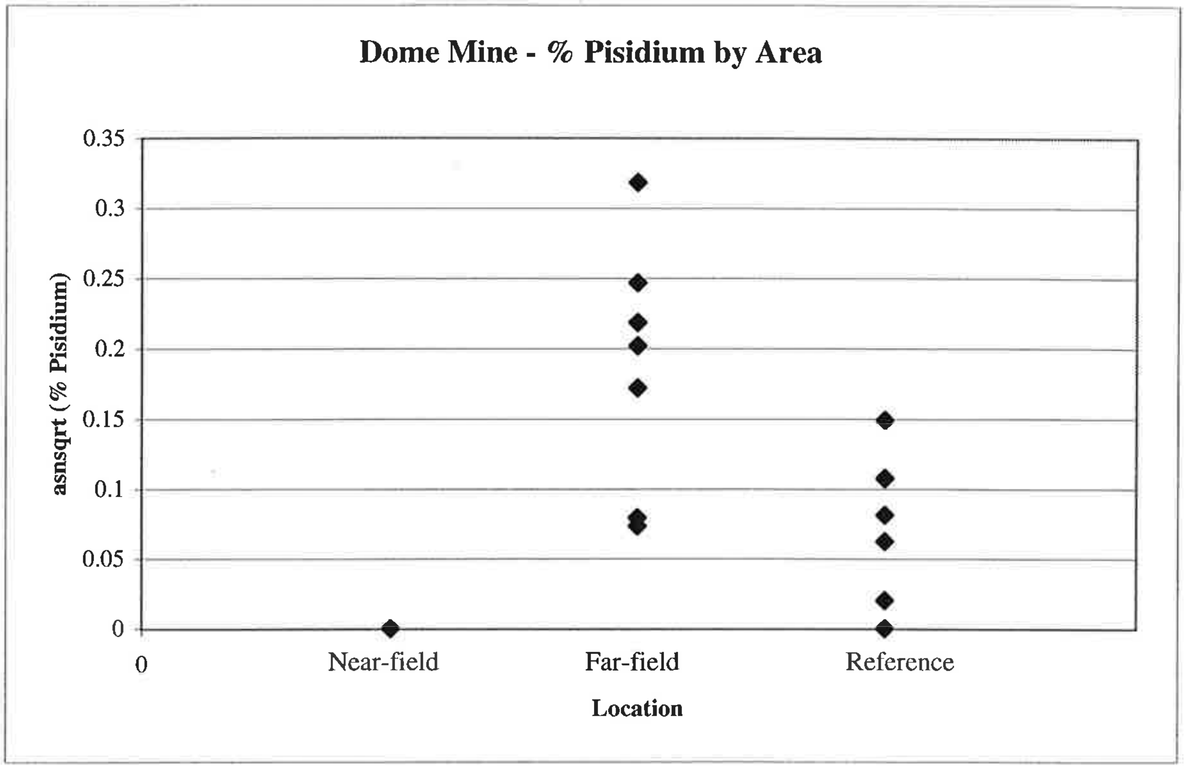
Source	SS	df	MS	F Ratio	P
Among Reac	0.124	2	0.062	17.704	**5.61E-05**
Error	0.063	18	0.004		

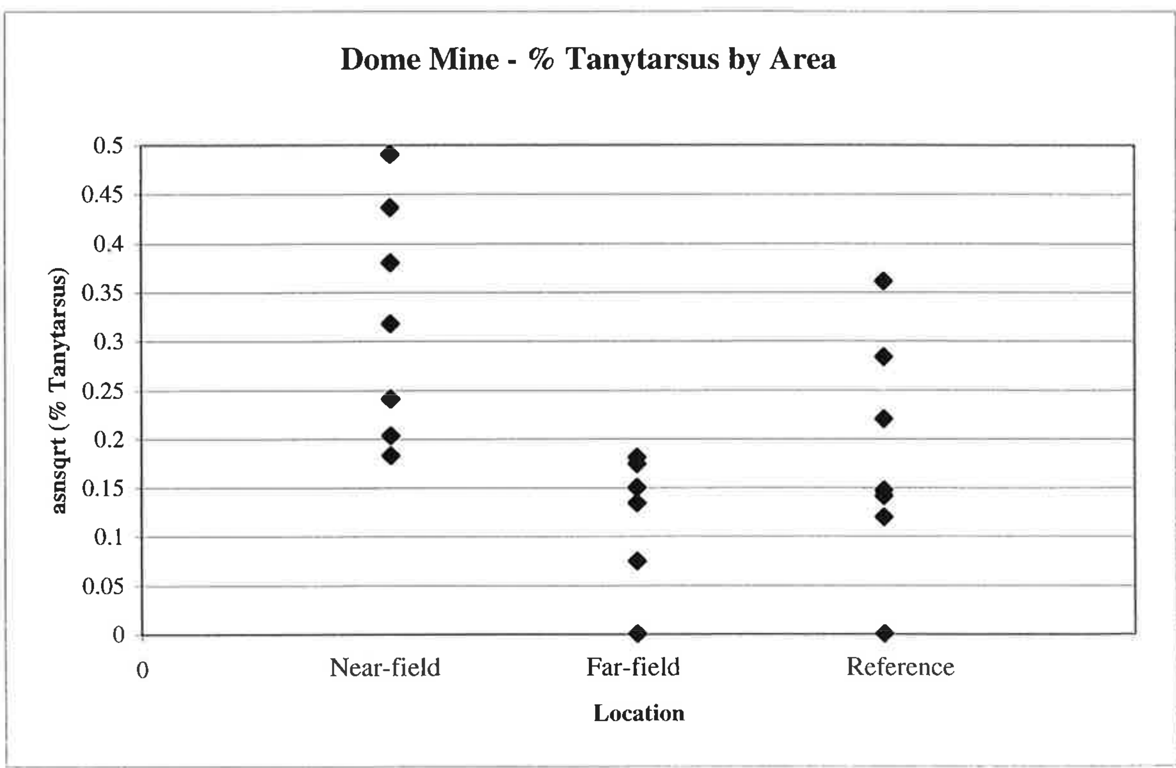

Dome Mine - Number of Taxa by Area
Number of Taxa
45
40
35
30
25
20
15
10
5
0
0
Near-field
Far-field
Reference
Location


Dome Mine - Number of EPT Taxa by Area
Number of EPT Taxa
7
6
5
4
3
2
1
0
0
Near-field
Far-field
Reference
Location


Dome Mine - Number of Individuals by Area
Log (Number of Individuals)
10
9
8
7
6
5
4
3
2
1
0
0
Near-field
Far-field
Reference
Location


Dome Mine - % Chironomids by Area
asnsqrt (% Chironomids)
1.4
1.2
1
0.8
0.6
0.4
0.2
0
0
Near-field
Far-field
Reference
Location


Dome Mine - % Pisidium by Area
asnsqrt (% Pisidium)
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
Near-field
Far-field
Reference
Location


Dome Mine - % Tanytarsus by Area
asnsqrt (% Tanytarsus)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
Near-field
Far-field
Reference
Location

Dome: Hypothesis 7

Fish Weight and Length at Age

Wild Pearl Dace Length

Source	SS	df	MS	F Ratio	P
Among Reach	0.26772	2	0.13386	5.993	**0.004989**
Age covariate	0.06338	1	0.06338	2.838	0.099153
Error	0.98271	44	0.02233		

Wild Pearl Dace Length (as above, but without NS age covariate)

Source	SS	df	MS	F Ratio	P
Among Reach	0.32277	2	0.16139	10.743	**0.000043**
Error	2.32838	155	0.01502		

note: dropping age covariate also increases sample size, since age was not measured for all fish.

Wild Pearl Dace Weight

Source	SS	df	MS	F Ratio	P
Among Reach	2.19842	2	1.09921	5.385	**0.008093**
Age covariate	0.45892	1	0.45892	2.248	0.140916
Error	8.98184	44	0.20413		

Wild Pearl Dace Weight (as above, but without NS age covariate)

Source	SS	df	MS	F Ratio	P
Among Reach	2.90915	2	1.45458	10.217	**0.000068**
Error	22.06692	155	0.14237		

note: dropping age covariate also increases sample size, since age was not measured for all fish.

Wild Yellow Perch Length

Source	SS	df	MS	F Ratio	P
Among Reach	0.05892	1	0.05892	8.448	**0.004741**
Age covariate	1.94347	1	1.94347	278.646	**0.000000**
Error	0.551	79	0.00697		

Wild Yellow Perch Weight

Source	SS	df	MS	F Ratio	P
Among Reach	1.82609	1	1.82609	31.007	**0.000000**
Age covariate	18.58577	1	18.58577	315.585	**0.000000**
Error	4.65256	79	0.05889		

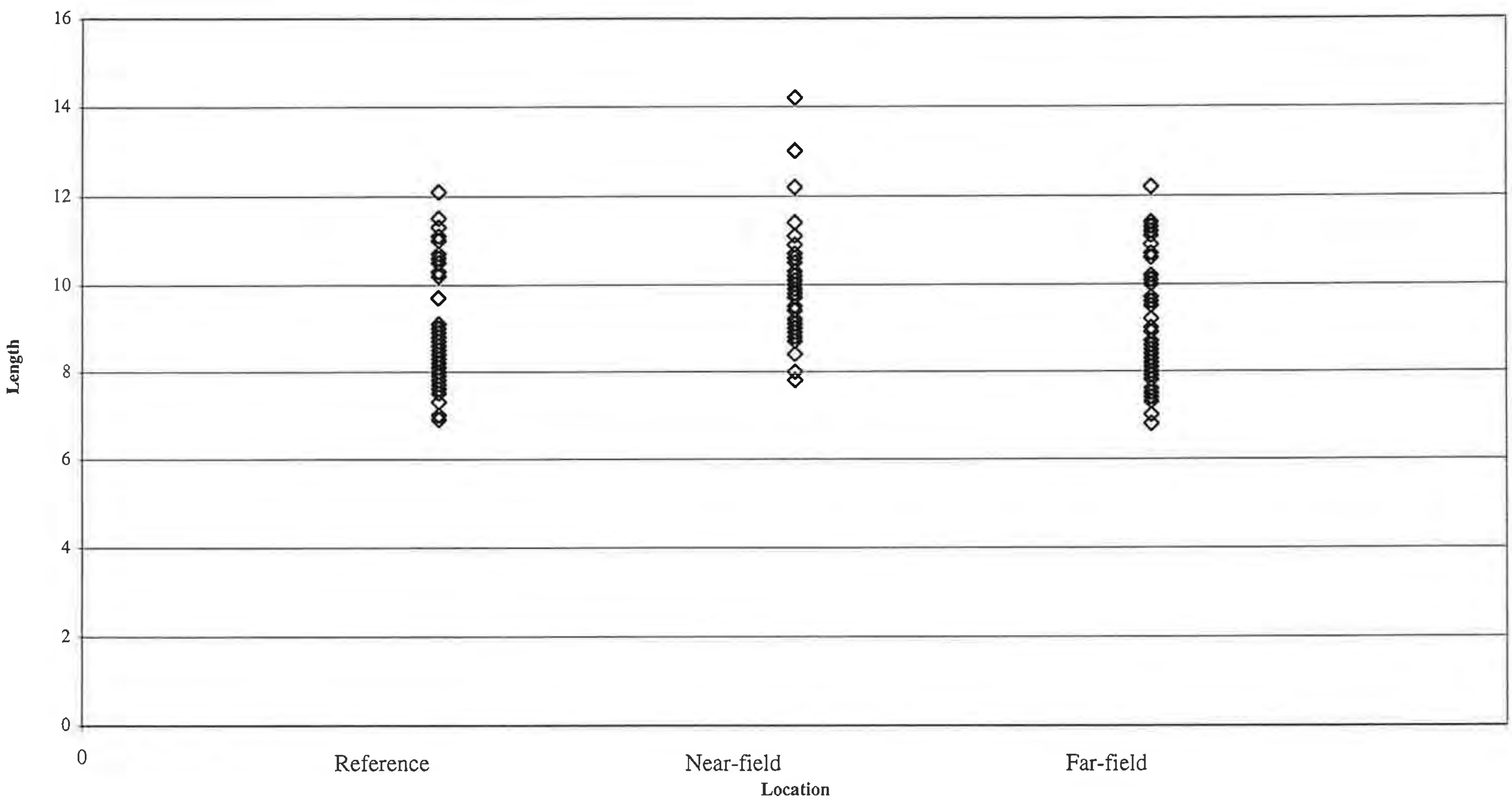
Caged Yellow Perch Length (fish not aged)

