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Manitoba Hydro
Comprehensive Environmental Management Plan for Residuals from Historical Operations at the Sutherland Avenue Former Manufactured Gas Plant
Updated Technical Information Prepared for the TAC

Prepared by:
UMA Engineering Ltd.
1479 Buffalo Place
Winnipeg, MB, R3T 1L7

UMA Project No.: 0217 158 03 (4.6.1.6)

February 2008

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UMA Engineering Ltd.
1479 Buffalo Place
Winnipeg, Manitoba R3T 1L7
T 204.284.0580 F 204.475.3646 www.uma.aecom.com

February 27, 2008

UMA Project: 0217 158 03 09 (4.6.1.6)

Mr. Bob Gill, M.N.R.M.
Senior Environmental Specialist
Manitoba Hydro/Centra Gas
820 Taylor Avenue
Winnipeg, Manitoba
R3C 2P4

Dear Bob:

Re: Updated Technical Information Prepared for the TAC Comprehensive Environmental Management Plan (CEMP) for Residuals from Historical Operations at the Sutherland Avenue Former Manufactured Gas Plant

UMA Engineering Ltd. (UMA) is pleased to provide twenty-three (23) copies of the *Updated Technical Information Prepared for the TAC* and six (6) digital copies documenting the issues raised by Manitoba Conservation's Technical Advisory Committee (TAC) for the review of the CEMP for the former Sutherland Manufactured Gas Plant site and responses to the issues.

Thank you for the opportunity to provide our services on this project. Please do not hesitate to call myself or Mr. Edwin Yee, B.Sc. at (204) 284-0580 should you have any questions regarding this report.

Sincerely,

UMA Engineering Ltd.

Tom Wingrove, P.Eng.
Senior Vice President
Earth and Water
tom.wingrove@uma.aecom.com

T. R.
WINGROVE
29/02/08

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Executive Summary

The intent of this document is to address technical review comments received from the Technical Advisory Committee (**TAC**), which was convened by Manitoba Conservation (**MC**) to provide inputs on the environmental status of the former Manufactured Gas Plant (**MGP**) site (the 'Site') at 35 Sutherland Avenue, Winnipeg, MB. In particular, we address comments received on the earlier circulated draft of the Site draft *Comprehensive Environmental Management Plan* (**CEMP**).

Issues identified by TAC have been broadly grouped into 3 main areas:

- Site Characterization/Environmental Risk Assessment;
- Monitoring Recommendations Arising from Risk Assessment and the Management Plan;
- Possible Alternative Remedial Options.

A detailed description of issues identified is provided in Chapter 2 of this report.

SITE CHARACTERIZATION/ENVIRONMENTAL RISK ASSESSMENT

TAC members identified some confusion regarding the presence of non-aqueous phase liquid (NAPL) at the Site. Further clarification is provided on the current distribution of contaminants and their implications for the upland portion of the Site (Chapter 3) and adjacent areas (river and surrounding lands) based on off-site transport. The report provides the site stratigraphy, contaminant distribution within the major soil units and analysis of soil vapour.

Stratigraphy

The Site is underlain by three major geological units:

- **lacustrine and fill materials**, up to 4.6 m depth or greater below ground surface (bgs) have been encountered in the majority of the test holes drilled at the site. This unit variously consists of a combination of clay, sand, gravel, and coal. Between the south bank of the Red River and the site building, the soil stratigraphy is highly variable and complex, consisting of distinct, interbedded layers of low to high plastic clay, low plastic silt, and fine sand.

- **glacial till**, consistently encountered at a depth of 8.2 m to 15.6 m bgs. It is estimated that between 17 m and 25 m of glacial till is present beneath the site.

- **carbonate bedrock** of the Selkirk Member, consisting of mottled, fossiliferous dolomitic limestone, with abundant chert nodules in the upper limestone layer. Based on the stratigraphy recorded in one monitoring well (BW-46), bedrock in the vicinity of the site is encountered at approximately 33 m below grade.

Updated cross-sections of soil stratigraphy are provided in Section 3.2.

Coal Tar Distribution in Soils

Updated drawings have also been provided that summarize all observations of the presence of free-phase coal tar in various boreholes advanced. Coal tar at MGP sites is often present in the subsurface environment as a dense non-aqueous phase liquid (DNAPL), which is more dense than water. Coal tar has been observed in the lacustrine deposits within test holes/monitoring wells MW-48, MW-24D, MW-

23C, MW-64A, MW-63A, MW-65A, MW-62A, and MW-51B,located in the northwestern portion of the property and along the river bank. The depth of the observed coal tar contamination ranges from 2.3 m to 10.7 m below ground surface (bgs), and is predominately localized within the sand layers in the stratigraphic unit. No free-phase coal tar was observed during the completion of any of the test holes drilled west of the Disraeli Freeway or in the eastern portion of the site, towards Anabella Street.

Volatile Contaminants in Soil Gas

Coal tar contains a subset of volatile hydrocarbons that can migrate from zones of soil and groundwater contamination to the air, via transport in soil gas. This is of particular importance in light of the possible health risks associated with movement of contaminated soil gas into confined spaces. Characterization of soil gas has been conducted through several studies, from 1995 to 2007.

The overall results of the soil vapour monitoring confirm that soil vapour concentrations within the property boundaries of the former Sutherland MGP may exceed criteria, guidelines and reference concentrations as a result of residual coal tar residues in subsurface soil. Sentinel off-site vapour monitoring results were below minimum laboratory detection limits. There does not appear to be any off-site migration of soil vapour, however, that would pose any public health risk or safety risk (i.e., based on explosion potential). Furthermore, the available data does not show evidence of any issues with indoor air quality at the Site. Quarterly monitoring of soil vapour is proposed in the Remedial Monitoring program for the former Sutherland MGP site.

Groundwater-Mediated Transport of Coal Tar Constituents

This section of the report provides an explanation of the annual naphthalene estimates, estimates of vertical hydraulic gradients and flow directions and flow path based on cross-sections requested by the TAC members. UMA previously provided an estimate of the annual flux in groundwater of naphthalene from the Site to the Red River. At least two issues merit re-evaluation: (i) possible unrepresentative nature of Darcy's velocity estimates across the entire contaminated groundwater outflow face; and (ii) possible role of groundwater-mediated transport in the two deeper geological units (till and bedrock).

Of the twelve monitoring wells that have been installed in the till layer, five of these have screened intervals that are fully isolated only within the till unit, at depths from 10.4 m to 14.6 m bgs. Detectable concentrations of various polycyclic aromatic hydrocarbon (PAH) parameters in excess of the CCME Freshwater Aquatic Life guidelines were detected in all of these wells (MW-42A; MW-50B,; MW-58B; MW-62A; and MW- 63A).

The water quality in the carbonate bedrock at the site was assessed in 2002 and all PAH results were below minimum laboratory detection limits. Based on the thickness of the till, the upward hydraulic gradient from the bedrock to the till and an expected increase in density in the till with depth, the potential for PAHs to reach the bedrock aquifer is considered to be slight.

Vertical hydraulic gradients and flow directions were calculated for each of the piezometer nests completed at the site. The vertical gradients were calculated to assess the potential for downward migration of contaminants from one depth to another within the lacustrine subunit; from the lacustrine subunit to the glacial till unit; and from the glacial till unit to the carbonate bedrock. Overall, it was concluded that groundwater flow within the overburden is a combination of lateral towards the river and downwards toward the till unit. The river is a significant influence on groundwater flow and is expected to be a discharge boundary for all overburden groundwater flow. The river will also be a discharge boundary for flow from the upper bedrock aquifer.

Detailed re-evaluation indicates that groundwater from the former MGP site contributes approximately 0.33 kg of naphthalene to the riverine environment each year. This confirms our earlier estimate.

Potential Toxicity of Coal Tar Constituents in Groundwater to Sensitive Species of Freshwater Life

The TAC members requested clarification of groundwater laboratory toxicity testing methodology and the fish species used in toxicity testing.

The toxicity of groundwater samples to various freshwater standardized test species provides an indication of the potential effects of the mixture of coal-tar derived constituents moving in groundwater before discharge into and mixing with the Red River. Three groundwater sampling and laboratory toxicity testing events have been completed for the Sutherland MGP Site. During all three events, the groundwater was tested using a 96-h swim-up rainbow trout fry laboratory toxicity assay, in accordance with Environment Canada methods

Groundwater collected from MW23, at the top of the river bank, exhibited evidence of toxicity to rainbow trout fry during the first toxicity testing event; however, groundwater samples collected closer to the groundwater outflow face into the Red River (MW 46 to 49) for the third testing event were not toxic to trout fry.

Toxicity Test Species

It was suggested by TAC that fathead minnow be used in the groundwater toxicity monitoring instead of juvenile rainbow trout, since the former and not the latter are native to the Red River ecosystem. Based on existing published ecotoxicity data, it is expected that the sensitivity of the two test species is sufficiently similar that they could be used interchangeably. Nonetheless, future laboratory-based toxicity tests will use fathead minnow sensitive life stages to the extent that this test species is available.

Surface Water Quality in the Red River

This section of the report provides a response to TAC members concern that there is only limited information on the concentrations of PAHs in the water of the Red River as well as a lack of sufficient information on surface water chemistry. Surface water in the Red River might be affected by two types of releases based on past MGP releases of residual coal tar: (i) inputs into the river of contaminants dissolved in groundwater (or being transported as DNAPL) along the edge of the Site; and (ii) re-mobilization from historically contaminated sediments, based either on particulate re-suspension or dissolution at or just beneath the sediment water interface.

UMA collected water samples in March 2007 at twelve sample locations along the established sediment monitoring transects adjacent to the former MGP site and both upstream and downstream from the site. Water samples collected from 15 to 30 cm above the river bed of the Red River adjacent to the Sutherland Site did not contain detectable concentrations of PAHs. A subset of PAHs was detected in three water samples collected approximately 1 m below the ice surface. There does not appear to be a relationship between PAH surface water values and the sediment PAH concentrations, and the presence of PAHs in surface water may be as a result of other upriver sources such as urban drainage. The water samples also exhibited aluminum, copper and iron concentrations that were higher than the applicable freshwater life protection guidelines, even though these substances are not contaminants of concern at the MGP Site. Manitoba Hydro will conduct future river water quality analysis for PAHs as part of its river sediment monitoring activities.

Spatial Distribution and Depth in Sediment of Coal Tar Contamination

The TAC members raised the issue of previous studies indicating changes in the extent of river bed contamination. The evidence from approximately 12 years of studies on the extent of coal tar contamination in Red River sediments adjacent to the site indicates:

- The 1997 extreme flood event (>100 year flood event) increased the apparent aerial extent of coal tar contaminated sediment in the Red River adjacent to the Site by scouring of recently deposited sediments at the surface to expose historical deposits discharged directly to the riverbed during the operation of the MGP.
- Since 1997-98, a thin accumulation of recent sediments has been re-deposited over top of historical coal tar contamination. The depth and spatial variability of this newer sediment accumulation has not been fully evaluated.
- The presence of a fine veneer of recent sediments results in steep concentration gradients that are challenging to adequately characterize based on sampling with either grabs or cores/drilling. This has resulted in substantial variation in the measured PAH concentration in surface sediments at a given site on the riverbed. The apparent discrepancy in estimated aerial extent of the coal tar contaminated sediments from year to year may be largely attributable to different sampling/observation methods used by different practitioners.
- There is a high degree of fine-scale spatial heterogeneity of PAH contamination in the sediments based on the nature of the deposited material. Between-sample variability, even within a single sampling event, has been relatively high.

3-D Visualizations of the Contaminated Sediment Plume

TAC members requested the development of three-dimensional visualizations of the coal-tar contaminated sediment plume within the Red River to assist with planning exercises. Visualizations were prepared based on a re-interpretation of the UMA (2003) drill core PAH data, based on both naphthalene and total unsubstituted PAH concentrations. The 3-D visualizations illustrate the limited area of higher PAH concentrations that have the potential to become bioavailable and pose a potential risk to aquatic organisms.

Screening Criteria for Sediment Quality

TAC members requested clarification of the criteria used to delineate contaminated sediment. Many Canadian ecological risk assessment practitioners have found that the CCME Interim Sediment Quality Guidelines (ISQG) are not reliable predictors of benthic community effects, and that the ISQG values are often so low that in many cases virtually all sediments in urban setting or even based on natural mineralization exceed one or more ISQGs.

In light of general reservations about the high degree of conservatism of CCME ISQGs, UMA (2003) elected to compare sediment PAH data to Probable Effect Levels (PELs). It should be noted, however, that many of the issues associated with derivation of the CCME ISQGs also apply to the derivation of PELs. The comparison, therefore, was simply intended to show relative degree of contamination within different areas of the riverbed.

Above all, a site-specific ecological risk assessment has been completed for the Red River adjacent to the Sutherland Site, and this is provided as a more proximate and more accurate assessment of the potential for ecological risks than the use of generic environmental quality criteria.

Individual PAH Surrogates of Coal Tar Contamination

In addition to the criteria used to delineate the contaminated sediment plume, TAC members requested clarification for the use of naphthalene and benzo(a)pyrene as surrogates. Naphthalene is considered a good surrogate for coal tar distribution since it is the individual PAH occurring in the highest proportion in coal tar contaminated sediments. Benzo(a)pyrene was secondarily used as a chemical surrogate of coal tar distribution based on its proportional concentration, known mode of action as a cancer-causing substance, and based on the large amount of scientific information available regarding its environmental fate and effects. The two surrogate PAHs also represent different ends of the spectrum of soil (or sediment) – water partitioning tendency, volatility, and expected toxicological mode of action in various biota [carcinogenic and strongly MFO (mixed function oxygenase)-inducing *vs* non-carcinogenic and based largely on non-polar narcosis].

Spatial Variation in Sediment PAHs and Benthos

TAC members requested clarification of the relative impacts of PAH impacted sediment to the macro-invertebrate population adjacent to the Site relative to the urban Red River aquatic environment. The aquatic risk assessment described in the CEMP makes reference to a possible influence of PAHs on reference station sediments down river from the Site. While the downriver reference sites contained average PAH concentrations that were five-fold higher than the upriver reference sites, such differences do not appear to be a result of downriver mobilization of coal-tar contaminated sediments from the riverbed adjacent to the former MGP site. Rather, the PAH composition of all reference site samples is consistent with expectations based on stormwater inputs from urbanized areas in other North American communities.

Other Possible Sources of PAH Contamination to the Urbanized Red River

TAC members inquired as to other sources of possible PAH contamination to the urbanized Red River. Within the Winnipeg environment, major expected sources of PAH loading to the Red River might include (in possible order of priority):

- Stormwater runoff;
- Discharge of treated sewage effluent;
- Direct discharge from adjacent industrial and historically contaminated sites and/or petroleum spills;
- Direct atmospheric deposition of combustion-derived fine particulates containing PAHs.

Chambers *et al.* (1997) reported that discharge of treated municipal sewage effluent in Montreal contributed approximately 1.2 kg/d (440 kg/y) of PAHs (including 21 individual PAH).). Current estimated PAH loading from the MGP site of dissolved naphthalene to the Red River via groundwater is 0.33 kg/y. No similar mass loading estimates are available for the City of Winnipeg based on either stormwater or treated sanitary wastewater inputs; however, the presence of PAHs in surficial sediments in the Red River is not surprising in light of studies on stormwater inputs that have been conducted in other cities.

Effects on Sediment Associated Fauna: Relationship Between PAH Bioavailability and Observed Ecological Response

TAC members raised the issue of site-related impact based on the benthos data and requested clarification of the risk assessment work. The CEMP for the Site is based on an ecological risk assessment completed in 2003/04. The risk assessment, based on the investigation of field occurrences of benthic macroinvertebrates, demonstrated that there is a very limited impact on benthos from PAH contamination in the Red River adjacent to the Site. While there was a statistically significant negative correlation between the $\log_{10}$ PAH concentration and macroinvertebrate abundance, this relationship accounted for only ~5% of the between-site variability in macrobenthos abundance. It was noted that measures of sediment particle size (% clay), sediment organic carbon content and various geological origin metals were at least as strongly correlated with variations in benthos abundance as the sediment PAH concentration, in spite of the fact that PAHs in sediment samples exhibited a concentration range spanning four orders of magnitude.

The apparent lack of substantial toxicological response of sediment-associated fauna to coal tar contamination bears further scrutiny from mechanistic/causal perspective. In particular, it was hypothesized that limited bioavailability of PAHs in the coal tar contaminated sediments could account for the observed benthos data. A follow-up study was conducted in August - October, 2007. To evaluate the apparent lack of bioavailability and hence toxicity of PAHs, the dissolved concentration of PAHs in porewater extracted from sediment samples was determined using recently published ASTM standard methods and guidance prepared by the U.S. Environmental Protection Agency for predicting the toxicity of PAH mixtures (ASTM, 2007; US EPA 2003).

The follow-up study confirmed that individual PAHs are less likely to partition from sediment particles into pore water, and hence exhibit bioavailability, by a factor of more than two orders of magnitude in comparison with predictions from simple partitioning theory.

The concentration of *bioavailable* PAHs measured in the Red River sediment samples was evaluated against the bioavailable PAH–toxicity curve for *Hyalella azteca* derived from existing data for 133 freshwater sediments from 7 MGP and 2 aluminum smelter sites across North America. *H. azteca* was selected as the test organism for assessing sediment toxicity because it is considered to be highly sensitive to hydrocarbon contaminants and its survival and growth test endpoints have good precision.

The site-specific bioavailability assessment indicated that sediment samples in the Red River adjacent to the Sutherland Site with PAH16[1] bulk sediment concentrations exceeding 285 mg/kg are likely to be toxic to benthic biota in laboratory toxicity tests, while sediments with <66 mg/kg PAH16 in bulk sediments are likely to be non-toxic.

Sediment samples in the Red River that exhibit high concentrations of bioavailable PAHs and may be expected to be toxic were geographically centered in the area located just north of the Disraeli Bridge. These areas of sediment with PAH16 bulk concentrations >285 mg/kg are likely to be toxic to benthic invertebrates if exposed at the sediment surface within the zone of benthos burrowing; however, the estimated aerial extent of surficial sediments with >285 mg/kg PAH16 is quite limited relative to the total volume of coal tar contaminated sediment adjacent to the Site. In addition, there currently exists a thin veneer of sediment over the coal tar deposits, which originates from upriver areas, and may provide sufficient depth of habitat to facilitate presence of a relatively diverse community of benthic invertebrates.

Above all, the new PAH bioavailability data helps to explain the 2003 benthic community data. Assuming that a bulk sediment concentration of 285 mg/kg PAH16 is indicative of a high probability of adverse effects on benthic invertebrates (and that the *Hyallela* laboratory-based toxicity test is a sensitive predictor of toxicity to aquatic animals), only 1 of 25 sites sampled in 2003 for the ecological risk assessment would be predicted to show unacceptable risks. An additional 2 of the 25 stations sampled in 2003 had PAH16 concentrations in the uncertain concentration range between 66 and 285 mg/kg, for which toxic potential is uncertain. 22 of 25 sites sampled in 2003 (10 reference sites plus 12 of 15 sites in the coal tar contaminated area) exhibited PAH concentrations that would be in the non-toxic range (<66 mg/kg PAH16). Overall, the previously observed status of the benthos is consistent with what would be predicted from the results of the 2007 bioavailability study.

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[1] PAH16 is the total concentration of the sixteen commonly analyzed unsubstituted PAHs.