Source	SS	df	MS	F Ratio	P
Among Reach	0.01780	2	0.00890	0.558	0.575833
Error	0.74901	47	0.01594		

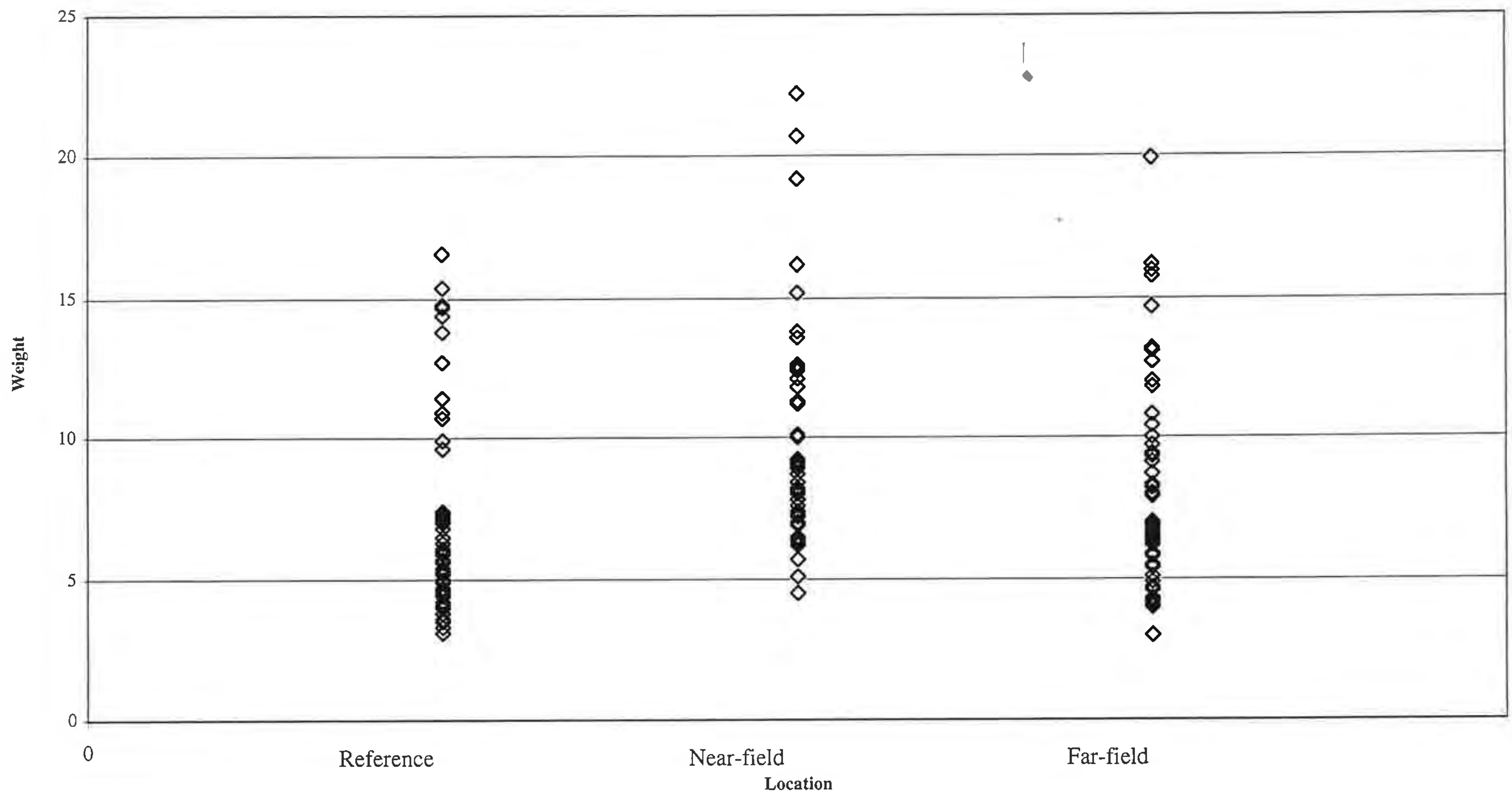
Caged Yellow Perch Weight (fish not aged)

Source	SS	df	MS	F Ratio	P
Among Reach	0.09008	2	0.04504	0.412	0.664462
Error	5.13365	47	0.10923		

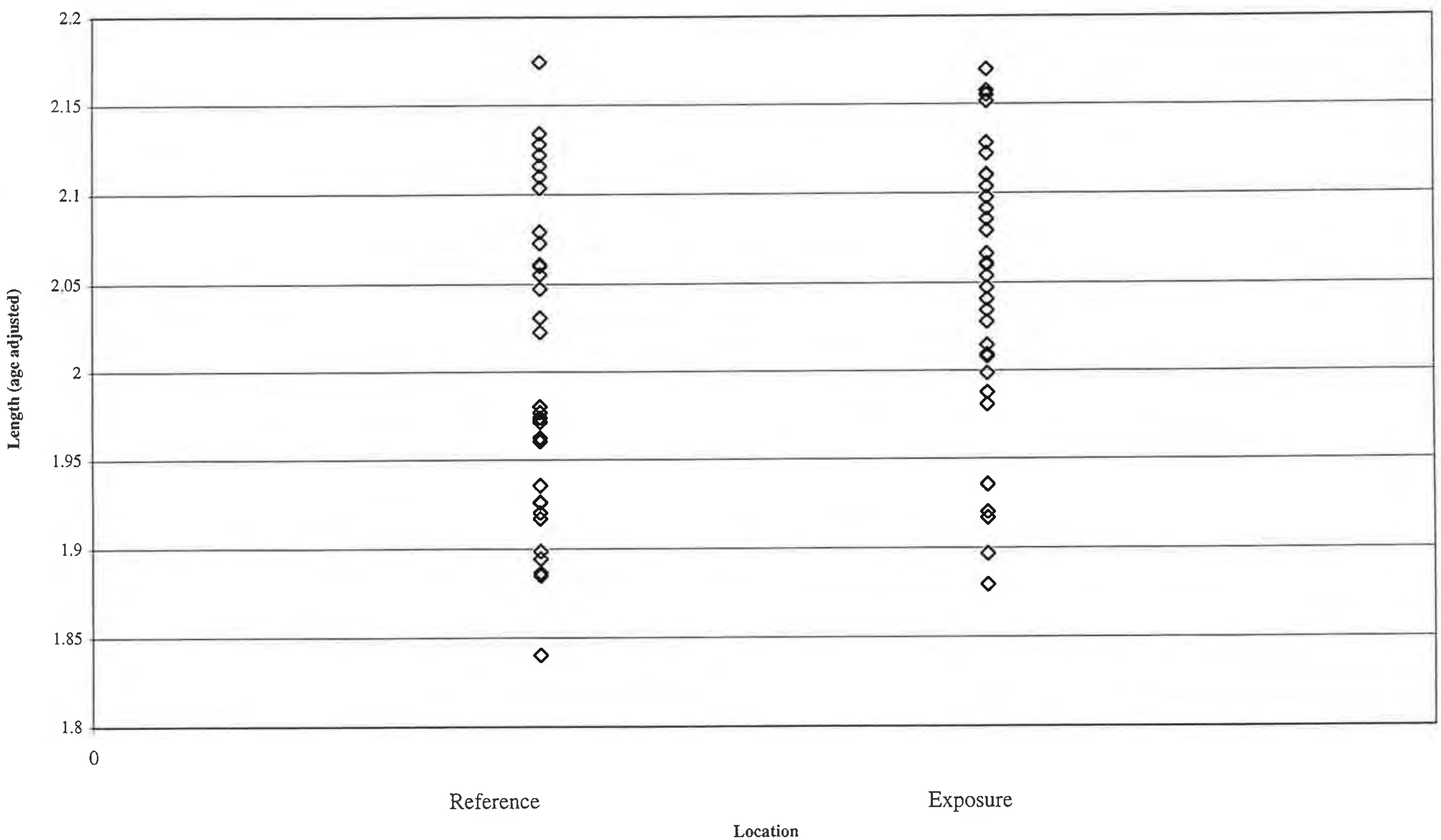
Dome Mine - Wild Pearl Dace Length

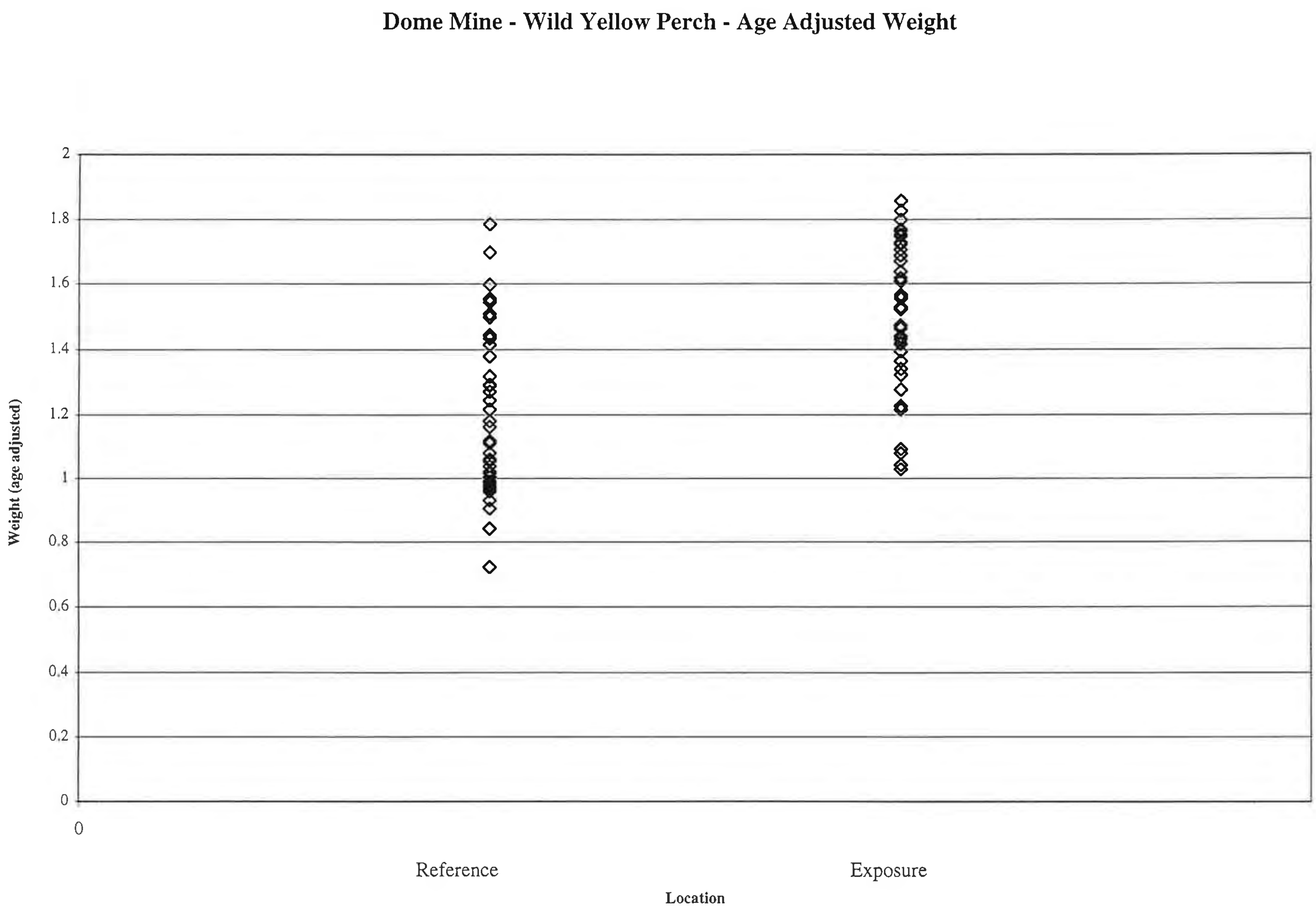


Dome Mine - Wild Pearl Dace Weight



Dome Mine - Wild Yellow Perch - Age Adjusted Length




Dome Mine - Wild Yellow Perch - Age Adjusted Weight
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Weight (age adjusted)
0
Reference
Exposure
Location