Human Health Risks Associated with River Water and Sediment Contact

TAC members inquired if human health risks associated with exposures in or adjacent to the Red River have been assessed. A quantitative evaluation of possible human health risks was completed for scenarios involving dermal (skin) contact with the contaminated sediments in the Red River

Consistent with the recommendations of Health Canada (2004), the toddler receptor was used to evaluate non-cancer risks while the adult was used to evaluate cancer risks. Both cancer-related and non-cancer risks risks are acceptably low for possible human exposures to surface sediment, based on current riverbed conditions adjacent to the Sutherland site.

Risks to humans from exposures to coal tar contaminated sediments are unlikely.

MONITORING RECOMMENDATIONS

Surface Water Chemistry

TAC members raised the issue that there is limited information on the concentrations of PAHs or other related coal tar related contaminants in the water of the Red River. It is the intention of MH to include sampling and analysis of riverine water in the ongoing Remedial Monitoring (RM) program.

Future Status of Coal Tar Contaminated Sediment in the Red River

TAC members noted that there is limited information about the re-mobilization of coal tar contaminated sediments and the effects of re-distribution of the sediment plume as a result of river currents and ice scouring. It is recognized that coal-tar contaminated sediment near the surface of the riverbed will continue to go through episodic burial with sediments originating from upriver sources, punctuated with scouring events during extreme floods.

Natural attenuation is a term used to describe naturally occurring processes that can reduce the mass, toxicity, mobility, volume or concentration of contaminants in soil, groundwater, or sediment. Processes that have a major influence on the fate of hydrophobic organic contaminants in soils include:

- dissolution of components at the source;
- mass transfer of the dissolved organics into groundwater;
- transport in groundwater by advection, dispersion and diffusion;
- sorption; and
- chemical and biological transformations.

An important sediment attenuation process in aquatic environments is the bulk transport of contaminated sediments either through bedload transport or sediment re-suspension and deposition in downcurrent areas.

A brief review is provided to the multimedia partitioning behaviour of coal tar mixtures in soil-groundwater and sediment-porewater-overlying water systems, and especially of potential for biodegradation or other attenuation mechanisms. In general, the rate of partitioning between solid-phases and the surrounding aqueous media is expected to be slow owing to the non-polar nature and strong hydrophobicity of PAHs and (to a lesser extent) monoaromatic hydrocarbons. Groundwater or porewater concentrations have been shown experimentally to be consistent with predictions from Raoult's Law: The actual observed concentrations of individual coal tar constituents, therefore, tend to be much lower than would be predicted from compound-specific solubility limits or K_{OW} estimates. Transport of dissolved chemicals from the sediment to overlying water is mediated by the velocity and variability of water flow across the sediment-water interface.

Overall, it is also expected that concentrations of coal-tar constituents will decrease only very slowly (over decadal time periods) in highly contaminated areas of subsurface soils and sediment. At the edges of the coal tar contaminant plume, the proportion of mass that partitions into porewater from soils/sediments and biodegradation rates should be much higher than in more contaminated zones. Thus, attenuation rates are likely to be enhanced in areas with lower concentrations of coal tar constituents along major transport pathways.

It is expected that there will be future re-suspension of coal tar contaminated sediments during high energy flood events. Depending on the energy and turbulence of river bottom flows, coal tar materials might be transported both as sorbents to sediment particles and as small free-based droplets and as coal tar pitch. Re-distribution would invariably result in deposition intermixed with sediments from other areas of the Red River. Therefore, either the concentration in downriver areas will decrease sufficiently to facilitate accelerated attenuation, or fine masses of concentrated PAHs will be intermixed with a much larger mass of less or non-contaminated sediment.

Changes in land use and construction activities along the river bank and the Disraeli Bridge could result in the release of coal-tar contaminants to the local environment and the potential for increases in human and ecological exposures. It is anticipated, however, that a screening level study of these construction activities, which could potentially impact fish habitat and therefore potentially involve the federal *Fisheries* Act, would be undertaken in accordance with the *Canadian Environmental Assessment Act* (CEAA). Any such activities, therefore, will need to consider whether the previous evaluations of human health or ecological risks have adequately accounted for new conditions that may arise as a result of the proposed project. Such a formal analysis will be an important pre-requisite to the establishment of appropriate risk management strategies; for example, avoidance or engineered controls. To facilitate such future planning, it will be important that the MH's CEMP and underlying information on site characteristics are adequately communicated to relevant parties, and are available for future review.

Ongoing Monitoring Program in the Context of the Federal Environmental Effect Monitoring (EEM) Programs

TAC members suggested that the effectiveness of the monitoring program be re-assessed by incorporating elements of federal EEM programs. The federal EEM program was designed to address active aqueous discharges into fish-bearing waters from continuing industrial operations (metal mining, pulp and paper production) while monitoring at the Sutherland Site is focussed on the historical release of coal tar residues, and has a slightly different objective.

Regardless of their differences in intent, the Sutherland RM Program and EEM programs share a common set of scientific tools, including use of chemical tracers to establish the spatial influence, laboratory toxicity tests to predict toxicity to fish in the receiving environment, and benthic infaunal analysis.

Proposed Sutherland Site RM Program

TAC members requested an explanation of the proposed frequency of sediment, groundwater, aquatic biota and soil vapour monitoring. The RM program incorporates elements of the EEM program including sub-lethal testing of the groundwater; chemical characterization of the groundwater; water quality monitoring of the Red River; site characterization (contaminant plumes in soil, groundwater flow and soil vapours); and monitoring of the benthic invertebrate community in accordance with the methodologies prescribed in the EEM program.

The proposed RM program includes the following:

- Upland Groundwater
- Upland Vapour, and
- River Sediments, River Water and Biota.

A monitoring frequency is proposed as follows:

- river surface sediments and water quality - annually;
- river subsurface sediments - every 10 years;
- bioavailability testing - 3 and 5 year frequency.

The benthic community monitoring frequency will be re-assessed based on the results of the bioavailability study.

The CEMP proposes that groundwater will be monitored annually to provide a continuing assessment of groundwater quality and estimates of the mass loading of naphthalene into the river environment.

Quarterly monitoring of combustible vapour is proposed in the RM program for the Site. This is in recognition of the potential strong seasonal variation in soil vapour concentrations of volatile contaminants arising from contaminated soils and groundwater. A reduced frequency may be warranted in future years, once an adequate understanding of both spatial and temporal variability is achieved.

Communication and Reporting Plan

TAC members requested that Manitoba Hydro develop a communications and reporting plan to keep all stakeholders informed. The CEMP includes the preparation of an annual report describing all field activities, monitoring results and recommendations for further remedial actions if required.

Manitoba Hydro will implement a communications plan that will keep stakeholders (regulatory agencies, public representatives, the local community and Manitoba Hydro Sutherland staff) informed of the management plan, current site investigation and monitoring activities, site conditions and future investigation/monitoring activities and remedial actions. The regulatory agencies identified in the communications plan include the TAC members, Environment Canada, Fisheries and Oceans Canada and the Public Utilities Board. The local community around the former Sutherland MGP site has been identified as the general public stakeholder. Additional agencies, groups and individuals may be added to the currently identified stakeholders based on the response to communications or specific requests received by Manitoba Hydro. Manitoba Hydro Sutherland staff has also been identified as a stakeholder.

Upon the approval of the Management Plan, Manitoba Hydro will prepare a summary document providing the background history of the former Sutherland MGP site, investigation studies, the Management Plan and Director's Order. MH will conduct an Open House for the local community.

POSSIBLE ALTERNATIVE REMEDIAL OPTIONS

TAC members requested evaluation of the possible range of remedial options for coal tar contaminated sediments in the Red River, including *in-situ* technologies and measures that might be taken to curtail or reduce the movement of coal tar contaminants from the Site. A monitored natural recovery (MNR) remedy has been proposed for the Sutherland Site and adjacent environment. This is based primarily on the evidence provided by the ecological risk assessment, showing no obvious impacts of the contaminated sediment on sediment-dwelling faunal communities. Follow-up studies have indicated that there is a relatively small, discrete area of riverbed in comparison with the entire contaminant plume for which biological impacts from PAHs would be expected if the most contaminated sediments were available to biota at the sediment surface.

The estimated total volume of contaminated sediments is 50,000 cubic metres contained in an area of up to 80 metres wide by 700 metres long. Remedial options other than MNR for sediments were not described in detail in the CEMP. The potential benefits and drawbacks of dredging, capping, and in-situ sediment treatment are further discussed in this document.

Dredging

A typical sequence of dredging steps includes (i) debris removal; (ii) sediment removal; (iii) transport; (iv) staging; (v) pretreatment/dewatering; (vi) water treatment and disposal; and (vii) sediment transport, treatment, and disposal. Dry dredging would likely not be feasible as it would involve re-routing the Red River or otherwise isolating the contaminated sediments from the flow of the river.

Contaminated sediment, and approximately 15 to 30 centimetres of material below the contaminated layer (overdredge), are usually targeted. Dredging of contaminated sediments in riverine environments typically results in loss of 10% or more of the contaminated sediment mass to surrounding areas, even using the best available technology. The Red River environment is far from conducive for retention of most of the contaminated soil mass if sediment removal were to occur “in the wet”. Due to re-suspension during dredge operations, and residual contaminated sediment left after dredging, additional dredging, capping, evaluation of aquatic ecological risks and/or monitored natural attenuation are commonly necessary.

A large amount of water that is incorporated into the dredgate must be subsequently removed by dewatering at an appropriately large staging area. There is likely to be insufficient land area local to serve as a dredgate handling/dewatering area for hydraulic removal, and possibly for mechanical removal. Dewatering invariably requires further treatment of decanted or filtered water.

Upstream and downstream water quality monitoring would be required to evaluate impacts to the river and provide feedback for modification to the dredging activity to reduce pollution. Air monitoring would be required to protect worker safety and public health.

Residual contaminants would likely be left in the river due to the proximity of the Disraeli Bridge piers and the natural gas pipeline.

Capping

Capping involves placing a layer of cleaner dredged material or geologic materials from upland borrow sources over contaminated sediments, to isolate the contaminated zone from the biologically active portion of the aquatic environment. Major steps in contaminated sediment capping project include (i) detailed site characterization; (ii) detailed sediment characterization; (iii) cap design and construction; (iv) monitoring and cap maintenance.

Caps are designed as a series of layers that function to physically isolate the contaminated sediments from the aquatic environment, stabilize the cap and protect it from erosion, and to achieve chemical isolation for contaminant migration through the cap.

The sediment to be capped at the Sutherland site is mostly fine grained with some sand. To stabilize the sediments and to prevent re-suspension, the capping material would need to be of similar grain size. If the capping material is placed slowly and evenly the load applied to the sediment is also more evenly distributed reducing the potential for isolated bearing failures. With time, as the pore pressure dissipates, the confined sediment becomes denser through consolidation, and gains strength. The potential for a cap to resist the possible vertical movement of dissolved contaminants by advection and the inevitable movement of contaminants by molecular diffusion needs to be assessed.

The main forces that could disturb the sediment cap are the river currents, especially from flood events. Armoring the cap with a layer of gravel or rock would minimize the potential for cap erosion during floods. The type of armouring (hard, soft, other) has obvious implications for the type of aquatic habitat available on the cap. A long-term monitoring program is required to evaluate the integrity of the cap, recolonization by biota and evidence of contaminant migration.

In-situ Sediment Treatment

A limited number of in-situ contaminated sediment treatment options exist in theory, including bioremediation, solidification/stabilization and chemical oxidation. None of these have been attempted for MGP site sediment contamination, however, and the efficacy is highly speculative. Enhancing microbial decomposition of PAHs in sediments might reduce PAH concentrations by as much as 75 percent; removal efficiencies of 90% or greater would be required to reduce PAH concentrations in the most highly contaminated zones if a concentration that is lower than risk-based thresholds is to be achieved. The overall effectiveness and rate of contaminant decrease achieved by in situ methods is strongly controlled by solid-phase to water partitioning rates, which tend to be very low for coal-tar contaminated soils and sediments. Just as the demonstrated limited PAH bioavailability would limit risks to bottom-dwelling biota, it will also strongly limit PAH availability to bacteria that exhibit degradation potential. Limnofix^{TM} has been used to destroy over 99% of sulphide contaminants in sediments, but has not been as efficient in destroying PAHs and has not been used to treat sediments at MGP sites.

Evaluation of Other Remedial Technologies to Address Contaminant Transport from Upland to the Red River

An annual flux of ~0.33 to 0.37 kilograms of naphthalene has been calculated for the groundwater flow. Another potential concern for off-site migration is DNAPL that may migrate independently from groundwater.

This flux could be curtailed through installation of an interceptor trench. Based on the Site configuration, such a trench would need to be approximately 300 metres long, located between the dike and the river bank. The trench would be keyed in to the till layer approximately 15 metres below the ground surface. The bottom of the trench would contain perforated piping and would be sloped to one or more sumps where DNAPL could collect for recovery.

Vertical risers in the trench would also allow for the recovery of groundwater, and the entire trench would be filled with coarse granular materials such as sand or pea gravel. Groundwater interception would require pumping approximately 300,000 litres per year and the average linear groundwater velocity of 2.8 x 10^{-8} metres per second.

A water treatment system would be needed to treat recovered groundwater to surface discharge standards. This would likely include iron removal and carbon filtration for organic compounds prior to discharge to the Red River.

Installation of the interceptor trench along the river bank may require removal of abandoned municipal infrastructure and measures to ensure river bank stability. A long-term maintenance and monitoring program would also be required.

1.0 Introduction and Objectives

The Technical Advisory Committee (**TAC**) was convened by Manitoba Conservation (**MC**) to provide technical input into the draft *Comprehensive Environmental Management Plan* (**CEMP**) that has been developed by Manitoba Hydro (**MH**) for the former Manufactured Gas Plant (**MGP**) site (the "Site") at 35 Sutherland Avenue, Winnipeg, MB. The TAC first met on December 14, 2006, and for a second time on March 1st, 2007. A major objective of the March 1st meeting was to discuss comments from the TAC on the draft Management Plan as well as supporting technical documents provided to the TAC during the first meeting.

Following the TAC meeting in March 2007, and a subsequent comment period, UMA Engineering Ltd. prepared a work plan on behalf of MH, outlining issues raised by TAC members and how these would be addressed. The intent of this document is to address in detail the technical review comments received verbally and in writing from the TAC regarding the Site and the earlier circulated draft of the CEMP.

2.0 Issues Identified by TAC

The issues identified by the TAC have been placed in the following categories to facilitate discussions:

- Site Assessment Studies/Environmental Risk Assessment (section 2.1);
- Monitoring Recommendations Arising from Risk Assessment and the Management Plan (section 2.2);
- Possible Alternative Remedial Options (section 2.3); and
- Miscellaneous (section 2.4).

Based on the state of practice in North America, Europe, Australia and New Zealand, decisions about contaminant risks and site remediation are grounded firstly in the best available knowledge about physical and chemical site conditions, and secondly in how such conditions might adversely influence the biosphere, including humans (i.e., possible ecological and human health risks). The order of listing herein of the issues identified by the TAC parallels this state of practice. Therefore, discussions in section 2.3 are based on an explicit understanding that any remedial options need to be explicitly linked to the prior scientific/technical decision making process, as addressed in sections 2.1 and 2.2. In particular, technical decisions around risk management as presented by MH have followed the logic that the need for risk reduction is very important for defining management objectives, and that any possible benefit of future actions is explicitly tied to expectations for a commensurate reduction in environmental risks.

2.1 Site Assessment Studies/Environmental Risk Assessment

The issues identified are divided into on-site and off-site issues to facilitate discussion.

On-site issues are those that relate to characterization, prediction of contaminant fate, human health or ecological risks, and risk management strategies for the Site proper.

Off-site issues revolve around the following:

(i) the potential for past-release contaminants to move toward and beneath adjacent uplands areas, including residential areas;

(ii) the potential for past-release contaminants to move into the Red River, including the embankment and seasonally wetted areas; and

(iii) the impact of past-release contaminants (coal tar) that have already been deposited on the river bed.

2.1.1 *On-Site Contaminant Assessment and Environmental Risk Issues Identified*

Major issues identified in this sub-area are tabulated below, along with the proposed resolution:

Issue	Proposed Resolution	Section in Report
There is some confusion surrounding statements about observations on NAPL presence in various boreholes and monitoring wells.	The issue arises from new information received from investigations undertaken since 2005. MH to provide updated site representations in plan view and cross-section, documenting observed NAPL occurrences.	3.0
No other substantive issues identified to date		

2.1.2 *Off-Site Contaminant Assessment and Environmental Risk Issues Identified*

Major issues identified in this sub-area are tabulated below, along with the proposed resolution:

Issue	Proposed Resolution	Section in Report
Delineation of contaminated sediment made reference to the Canadian Council of Ministers of the Environment (**CCME**) Probable Effects Level (**PEL**) guideline, but not the more sensitive Interim Sediment Quality Guideline (**ISQG**).	Additional clarification required about limitations of CCME sediment quality guidelines and especially ISQG as a predictor of ecological risks. In addition, we wish to clarify that the Comprehensive Environmental Management Plan is based on site-specific studies that are more directly applicable than use of generic CCME sediment quality guidelines.	4.7
Naphthalene (and benzo[a]pyrene) was used as the surrogate PAH for delineation of contaminated sediment.	Further detail on underlying rationale and implications to be provided. Evaluation of coal tar residues distribution based on total unsubstituted PAH concentrations is also provided	.4.8
A 3-D visualization of the coal tar contaminated sediment plume in the Red River would assist with planning exercises.	MH will evaluate feasibility of developing such a visualization.	4.6
Explanation required of the annual naphthalene loading estimates via the groundwater (and associated uncertainty) as well as the term "significant" as it relates to potential aquatic impact.	Explanation, updated estimates and detailed examination of uncertainties to be provided.	4.2
There was concern that a single estimate of groundwater transport velocities and hydraulic conductivity was used to estimate rate of transport of coal-tar derived contaminants from the site to the	Additional discussion required of subsurface soil conditions, including hydraulic conductivities, the assessment of groundwater flow and preferential pathways. MH to clarify that contaminant flux estimates were based on different	4.2

Issue	Proposed Resolution	Section in Report
Red River, based on dissolved phase transport. The estimates may be unrealistic relative to variations in subsurface conditions along the larger implicated flow path.	observed groundwater concentrations and K values at different zones between the site and outflow face.	
"The till is apparently being considered as an impermeable base and there would be minimal contamination below the top of the till. These tills can be relatively permeable. Any ideas on the hydraulic conductivity of the till and how it compares to the overlying materials? "	Additional clarification of the vertical extent of soil and groundwater contamination and the expected influence of various soil strata or channels, including deeper till, to be provided.	4.2
A flow path diagram has not been developed, based on the cross-sections or water table elevation maps as presented. Is groundwater movement through preferential pathways or units? There was reference to an older report that said groundwater wasn't able to transmit to the river through the sand layers since these layers are not aerially extensive. Is this the same conclusion that is reached after additional drilling has been done?	Additional discussion/evaluation of groundwater flow paths is merited.	4.2
The reports lack sufficient information on surface water chemistry (see also comments in Section 2.2)	MH will arrange for collection of additional Red River water samples to assess surface water chemistry, especially at the sediment surface.	4.4
The risk assessment report indicated that there was a significant difference in macroinvertebrate density between various station groupings, but did not indicate whether there was a significant difference in sediment PAH concentration between the five groups (low, medium, high PAH levels; up-river reference; down-river reference).	MH will elaborate on the basis of interpretation of the sediment risk assessment by providing additional detail to what was provided in the risk assessment.	4.9
There was an assertion that the benthos data clearly show a site-related impact.	MH elaboration on risk assessment will expand on the original intent to develop a site-specific remedial objective based on concentration-response relationships. The clarification will further discuss the	4.11