Dome: Hypothesis 8

Fish Liver and Gonad Weight and Fecundity, at Body Weight

Wild Yellow perch Liver Weight at Age

Source	SS	df	MS	F Ratio	P
Among Reach	0.160	1	0.160	15.400	**1.85E-04**
Age covariate	1.337	1	1.337	128.443	**3.10E-18**
Within Reach (Error)	0.822	79	0.010		

Wild Yellow perch Gonad Weight at Age - Female

Source	SS	df	MS	F Ratio	P
Among Reach	0.005	1	0.005	0.128	0.723
Age covariate	1.139	1	1.139	29.938	**2.80E-06**
Within Reach (Error)	1.484	39	0.038		

Wild Yellow perch Gonad Weight at Age - Male

Source	SS	df	MS	F Ratio	P
Among Reach	0.006	1	0.006	0.291	0.593
Age covariate	2.373	1	2.373	116.893	**7.41E-13**
Within Reach (Error)	0.731	36	0.020		

Wild Yellow perch Fecundity at Age

Source	SS	df	MS	F Ratio	P
Among Reach	0.005	1	0.005	0.054	0.818
Age covariate	1.546	1	1.546	17.201	**1.96E-04**
Within Reach (Error)	3.236	36	0.090		

Wild Yellow perch Liver Weight at Body Weight

Source	SS	df	MS	F Ratio	P
Among Reach	0.016	1	0.016	0.898	0.346
Body Weight Covariate	4.042	1	4.042	221.883	**1.19E-24**
Within Reach (Error)	1.439	79	0.018		

Wild Yellow perch Gonad Weight (log) at Body Weight (log) - Female

Source	SS	df	MS	F Ratio	P
Among Reach	0.064	1	0.064	13.733	**6.69E-04**
Body Weight Covariate	0.793	1	0.793	170.893	**1.11E-16**
Within Reach (Error)	0.176	38	0.005		

Wild Yellow perch Gonad Weight at Body Weight - Male

Source	SS	df	MS	F Ratio	P
Among Reach	0.097	1	0.097	35.044	**8.73E-07**
Body Weight Covariate	1.634	1	1.634	592.270	**1.11E-16**
Within Reach (Error)	0.099	36	0.003		

Wild Yellow perch Fecundity (log) at Body Weight (log)

Source	SS	df	MS	F Ratio	P
Among Reach	0.023	1	0.023	2.561	0.118
Body Weight Covariate	0.581	1	0.581	65.029	**7.92E-11**
Within Reach (Error)	0.322	36	0.009		

Pearl Dace Liver Weight

Source	SS	df	MS	F Ratio	P
Among Reach	0.097	2	0.048	13.393	**5.79E-06**
Within Reach (Error)	0.422	117	0.004		

*age covariate not significant, data re-analyzed below without covariate

Pearl Dace Gonad Weight - Female*

Source	SS	df	MS	F Ratio	P
Among Reach	0.367	2	0.183	4.379	**0.017**
Within Reach (Error)	2.469	59	0.042		

* age covariate not significant; data re-analyzed without covariate.

Pearl Dace Gonad Weight - Males*

Source	SS	df	MS	F Ratio	**P**
Among Reach	0.036	2	0.018	13.472	**1.67E-05**
Within Reach (Error)	0.074	56	0.001		

* age covariate could not be tested; data re-analyzed without covariate.

Pearl Dace Fecundity*

Source	SS	df	MS	F Ratio	P
Among Reach	3.191	2	1.596	9.581	**2.59E-04**
Within Reach (Error)	9.493	57	0.167		

* age and sex not covariates; all fish were age 1 females.

Pearl Dace Liver Weight at Body Weight

Source	SS	df	MS	F Ratio	P
Among Reach	0.058	2	0.029	2.754	0.068
Body Weight Covariate	2.391	1	2.391	228.895	**3.23E-29**
Within Reach (Error)	1.212	116	0.010		

Pearl Dace Gonad Weight at Body Weight - Female

Source	SS	df	MS	F Ratio	P
Among Reach	0.111	2	0.055	3.753	**0.029**
Body Weight Covariate	3.024	1	3.024	204.520	**1.13E-20**
Within Reach (Error)	0.858	58	0.015		

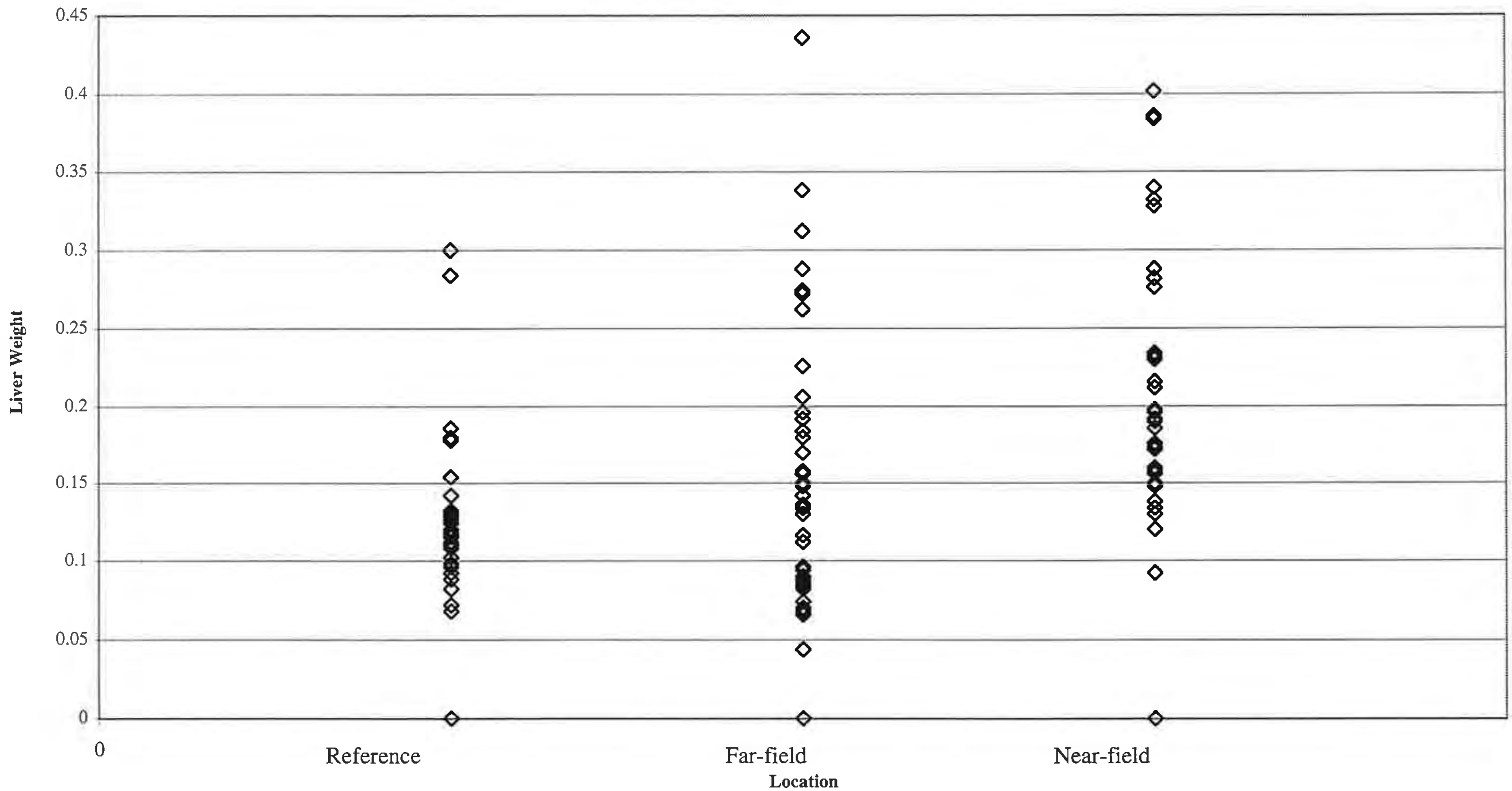
Pearl Dace Gonad Weight at Body Weight - Male

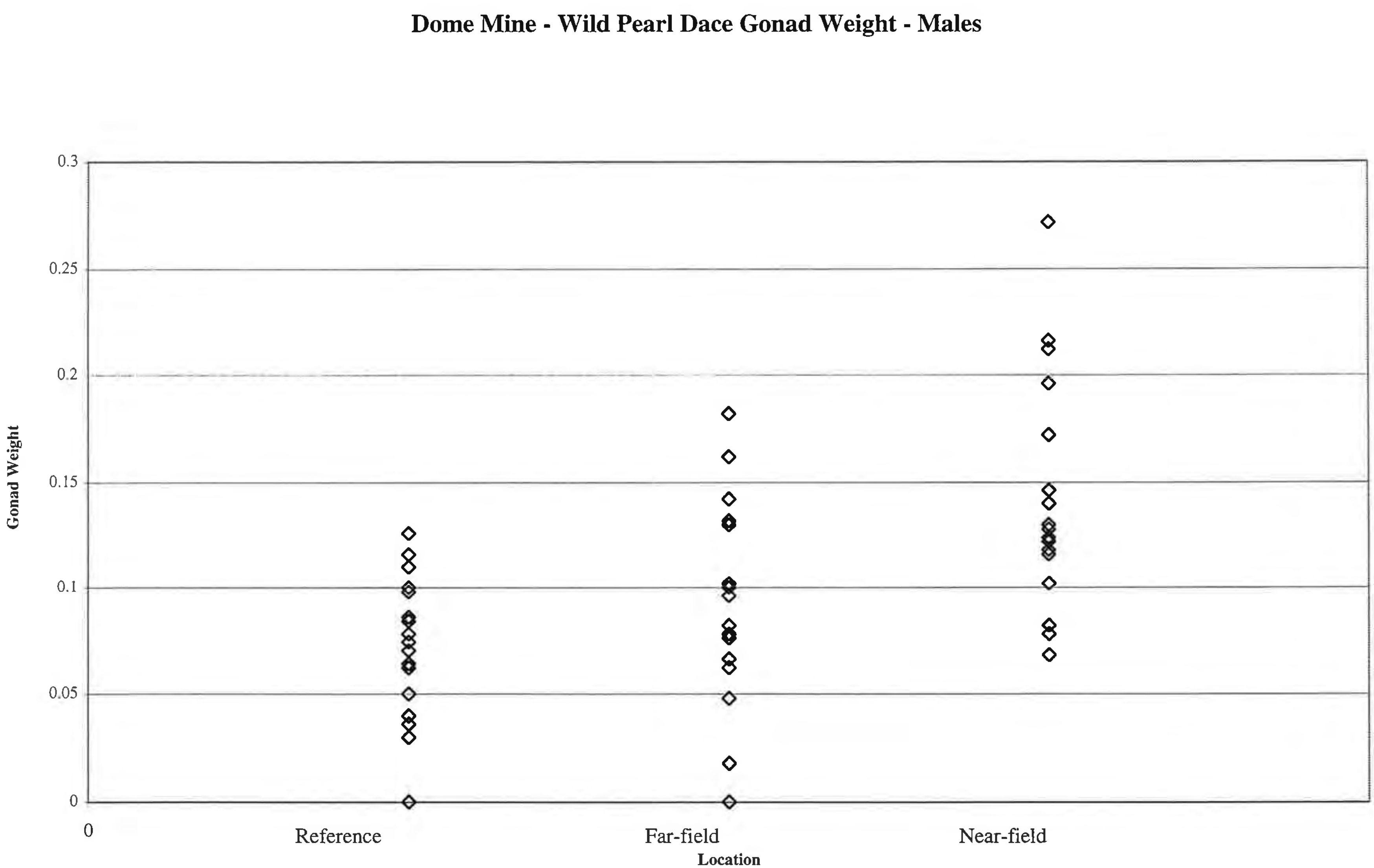
Source	SS	df	MS	F Ratio	P
Among Reach	0.012	2	0.006	0.269	0.765
Body Weight Covariate	0.790	1	0.790	35.319	**1.97E-07**
Within Reach (Error)	1.231	55	0.022		