Issue	Proposed Resolution	Section in Report
	statistical evaluations, including their power to detect site related impacts if present. The response will discuss the role of bioavailability, and how this influences links between chemical concentration and biological response. The response will also provide a review of experiences about aquatic life risks and bioavailability at other North American MGP sites.	
Sediment samples from downstream reference stations exhibited much lower PAH concentrations than sediments from the areas adjacent to the Sutherland Site, although these samples exhibited PAH concentrations that were more than two fold higher on average than the upstream stations. Are these differences in PAH contamination significant?	Evaluation of statistical significance of differences in PAH concentrations for various station groupings to be undertaken and provided to TAC.	4.9, 4.11
The report suggests that there is a separate PAH source affecting the sediment samples at the downstream sites. Could flow and scouring perhaps have carried more contaminated sediment that was adjacent to the Sutherland Site further downstream? If this is not plausible, what would be the other potential sources of PAH downstream?	Response to provide additional discussion of major processes that have and will likely continue to affect fate within the river bed of PAH-contaminated sediments from coal tar and other sources, including deposition, burial, scouring, and downriver transport. The discussion will describe techniques for differentiating coal-tar derived from other PAH source types (or non-point source inputs, including CSOs and storm sewers).	4.10, 4.11, 5.3
Clarification required of the relative impacts of the PAH impacted sediment adjacent to the Sutherland site relative to the urban Red River aquatic environment (relationship to PAH concentrations in the sediment to macro-invertebrate population).	Benthic biota risk assessment to be further explained. Some discussion about other potential sources of contaminants to the Red River to be provided.	4.9, 4.11
Have human health risks associated with exposures in or adjacent to the Red River been assessed?	MH to provide additional quantitative assessment of human health risks associated with possible exposures of humans from coal-tar contaminated soil, sediment and water associated with other than soil vapour intrusion into on-site or off-site buildings.	4.12

2.2 Monitoring

The proposed management plan includes an ongoing monitoring component, and might include specialized studies. In addition, it may be necessary to develop contingency strategies for either (i) the re-evaluation of degree of impact, or (ii) potential influence of other planned activities on the status of contaminant distribution and risks in the river bed. The following comments relate to the monitoring program as either inferred from or proposed in the draft management plan:

Issue	Proposed Resolution	Section in Report
There is very limited information on the concentrations of PAHs or other coal-tar related contaminants in the water of the Red River as opposed to sediments, and this in turn undermines confidence in predictions about either groundwater-related releases from the site or re-mobilization to the water column from coal tar contaminated sediments.	MH will arrange for collection of additional Red River water samples to assess surface water chemistry, especially at the sediment surface. A spatial sampling pattern is needed to characterize up-river water quality to compare with water quality adjacent to or down-river from the site.	4.4
There is only limited information on Red River water quality or sediment-water fluxes of PAHs seasonally within a year, or between years. Annual monitoring of the spatial extent and concentration of PAH in the sediments and monitoring of the benthic community every five years is not sufficient to detect environmental changes.	The proposed monitoring program will be updated to better address intra- and inter-annual variability in exposure concentrations in the water column and down river.	5.5
Some previous reports make reference to a "doubling in size" of the coal tar contaminated sediment plume between 1995 and 1997, and made references to other changes in spatial extent of river bed contamination.	MH to clarify the relationship between observational techniques used in previous studies and the various assertions about spatial and depth extent of coal tar contamination in the Red River sediments. This will also include discussions about future evaluations of riverbed distribution.	4.5
While the draft Management Plan and supporting documents make reference to other sources of contaminants, including PAHs, to the Red River, no specific information is available.	Assessment of other sources of PAHs to the Red River would be based on inclusion in future water and sediment sampling programs of an expanded number of both up-river and down-river reference sites.	4.10
The effectiveness of the monitoring program should be re-assessed by incorporating elements of Environmental Effects Monitoring (**EEM**) to better assess changes to the aquatic ecosystem including toxicity testing of other aquatic	The proposed monitoring program will be re-evaluated relative to the particulars of the metal mining and pulp and paper EEM programs.	5.4

Issue	Proposed Resolution	Section in Report
species and evaluation of toxicological thresholds of/effects of PAH metabolites.		
Explanation required for the proposed frequency of monitoring sediments, groundwater, aquatic biota and soil vapours.	Additional details of the monitoring program to be developed.	5.5
Results from two rounds of groundwater laboratory toxicity testing have been provided to TAC. These apparently employed different methodologies. Use of larval fathead minnows may be preferable to use of larval trout in groundwater bioassays, since the former are endemic species to the Red River.	UMA has clarified that the methods used to sample groundwater and develop the piezometers were the same for both programs. This will be clarified in writing. Updated proposed monitoring program will re-evaluate toxicity test species and methods that will be used to assess ongoing risks from groundwater-mediated transport.	5.5
There is a need to establish response levels for various forms of future risk management action, and the type of response that would be implemented.	Agreed. This will be provided for evaluation by TAC.	5.6
No detailed assessment was provided on the possible characteristics of and effects of re-distribution of the sediment plume as a result of Red River currents and ice scouring based on PAH concentration and spatial distribution.	A desk-top evaluation to be completed and provided, based on the current state of predictive knowledge.	5.3
MH should develop a communication and reporting plan in addition to Manitoba Conservation's regulatory reporting requirements, to keep all stakeholders informed (*Based on acceptance of the management plan, Conservation would issue a Director's Order that would include reporting requirements*).	A section outlining reporting and communication responsibilities will be provided as an addendum to the Management Plan.	5.7
Other activities might occur in the future that would disturb coal-tar contaminated soils and sediment.	Provide a more detailed explanation of contingency plans to address changes in land use and construction activities along the river bank and the Disraeli Bridge that would result in potential exposure to PAHs. In particular, it is recognized that relevant site conditions will require documentation and communication to anyone who might	5.3

Issue	Proposed Resolution	Section in Report
	encounter them in the future.	

2.3 Alternative Remedial Options

Major issues identified in this sub-area are tabulated below, along with the proposed resolution:

Issue	Proposed Resolution	Section in Report
No assessment completed to date of natural attenuation / bioremediation / bioavailability and release of PAH from the sediment over time, including releases due to ice scouring and flooding.	A scientific literature review will be completed to assess (i) rates of coal tar and PAH biodegradation in freshwater riverine sediments, (ii) factors that enhance or retard contaminant degradation rates in freshwater sediments, and (iii) expected effects on benthic infaunal macroinvertebrates relative to the currently documented riverbed conditions	5.3
The draft Management Plan does not evaluate the possible range of remedial options for the uplands portion of the contaminated site.	Pros and cons, and especially need for active remediation of impacted soils and groundwater, will also be examined in more detail.	6.3
The draft Management Plan does not evaluate the possible range of remedial options for coal-tar contaminated sediments in the Red River.	MH will provide a high-level (conceptual) assessment of the alternative remedial options that might be considered. For each option, the possible benefits of each approach will be listed, along with potential issues and/or critical success factors, including estimation of PAHs released and their potential impact to the aquatic environment; requirements for management of PAH impacted sediments removed from the river by dredging option, regulatory approvals required and limitations of alternative remedial options. Assessment of alternatives to include (i) sediment removal by dredging in the wet, (ii) removal in the dry after re-routing or excluding river water, (iii) barriers, and other. Advantages and possible limitations of "Limnofix^{TM}" will be discussed, along with other experimental and proven technologies, including information from other jurisdictions. The overall analysis will be conceptual only.	6.2
The draft Management Plan does not evaluate the possible	MH will provide an updated assessment of other alternative remedial	6.3

Issue	Proposed Resolution	Section in Report
measures that might be taken to curtail or reduce the movement of coal-tar associated contaminants from the uplands site into the Red River, either in dissolved phase or the non-aqueous liquid phase (**NAPL**).	technologies including pump-and-treat, cut-off barrier walls, etc. to address sub-surface transport pathway.	
Overall -	MH will establish response levels that would require consideration of implementing an alternative remedial option.	5.6

2.4 Miscellaneous Issues

Major issues identified in this sub-area are tabulated below, along with the proposed resolution:

Issue	Resolution
The term "approved backfill" was used in some of the reports. What does this mean?	Reference to approved backfill appears to be in the context of past re-development of the Site, from a decommissioned MGP site to its current configuration. Manitoba hydro believes based on the information reviewed that all materials brought in when the site was converted from the MGP to the current commercial facility was uncontaminated (i.e. sourced from a clean borrow area).

3.0 On-Site Contaminant Distribution and Fate

3.1 Issues Identified

Issues identified include –

- There is some confusion surrounding statements about observations on NAPL presence in various boreholes and monitoring wells.
- Relationship between observational techniques used in previous studies and the various assertions about spatial distribution and depth of coal tar contamination.

In addition to this, we provide herein a summary of the results of recent soil vapour analysis work.

3.2 Soil Stratigraphy

Based on observations made during the various drilling investigations that have been undertaken at the site, the undisturbed subsurface stratigraphy at 35 Sutherland Avenue consists of three major units: lacustrine materials, glacial till, and carbonate bedrock. A base plan of the site is included in Figure 3-1. Updated cross-sections of the soil stratigraphy at the site are provided in Figure 3-2, Figure 3-3, Figure 3-4, and Figure 3-5, and the stratigraphic units are described in more detail, below.

3.2.1 Alluvial/Lacustrine Materials

Fill materials, up to 4.6 m in thickness and consisting of a combination of clay, sand, gravel, and coal, have been encountered in the majority of the test holes drilled at the site. The types and quantities of the native soils beneath the fill materials at the site are highly variable. To the south of the Main Operations Building and along Gladstone and Annabella Streets, the soil stratigraphy primarily consists of high plastic clay, with inclusions of sand, silt and gravel. In the northern portion of the site, between the south bank of the Red River and the site building, the soil stratigraphy is highly variable and complex, consisting of distinct, interbedded layers of low to high plastic clay, low plastic silt, and fine sand.

3.2.2 Glacial Till

Several of the test holes at the site have been advanced into the glacial till underlying the lacustrine materials. Though the primary constituent of the till is silt, some sand and gravel are also present. The depth at which till is encountered is fairly consistent across the site, ranging from 8.2 m to 15.6 m below grade.

3.2.3 Bedrock

According to the Geological Engineering Maps and Report produced by the former University of Manitoba Department of Geological Engineering in 1983, the carbonate bedrock in the area of the site is of the Selkirk Member and consists of mottled, fossiliferous dolomitic limestone, with abundant chert nodules in the upper limestone layer. Based on the stratigraphy recorded in monitoring well BW-46, completed northwest of the MH property, on the north side of Rover Avenue, bedrock in the vicinity of the site is encountered at approximately 33 m below grade.

3.3 Spatial Distribution and Depth of Coal Tar Contamination

We provide herein updated drawings and textual summary regarding what is known about the distribution of non-aqueous phase liquids (NAPL) (coal tar) beneath the Sutherland Site. A plan view of the locations in which coal tar contamination has been previously identified during the historical and most recent drilling investigations is provided in Figure 3-6. Figure 3-7 illustrates our understanding of the depth NAPL presence at the site, based on the data and observations available to the present time.

As indicated on Figure 3-6, seeping or free-phase coal tar was observed during various drilling investigations in the lacustrine deposits within test holes/monitoring wells MW-48, MW-24D, MW-23C, MW-64A, MW-63A, MW-65A, MW-62A, and MW-51B (from north to south), located in the northwestern portion of the property. The depth of the observed coal tar contamination ranged from 2.3 m to 10.7 m below the existing ground surface, and was predominately localized within the sand layers in the stratigraphic unit. In the cross-section shown in Figure 3-7, it is assumed that some of the observed seepage faces are connected to one another across the section, as shown. This assumption is based solely on the limited stratigraphic information obtained from the historical subsurface investigations completed at the site and observations of coal tar within the stratigraphy during those investigations. Without additional stratigraphic information from the site (i.e. a denser network of test holes), the validity of this assumption cannot be confirmed. However, no coal tar inclusions were observed during the completion of any of the test holes drilled west of the Disraeli Freeway or in the eastern portion of the site, towards Anabella Street. This provides evidence that there may be some connectivity of the higher permeability layers of soil in the direction of groundwater flow.

3.4 Soil Vapour Analysis

Coal tar, and heating fuel that may have also been used at the Site to enhance coal gas production, contains a subset of volatile hydrocarbons that can migrate from zones of soil and groundwater contamination to the air, via transport in soil gas. This is of particular importance in light of the documented health risks associated with movement of contaminated soil gas into confined spaces (especially residential and commercial buildings). Characterization of soil gas has been conducted through several studies, beginning in 1995. The latest soil gas survey was completed by UMA in 2007, and a brief report has been provided to the TAC. We provide a brief summary below of soil vapour studies completed to the present time.

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PLAN

0 20 40 m SCALE 1:2000

LEGEND

● GROUNDWATER MONITORING WELL/NEST

Manitoba Hydro
Sutherland Management Plan
TAC Response

Base Plan

UMA | AECOM

Figure 3-1

B SIZE 11" x 17" (279.4mm x 431.8mm)

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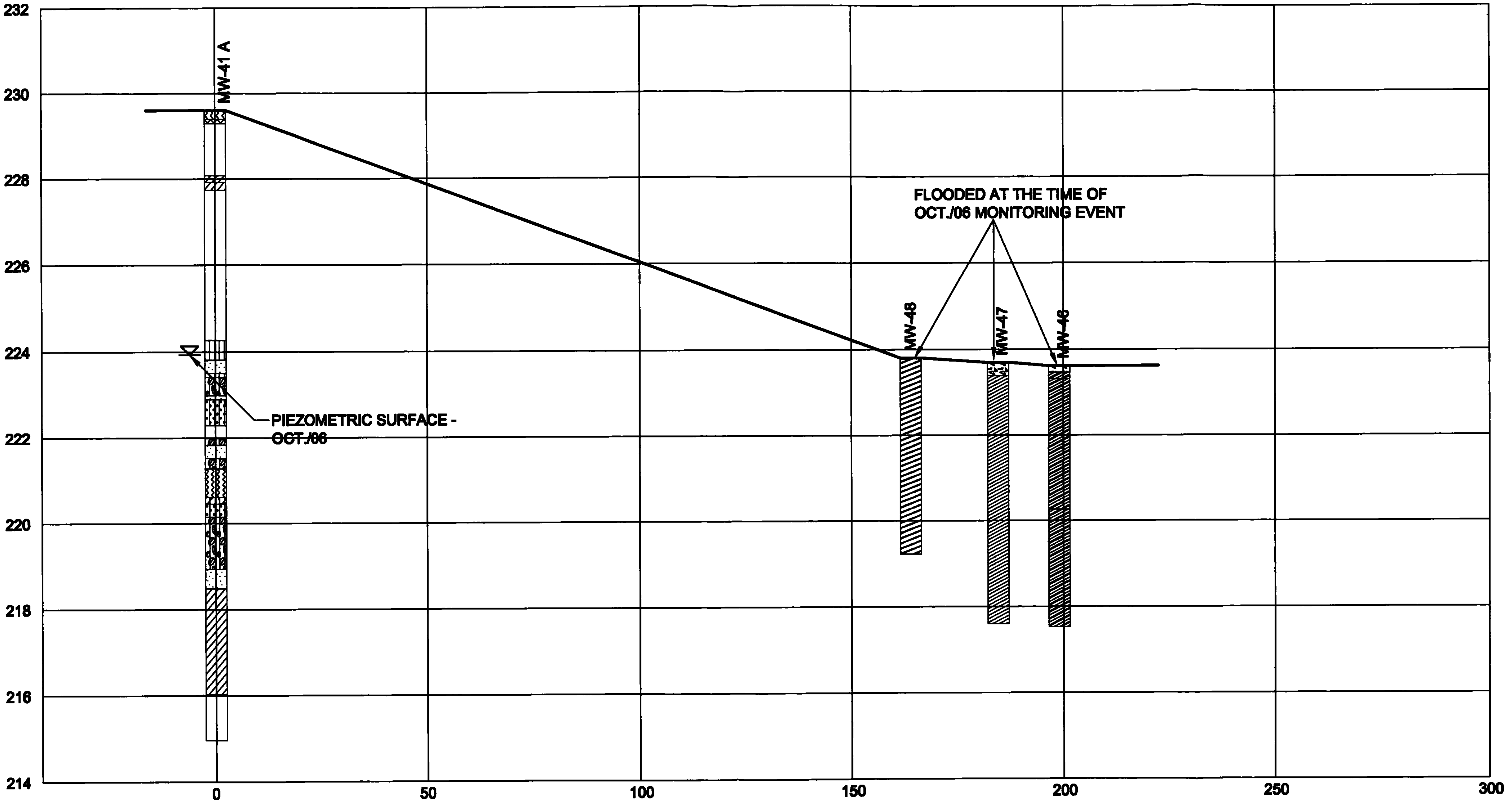

SECTION A 3-1

0 10 20 m H=1:1000
0 1 2 V=1:100

SOIL LEGEND

- ▨ INTERMEDIATE PLASTICITY CLAY
- ▨ LOW PLASTICITY CLAY
- ▦ CLAYEY SILT
- ▩ FILL
- ▦ POORLY-GRADED GRAVEL
- ▦ WELL-GRADED GRAVEL
- ▥ LOW PLASTICITY SILT
- ▦ ORGANICS
- ▦ SAND
- ▦ SANDY SILT
- ▦ SILTY SAND
- ☐ NO RECOVERY