Pearl Dace Fecundity at Body Weight

Source	SS	df	MS	F Ratio	P
Among Reach	0.168	2	0.084	7.002	**0.002**
Body Weight Covariate	1.121	1	1.121	93.414	**2.22E-16**
Within Reach (Error)	0.672	56	0.012		

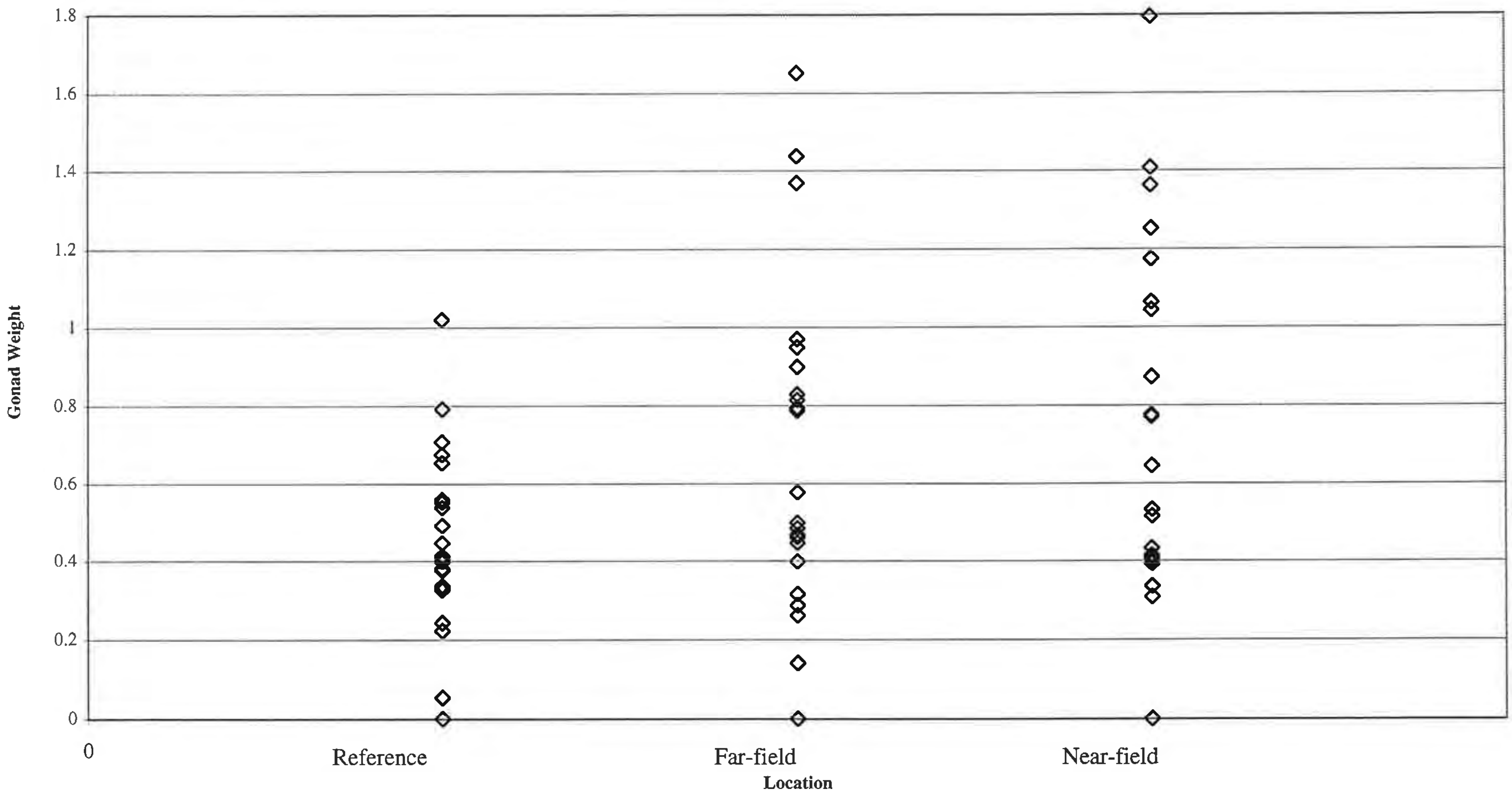
Dome Mine - Wild Pearl Dace Liver Weight



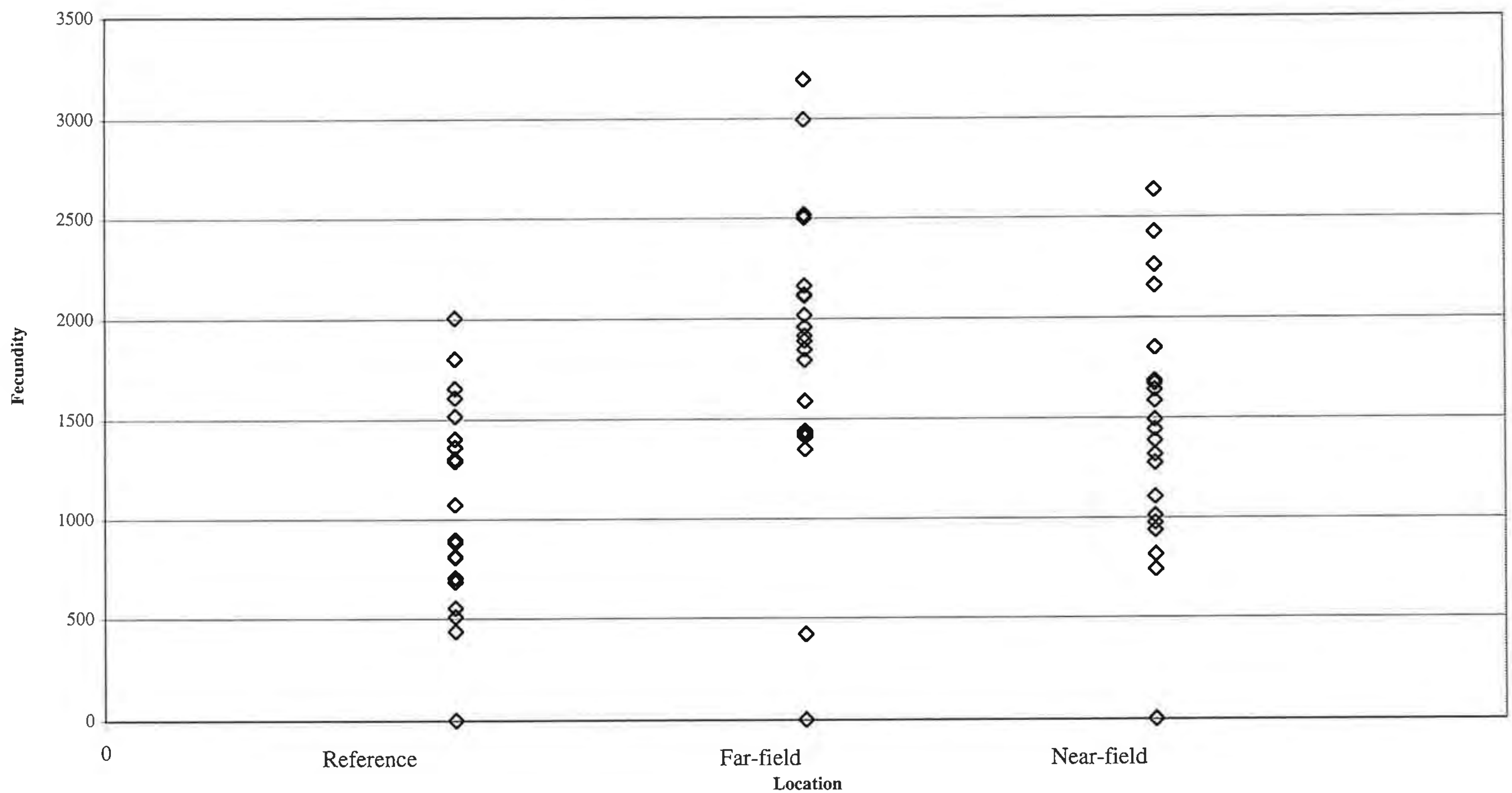


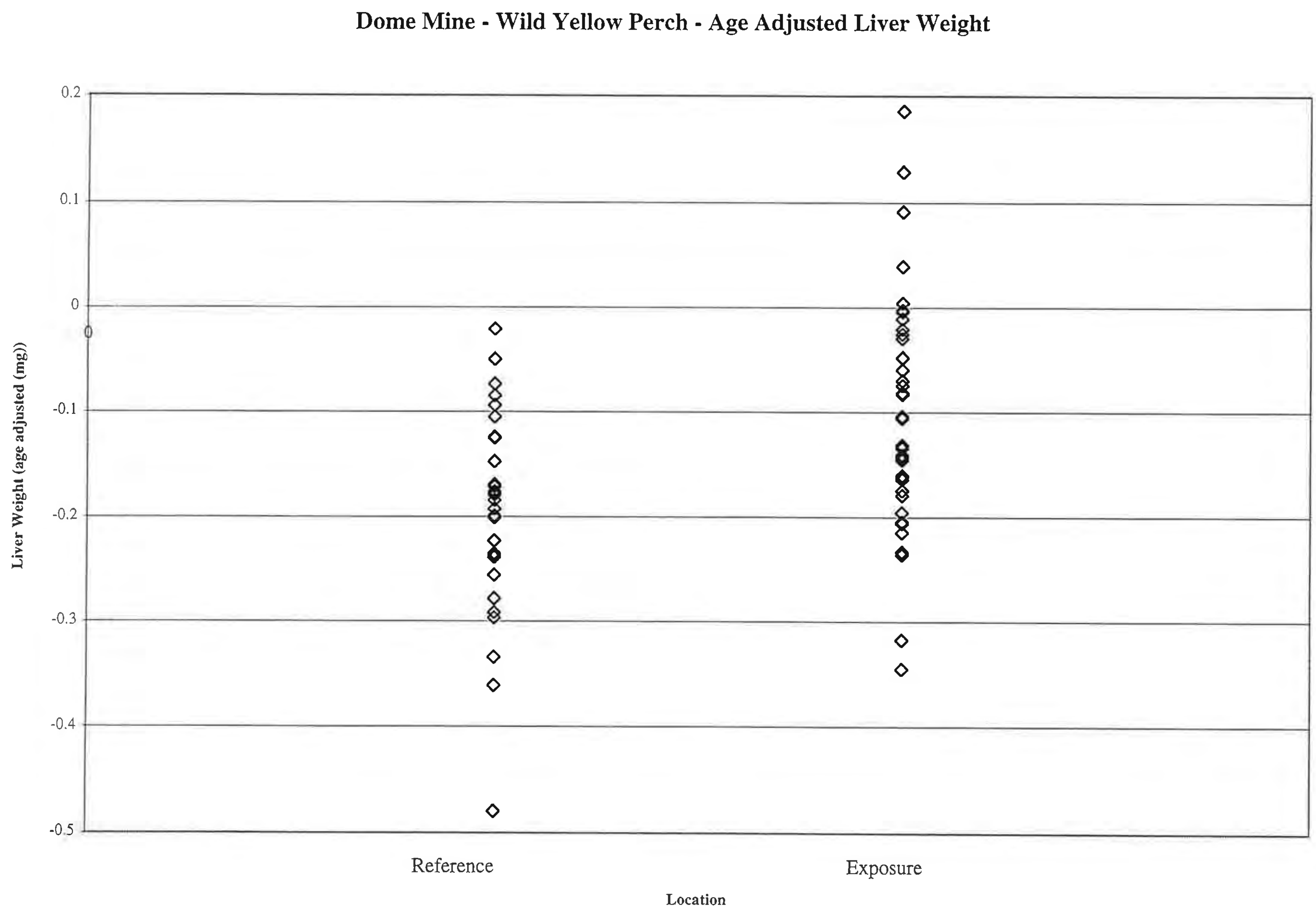
Dome Mine - Wild Pearl Dace Gonad Weight - Males
Gonad Weight
0.3
0.25
0.2
0.15
0.1
0.05
0
0
Reference
Far-field
Near-field
Location

Dome Mine - Wild Pearl Dace Gonad Weight - Females

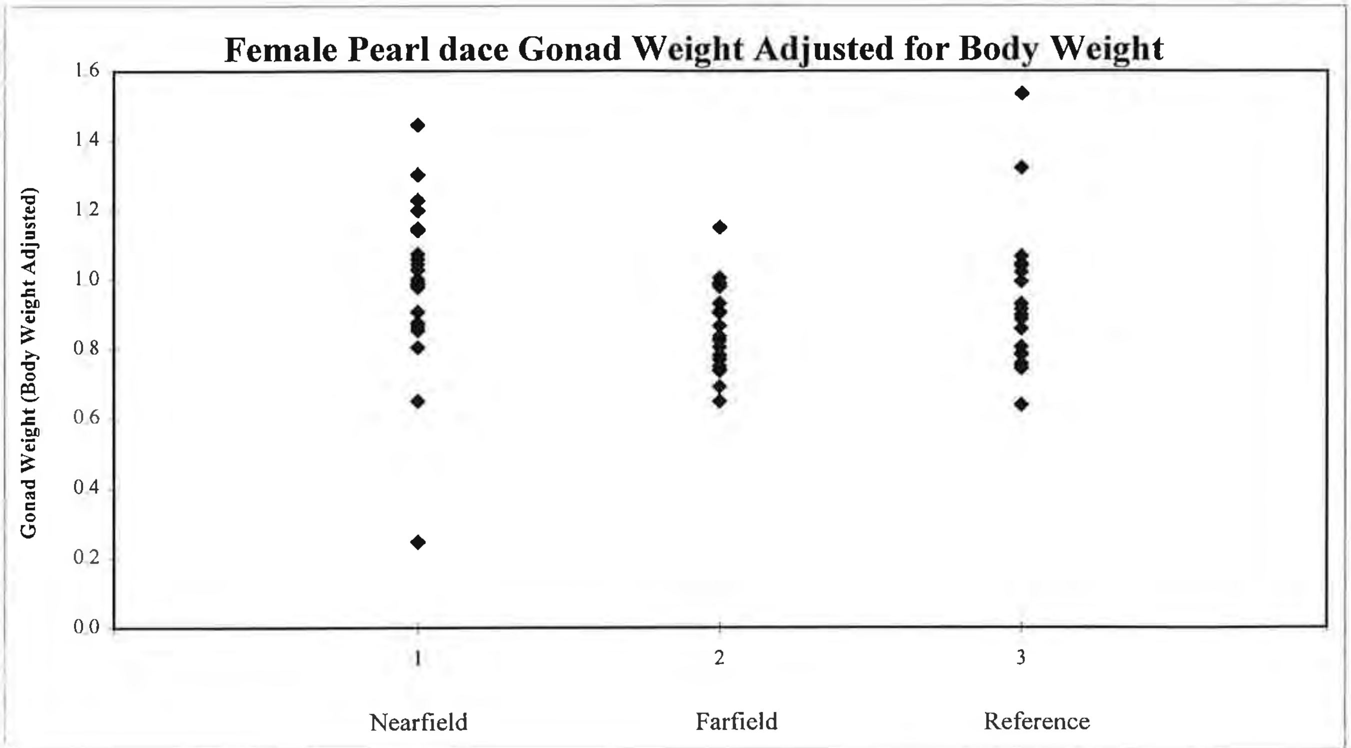


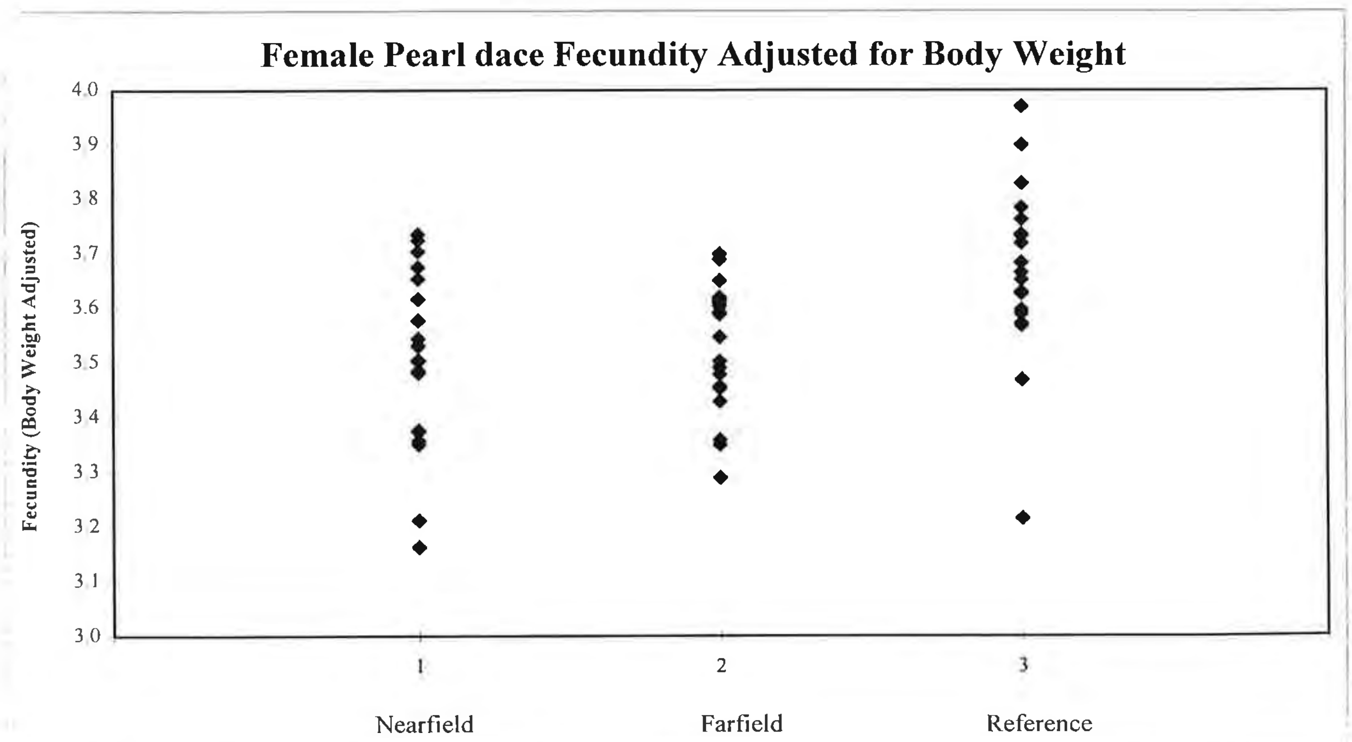
Dome Mine - Wild Pearl Dace Fecundity





Dome Mine - Wild Yellow Perch - Age Adjusted Liver Weight
0.2
0.1
0
-0.1
-0.2
-0.3
-0.4
-0.5
Liver Weight (age adjusted (mg))
Reference
Exposure
Location


Female Pearl dace Gonad Weight Adjusted for Body Weight
Gonad Weight (Body Weight Adjusted)
1.6
1.4
1.2
1.0
0.8
0.6
0.4
0.2
0.0
1
2
3
Nearfield
Farfield
Reference


Female Pearl dace Fecundity Adjusted for Body Weight
Fecundity (Body Weight Adjusted)
4.0
3.9
3.8
3.7
3.6
3.5
3.4
3.3
3.2
3.1
3.0
1
2
3
Nearfield
Farfield
Reference

Dome Mines - Hypothesis 9

Matrix of Pearson Correlations between Biological Endpoints and Metal Concentrations in Water