Manitoba Hydro
Sutherland Management Plan
TAC Response

Representative Cross-Section - Upland Area - Section A

Figure 3-2

UMA | AECOM

B SIZE 11" x 17" (279.4mm x 431.8mm)
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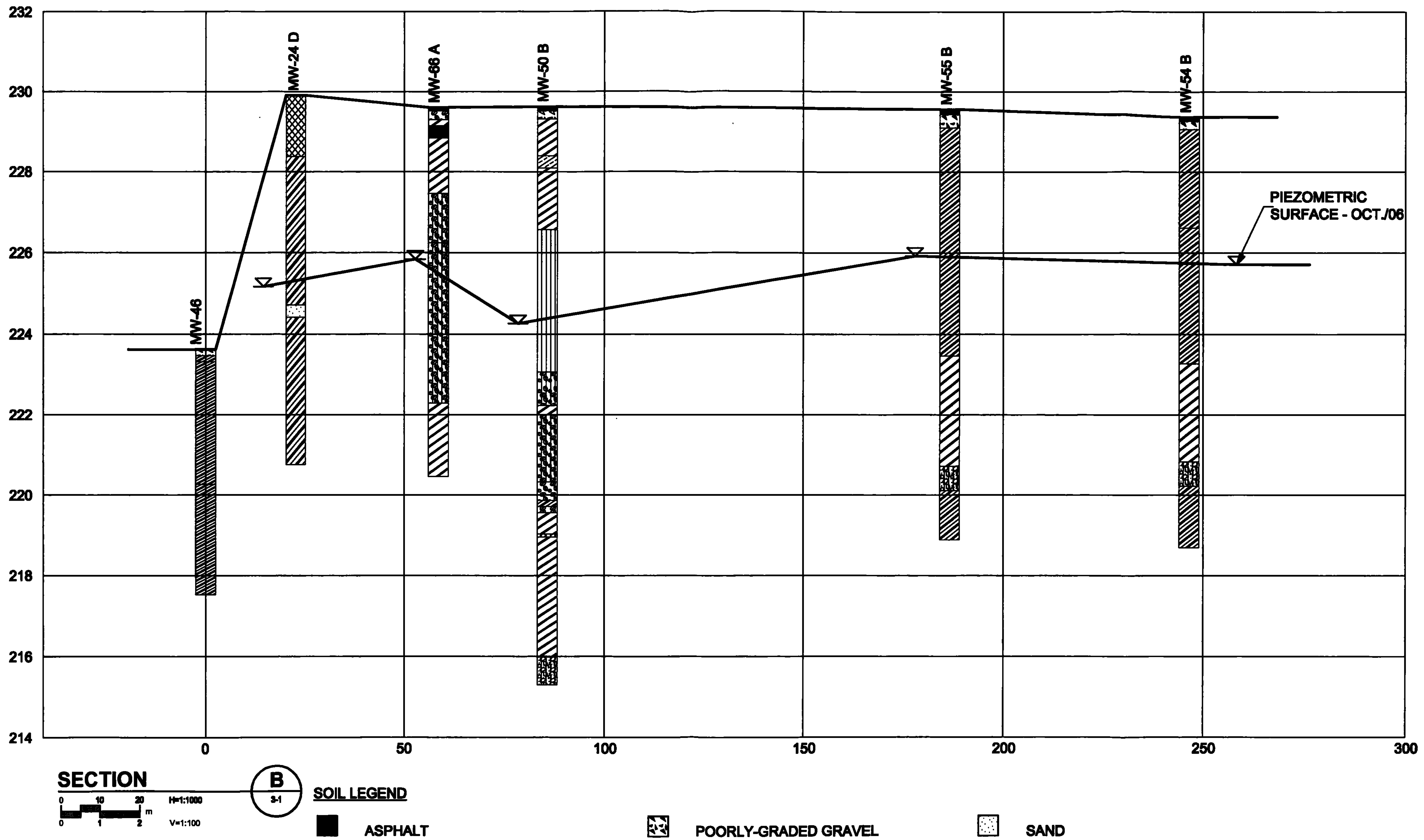

SOIL LEGEND

- ■ ASPHALT
- ▨ HIGH PLASTICITY CLAY
- ▨ INTERMEDIATE PLASTICITY CLAY
- ■ COAL
- ⊠ FILL
- ▨ POORLY-GRADED GRAVEL
- ▨ WELL-GRADED GRAVEL
- ▥ LOW PLASTICITY SILT
- ▨ HIGH PLASTICITY ORGANIC SILT OR CLAY
- ▨ SAND
- ▨ SILTY SAND
- ▨ POORLY-GRADED SAN
- ▨ TILL

Manitoba Hydro
Sutherland Management Plan
TAC Response

Representative Cross-Section - Upland Area - Section B

Figure 3-3

UMA | AECOM

B SIZE 11" x 17" (279.4mm x 431.8mm)

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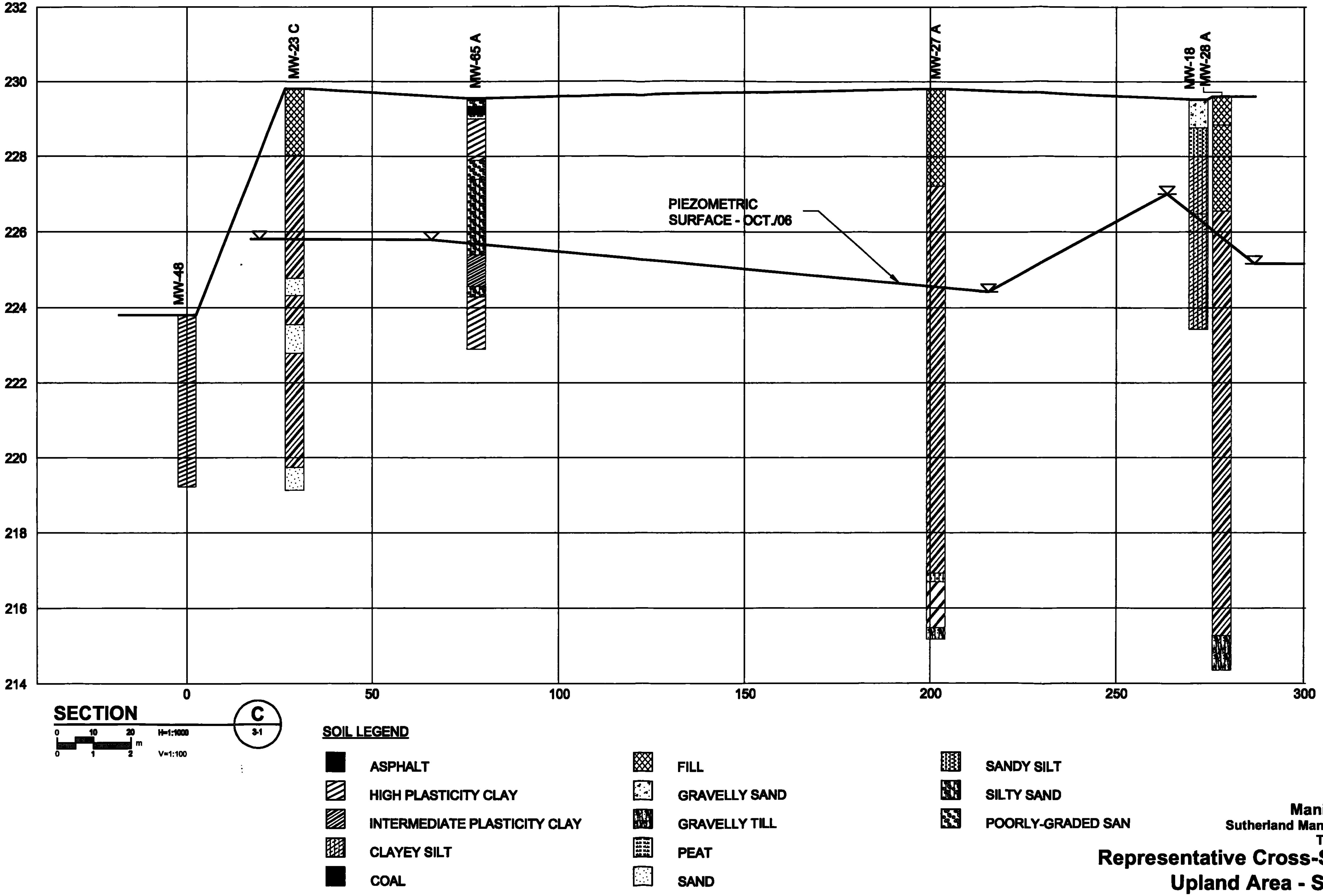

Manitoba Hydro
Sutherland Management Plan
TAC Response

Representative Cross-Section - Upland Area - Section C

Figure 3-4

UMA | AECOM

B SIZE 11" x 17" (279.4mm x 431.8mm)

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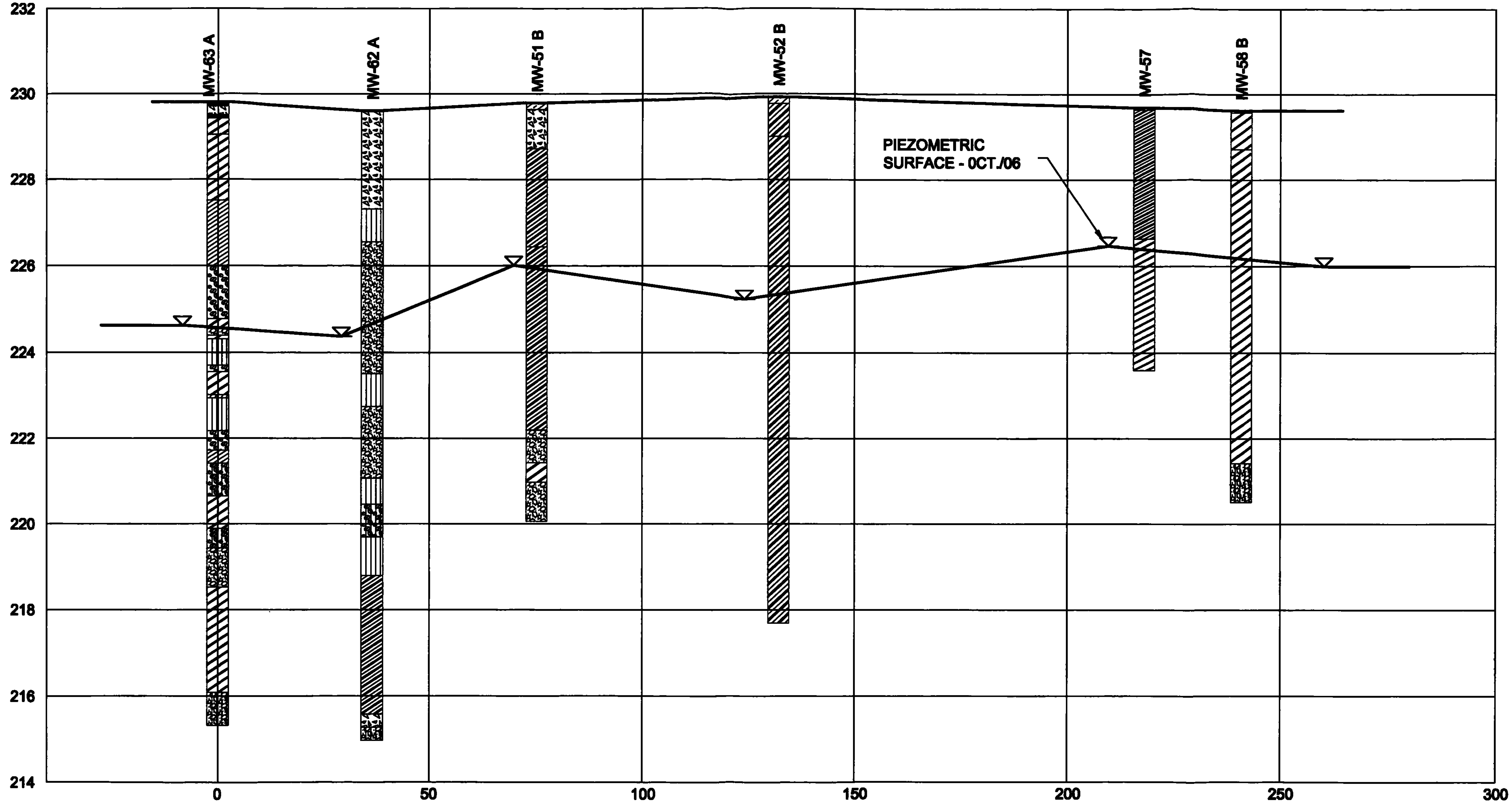

SECTION D 3-1

0 10 20 m H=1:1000
0 1 2 V=1:100

SOIL LEGEND

■ ASPHALT
▨ HIGH PLASTICITY CLAY
▨ LOW PLASTICITY CLAY
■ COAL
▨ WELL-GRADED GRAVEL
▥ LOW PLASTICITY SILT
▨ HIGH PLASTICITY ORGANIC SILT OR CLAY
▨ SILTY SAND
▨ POORLY-GRADED SAND
▨ WELL GRADED SAND
▨ TILL

Manitoba Hydro
Sutherland Management Plan
TAC Response

Representative Cross-Section - Upland Area - Section D

Figure 3-5

UMA | AECOM

B SIZE 11" x 17" (279.4mm x 431.8mm)

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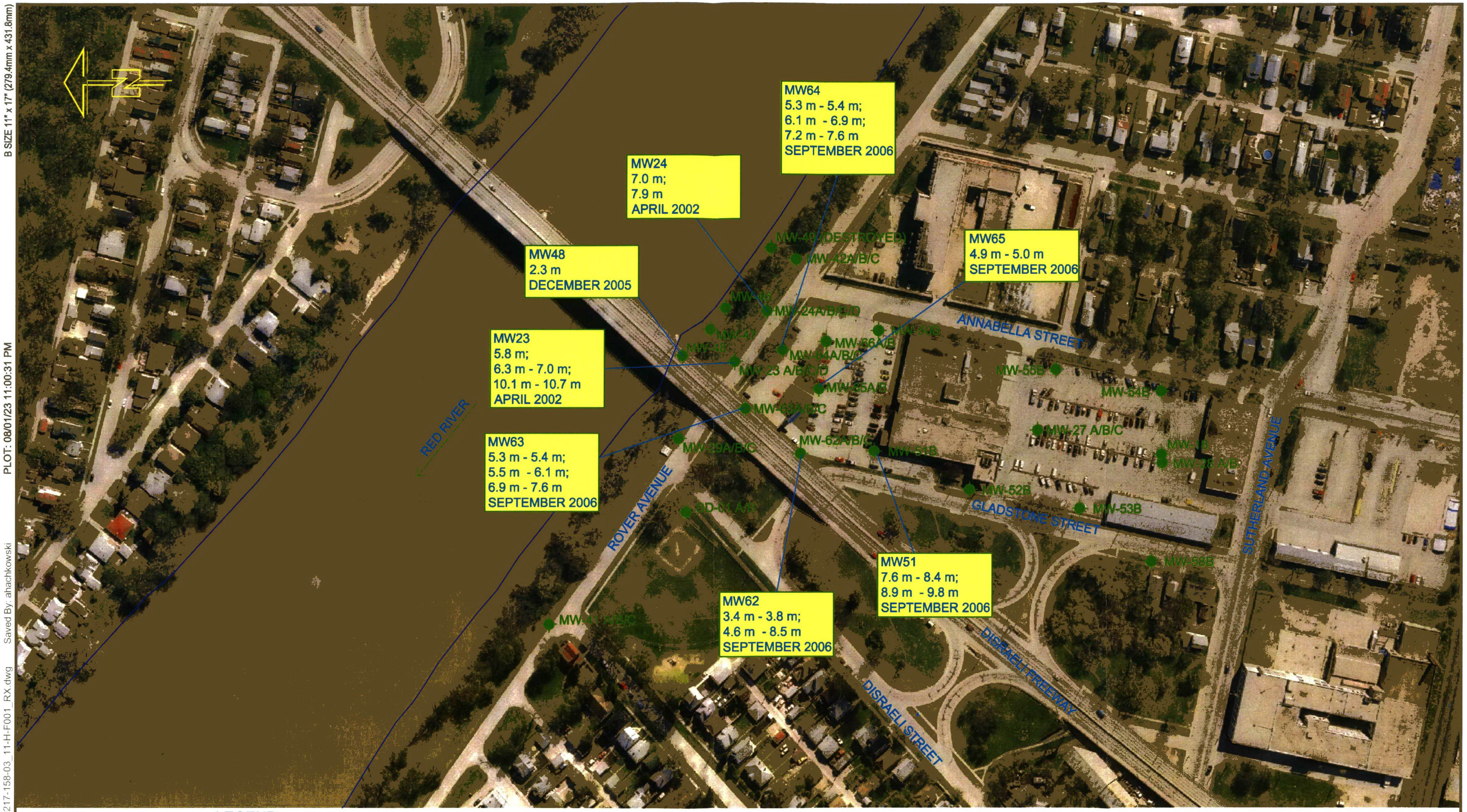

MW64
5.3 m - 5.4 m;
6.1 m - 6.9 m;
7.2 m - 7.6 m
SEPTEMBER 2006

MW24
7.0 m;
7.9 m
APRIL 2002

MW65
4.9 m - 5.0 m
SEPTEMBER 2006

MW48
2.3 m
DECEMBER 2005

MW23
5.8 m;
6.3 m - 7.0 m;
10.1 m - 10.7 m
APRIL 2002

MW63
5.3 m - 5.4 m;
5.5 m - 6.1 m;
6.9 m - 7.6 m
SEPTEMBER 2006

MW51
7.6 m - 8.4 m;
8.9 m - 9.8 m
SEPTEMBER 2006

MW62
3.4 m - 3.8 m;
4.6 m - 8.5 m
SEPTEMBER 2006

PLAN

0 20 40 m SCALE 1:2000

LEGEND

● GROUNDWATER MONITORING WELL/NEST

*TEXT BOXES INDICATE LOCATION, DEPTH (BELOW GRADE) OF OBSERVED COAL TAR SEEPAGE DURING DRILLING, AND THE DATE OF OBSERVATION.

UMA | AECOM

Manitoba Hydro
Sutherland Management Plan
TAC Response

Interpreted Spatial Extent of Coal Tar Contamination - Upland Area

Figure 3-6

B SIZE 11" x 17" (279.4mm x 431.8mm)

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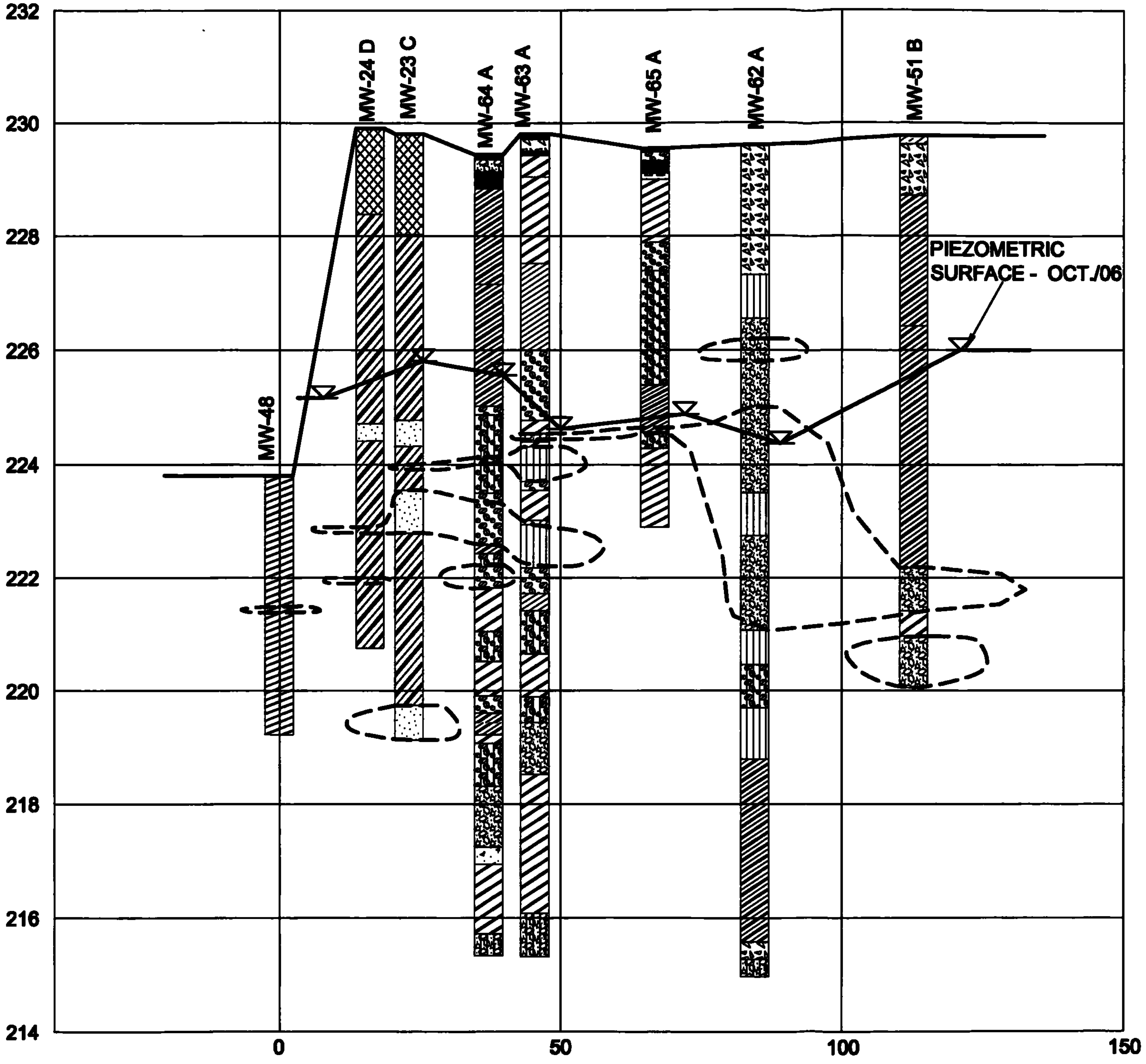

SECTION E 3-1

SOIL LEGEND

■ ASPHALT
▨ HIGH PLASTICITY CLAY
▨ INTERMEDIATE PLASTICITY CLAY
■ COAL
▨ GRAVELLY SAND
▦ PEAT
▩ SILTY SAND
▩ POORLY-GRADED SAND
▩ WELL GRADED SAND
▩ TILL

LEGEND

ZONE OF OBSERVED COAL TAR SEEPAGE
(AREA BETWEEN TEST HOLES INFERRED)

Manitoba Hydro
Sutherland Management Plan
TAC Response

Interpreted Spatial Extent of Coal Tar Contamination - Section E

Figure 3-7

UMA | AECOM

3.4.1 CH2M Hill, 1995

An off-site soil vapour survey was conducted for Centra Gas Manitoba Ltd. as part of the *Environmental, Health and Safety Assessment of the Sutherland Avenue Operations Facility in Winnipeg, Manitoba* (CH2M Hill, 1995). Seven boreholes were installed along the boulevard of Gladstone Street and nine along the boulevard of Annabella Street to determine whether soil gases characteristic of manufactured gas plant residues are present at and beyond the east and west property boundaries adjacent to areas of residential land use. A field vapour screening was completed and soil vapour samples were collected based on the screening results from five of the boreholes using special canisters. The results were compared to documented ambient air quality data for other urban centres, ambient air quality criteria and workplace air quality standards. The comparison with other urban centres suggests that although the soil gas levels are above ambient concentrations, they are not unusual relative to typical values in large urban environments. Soil gas concentrations were detected below the ambient air quality criteria and workplace air quality standards (Time Weighted Average).