	Benthic Community						Pearl dace							
	Number of Taxa	No. of EPT Taxa	Total Abundance[1]	% Chironomids[2]	% *Tanytarsus*[2]	% *Pisidium*[2]	Fork Length[1]	Body Weight[1]	Liver Weight[1]	Female Gonad Weight[1]	Female Gonad Weight @Body Weight	Male Gonad Weight[1]	Fecundity[1]	Female Fecundity @Body Weight
Arsenic_Dissolved	-0.088	-0.554	-0.194	0.352	0.598	-0.677	-0.633	-0.735	-0.562	-0.820	0.747	-0.525	-0.998	-0.272
Arsenic_Total	-0.050	-0.527	-0.154	0.376	0.643	-0.635	-0.671	-0.768	-0.602	-0.847	0.790	-0.566	-0.994	-0.207
Cobalt_Dissolved	0.147	0.286	0.094	-0.934	-0.629	-0.226	0.953	0.986	0.922	0.999	-0.999	0.904	0.807	-0.404
Cobalt_Total	0.076	0.234	0.025	-0.918	-0.676	-0.264	0.959	0.989	0.930	1.000	-1.000	0.913	0.794	-0.426
Copper_Dissolved	0.240	0.419	0.201	-0.978	-0.643	-0.074	0.945	0.981	0.912	0.998	-0.997	0.893	0.821	-0.361
Copper_Total	0.150	0.372	0.119	-0.964	-0.722	-0.097	0.930	0.972	0.894	0.995	-0.987	0.873	0.844	-0.289
Potassium_Dissolved	-0.006	0.373	0.008	-0.879	-0.899	0.051	0.825	0.896	0.771	0.948	-0.906	0.743	0.942	-0.015
Potassium_Total	0.132	0.436	0.125	-0.955	-0.801	0.031	0.814	0.887	0.759	0.941	-0.913	0.730	0.949	-0.031
Magnesium_Dissolved	0.475	0.743	0.482	-0.967	-0.587	0.367	0.499	0.616	0.420	0.716	-0.515	0.380	0.994	0.546
Magnesium_Total	0.478	0.745	0.485	-0.967	-0.584	0.368	0.476	0.594	0.395	0.697	-0.504	0.355	0.991	0.557
Nickel_Dissolved	0.241	0.495	0.224	-0.985	-0.714	0.051	0.604	0.710	0.530	0.798	-0.419	0.493	1.000	0.634
Nickel_Total	0.174	0.470	0.166	-0.966	-0.778	0.059	0.658	0.757	0.588	0.838	-0.481	0.553	0.996	0.578
Zinc_Dissolved	0.924	0.893	0.904	-0.718	0.091	0.546	-0.473	-0.345	-0.550	-0.216	0.252	-0.586	0.434	0.981
Zinc_Total	0.764	0.964	0.794	-0.781	-0.249	0.718	-0.203	-0.064	-0.290	0.071	0.137	-0.331	0.672	0.951
Probabilities (1-tailed test)														
Arsenic_Dissolved	0.456	0.223	0.403	0.324	0.201	0.161	0.282	0.237	0.310	0.194	0.232	0.324	0.018	0.412
Arsenic_Total	0.475	0.236	0.423	0.312	0.178	0.182	0.266	0.221	0.294	0.178	0.210	0.308	0.034	0.434
Cobalt_Dissolved	0.426	0.357	0.453	0.033	0.186	0.387	0.098	0.054	0.127	0.011	0.012	0.141	0.201	0.368
Cobalt_Total	0.462	0.383	0.487	0.041	0.162	0.368	0.092	0.047	0.120	0.004	0.004	0.134	0.208	0.360
Copper_Dissolved	0.380	0.290	0.400	0.011	0.179	0.463	0.106	0.062	0.135	0.019	0.026	0.149	0.193	0.383
Copper_Total	0.425	0.314	0.440	0.018	0.139	0.452	0.119	0.075	0.148	0.032	0.051	0.162	0.180	0.407
Potassium_Dissolved	0.497	0.314	0.496	0.061	0.051	0.474	0.191	0.147	0.220	0.103	0.139	0.234	0.109	0.495
Potassium_Total	0.434	0.282	0.437	0.023	0.099	0.485	0.197	0.153	0.226	0.110	0.134	0.240	0.102	0.490
Magnesium_Dissolved	0.263	0.128	0.259	0.017	0.206	0.316	0.334	0.289	0.362	0.246	0.328	0.376	0.034	0.316
Magnesium_Total	0.261	0.127	0.257	0.017	0.208	0.316	0.342	0.297	0.371	0.254	0.332	0.384	0.042	0.312
Nickel_Dissolved	0.379	0.253	0.388	0.007	0.143	0.474	0.294	0.249	0.322	0.206	0.362	0.336	0.006	0.282
Nickel_Total	0.413	0.265	0.417	0.017	0.111	0.470	0.271	0.227	0.300	0.184	0.340	0.314	0.028	0.304
Zinc_Dissolved	0.038	0.054	0.048	0.141	0.455	0.227	0.343	0.388	0.315	0.431	0.419	0.301	0.357	0.063
Zinc_Total	0.118	0.018	0.103	0.109	0.376	0.141	0.435	0.480	0.406	0.477	0.456	0.392	0.265	0.100
Cell Frequency =	4	4	4	4	4	4	3	3	3	3	3	3	3	3
Degrees of Freedom =	2	2	2	2	2	2	1	1	1	1	1	1	1	1

(shaded) significant at $\alpha = 0.05$

Notes:

[1] log transformed

[2] arcsine square root transformed

Dome Mines - Hypothesis 10

Matrix of Pearson Correlations

Comparison of Biological Endpoints and Metals in Sediment

	Benthic Community						Toxicity	
	Number of Taxa	No. of EPT Taxa	Total Abundance[1]	% Chironomids[2]	% *Tanytarsus*[2]	% *Pisidium*[2]	%*Hyalella* mortality[3]	*Hyalella* Growth[1]
Silver_Total	-0.133	0.059	-0.166	-0.753	-0.555	-0.149	0.467	-0.352
Aluminum_Partial	0.599	0.547	0.511	0.111	0.418	0.231	-0.168	0.175
Aluminum_Total	0.688	0.676	0.606	-0.624	-0.097	0.275	-0.076	0.243
Arsenic_Partial	-0.356	-0.534	-0.409	0.121	-0.006	-0.731	0.738	-0.102
Arsenic_Total	-0.413	-0.575	-0.443	0.248	-0.074	-0.670	0.759	-0.152
Barium_Partial	0.548	0.280	0.490	-0.098	0.449	0.100	-0.151	0.593
Barium_Total	0.779	0.610	0.712	0.107	0.456	0.547	-0.503	0.666
Cadmium_Partial	0.546	0.533	0.609	-0.505	0.126	0.277	-0.041	0.136
Cadmium_Total	0.675	0.606	0.753	-0.014	0.203	0.890	-0.584	0.425
Cobalt_Partial	0.015	0.080	-0.003	-0.404	-0.283	-0.300	0.675	-0.269
Cobalt_Total	-0.080	0.017	-0.080	-0.589	-0.446	-0.292	0.627	-0.329
Chromium_Partial	-0.303	-0.225	-0.364	-0.155	-0.306	-0.497	0.753	-0.430
Chromium_Total	-0.221	-0.223	-0.217	0.022	-0.203	-0.497	0.652	-0.276
Copper_Partial	0.183	0.317	0.120	-0.780	-0.321	-0.114	0.354	-0.149
Copper_Total	0.138	0.190	0.070	-0.749	-0.356	-0.168	0.404	-0.119
Iron_Partial	0.004	0.055	-0.038	-0.592	-0.345	-0.308	0.584	-0.213
Iron_Total	0.115	0.153	0.051	-0.658	-0.330	-0.235	0.439	-0.119
Mercury_Total	0.695	0.836	0.744	-0.545	-0.171	0.705	-0.286	0.098
Magnesium_Partial	-0.496	-0.436	-0.499	-0.329	-0.559	-0.458	0.785	-0.476
Magnesium_Total	-0.303	-0.228	-0.318	-0.377	-0.480	-0.406	0.758	-0.408
Manganese_Partial	0.012	0.013	-0.101	-0.581	-0.208	-0.349	0.540	-0.121
Manganese_Total	0.122	0.157	0.023	-0.706	-0.302	-0.202	0.423	-0.102
Molybdenum_Partial	-0.468	-0.299	-0.405	-0.606	-0.580	-0.239	0.534	-0.611
Molybdenum_Total	0.178	0.114	0.105	-0.706	-0.184	-0.179	0.367	0.079
Nickel_Partial	-0.187	0.022	-0.142	-0.483	-0.497	-0.271	0.609	-0.476
Nickel_Total	-0.211	0.021	-0.150	-0.506	-0.562	-0.230	0.570	-0.509
Lead_Partial	0.349	0.301	0.354	-0.280	0.068	0.040	0.362	-0.012
Lead_Total	0.408	0.286	0.462	0.384	0.279	0.340	0.072	0.162
Selenium_Total	-0.252	-0.259	-0.444	0.363	-0.094	-0.432	0.288	-0.182
Vanadium_Partial	0.112	0.092	-0.101	-0.371	-0.038	-0.401	0.488	-0.165
Vanadium_Total	0.393	0.369	0.308	-0.637	-0.201	-0.074	0.256	0.079
Zinc_Partial	0.618	0.457	0.507	-0.462	0.194	0.100	0.147	0.286
Zinc_Total	0.834	0.660	0.711	-0.405	0.214	0.463	-0.244	0.507
SEM/AVS ratio	0.320	0.303	0.305	-0.142	0.513	-0.038	-0.239	0.198
SEM Molar Sum	0.199	0.216	0.186	-0.371	-0.175	-0.132	0.522	0.049
Probabilities (1-tailed test)								
Silver_Total	0.283	0.400	0.236	4.15E-05	0.004	0.259	0.017	0.059
Aluminum_Partial	0.002	0.005	0.009	0.317	0.030	0.156	0.233	0.224
Aluminum_Total	2.83E-04	3.81E-04	0.002	0.001	0.338	0.113	0.371	0.145
Arsenic_Partial	0.057	0.006	0.033	0.300	0.489	8.24E-05	6.60E-05	0.330
Arsenic_Total	0.031	0.003	0.022	0.139	0.376	4.43E-04	3.34E-05	0.256
Barium_Partial	0.005	0.110	0.012	0.336	0.021	0.333	0.257	0.002
Barium_Total	1.59E-05	0.002	1.47E-04	0.323	0.019	0.005	0.010	4.88E-04
Cadmium_Partial	0.005	0.006	0.002	0.010	0.294	0.112	0.429	0.278
Cadmium_Total	3.90E-04	0.002	4.05E-05	0.476	0.189	3.39E-08	0.003	0.027
Cobalt_Partial	0.475	0.364	0.495	0.035	0.107	0.094	3.90E-04	0.119
Cobalt_Total	0.365	0.470	0.364	0.002	0.021	0.100	0.001	0.073
Chromium_Partial	0.091	0.163	0.052	0.251	0.089	0.011	4.12E-05	0.026
Chromium_Total	0.167	0.166	0.173	0.463	0.188	0.011	0.001	0.113
Copper_Partial	0.214	0.081	0.303	1.50E-05	0.078	0.311	0.058	0.259
Copper_Total	0.275	0.205	0.382	4.71E-05	0.056	0.233	0.034	0.304
Iron_Partial	0.494	0.406	0.435	0.002	0.063	0.087	0.003	0.177
Iron_Total	0.309	0.254	0.412	0.001	0.072	0.153	0.023	0.304
Mercury_Total	2.36E-04	1.16E-06	5.60E-05	0.005	0.229	1.78E-04	0.104	0.336
Magnesium_Partial	0.011	0.024	0.011	0.073	0.004	0.018	1.26E-05	0.015
Magnesium_Total	0.091	0.160	0.080	0.046	0.014	0.034	3.44E-05	0.033
Manganese_Partial	0.479	0.478	0.331	0.003	0.182	0.061	0.006	0.301
Manganese_Total	0.299	0.249	0.461	1.77E-04	0.091	0.190	0.028	0.330
Molybdenum--Partial	0.016	0.094	0.034	0.002	0.003	0.148	0.006	0.002
Molybdenum_Total	0.220	0.311	0.325	1.73E-04	0.212	0.219	0.051	0.367
Nickel_Partial	0.209	0.463	0.270	0.013	0.011	0.117	0.002	0.015
Nickel_Total	0.179	0.464	0.258	0.010	0.004	0.158	0.003	0.009
Lead_Partial	0.060	0.092	0.057	0.109	0.385	0.432	0.053	0.479
Lead_Total	0.033	0.104	0.018	0.043	0.111	0.066	0.379	0.242
Selenium_Total	0.135	0.129	0.022	0.053	0.342	0.025	0.102	0.214
Vanadium_Partial	0.314	0.347	0.331	0.049	0.434	0.036	0.012	0.237
Vanadium_Total	0.039	0.050	0.087	0.001	0.192	0.375	0.131	0.367
Zinc_Partial	0.001	0.019	0.010	0.017	0.200	0.334	0.263	0.104
Zinc_Total	1.31E-06	0.001	1.50E-04	0.034	0.176	0.017	0.144	0.009
SEM/AVS ratio	0.079	0.091	0.090	0.270	0.009	0.435	0.148	0.194
SEM Molar Sum	0.193	0.174	0.209	0.049	0.224	0.284	0.008	0.416

significant at $\alpha = 0.05$

Notes:

- cell frequency = 21 for all tests
- all chemistry data (except SEM/AVS ratio) log transformed

[1] log transformed

[2] arcsine square root transformed

[3] arcsine square root transformed on Abbott's corrected mortality data

Dome Mines - Hypothesis 11

Matrix of Pearson Correlations

	Benthic Community					
	Number of Taxa	No. of EPT Taxa	Total Abundance[1]	% Chironomids[2]	% *Tanytarsus*[2]	% *Pisidium*[2]
%*Hyalella* mortality[3]	-0.410	-0.478	-0.405	-0.056	-0.260	-0.464
Hyalella growth[1]	0.496	0.188	0.419	0.210	0.381	0.197
%*Chironomus* mortality[3]	0.345	0.338	0.217	0.269	0.422	0.148
Chironomus growth[1]	-0.153	-0.155	-0.111	-0.199	0.140	-0.049
Tubifex cocoons	0.233	0.232	0.224	-0.028	0.247	-0.195
%*Tubifex* Hatch[3]	-0.272	-0.215	-0.121	-0.138	-0.216	0.038
Tubifex Young	0.179	0.092	0.301	0.326	0.322	-0.015
Probabilities (1-tailed test)						
%*Hyalella* mortality[3]	0.032	0.014	0.034	0.404	0.128	0.017
Hyalella growth[1]	0.011	0.207	0.029	0.181	0.044	0.196
%*Chironomus* mortality[3]	0.063	0.067	0.172	0.119	0.028	0.261
Chironomus growth[1]	0.254	0.251	0.316	0.193	0.273	0.417
Tubifex cocoons	0.154	0.156	0.165	0.452	0.140	0.199
%*Tubifex* Hatch[3]	0.116	0.174	0.300	0.276	0.174	0.435
Tubifex Young	0.219	0.346	0.093	0.075	0.078	0.475

[shaded] significant at $\alpha = 0.05$

Notes:

- cell frequency = 21 for all tests.