The CH2M Hill (1995) work also included an evaluation of coal tar vapour transport along sewers and a possible off-site transport mechanism. Inspection of sewers indicated no impacts to the sewer system in the area. Gas samples were collected from four sewer manholes at or adjacent to the site, following an initial set of sewer inspections and confirmation of tributary origins. The sampled locations were (i) Rover Ave., west Disraeli overpass; (ii) Rover Ave, east side of Disraeli overpass; (iii) Rover and Annabella St; (iv) Gladstone near Centra Gas parking lot exit. Samples were evaluated for PAHs and BTEX. Only xylenes were detected, at a concentration marginally above the detection limit of 0.5 µg/charcoal tube. Estimated xylene concentrations were 0.034 to 0.067 mg/m^3, which is below the Time Weighted Average (TWA) exposure criteria for xylene of 434 mg/m^3 (American Conference of Governmental Industrial Hygienists, 1992).

3.4.2 UMA, 2006

The Remedial Monitoring (**RM**) Program established under the CEMP for residuals from historic 0perations at the Sutherland Avenue Former Manufactured Gas Plant provides for the ongoing monitoring of on-site and off-site soil vapour levels. Seven additional dedicated soil vapour probes were installed in 2006: three along the east side of the MH property and four along the west side of the property (UMA, 2006). Soil benzene concentrations exceeded the applicable CCME soil quality guidelines in a number of vapour probe locations. CCME soil quality guidelines for PAHs were exceeded in three of the vapour probe locations. Field screening was conducted and soil vapour samples were collected from all of the vapour probes using calibrated pumps and Carbotrap tubes.

The soil vapour results were compared to ambient air quality criteria and available guidelines and human inhalation reference values. Benzene values for all of the wells including the ambient air sample exceeded the air quality criteria and guidelines. The naphthalene and toluene results in all but one of the wells exceeded the criteria and guidelines.

The soil vapour data do not reflect the potential for vapour attenuation from the point of measurement to either the potential point of exposure above the ground surface or within onsite buildings, or laterally, including off-site areas. To better characterize potential off-site soil vapour intrusion risks, therefore, six additional dedicated soil vapour probes were installed farther out along possible subsurface contaminant transport pathways, towards adjacent residential areas. Three of the probes were installed along the boulevard of Gladstone Street and three along the boulevard of Annabella Street (UMA, 2007). The same sampling protocols and assessment criteria were used as employed in the UMA (2006) study. Soil concentrations of petroleum hydrocarbon (PHC) and PAHs were either lower than their laboratory minimum detection limits or the applicable CCME soil quality guidelines (residential). Laboratory analytical results for volatile contaminants of concern from all of the vapour probes were either at or below the laboratory minimum detection limits or below the applicable guidelines and human inhalation toxicity reference values.

The results of the soil vapour monitoring confirm that soil vapour concentrations within the property boundaries of the former Sutherland MG exceed criteria, guidelines and reference concentrations as a result of residual coal tar residues in subsurface soil. There does not appear to be any off-site migration of soil vapour, however, that would pose any public health risk or safety risk (i.e., based on explosion potential). Furthermore, the available data does not show evidence of any issues with indoor air quality at the Site. Quarterly monitoring of soil vapour is proposed in the Remedial Monitoring program for the former Sutherland MGP site.

4.0 Off-Site Contaminant Distribution

4.1 Issues Identified

Issues identified include –

- Use of generic sediment quality guidelines in the context of the Red River sediment assessment and risk assessment work;
- Applicability of individual PAHs as surrogates for coal tar releases to the Red River;
- Three dimensional distribution of coal tar in river sediments;
- Estimates of annual fluxes of dissolved-phased contaminants in groundwater from the Site to the Red River;
- Role of soil stratigraphy (especially glacial till) in groundwater-mediated contaminant transport;
- Adequacy of data on the water quality in the Red River near the Site;
- Spatial variation (especially between Site stations and upriver or downriver reference locations) in sediment PAH concentrations and benthos;
- Human health risks associated with dermal contact with river water and coal tar contaminated sediments near the Site.

The issues are discussed in a sequence relating the current upland source of contamination to the riverine environment, via groundwater-mediated transport. The current contaminated sediment distribution and expected fate is subsequently discussed along with implications for risks to humans or aquatic life.

> Section 4.2 re-visits groundwater contaminant flux estimates. The results of the 2006 groundwater monitoring are presented in Table 4-1, with the naphthalene concentrations in groundwater presented in Table 4-2. This data was used in the groundwater flux estimate, presented in Table 4-3. All remaining 2006 groundwater PAH results are presented in Table 4-4.
>
> Section 4.3 and Appendix A discuss expected toxicity to aquatic life based on laboratory toxicity test results of groundwater samples, and discusses use of fathead minnow fry versus rainbow trout fry in the monitoring program.
>
> Section 4.4 and Appendix B present new data for water quality in the Red River adjacent to the former MGP site.
>
> Section 4.5 provides further discussion of the spatial distribution of PAHs in the Red River.
>
> Section 4.6 reinforces the spatial analysis through presentation of three dimensional visualizations of the coal tar sediment plume.
>
> Section 4.7 discusses the CCME Sediment Quality Guidelines and relevance for use in assessing environmental quality in the Red River adjacent to the Site.

Section 4.8 discusses use of individual PAHs (naphthalene, benzo(a)pyrene and mixtures (PAH16[2]) as surrogates of the overall coal tar mixture in sediments.

Section 4.9 provides clarification of issues identified during TAC review of the ecological risk assessment component of the CEMP.

Section 4.10 discussed other potential sources of PAHs to the Red River in Winnipeg.

Section 4.11 provides new information on sediment – porewater partitioning of PAHs in coal tar contaminated samples from the Red River, and associated expectations for bioavailability and toxicity. In particular, this information is provided to provide a better understanding between causal links between the bulk sediment PAH concentrations and the results of the benthic faunal assessment completed in 2003 as part of the site-specific ecological risk assessment.

Section 4.12 presents the results and conclusions of a formal evaluation of human health risks associated with possible exposures to coal tar contaminated sediments adjacent to the Site.

4.2 PAH Loading Estimates to the Red River via Groundwater

At the request of the TAC, UMA/ENSR Corporation (ENSR) re-evaluated the predicted magnitude of groundwater-mediated flux of naphthalene to the Red River from the Site.

Hydraulic conductivity determinations were completed during the 2002 investigation on all of the installed monitoring wells to calculate the average linear groundwater velocity and groundwater flux across the riverbank boundary and ultimately the mass loading of contaminants into the river environment. The average linear groundwater velocity was determined to be 2.8×10^{-8} m/s and the groundwater flux estimated to be 9.6×10^{-6} m^3/s. Based on these values, the total volume of water passing through the impacted area along the river bank was estimated to be 300 m^3, or 300,000 litres, annually. Using the reported groundwater naphthalene concentrations along the riverbank, it was estimated that, based on the 2002 groundwater laboratory data, groundwater from the former MGP site contributes approximately 0.37 kg of naphthalene to the riverine environment each year.

TAC concerns were apparently predicated in part from a concern that a single point estimate of lateral hydraulic conductivity was used in the flux calculation. It should be noted, however, that the estimated flux was based on spatially representative estimates of groundwater contaminant concentrations and local hydraulic conductivity estimates for a line of wells close to the groundwater outflow face into the Red River.

Based on the groundwater analysis completed during the 2006 groundwater monitoring event, the mass loading of naphthalene from the site to the Red River was re-calculated in the same manner as that used as part of UMA's 2002 investigation. The mass loading was calculated using only the concentrations of naphthalene observed in the riverbank piezometers installed perpendicular to the direction of groundwater flow (5 monitoring wells including and between monitoring well MW-41 east to monitoring well MW-42). The flow at each piezometer location was calculated using the average value of the hydraulic conductivities measured at the site in 2002 (4.6×10^{-7} m/s), the measured hydraulic gradient between monitoring wells MW-18 and MW-23 B (0.007 m/m), and the cross-sectional area (thickness times width) of each set of nested piezometers. Based on the consistency of the soil stratigraphy in the

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[2] **PAH16** concentration is the total measured concentration of all commonly analyzed unsubstituted PAHs, including naphthalene, acenaphthene, acenaphthylene, fluorene, anthracene, phenanthrene, fluoranthene, pyrene, benzo(a)anthracene, chrysene, benzo(b)fluoranthene, benzo(k)fluoranthene, benzo(a)pyrene, benzo(ghi)perylene, indeno(123-cd)pyrene, and dibenz(ah)anthracene. These PAHs are referred to as the parent PAHs.

test holes completed in the 2006 subsurface and the stratigraphy observed during the historical investigations, the average hydraulic conductivity at the site would be on the order of the value calculated in 2002. The hydraulic gradient across the site was re-calculated based on the 2006 data, and the result was not appreciably different from the value calculated in 2002 (0.007 m/m in 2006 versus 0.006 m/m in 2006).

The thickness for the shallowest monitoring well was determined as the distance from the water table in the piezometer to the midpoint between the shallow and intermediate piezometer. The thickness for the intermediate monitoring well is measured as the distance from the midpoint between the shallow and intermediate monitoring wells and the intermediate and deep monitoring wells. The thickness for the deepest monitoring well is measured as the distance from the midpoint between the intermediate and deep monitoring well to the base of the deepest piezometer. In each case, the midpoint is measured between the midpoints of any two screened intervals.

The width assigned to each nest of piezometers was calculated as the distance between the midpoint of one piezometer nest to the midpoint to the next. In the case of monitoring wells MW-41 and MW-42, the plume was assumed to extend a nominal distance of 30 m to the west and east, respectively.

The groundwater flux at each point (in m^3/s) was calculated by multiplying the hydraulic conductivity by the gradient and the area. The mass loading of naphthalene at each point was determined by multiplying the reported naphthalene concentration in each monitoring well by the flow rate (groundwater flux converted to L/year) at each point. The total mass loading was calculated by summing the individual mass loading values. Based on the above calculations, the total naphthalene loading to the Red River was calculated to be approximately 0.33 kg/year, similar to the value of 0.37 kg/year calculated in 2002. A summary of the naphthalene mass loading is included in Table 4-3.

The mass loading could not be calculated at monitoring wells MW-23D or MW-24D as no groundwater samples were collected at these locations. This was due to the presence of minute globules of product sorbed to the sediment present at the base of these piezometers. As shown in Table 4-3, monitoring well MW-23D was screened from 6.7 m to 8.2 m below grade and MW-24D was screened from 7.6 m to 9.1 m below grade. The screened interval in each well is situated within a soil unit in which coal tar was observed during drilling (sand from 6.3 m to 7.0 m in MW-23D and a sand seam at 7.9 m in MW-24D). There has never been a measurable thickness of free product in either of these monitoring wells either in 2006 or during other observational periods. The observed quantity of product in these wells is of minimal significance at this time and would not likely impact the overall naphthalene mass loading to downgradient receptors. Continued groundwater monitoring at these locations will indicate the validity of this assumption.

In order to assess the horizontal and vertical groundwater flow regimes at the site, several nested piezometers have been installed, particularly in the northern portion of the property where the soil stratigraphy is more complex. At the time of the 2006 groundwater monitoring event, the piezometric elevations at the site ranged from 223.908 m in monitoring well MW-29B to 227.715 m in monitoring well MW-27B (2.068 m to 6.026 m below grade). Historically, four (4) separate flow pathways have been observed at the site, influenced by the upper clay/silt units, the distinct sand layers present in the clay unit, the glacial till unit, and the carbonate bedrock. Sufficient site information was available to generate groundwater contours for the flow within the clay/silt, sand, and till layers. The inferred groundwater contours are presented on Figures 4-1, 4-2, and 4-3.

4.2.1 Horizontal Flow Regime

Based on the generated contours, the approximate horizontal hydraulic gradient within the clay/silt layer ranges from 0.009 m/m to 0.03 m/m. Using an average hydraulic conductivity of 5.7×10^{-7} m/s, as calculated from the results of bail tests completed at the site in 2002, and a conservative effective porosity estimate of 10%, the advective velocity within the clay/silt subunit is on the order of 2 m/year to 5 m/year. The inferred groundwater contours for the clay/silt subunit are shown on Figure 4-1.

Within the discrete sand layers encountered, primarily in the northern portion of the site, the approximate horizontal hydraulic gradient is on the order of 0.004 m/m to 0.02 m/m. The corresponding horizontal hydraulic conductivity in the sand subunit is approximately 3.3 x 10^{-6} m/s, and using an effective porosity of 30%, the advective velocity within the sand is on the order of 1 m/year to 7 m/year. The inferred groundwater contours for the sand subunit are shown on Figure 4-2.

The calculated gradient within the till subunit is similar to that calculated in both the clay/silt and sand subunits, ranging from approximately 0.004 m/m to 0.01 m/m across the site. The estimated hydraulic conductivity of the glacial till, is on the order of 4 x 10^{-7} m/s. Using the aforementioned gradient range and hydraulic conductivity, and assuming a conservative porosity of 30%, the advective velocity within the till subunit is estimated to be approximately 0.2 to 0.4 m/year. The inferred groundwater contours for the glacial till are shown on Figure 4-3.

For each of the above flow pathways, the direction of groundwater and contaminant flow is towards the Red River, as expected. Based on the above calculations, the preferential flow pathway is likely through the sand subunit.

4.2.2 Vertical Flow Regime

Vertical hydraulic gradients and flow directions were calculated for each of the piezometer nests completed at the site. The vertical gradients were calculated to assess the potential for downward migration of contaminants from one depth to another within the lacustrine subunit; from the lacustrine subunit to the glacial till unit; and from the glacial till unit to the carbonate bedrock. The calculation of the vertical gradients was taken from the midpoint of the screened interval of one piezometer to another, starting with the shallowest piezometer installation. The calculations were based on the results of the 2006 groundwater monitoring event. Figure 4-4 illustrates the method of calculating the vertical hydraulic gradient within a piezometer nest, using the data from monitoring well MW-62A/B/C as an example.

Within the lacustrine subunit, the estimated vertical gradient ranges from approximately 0.02 m/m to 0.06 m/m. With the exception of the gradient between monitoring wells MW-42 B and MW-42C, all of the shallow vertical gradients are downward. The vertical gradient between the lacustrine and glacial till subunits is more variable, ranging from approximately 0.04 m/m to 0.4 m/m. The vertical gradients calculated through the transition zone from the clay/silt/sand to the silt till unit were all downward. Between monitoring well MW-41A, screened in glacial till, and monitoring well BW-46, screened in the carbonate bedrock, the vertical gradient was calculated to be 0.03 m/m, upwards.

Groundwater flow within the overburden is a combination of lateral towards the river and downwards toward the till unit. The river is a significant influence on groundwater flow and is expected to be a discharge boundary for all overburden groundwater flow. The river will also be a discharge boundary for flow from the shallow bedrock aquifer.

Table 4-1 provides a summary of the available site groundwater data, including sampling date, soils description around screened section, water level, and calculated hydraulic conductivities from field observations. Subsurface soils vary from sands with fines (e.g., BD01B, MW-23C and D, MW-41C) to clay/till (e.g., BD-01A, MW23-A). Calculated hydraulic conductivities of 25 different piezometers fell in the range of 5.5x10^{-9} to 4.8x10^{-6} m/s (Table 4-1).