[1] log transformed

[2] arcsine square root transformed

[3] arcsine square root transformed on Abbott's corrected mortality data

Dome Mines - Hypothesis 12

Matrix of Pearson Correlations

Water

	Viscera of Pearl Dace										
	MT	Aluminum	Arsenic	Cobalt	Chromium	Copper	Iron	Nickel	Lead	Zinc	CdCuZn
Aluminum_Total	0.315	-0.653									
Arsenic_Total	0.400		0.510								
Cobalt_Total	-0.094			0.987							
Chromium_Total	-0.231				-0.049						
Copper_Total	-0.201					0.983					0.968
Iron_Total	0.384						0.107				
Nickel_Total	-0.797							0.926			
Lead_Total	0.250								-0.609		
Zinc_Total	-0.911									-0.250	0.172
Aluminum_Dissolved	0.168	-0.546									
Arsenic_Dissolved	0.442		0.564								
Cobalt_Dissolved	-0.117			0.990							
Chromium_Dissolved	0.248				-0.499						
Copper_Dissolved	-0.147					0.980					0.975
Iron_Dissolved	0.367						0.069				
Nickel_Dissolved	-0.825							0.902			
Lead_Dissolved	0.788								-0.494		
Zinc_Dissolved	-0.941									-0.380	0.039
Probabilities (1-tailed test)											
Aluminum_Total	0.342	0.173									
Arsenic_Total	0.300		0.245								
Cobalt_Total	0.453			0.007							
Chromium_Total	0.384				0.476						
Copper_Total	0.400					0.008					0.016
Iron_Total	0.308						0.446				
Nickel_Total	0.101							0.037			
Lead_Total	0.375								0.195		
Zinc_Total	0.045									0.375	0.414
Aluminum_Dissolved	0.416	0.227									
Arsenic_Dissolved	0.279		0.218								
Cobalt_Dissolved	0.441			0.005							
Chromium_Dissolved	0.376				0.250						
Copper_Dissolved	0.427					0.010					0.013
Iron_Dissolved	0.317						0.465				
Nickel_Dissolved	0.087							0.049			
Lead_Dissolved	0.106								0.253		
Zinc_Dissolved	0.030									0.310	0.480

(shaded) significant at $\alpha = 0.05$

Notes: all chemistry data log transformed

N = 4 for all analyses

Dome Mines - Hypothesis 12

Matrix of Pearson Correlations

Sediment

	Viscera of Pearl Dace																		
	MT	Silver	Aluminum	Arsenic	Barium	Cadmium	Cobalt	Chromium	Copper	Iron	Mercury	Molybdenum	Nickel	Lead	Antimony	Selenium	Vanadium	Zinc	CdCuZn
Aluminum_Total	-0.544		0.690																
Antimony_Total	-0.286														-0.954				
Arsenic _Total	0.926			0.826															
Barium_Total	-0.441				-0.219														
Cadmium_Total	-0.766					-0.939													
Chromium_Total	0.508							-0.812											
Cobalt_Total	-0.150						0.981												
Copper_Total	-0.204								0.678										0.693
Iron_Total	-0.174									0.818									
Lead_Total	-0.404													-0.096					
Mercury_Total	-0.959										-0.686								
Molybdenum_Total	-0.098											0.302							
Nickel_Total	-0.246												0.922						
Selenium_Total	0.584															-0.040			
Silver_Total	-0.218	0.875																	
Vanadium_Total	-0.277																0.535		
Zinc_Total	-0.551																	-0.203	-0.141
Aluminum_Partial	-0.603		0.139																
Arsenic _Partial	0.765			0.948															
Barium_Partial	-0.064				-0.512														
Cadmium_Partial	-0.603					-0.227													
Chromium_Partial	0.309							-0.522											
Cobalt_Partial	-0.213						0.978												
Copper_Partial	-0.334								0.756										0.742
Iron_Partial	-0.108									0.835									
Lead_Partial	-0.573													0.717					
Molybdenum_Partial	0.057											0.695							
Nickel_Partial	-0.230												0.905						
Vanadium_Partial	0.068																0.259		
Zinc_Partial	-0.356																	0.121	0.103
Probabilites (1-tailed test)																			
Aluminum_Total	0.228		0.155																
Antimony_Total	0.357														0.023				
Arsenic _Total	0.037			0.087															
Barium_Total	0.280				0.390														
Cadmium_Total	0.117					0.030													
Chromium_Total	0.246							0.094											
Cobalt_Total	0.425						0.010												
Copper_Total	0.398								0.161										0.154
Iron_Total	0.413									0.091									
Lead_Total	0.298													0.452					
Mercury_Total	0.021										0.157								
Molybdenum_Total	0.451											0.349							
Nickel_Total	0.377												0.039						
Selenium_Total	0.208															0.480			
Silver_Total	0.391	0.062																	
Vanadium_Total	0.362																0.233		
Zinc_Total	0.224																	0.399	0.430
Aluminum_Partial	0.199		0.431																
Arsenic _Partial	0.117			0.026															
Barium_Partial	0.468				0.244														
Cadmium_Partial	0.198					0.387													
Chromium_Partial	0.346							0.239											
Cobalt_Partial	0.394						0.026												
Copper_Partial	0.333								0.122										0.129
Iron_Partial	0.446									0.083									
Lead_Partial	0.214													0.142					
Molybdenum_Partial	0.471											0.153							
Nickel_Partial	0.385												0.047						
Vanadium_Partial	0.466																0.371		
Zinc_Partial	0.322																	0.439	0.448

[shaded] significant at $\alpha = 0.05$

Notes: all chemistry data log transformed

N = 4 for all analyses

TRIAD HYPOTHESIS

Relative Contributions of Physical-Chemical Variables to Sediment Principal Components at Dome

	Principal Components				
	1	2	3	4	5
%Variance Explained	44.1	22.6	11	7.4	5.2
Manganese	0.9746	0.0999	0.1187	-0.0991	-0.0467
Iron	0.9721	0.0388	0.1968	-0.0519	0.0322
Strontium	0.9702	-0.0599	-0.0880	0.0508	0.0891
Cobalt	0.9590	-0.1222	0.0455	0.1424	0.1497
Copper	0.9445	0.0791	0.1490	-0.1845	0.1660
Magnesium	0.8932	-0.3442	0.0117	0.2449	0.0304
%TOC	-0.8801	-0.1432	0.2271	0.2383	0.0887
Molybdenum	0.8356	0.0238	0.1804	-0.3731	0.0010
Nickel	0.8329	-0.1590	-0.1286	0.2832	0.2957
Calcium	0.7760	-0.4590	0.1291	0.0188	-0.1508
Silver	0.7637	-0.2015	-0.3495	-0.1794	0.3432
Aluminum	0.6537	0.6102	0.3800	-0.0656	-0.0163
Chromium	0.6310	-0.4400	0.2871	0.4978	-0.1377
Mercury	0.1672	0.8596	-0.0357	0.1710	0.3239
Zinc	0.3379	0.7699	0.4054	0.0015	-0.1532
%Moisture	-0.5273	-0.7529	-0.0428	0.0535	0.2709
Dry Bulk Density	0.5162	0.7506	0.0339	-0.0628	-0.2752
Cadmium	-0.3895	0.7366	0.2543	0.1114	0.2736
Arsenic	0.4303	-0.6973	0.3120	0.3781	-0.2194
Barium	-0.3005	0.6823	0.4279	0.0319	-0.1771
%Clay	0.1005	0.5347	-0.3399	0.2547	0.5023
%Gravel	-0.0559	-0.2793	0.7574	-0.3756	0.0999
%Sand	-0.3865	-0.4311	0.7174	-0.0883	0.1932
%Silt	0.3317	0.1716	-0.6424	0.0363	-0.5006
Lead	-0.1347	0.3034	0.2509	0.8722	-0.0714

Placer Dome Benthic PCA: loadings for taxa

	Loadings		
	PC1	PC2	PC3
%Variance Explained	21.5	16.5	10.9
Paratanytarsus	0.9215	-0.1508	0.0053
Cl. Ostracoda	0.8882	-0.0475	0.3260
Caenis	0.8604	0.1251	0.1181
O. Hydracarina	0.8583	0.2454	0.2523
Mallochohelea	0.8237	-0.3573	-0.0169
Hydroptila	0.7465	-0.2325	-0.3631
Psectrocladius	0.7289	-0.1553	-0.3513
Polypedilum	0.7167	-0.2006	-0.1719
P. Nematoda	0.7064	-0.0794	0.0646
Tribelos	0.6942	-0.1706	0.3913
Paratendipes	0.6387	-0.2091	-0.4703
Phaenopsectra	0.6172	0.0340	0.3546
Dicrotendipes	0.5931	0.6400	-0.2226
Physella	0.5912	0.0730	0.5265
Polycentropus	0.5792	-0.2345	-0.5204
Amnicola	0.5761	-0.0464	0.2402
immatures without hair chaetae	0.5614	-0.1006	0.5505
Hyalella azteca	0.5503	0.1186	-0.5789
Tanytarsus	0.5490	0.6842	-0.0114
Pisidium	0.5273	-0.2559	0.4104
Nais simplex	0.5125	-0.2040	-0.5466
Probezzia	0.4573	-0.0029	-0.7860
Prostoma	0.4513	0.1767	0.3454
Phryganea	0.4508	0.1164	-0.3527
Ablabesmyia	0.4432	0.8053	0.0361
Procladius	0.4401	-0.2907	-0.5535
Phylocentropus	0.4045	-0.1947	-0.1255
Sialis	0.3750	-0.1358	0.5121
Micropsectra	0.3656	-0.1687	-0.1010
Limnodrilus hoffmeisteri	0.3559	0.0056	0.4416
Valvata tricarinata	0.3548	-0.2517	0.0715
F. Enchytraeidae	0.3255	-0.1133	-0.6619
Cricotopus	0.2956	0.1543	-0.4514
Gyraulus	0.2765	0.9293	0.1403
Nais variabilis	0.2478	0.3565	0.2427
Cladotanytarsus	0.2430	-0.2848	0.2074
Glossiphonia complanata	0.2191	-0.3057	0.2498
Helisoma anceps	0.1694	-0.2728	0.2309
Parachironomus	0.1453	0.1460	0.0509
O. Harpacticoida	0.1408	-0.1922	-0.1066
Bezzia	0.1269	0.0518	-0.3801
Leptophlebiidae	0.1248	0.8752	0.1553
Endochironomus	0.0134	0.8884	0.0802
Nephelopsis obscura	0.0011	0.6778	-0.1989
Haliplus	-0.0014	0.9051	-0.0874
immatures with hair chaetae	-0.0083	0.7830	0.0955
Guttipelopia	-0.0126	0.7738	-0.3328
F. Tricladida	-0.0239	0.8915	-0.0750
Dero nivea	-0.0266	0.7243	-0.0718
Chironomus	-0.0336	0.2037	-0.2167
Oxyethira	-0.0605	-0.0181	0.2267
Serromyia	-0.0792	0.1852	-0.5688
Einfeldia	-0.0964	0.0921	-0.5585
Cladopelma	-0.1355	0.0980	-0.5628
Tanypus	-0.1530	0.4330	0.0535
Cryptochironomus	-0.2515	-0.1687	-0.0741
Zalutschia	-0.2624	0.3218	0.0812
Acricotopus	-0.3010	-0.0348	-0.2677
Chaoborus punctipennis	-0.3203	-0.1337	0.0517
Chaoborus flavicans	-0.3521	-0.0944	0.0752