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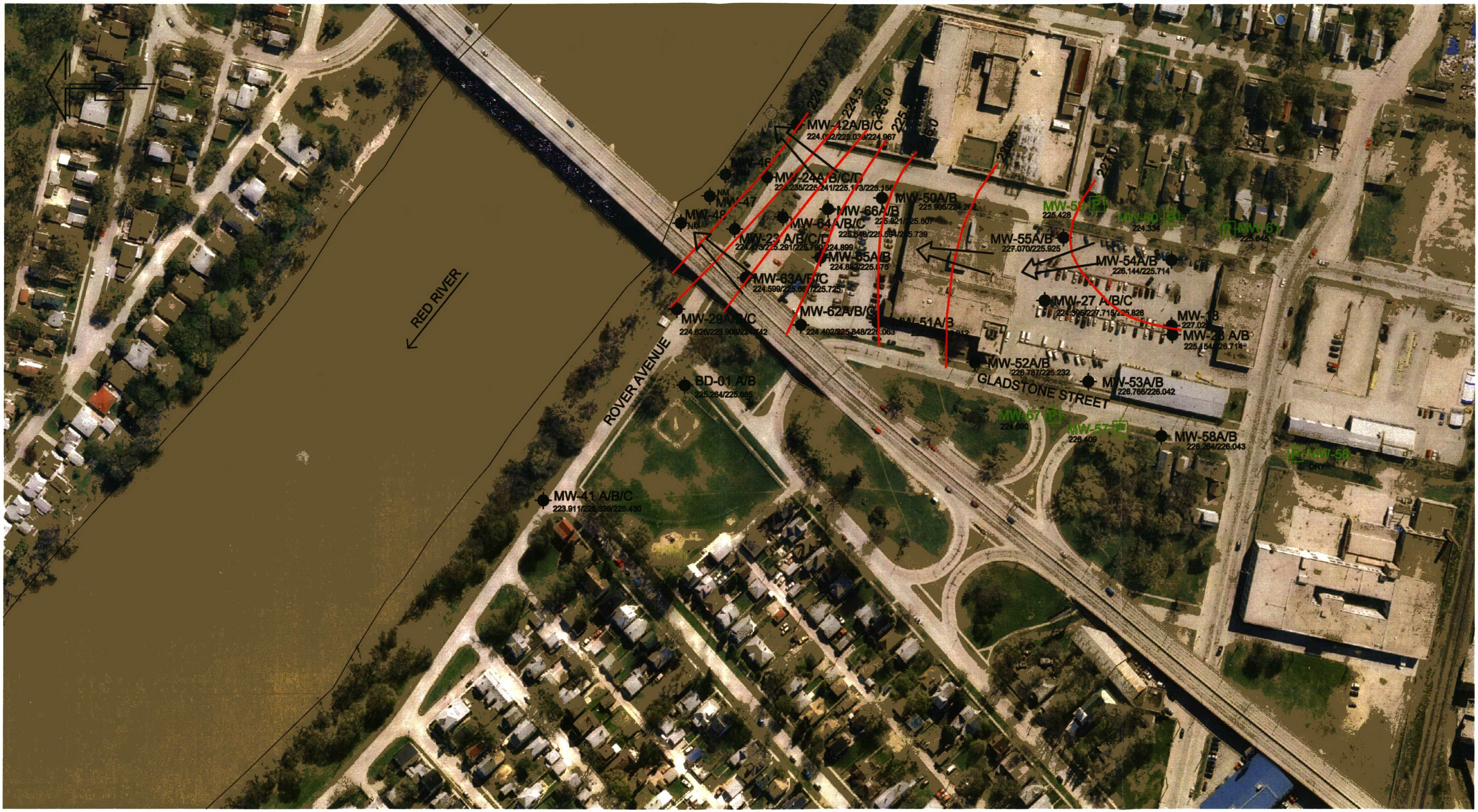

PLAN

0 20 40 m SCALE 1:2000

LEGEND

● GROUNDWATER MONITORING WELL/NEST

⊕ DESTROYED MONITORING WELL

224.0 GROUNDWATER CONTOUR (IN METRES)

P VAPOUR PROBE (INCLUDING MW-50A, MW-51A, MW-52A, MW53A, MW54A, MW55A, MW-56, MW-57, MW-58A, MW-59, MW-60, MW-61, MW-67)

⇐ GROUNDWATER FLOW DIRECTION

NM - NOT MONITORED (FLOODED)

Manitoba Hydro
Sutherland Management Plan
TAC Response

Groundwater Contours and Flow Direction Wells Screened in Upper Clay/Silt

Figure 4-1

UMA | AECOM

PLAN

SCALE 1:2000

LEGEND

- ● GROUNDWATER MONITORING WELL/NEST
- DESTROYED MONITORING WELL
- 224.0 GROUNDWATER CONTOUR (IN METRES)
- P VAPOUR PROBE (INCLUDING MW-50A, MW-51A, MW-52A, MW53A, MW54A, MW55A, MW-56, MW-57, MW-58A, MW-59, MW-60, MW-61, MW-67)
- ⟵ GROUNDWATER FLOW DIRECTION
- NM - NOT MONITORED (FLOODED)

Manitoba Hydro
Sutherland Management Plan
TAC Response

Groundwater Contours and Flow Direction
Wells Screened in Sand

Figure 4-2

UMA | AECOM

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PLAN

0 20 40 m SCALE 1:2000

LEGEND

● GROUNDWATER MONITORING WELL/NEST

DESTROYED MONITORING WELL

224.0 GROUNDWATER CONTOUR (IN METRES)

P VAPOUR PROBE (INCLUDING MW-50A, MW-51A, MW-52A, MW53A, MW54A, MW55A, MW-56, MW-57, MW-58A, MW-59, MW-60, MW-61, MW-67)

← GROUNDWATER FLOW DIRECTION

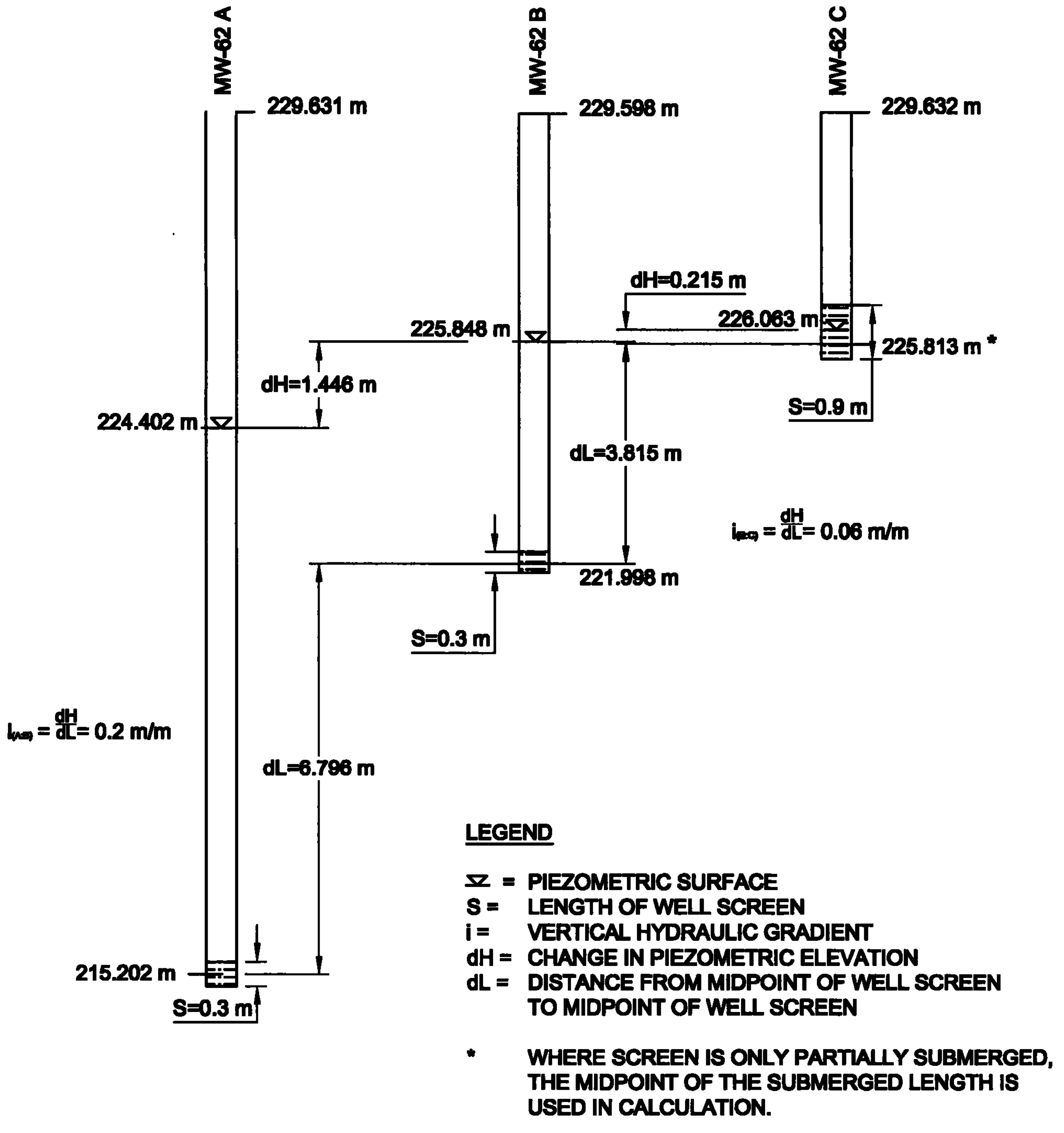
NM - NOT MONITORED (FLOODED)

UMA | AECOM

Manitoba Hydro
Sutherland Management Plan
TAC Response

Groundwater Contours and Flow Direction Wells Screened in Till

Figure 4-3



Manitoba Hydro
Sutherland Management Plan
TAC Response

Representation of Vertical Gradient in MW-62A/B/C

UMA | AECOM

Figure 4-4

UMA FILE NAME: 0217-158-03_09-H-F010_RX.dwg Saved By: ahachkowski PLOT: 08/01/24 9:52:57 PM A SIZE 8.5" x 11" (215.9mm x 279.4mm)

Table 4-1: Summary of Groundwater Monitoring Field Data

Monitor-ing Location	Date of Installation	Reference Elevation (m) (Ground)	Refer-ence Elevation (m) (TOP)	Monitoring Date	Piezometric Elevation (m)	Screened Interval (m)	Hydraulic Conductivity (m/s)	Well Sampled (Y/N)
BD-01A	2-Apr-02	228.988	228.924	12-Oct-06	225.264	12.2 - 15.2	7.335e-08	Y
BD-01B	2-Apr-02	228.988	228.945	12-Oct-06	225.685	7.0 - 9.1	4.336e-06	Y
MW-18	29-Sep-93	229.524	229.309	13-Oct-06	227.029	1.8 - 4.9	1.006e-06	Y
MW-23A	8-Jun-94	229.779	229.733	12-Oct-06	224.473	13.7 - 15.2	4.772e-07	Y
MW-23B	8-Jun-94	229.799	229.681	12-Oct-06	225.291	3.7 - 6.7	8.507e-07	Y
MW-23C	30-Apr-02	229.783	229.730	12-Oct-06	225.790	9.1 - 10.7	6.112e-06	Y
MW-23D	30-Apr-02	229.785	229.639	12-Oct-06	224.899	6.7 - 8.2	4.484e-06	N[1]
MW-24A	10-Jun-94	229.878	229.835	11-Oct-06	225.235	13.4 - 14.8	8.132e-07	Y
MW-24B	10-Jun-94	229.861	229.766	11-Oct-06	225.241	10.8 - 12.4	5.452e-06	Y
MW-24C	10-Jun-94	229.971	229.813	11-Oct-06	225.173	3.5 - 6.6	2.366e-06	Y
MW-24D	30-Apr-02	229.889	229.826	11-Oct-06	225.156	7.6 - 9.1	5.229e-07	N[1]
MW-27A	29-Apr-02	229.776	229.675	13-Oct-06	224.395	13.1 - 14.6	3.577e-08	Y
MW-27B	29-Apr-02	229.783	229.695	13-Oct-06	227.715	9.1 - 10.7	4.751e-06	Y
MW-27C	29-Apr-02	229.785	229.676	13-Oct-06	225.826	4.6 - 6.1	6.904e-08	Y
MW-28A	29-Apr-02	229.591	229.539	13-Oct-06	225.154	13.1 - 14.6	6.562e-07	Y
MW-28B	29-Apr-02	229.637	229.574	13-Oct-06	226.714	7.6 - 9.1	5.539e-09	Y
MW-29A	30-Apr-02	229.872	229.806	12-Oct-06	224.626	13.1 - 14.6	3.774e-07	Y
MW-29B	30-Apr-02	229.934	229.888	12-Oct-06	223.908	7.8 - 9.3	7.958e-07	Y
MW-29C	30-Apr-02	229.950	229.942	12-Oct-06	224.742	4.1 - 5.6	6.767e-07	Y
MW-41A	24-Oct-02	229.586	229.551	12-Oct-06	223.911	13.1 - 14.6	5.012e-07	Y
MW-41B	24-Oct-02	229.572	229.474	12-Oct-06	225.339	9.8 - 11.2	1.204e-08	Y
MW-41C	24-Oct-02	229.568	229.520	12-Oct-06	225.430	5.8 - 7.3	9.472e-07	Y
MW-42A	24-Oct-02	229.184	229.142	12-Oct-06	224.092	13.1 - 14.6	3.096e-07	Y
MW-42B	24-Oct-02	229.140	229.124	12-Oct-06	225.039	9.1 - 10.7	4.787e-08	Y
MW-42C	24-Oct-02	229.197	229.182	12-Oct-06	224.967	6.1 - 7.6	2.878e-07	Y
MW-46	12-Dec-05	223.620	223.513			1.5 - 6.1		Y
MW-47	12-Dec-05	223.696	223.524			1.5 - 6.1		Y
MW-48	12-Dec-05	223.799	223.731			1.5 - 4.6		Y
MW-49	12-Dec-05					**Destroyed**		
MW-50A	12-Dec-05	229.592	229.465	13-Oct-06	225.905	1.5 - 6.1		N[2]
MW-50B		229.620	229.447	13-Oct-06	224.262	14.0 - 14.3		Y
MW-51A	13-Dec-05	229.765	229.669	13-Oct-06	226.019	1.5 - 6.1		N[2]
MW-51B		229.782	229.672	13-Oct-06	226.012	9.1 - 9.8		Y
MW-52A	13-Dec-05	229.917	229.837	13-Oct-06	226.787	1.5 - 6.1		N[2]
MW-52B		229.917	229.762	13-Oct-06	225.232	10.7 - 12.2		Y
MW-53A	13-Dec-05	229.993	229.886	13-Oct-06	226.766	1.5 - 6.1		N[2]
MW-53B		229.993	229.912	13-Oct-06	226.042	9.1 - 10.7		Y
MW-54A	13-Dec-05	229.361	229.244	13-Oct-06	226.144	1.5 - 6.1		N[2]
MW-54B		229.361	229.284	13-Oct-06	225.714	9.1 - 10.7		Y
MW-55A	13-Dec-05	229.556	229.460	13-Oct-06	227.070	1.5 - 6.1		N[2]
MW-55B		229.556	229.495	13-Oct-06	225.925	9.1 - 10.7		Y
MW-56	13-Dec-05	229.901	229.839	13-Oct-06		1.5 - 6.1		N[2]

Monitor-ing Location	Date of Installation	Reference Elevation (m) (Ground)	Refer-ence Elevation (m) (TOP)	Monitoring Date	Piezometric Elevation (m)	Screened Interval (m)	Hydraulic Conductivity (m/s)	Well Sampled (Y/N)
MW-57	14-Aug-06	229.622	229.584	11-Oct-06	226.409	1.5 - 6.1		N[2]
MW-58A	14-Aug-06	229.607	229.499	11-Oct-06	226.264	1.5 - 6.1		N[2]
MW-58B		229.619	229.613	11-Oct-06	226.043	10.4 - 10.7		Y
MW-59	15-Aug-06	229.140	229.053	11-Oct-06	225.428	1.5 - 6.1		N[2]
MW-60	15-Aug-06	229.189	229.139	11-Oct-06	224.334	1.5 - 6.1		N[2]
MW-61	15-Aug-06	229.364	229.235	11-Oct-06	225.645	1.5 - 6.1		N[2]
MW-62A	7-Sep-06	229.631	229.552	12-Oct-06	224.402	14.2 - 14.5		Y
MW-62B	7-Sep-06	229.598	229.508	12-Oct-06	225.848	7.3 - 7.6		Y
MW-62C	7-Sep-06	229.632	229.563	12-Oct-06	226.063	3.1 - 4.0		Y
MW-63A	25-Sep-06	229.776	229.699	12-Oct-06	224.599	14.2 - 14.5		Y
MW-63B	25-Sep-06	229.777	229.677	12-Oct-06	225.667	6.7 - 7.3		N[1]
MW-63C	25-Sep-06	229.775	229.670	12-Oct-06	225.725	5.2 - 5.5		Y
MW-64A	27-Sep-06	229.530	229.421	12-Oct-06	225.646	11.6 - 12.5		Y
MW-64B	27-Sep-06	229.499	229.329	12-Oct-06	225.594	6.1 - 6.7		Y
MW-64C	27-Sep-06	229.531	229.374	12-Oct-06	225.739	4.6 - 5.3		Y
MW-65A	28-Sep-06	229.550	229.463	12-Oct-06	224.883	8.2 - 9.1		Y
MW-65B	28-Sep-06	229.547	229.355	12-Oct-06	225.875	4.3 - 5.2		Y
MW-66A	28-Sep-06	229.581	229.471	12-Oct-06	225.821	8.5 - 9.1		Y
MW-66B	28-Sep-06	229.590	229.502	12-Oct-06	225.807	3.6 - 4.6		Y
MW-67[3]	14-Aug-06	230.346	230.305	11-Oct-06	224.690	1.5 - 20		N[2]

Notes:

[1] No sample taken - minute globules of free product sorbed to sediment at base of well.

[2] No sample taken - vapour probe

[3] Formerly called MW06-56

Table 4-2: Summary of Groundwater Naphthalene Results (ug/L) Former Sutherland MGP, Winnipeg, Manitoba

Monitoring Well I.D.	Sampling Date										
	Oct-93	Jun-94	Aug-94	Dec-96	Mar-97	May-97	Jun-97	Oct-99	Oct-02	Apr-05	Oct-06
BD-01A									0.21	--	0.23
BD-01B									11	--	10
BW-46									<0.05	--	--
MW-01	0.044	0.457	0.065	Assumed Destroyed							
MW-02	2.63	0.831	Destroyed								
MW-03	3150	13400	6650	Destroyed							
MW-05	1.3	6390	2.43	130	39	3100	2700	3400	Assumed Destroyed		
MW-12	7.81	39.4	6.09	--	--	--	--	95	Assumed Destroyed		
MW-14	3330	15614		200	1200	3200	6300	8200	Assumed Destroyed		
MW-18	--	2.43	5.47	--	--	--	--	1.48	1020	--	5.2
MW-21		0.03	--	--	--	--	--	ND	Assumed Destroyed		
MW-22	11.1	13600	--	--	--	--	--	8800	Assumed Destroyed		
MW-23A		0.436	0.488	--	--	--	--	0.577	2720	--	1300
MW-23B		22800	12400	--	--	--	--	7100	9120	--	12000
MW-23C									6830	5400	5200
MW-23D									10100	6000	FP
MW-24A	0.399	0.018	--	--	--	--	--	131	<0.1	--	0.29
MW-24B		0.084	--	--	--	--	--	--	12	--	7300
MW-24C		3090	3030	--	--	--	--	790	10	--	3800
MW-24D									3610	4100	FP
MW-27A									0.45	--	0.001
MW-27B									0.097	--	0.11
MW-27C									<0.1	--	0.25
MW-28A									<0.1	--	0.57
MW-28B									0.091	--	660
MW-29A									0.059	--	7.3
MW-29B									78	--	140
MW-29C									3020	--	2800
MW-41A									1.3	--	0.28
MW-41B									0.23	--	0.14
MW-41C									0.16	--	0.14
MW-42A									12	--	<0.05
MW-42B									23	--	31
MW-42C									2030	--	6.3
MW-46											0.86
MW-47											0.08
MW-48											8600
MW-50B											0.32
MW-51B											10000
MW-52B											<0.05
MW-53B											0.3
MW-54B											0.23
MW-55B											970
MW-58B											1.6
MW-62A											7.5
MW-62B											0.27
MW-62C											670
MW-63A											3.9
MW-63C											9900
MW-64A											2.7
MW-64B											6100
MW-64C											630
MW-65A											830
MW-65B											150
MW-66A											<5
MW-66B											220

Notes:

-- indicates Not Monitored

ND indicates Not Detected (AMEC)