Dome Mine
Sediment Quality Triad Correlations for the South Porcupine River

x variable	y variable(s)	Multiple R	p
Sediment Chemistry x Benthos			
SPC1	BPC1	0.040	0.431
SPC1	BPC2	-0.033	0.443
SPC2	BPC1	0.84	<0.001
SPC2	BPC2	0.016	0.473
Sediment Chemistry x Toxicity			
SPC1	*Hyalella* Mortality, *H.* Growth	0.65	0.023
SPC2	*Hyalella* Mortality, *H.* Growth	0.536	0.047
Benthos x Toxicity			
BPC1	*Hyalella* Mortality, *H.* Growth	0.664	0.018
BPC2	*Hyalella* Mortality, *H.* Growth	0.335	0.342

[shaded] - statistically significant at α=0.05
[boxed] - Selected for use in triad analysis

DOME
SEDIMENT QUALITY TRIAD
BENTHIC COMMUNITY - EUCLIDEAN DISTANCE MATRIX

Lake Sampling Station																				
D1B-1	D1B-2	D1B-3	D2-1	D2-2	D2-3	D2-4	D3-1	D3-2	D3-3	D3-4	D3-5	D3-6	D3-7	D4-1	D4-2	D4-3	D4-4	D4-5	D4-6	D4-7
0.00000																				
4.21219	0.00000																			
4.44775	3.89987	0.00000																		
6.37939	5.99256	6.58985	0.00000																	
7.91401	8.41547	8.35482	6.45084	0.00000																
7.82326	7.91399	7.87481	6.21737	5.25892	0.00000															
7.86677	7.18181	7.33617	7.26796	7.77805	6.60801	0.00000														
5.07088	5.28641	5.59079	6.66250	7.76270	8.23154	8.24064	0.00000													
4.85524	4.73628	4.83996	6.03026	7.36203	7.80324	8.03625	3.01137	0.00000												
5.12828	5.55174	5.67647	6.63534	7.42412	8.02479	8.41074	3.65188	3.16532	0.00000											
5.10033	5.19715	5.45050	5.65734	6.76385	6.95521	6.79314	4.09315	3.69109	3.74896	0.00000										
5.20219	5.43524	5.41187	6.56012	7.32239	8.02185	8.14670	4.23811	3.80692	3.41751	4.35975	0.00000									
5.16456	5.45041	5.94982	7.19813	8.72694	9.30526	8.79807	3.81344	4.52998	4.76759	5.13972	4.95902	0.00000								
5.60288	5.42338	5.56206	6.61190	7.70999	8.20142	7.88021	3.75552	3.26915	3.37300	3.45924	3.96701	4.13307	0.00000							
10.65975	10.35479	10.41840	9.38560	8.56701	9.55078	10.37313	9.19485	8.70574	8.73657	9.40287	8.94096	10.27034	9.18599	0.00000						
9.83639	9.08803	9.15259	8.83622	9.36969	9.65516	9.76256	8.29454	7.82657	7.93650	8.79860	7.99903	8.66012	7.99482	7.21822	0.00000					
10.09728	9.67639	10.03823	9.54946	9.46098	9.75906	10.32003	9.32807	9.15483	8.69387	9.84389	8.83373	10.11210	9.64886	7.11812	7.18659	0.00000				
9.71881	9.12431	9.29507	8.59796	8.77019	9.20558	9.82291	8.77807	8.71734	8.35853	8.95898	8.22595	9.33097	8.68742	7.14082	6.79746	5.64292	0.00000			
9.61651	8.91055	9.05700	8.43334	9.02306	9.65387	9.73348	8.50883	8.45852	8.28617	8.82166	8.20329	9.09598	8.51962	7.68751	7.23772	7.34461	5.18019	0.00000		
9.32339	8.59519	8.74542	8.05818	9.00683	9.43305	9.51616	8.10098	7.84447	7.91297	8.21968	7.54782	8.89277	8.02754	7.40618	5.73094	7.51423	5.95263	6.00430	0.00000	
10.18519	9.17701	9.13761	9.11824	8.95633	9.13856	10.25688	8.96438	8.42640	8.81702	9.15598	8.76739	9.77449	8.93437	7.52620	7.41191	7.80777	6.76026	6.90590	6.48215	0.00000

DOME

SEDIMENT QUALITY TRIAD

SEDIMENT CHEMISTRY - EUCLIDEAN DISTANCE MATRIX

Lake Sampling Station																				
D1B-1	D1B-2	D1B-3	D2-1	D2-2	D2-3	D2-4	D3-1	D3-2	D3-3	D3-4	D3-5	D3-6	D3-7	D4-1	D4-2	D4-3	D4-4	D4-5	D4-6	D4-7
0.00000																				
0.69548	0.00000																			
0.80365	0.08473	0.00000																		
0.52237	0.78841	0.82638	0.00000																	
0.52813	0.73040	0.76791	0.03462	0.00000																
0.56096	0.81248	0.85791	0.07208	0.12674	0.00000															
0.62814	0.58393	0.65948	0.62511	0.57924	0.55479	0.00000														
0.49264	0.86119	0.92263	0.36387	0.35935	0.40701	0.73012	0.00000													
0.51038	0.92498	0.99103	0.41182	0.39911	0.40174	0.67280	0.11502	0.00000												
0.46785	0.91326	0.97130	0.32232	0.35071	0.36817	0.71038	0.06981	0.10544	0.00000											
0.50045	0.88464	0.95022	0.46876	0.49332	0.50336	0.72282	0.21210	0.27693	0.13311	0.00000										
0.43530	0.89097	0.95495	0.36119	0.39540	0.41402	0.71037	0.13867	0.17797	0.00000	0.05467	0.00000									
0.44243	0.88685	0.95101	0.36238	0.37979	0.40036	0.73000	0.09403	0.13397	0.02549	0.12226	0.01446	0.00000								
0.47946	0.93813	1.00000	0.37859	0.39737	0.44756	0.80581	0.09022	0.16317	0.06339	0.20909	0.07580	0.00164	0.00000							
0.52250	0.61723	0.68051	0.31401	0.27572	0.37701	0.59318	0.41938	0.46861	0.42991	0.49721	0.42296	0.40377	0.42509	0.00000						
0.66868	0.83751	0.89524	0.35615	0.38413	0.39691	0.76011	0.56874	0.63624	0.54895	0.63274	0.55796	0.53918	0.55421	0.23197	0.00000					
0.66311	0.77486	0.82921	0.35307	0.36018	0.37468	0.71841	0.49931	0.57227	0.53799	0.66660	0.58475	0.56538	0.56686	0.29203	0.27274	0.00000				
0.58969	0.79328	0.84924	0.27604	0.32342	0.31870	0.70065	0.44251	0.50974	0.42587	0.51715	0.44152	0.42724	0.44591	0.17190	0.06176	0.18363	0.00000			
0.64457	0.90179	0.96347	0.33979	0.37797	0.37993	0.77322	0.47088	0.49557	0.44142	0.55305	0.45311	0.42297	0.41935	0.21267	0.13580	0.30465	0.07854	0.00000		
0.62945	0.86005	0.91924	0.31760	0.39561	0.32470	0.73262	0.45282	0.51132	0.43473	0.54235	0.46753	0.45703	0.47398	0.32498	0.23033	0.20459	0.08591	0.18022	0.00000	
0.63174	0.85746	0.92101	0.33731	0.38660	0.34841	0.71033	0.50554	0.52686	0.45637	0.53356	0.45785	0.44366	0.47430	0.22567	0.08566	0.32952	0.06386	0.06245	0.19942	0.00000

DOME
SEDIMENT QUALITY TRIAD
SEDIMENT TOXICITY - EUCLIDEAN DISTANCE MATRIX

										Lake Sampling Station										
D1B-1	DIB-2	D1B-3	D2-1	D2-2	D2-3	D2-4	D3-1	D3-2	D3-3	D3-4	D3-5	D3-6	D3-7	D4-1	D4-2	D4-3	D4-4	D4-5	D4-6	D4-7
0.00000																				
0.87413	0.00000																			
0.77698	0.13539	0.00000																		
0.99032	0.75782	0.64904	0.00000																	
0.56954	0.48533	0.35033	0.47217	0.00000																
0.59686	0.43015	0.29503	0.48414	0.05547	0.00000															
0.71381	0.49894	0.36886	0.33288	0.15016	0.15169	0.00000														
0.33834	0.56199	0.48965	0.90348	0.43131	0.42598	0.57585	0.00000													
0.38031	0.57249	0.51780	0.97477	0.50340	0.49309	0.64441	0.08135	0.00000												
0.50216	0.57519	0.44148	0.49998	0.09786	0.15116	0.21547	0.42386	0.50225	0.00000											
0.16357	1.00485	0.89724	1.01069	0.64141	0.67915	0.77282	0.49373	0.54178	0.55769	0.00000										
0.30832	0.62995	0.56448	0.97620	0.50453	0.50222	0.65096	0.07902	0.07283	0.48922	0.47053	0.00000									
0.38679	0.52110	0.45580	0.90293	0.43218	0.42064	0.57208	0.04848	0.07271	0.43565	0.54207	0.10943	0.00000								
0.22736	0.74040	0.62389	0.76296	0.35764	0.39394	0.49477	0.32042	0.39592	0.27988	0.28527	0.34508	0.35997	0.00000							
0.64342	0.27860	0.14922	0.59776	0.21410	0.16179	0.27756	0.38860	0.43535	0.29824	0.75518	0.46730	0.36532	0.47767	0.00000						
0.56392	0.40509	0.27306	0.54361	0.09578	0.05983	0.21084	0.37054	0.43550	0.17146	0.65798	0.44779	0.36287	0.37391	0.12699	0.00000					
0.86160	0.19704	0.12505	0.56201	0.36552	0.31256	0.33129	0.59735	0.63305	0.46318	0.96874	0.67446	0.56767	0.68690	0.21861	0.31460	0.00000				
0.62239	0.36259	0.22780	0.52013	0.12281	0.06811	0.19071	0.41404	0.47367	0.21458	0.71734	0.49250	0.40110	0.43311	0.09531	0.05939	0.25705	0.00000			
0.22507	0.65068	0.55193	0.83521	0.37801	0.39374	0.52798	0.16087	0.23478	0.33564	0.35854	0.18630	0.20361	0.16117	0.42024	0.35210	0.63883	0.40829	0.00000		
0.62067	0.36102	0.22637	0.52360	0.12454	0.07016	0.19415	0.41102	0.47047	0.21564	0.71625	0.48952	0.39791	0.43216	0.09262	0.05828	0.25734	0.00347	0.40617	0.00000	
0.51729	0.35685	0.27050	0.74792	0.29789	0.26778	0.41574	0.22026	0.25972	0.34024	0.65147	0.29705	0.19119	0.40223	0.17618	0.20833	0.37741	0.22907	0.29457	0.22563	0.00000