FP-minute globules of free product sorbed to sediment at base of monitoring well

Table 4-3: Naphthalene Mass Loading, Former Sutherland MGP, Winnipeg, Manitoba

Well Location	Piezometer	Depth of Well Screen (m)	Screened Material	Naphthalene Concentration (mg/L)	Thickness (m)	Width (m)	Area (m^2)	Groundwater Flux (m^3/s)	Flow Rate (L/yr)	Mass Loading	
										(mg/yr)	(kg/yr)
MW-41	A	13.1 - 14.6	silt till	0.00028	2.4	80	193.4	6.23E-07	1.96E+04	5.50E+00	5.50E-06
	B	9.8 - 11.2	sand and silt	0.00014	3.6		291.3	9.38E-07	2.96E+04	4.14E+00	4.14E-06
	C	5.8 - 7.3	sand	0.00014	4.4		350.8	1.13E-06	3.56E+04	4.99E+00	4.99E-06
BD-01	A	12.2 - 15.2	clay/till	0.00023	4.3	70	302.8	9.75E-07	3.07E+04	7.07E+00	7.07E-06
	B	7.0 - 9.1	sand	0.01	7.6		530.0	1.71E-06	5.38E+04	5.38E+02	5.38E-04
MW-29	A	13.1 - 14.6	silt till/silty clay	0.0073	3.4	45	154.4	4.97E-07	1.57E+04	1.14E+02	1.14E-04
	B	7.8 - 9.3	silty clay (sand seam)	0.14	4.5		204.3	6.58E-07	2.07E+04	2.90E+03	2.90E-03
	C	4.1 - 5.6	clay (sand seams)	2.8	1.5		67.5	2.17E-07	6.85E+03	1.92E+04	1.92E-02
MW-23	A	13.7 - 15.2	silty clay/silt till	1.3	3.0	45	136.2	4.39E-07	1.38E+04	1.80E+04	1.80E-02
	B	3.7 - 6.7	sandy silt/silty clay	12	1.8		82.1	2.64E-07	8.33E+03	1.00E+05	1.00E-01
	C	9.1 - 10.7	sand/sand seams	5.2	3.5		157.6	5.08E-07	1.60E+04	8.32E+04	8.32E-02
	D	6.7 - 8.2	sand/sand seams	NM	2.4		106.1	3.42E-07	1.08E+04	NM	NM
MW-24	A	13.4 - 14.8	silt till/silty clay	0.00029	1.9	35	68.0	2.19E-07	6.90E+03	2.00E+00	2.00E-06
	B	10.8 - 12.4	sand	7.3	2.9		100.8	3.25E-07	1.02E+04	7.47E+04	7.47E-02
	C	3.5 - 6.6	sandy silt w/ sand	3.8	1.9		68.0	2.19E-07	6.91E+03	2.62E+04	2.62E-02
	D	7.6 - 9.1	clay/sand seams	NM	3.3		116.6	3.75E-07	1.18E+04	NM	NM
MW-42	A	13.1 - 14.6	silt till	0.00005	2.7	45	121.6	3.92E-07	1.24E+04	6.18E-01	6.18E-07
	B	9.1 - 10.7	sand	0.031	3.5		157.7	5.08E-07	1.60E+04	4.96E+02	4.96E-04
	C	6.1 - 7.6	sand	0.0063	4.2		187.8	6.05E-07	1.91E+04	1.20E+02	1.20E-04
						Total Area:	3397 m^2			**Total Mass:**	0.33 kg/y

NM - not measured; globules of product sorbed to sediment at the base of piezometer. No measurable free product thickness.

Hydraulic Conductivity (m/s) = 4.60E-07

Hydraulic Gradient (m/m) = 0.007

Table 4-4: Summary of 2006 Groundwater PAH Results Former Sutherland MGP, Winnipeg, Manitoba

Parameter	MDL	CCME[1] (ug/L)	Well/Sample ID								
			BD-01A 06/10/26	BD-01B 06/10/26	MW-18 06/10/27	MW-23A 06/10/26	MW-23B 06/10/26	MW-23C 06/10/26	MW-24A 06/10/26	MW-24B 06/10/26	MW-24C 06/10/26
Acridine	0.01	**4.4**	<0.1	<0.01	<0.1[2]	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	0.01	**0.018**	<0.1	<0.01	**0.1[2]**	**0.16**	**17**	**0.04**	**0.13**	**0.80**	**0.26**
Benzo(b)fluoranthene	0.01	**--**	<0.1	<0.01	0.3[2]	0.11	19	0.03	0.16	0.65	0.06
Benzo(k)fluoranthene	0.01	**--**	<0.1	<0.01	<0.1[2]	0.03	4.5	<0.01	0.05	0.17	0.02
Benzo(a)pyrene	0.01	**0.015**	<0.1	<0.01	**0.2[2]**	**0.17**	**22**	**0.04**	**0.17**	**0.73**	**0.07**
Fluoranthene	0.01	**0.04**	<0.1	<0.01	**0.4[2]**	**0.43**	**31**	**0.31**	**0.33**	**3.6**	**4.9**
Dibenzo(ah)anthracene	0.01	**--**	<0.1	<0.01	<0.1[2]	0.03	2.6	<0.01	0.05	0.19	0.01
Indeno(1,2,3 cd)pyrene	0.01	**--**	<0.1	<0.01	0.3[2]	0.16	15	0.03	0.21	0.47	0.06
Pyrene	0.01	**0.025**	<0.1	<0.01	**0.3[2]**	**0.61**	**41**	**0.36**	**0.48**	**4.4**	**4.1**
Quinoline	0.01	**3.4**	<0.1	<0.01	<0.1[2]	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	0.05	**1.1**	0.23	**10**	**5.2[3]**	**1300**	**12000**	**5200**	0.29	**7300**	**3800**

Notes:
1 - CCME Water Quality Guidelines for Freshwater Aquatic Life, December 2006
2 - MDL = 0.1
3 - MDL = 0.5
4 - MDL = 1.0
5 - MDL = 5.0
Bold and shaded indicates a parameter exceedance.

Table 4-4: Summary of 2006 Groundwater PAH Results Former Sutherland MGP, Winnipeg, Manitoba

Parameter	MDL	CCME[1] (ug/L)	Well/Sample ID								
			MW-27A	MW-27B	MW-27C	MW-28A	MW-28B	MW-29A	MW-29B	MW-29C	MW-41A
			06/10/27	06/10/27	06/10/27	06/10/27	06/10/27	06/10/26	06/10/26	06/10/26	06/10/26
Acridine	0.01	**4.4**	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	0.01	**0.018**	**0.03**	<0.01	**0.05**	0.01	0.01	**0.02**	0.01	**0.05**	<0.01
Benzo(b)fluoranthene	0.01	--	0.05	0.02	0.05	0.01	0.01	0.01	<0.01	0.10000	<0.01
Benzo(k)fluoranthene	0.01	--	0.02	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	0.03	<0.01
Benzo(a)pyrene	0.01	**0.015**	**0.03**	<0.01	**0.05**	0.01	0.01	**0.02**	<0.01	**0.11**	<0.01
Fluoranthene	0.01	**0.04**	**0.07**	<0.01	**0.21**	<0.01	**0.16**	**0.06**	**0.06**	**0.09**	0.02
Dibenzo(ah)anthracene	0.01	--	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	0.02	<0.01
Indeno(1,2,3 cd)pyrene	0.01	--	0.05	0.01	0.07	0.02	0.02	0.01	<0.01	0.16	<0.01
Pyrene	0.01	**0.025**	**0.08**	<0.01	**0.23**	**0.04**	**0.10**	**0.17**	**0.09**	**0.11**	0.02
Quinoline	0.01	**3.4**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	0.05	**1.1**	0.001	0.11	0.25	0.57	**660**	**7.3**	**140**	**2800**	0.28

Notes:

1 - CCME Water Quality Guidelines for Freshwater Aquatic Life, December 2006
2 - MDL = 0.1
3 - MDL = 0.5
4 - MDL = 1.0
5 - MDL = 5.0
Bold and shaded indicates a parameter exceedance.

Table 4-4: Summary of 2006 Groundwater PAH Results Former Sutherland MGP, Winnipeg, Manitoba

Parameter	**MDL**	**CCME[1] (ug/L)**	**Well/Sample ID**								
			MW-41B	**MW-41C**	**MW-42A**	**MW-42B**	**MW-42C**	**MW-46**	**MW-47**	**MW-48**	**MW-50B**
			06/10/26	**06/10/26**	**06/11/13**	**06/11/13**	**06/11/13**	**06/11/13**	**06/11/13**	**06/11/13**	**06/11/13**
Acridine	0.01	**4.4**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.8[2]	0.01
Benzo(a)anthracene	0.01	**0.018**	<0.01	<0.01	0.01	0.01	**0.02**	**0.17**	**0.38**	**33**	**0.02**
Benzo(b)fluoranthene	0.01	**--**	<0.01	<0.01	0.01	<0.01	0.02	0.23	0.81	35	0.02
Benzo(k)fluoranthene	0.01	**--**	<0.01	<0.01	<0.01	<0.01	0.01	0.05	0.19	9.7	<0.01
Benzo(a)pyrene	0.01	**0.015**	<0.01	<0.01	<0.01	<0.01	**0.03**	**0.22**	**0.83**	**39**	**0.02**
Fluoranthene	0.01	**0.04**	0.02	<0.01	0.03	0.04	**0.29**	**0.41**	**0.65**	**92**	0.05
Dibenzo(ah)anthracene	0.01	**--**	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	0.15	5.3	<0.01
Indeno(1,2,3 cd)pyrene	0.01	**--**	<0.01	<0.01	<0.01	<0.01	0.02	0.22	0.67	28	0.02
Pyrene	0.01	**0.025**	**0.03**	0.01	**0.04**	**0.05**	**0.26**	**0.37**	**1.0000**	**130**	**0.22**
Quinoline	0.01	**3.4**	<0.01	<0.01	<0.01	<0.01	1.4	<0.01	<0.01	<1.0[4]	<0.01
Naphthalene	0.05	**1.1**	0.14	0.14	<0.05	**31**	**6.3**	0.86	0.08	**8600**	0.32

Notes:

1 - CCME Water Quality Guidelines for Freshwater Aquatic Life, December 2006
2 - MDL = 0.1
3 - MDL = 0.5
4 - MDL = 1.0
5 - MDL = 5.0
Bold and shaded indicates a parameter exceedance.

Table 4-4: Summary of 2006 Groundwater PAH Results Former Sutherland MGP, Winnipeg, Manitoba

Parameter	MDL	CCME[1] (ug/L)	Well/Sample ID								
			MW-51B	MW-52B	MW-53B	MW-54B	MW-55B	MW-58B	MW-62A	MW-62B	MW-62C
			06/11/13	06/11/13	06/11/13	06/11/13	06/11/13	06/11/13	06/11/13	06/11/13	06/11/13
Acridine	0.01	**4.4**	<0.01	<0.01	<1.0[4]	<0.01	0.28	<0.01	<0.01	<0.01	<0.1[2]
Benzo(a)anthracene	0.01	**0.018**	**0.05**	0.01	**0.39**	**0.02**	0.03	<0.01	**0.06**	**1.1**	**140.0[2]**
Benzo(b)fluoranthene	0.01	**--**	0.04	<0.01	0.32	0.03	0.01	<0.01	0.03	1.0000	93.0[2]
Benzo(k)fluoranthene	0.01	**--**	0.02	<0.01	0.10000	<0.01	<0.01	<0.01	0.01	0.35	<30.0[2]
Benzo(a)pyrene	0.01	**0.015**	**0.05**	<0.01	**0.24**	**0.02**	<0.01	<0.01	**0.04**	**0.85**	**130.0[2]**
Fluoranthene	0.01	**0.04**	**0.96**	<0.01	**2.0**	0.04	**2.2**	<0.01	**0.74**	**3.00**	**390.0[2]**
Dibenzo(ah)anthracene	0.01	**--**	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	0.33	22.0[2]
Indeno(1,2,3 cd)pyrene	0.01	**--**	0.03	<0.01	0.19	0.02	<0.01	<0.01	0.04	0.70000	63.0[2]
Pyrene	0.01	**0.025**	**1.2**	0.02	**1.3**	**0.03**	**1.3**	<0.01	**0.92**	**4.3**	**610.0[2]**
Quinoline	0.01	**3.4**	<1.0[4]	<0.01	<0.1[2]	<0.01	**20.0**	<0.01	<1.0[4]	<1.0[4]	<1.0[4]
Naphthalene	0.05	**1.1**	**10000**	<0.05	0.30000	0.23	**970**	**1.6**	**7.5**	0.27	**670.0[3]**

Notes:

1 - CCME Water Quality Guidelines for Freshwater Aquatic Life, December 2006
2 - MDL = 0.1
3 - MDL = 0.5
4 - MDL = 1.0
5 - MDL = 5.0
Bold and shaded indicates a parameter exceedance.

Table 4-4: Summary of 2006 Groundwater PAH Results Former Sutherland MGP, Winnipeg, Manitoba

Parameter	**MDL**	**CCME[1] (ug/L)**	**Well/Sample ID**								
			MW-63A	**MW-63C**	**MW-64A**	**MW-64B**	**MW-64C**	**MW-65A**	**MW-65B**	**MW-66A**	**MW-66B**
			06/11/13	**06/11/13**	**06/11/13**	**06/10/26**	**06/10/26**	**06/10/26**	**06/10/26**	**06/10/26**	**06/10/26**
Acridine	0.01	**4.4**	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.1[2]	<1.0[4]	<0.1[2]
Benzo(a)anthracene	0.01	**0.018**	0.18	**0.37**	**0.12**	**0.34**	**2.6**	**0.04**	**6.2[2]**	<1.0[4]	**1.9[2]**
Benzo(b)fluoranthene	0.01	--	0.23	0.34	0.23	0.39	1.8	0.03	5.9[2]	<1.0[4]	1.7[2]
Benzo(k)fluoranthene	0.01	--	0.06	0.09	0.07	0.10000	0.54	<0.01	2.3[2]	<1.0[4]	0.6[2]
Benzo(a)pyrene	0.01	**0.015**	**0.16**	**0.36**	**0.23**	**0.37**	**3.0000**	**0.03**	**7.2[2]**	<1.0[4]	**2.4[2]**
Fluoranthene	0.01	**0.04**	**0.70**	**3.00**	**0.38**	**1.3**	**11**	**0.15**	**13.[2]**	<1.0[4]	**2.8[2]**
Dibenzo(ah)anthracene	0.01	--	0.03	0.08	0.05	0.07	0.38	<0.01	5.1[2]	<1.0[4]	1.3[2]
Indeno(1,2,3 cd)pyrene	0.01	--	0.25	0.51	0.31	0.56	1.9	0.03	4.2[2]	<1.0[4]	4.9[2]
Pyrene	0.01	**0.025**	**0.76**	**3.4**	**0.31**	**1.4**	**15**	**0.21**	**17.0[2]**	<1.0[4]	**4.3[2]**
Quinoline	0.01	**3.4**	<0.01	<1.0[4]	0.18	<0.01	<0.01	<0.01	<0.1[2]	<1.0[4]	<0.1[2]
Naphthalene	0.05	**1.1**	**3.9**	**9900**	**2.7**	**6100**	**630**	**830**	**150.0[3]**	<5.0[5]	**220.0[3]**

Notes:

1 - CCME Water Quality Guidelines for Freshwater Aquatic Life, December 2006
2 - MDL = 0.1
3 - MDL = 0.5
4 - MDL = 1.0
5 - MDL = 5.0
Bold and shaded indicates a parameter exceedance.

4.2.3 Groundwater-Mediated Transport in Deeper Till

The subsurface soil conditions at the Site are described in UMA (2003) and earlier site assessment reports. Several boreholes advanced at the site have extended into the till layer. To date, dissolved PAH concentrations have been detected in groundwater samples obtained from both the shallow till and the overlying clay/silt/sand subunits. Of the twelve (12) monitoring wells installed in the till layer, only monitoring wells MW-42A, MW-50B, MW-58B, MW-62A, MW-63A have screened intervals ranging from 10.4 m to 14.6 m below existing ground surface that are fully isolated only within the till unit.

At the time of the latest (2006) groundwater monitoring event, laboratory analysis indicated that dissolved concentrations of various PAH parameters in excess of the CCME Freshwater Aquatic Life guidelines were detected in till monitoring wells MW-42A; MW-50B,; MW-58B; MW-62A; and MW- 63A, with 62A and 63A having the highest exceedances. The results of the PAH analysis completed on groundwater samples obtained during the 2006 monitoring event are presented in Table 4-4.

Glacial till has been encountered at the site, at depths ranging from 8.2 m to 15.6 m below the existing ground surface. Given that bedrock was encountered at approximately 33 m below grade in monitoring well BW-46, it is estimated that between 17 m and 25 m of glacial till is present beneath the site. The water quality in the carbonate bedrock at the site was assessed in 2002 and all PAH results were non-detect. Based on the thickness of the till and the upward hydraulic gradient from the bedrock to the till, the potential for PAHs to reach the bedrock aquifer is considered to be slight. The measured hydraulic conductivity of the shallow till is on the order of 4.5×10^{-7} m/s. Based on UMA's experience, it is expected that the density of the till increases with depth. An increase in the density of the till would correspond to a decrease in its hydraulic conductivity, further decreasing the risk to the carbonate bedrock.

4.3 Groundwater Toxicity Test Results

Three rounds of groundwater sampling and laboratory toxicity testing have been completed for the Sutherland MGP Site.

- Six groundwater samples were collected on April 25, 2005, from monitoring wells MW-41C, -29B&C, -23C&D, -24D, and -42C.
- Additional unfiltered groundwater samples were collected in 2006 using slow sampling techniques from MW-05-46, -47, -48 and -49, installed along the river bank.
- A third round of sampling was conducted on October 31, 2006. 40 L of unfiltered groundwater was obtained from each of MW05-46, -47, and -48.

During all three rounds, the groundwater was tested using a 96-h swim-up rainbow trout fry laboratory toxicity assay, in accordance with Environment Canada methods (2000: *Reference Method for Determining Acute Lethality of Effluent to Rainbow Trout, EPS 1/RM/13, 2nd ed.*)

Results of the toxicity tests have been provided previously to the TAC, in the following three reports:

- UMA Engineering Ltd. 2005. Toxicity Tests of Groundwater Entering the Red River Report. A report prepared for Manitoba Hydro. 10 pp plus appendices.
- UMA Engineering Ltd. 2006. Phase 2 Toxicity Tests of Groundwater Entering the Red River Report. A report prepared for Manitoba Hydro. 11 pp plus appendices.
- UMA Engineering Ltd. 2007. Phase 3 Toxicity Tests of Groundwater Entering the Red River Report. A report prepared for Manitoba Hydro. 11 pp plus appendices.

Refer in particular to the Discussion section of UMA (2007) for a summary of all toxicity testing completed to date. In summary, groundwater collected from MW23, at the top of the bank, exhibited evidence of toxicity to rainbow trout fry during the first round of toxicity testing; however, groundwater samples collected closer to the groundwater outflow face into the Red River (MW 46 to 49) was not toxic to trout fry.

4.3.1 Toxicity Test Species

It was suggested by TAC that fathead minnow be used in the groundwater toxicity monitoring instead of juvenile rainbow trout, since the former and not the latter are native to the Red River ecosystem. This is recognized by MH as a valuable suggestion, and future laboratory-based toxicity tests will use fathead minnow sensitive life stages to the extent that this test species is available.

Several researchers have evaluated relative sensitivity to water-borne toxicants of different species, and there is a particular interest in larval fathead minnows and rainbow trout as standardized test organisms. For example, Teather and Parrot (2006)[3] noted –

> "Using information from published studies, the relative sensitivity of various freshwater fish to a range of chemicals was examined. Specifically, the objectives were to: (1) determine which species are used most often in toxicity tests, (2) assess the relative sensitivity of these species to various chemicals, and (3) determine whether the two most commonly tested species exhibit differences in their relative sensitivity to different classes of chemicals. Fathead minnows, rainbow trout and bluegill sunfish were the three most commonly used species in 96-h LC50 tests. Of the nine species examined, Coho salmon and rainbow trout were the most sensitive species to 190 chemicals, while goldfish and carp were the least sensitive. Fathead minnows and rainbow trout were not equally sensitive to 13 different classes of chemicals; for example, while trout were significantly more sensitive to metals, fathead minnows were more sensitive to hydrocarbons. Such comparisons are expected to be useful for predicting the relative responses of different species to previously untested chemicals in such groups, and in gaining insight into physiological modes of action."

Munkittrick et al (1991)[4] noted the following:

> "Relative sensitivity and correlations between the Microtox® test and three commonly used acute lethality bioassays (i.e., rainbow trout, fathead minnow, *Daphnia*) are reviewed and discussed. All relevant data available for comparison were separated and evaluated based on chemical groupings. Generally, Microtox was more sensitive than or as sensitive as the acute lethality tests for pure individual organics, but was less sensitive to most inorganics. Microtox was not as sensitive as acute lethality tests to effluents or leachates with a high component of insecticides, herbicides, inorganics, pharmaceuticals or textiles, or highly lipophilic contaminants. As the complexity and toxicity of industrial effluents increased, the correlations and sensitivity of Microtox increased, with a corresponding decrease in data variability. Additionally, limitations of the available data are that (1) comparisons of relative sensitivity varied with the compounds and organisms tested; (2) there was a lack of standardization in approach and a failure to provide adequate details on the origin of the cited toxicity data, which confused and obscured

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[3] Teather, K, J. Parrott, 2006. Assessing the chemical sensitivity of freshwater fish commonly used in toxicological studies. Water Quality Research Journal of Canada, 41: 100-105.

[4] Munkittrick, K.R., E. A. Power , G. A. Sergy, 1991. The relative sensitivity of microtox®, daphnid, rainbow trout, and fathead minnow acute lethality tests. Environmental Toxicology and Water Quality, 6: 35-62.

comparisons; and (3) published reviews commonly failed to identify fish species and test details for cited data."

In order to evaluate the relative sensitivities of the two test species to PAHs, UMA completed a query of the USEPA "Ecotox" database for relevant ecotoxicity data. Tabulated data were available for both fathead minnow and rainbow trout larvae for only three PAHs: naphthalene, acenaphthene, and fluoranthene. The data are appended in Appendix A. Figure 4-5 shows the comparative sensitivity of the two species to these three PAHs. In all cases, the LC_{50} is estimated from the geometric mean of all reported values, which was up to 7 different values in some instances. For fluoranthene, the geometric mean 96-h LC50 includes toxicity endpoints for non photo-induced toxicity, but not both photo-induced toxicity.

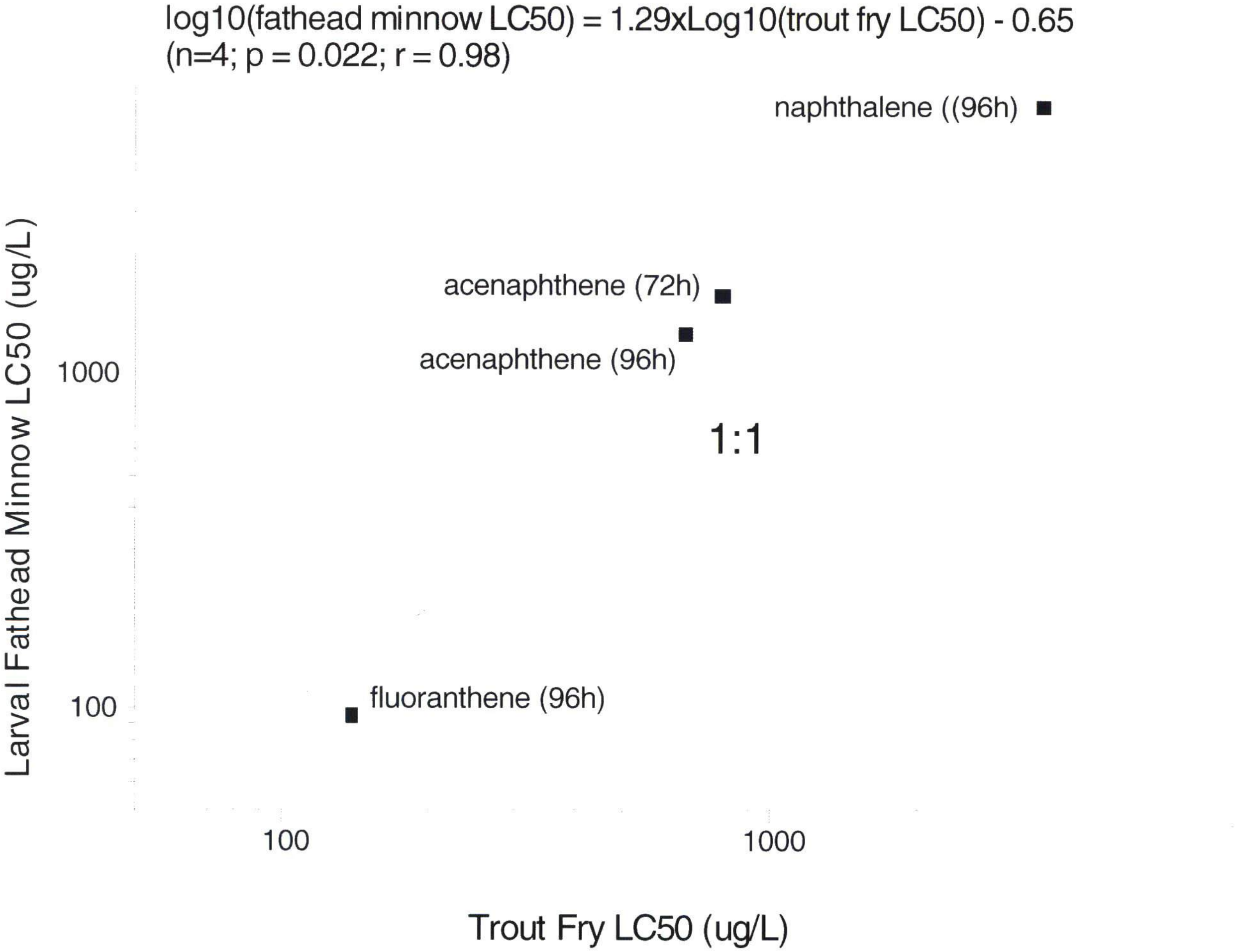


Figure 4-5: Relative Sensitivity of Trout and Fathead Minnow Larvae to PAHs in Water

Based on existing ecotoxicity data, fathead minnow were observed to be only slightly less sensitive to PAHs than the rainbow trout larvae. The LC_{50} values were on average about 16% higher for fathead minnows across the three PAHs for which toxicity data are available for both species. In light of this, it is expected that the sensitivity of the two test species is sufficiently similar that they could be used interchangeably.

As mentioned above, MH will attempt to use the fathead minnow in future laboratory toxicity tests, for the simple reason that this is an endemic species in the Red River study area.

4.4 Surface Water Quality in the Red River

Surface water in the Red River might be affected by two types of releases based on past MGP releases of residual coal tar:

- Inputs into the river of contaminants dissolved in groundwater (or being transported as DNAPL) along the edge of the Site, and
- Re-mobilization from historically contaminated sediments, based either on particulate re-suspension or dissolution at or just beneath the sediment water interface.

Relevant information on water quality in the Red River is provided by the following reports/programs:

- CH2M Hill (1995): Environmental, Health and Safety Assessment of the Sutherland Avenue Operations Facility in Winnipeg, Manitoba Phase II: Detailed Site Characterization.
- MC (November 2002): Water Quality Assessment of the Red River and Lake Winnipeg Following Release of Raw Sewage from the City of Winnipeg, September 2002. Unpublished Report, 40 pp. (metals and sewage associated chemical variables)
- Manitoba Water Stewardship: collated water quality data (2000 to 2007) for the Red River – monitoring stations at south gate of floodway, and Selkirk Bridge (metals and major ion concentrations only)
- UMA Engineering Ltd., August 2007. River Sediment and Surface Water Monitoring. A report prepared for Manitoba Hydro. 8 pp.

The fourth of these reports comprises new information since MH last met with the TAC, and the report is included herein as Appendix B.

Water sampling was conducted in the Red River adjacent to the former Sutherland MGP site as part of the *Phase II Detailed Site Characterization* (CH2M Hill, 1995). Ten water samples were collected along the south shore of the Red River in late March, 1994. Samples were collected at a distance of 7 m from the shore at all transects and at all 5 locations along transect L4 adjacent to the former MGP site. A diagram providing the transect locations is provided in Appendix C. All samples were collected from the surface of the ice by first cutting a hole through the ice with an ice auger and lowering a jar and stopper assembly to approximately 0.5 m from the river bottom. Eight water samples were submitted for analysis of PAHs. No PAHs were detected above the minimum laboratory detection limits in any of the samples.

CH2M Hill (1995) concluded that although groundwater containing residues is flowing towards the river, the concentrations reaching the river are too low to be detected in river water. The results of river water analysis found no detectable levels of PAHs in the river indicating no evidence of coal tar by-products exist in the water column.

Manitoba Water Stewardship conducts ambient water quality monitoring activities at over 50 sites in Manitoba for basic water chemistry including pesticides and some pharmaceuticals. The water quality monitoring does not include PAHs. Water Stewardship has established long-term monitoring locations at St. Norbert and Selkirk on the Red River but not within the Winnipeg urban Red River environment. MH has conducted water quality monitoring for PAHs, metals and basic water chemistry within the PAH sediment plume area and upstream and downstream of the PAH plume area as part of the river sediment monitoring activities. Selected metals monitoring data for a station at the south gate of the floodway, and for the Selkirk Bridge site, are provided in Figure 4-6 and Figure 4-7, respectively.

Figure 4-6: Temporal Trends in Selected Metals and Major Ions in the Red River at the South Gate of the Floodway (Manitoba Conservation Data)

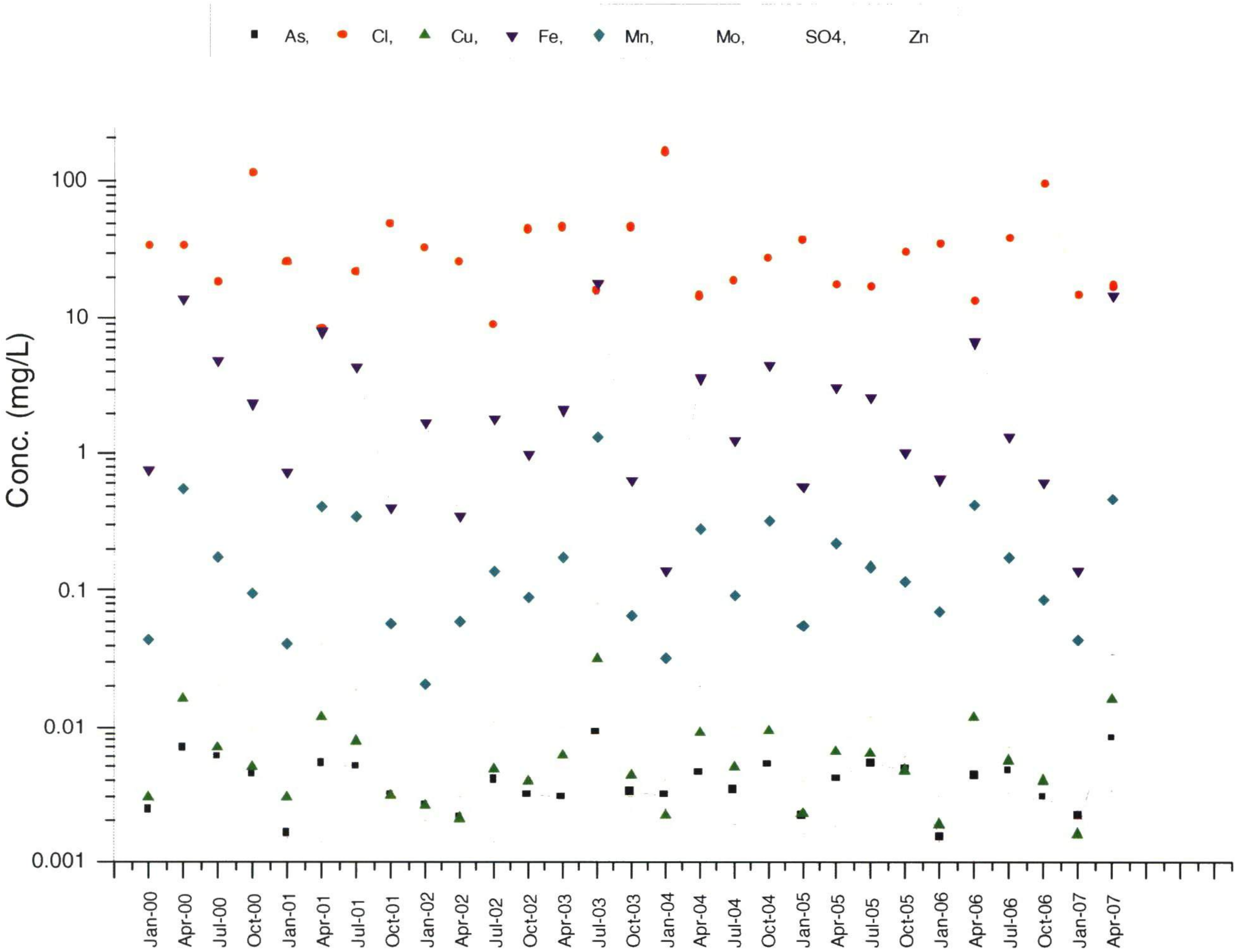
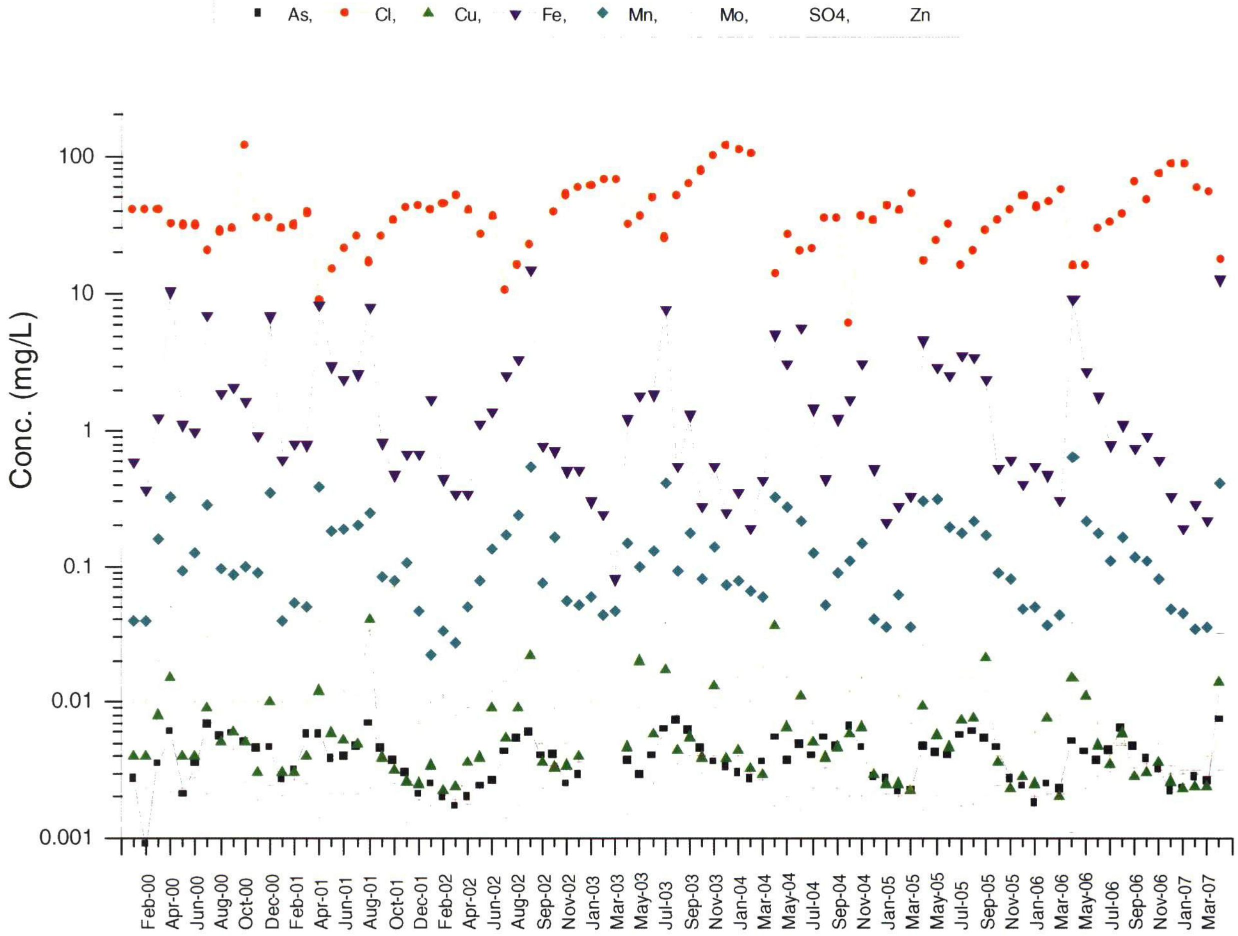


Figure 4-7: Temporal Trends in Selected Metals and Major Ions in the Red River at Selkirk Bridge (Manitoba Conservation Data)



Seasonal trends are apparent for several of the metals and ions, including chloride (possibly as a result of road salt use and runoff), as well as iron and manganese (probably a result of seasonal variation in suspended sediment load, since the metals were measured as totals rather than in filtered samples). Observed concentrations of several of these have often exceeded Canadian Water Quality Guidelines for Freshwater Life Protection (FWAL): [arsenic: FWAL = 0.005 mg/L; copper: FWAL = 0.002 to 0.004 mg/L; iron: FWAL = 0.3 mg/L; zinc: FWAL = 0.03 mg/L].

UMA (2007) collected water samples in March 2007 at twelve sample locations along the established sediment monitoring transects adjacent to the former MGP site and upstream and downstream from the site. The water sample collection locations are provided in Appendix B. Sample holes were cut into the ice using a power auger. Water samples were collected at approximately 0.15 to 0.3 m above the river sediment (13 samples) and 1.0 m below the ice level (12 samples) using a peristaltic low flow pump with the sampling tube fixed to a graduated steel rod lowered through the sampling hole. All of the river water samples collected in the field were submitted to ALS Laboratories in Winnipeg for PAH, benzene, toluene, ethylbenzene and xylenes (BTEX), Total Volatile Hydrocarbons (TVH), Total Extractable Hydrocarbons (TEH), metals, Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) analysis.

The results of the water monitoring are provided in the *River Sediment and Surface Water Monitoring* report (UMA, 2007: Appendix B). PAHs were detected in three (3) of the twenty-five (25) water samples (Table 4-5) and the remainder were below minimum laboratory detection limits. All three water samples with detectable levels of PAHs were collected 1.0 m below the ice level. Matching samples collected at a depth of 0.15 to 0.30 cm above the river bed did not contain detectable PAH concentrations. Two (2) of shallower depth water samples exceeded the CCME guidelines for freshwater aquatic life for benzo(a)anthracene, fluoranthene, and pyrene. Based on the recent sediment PAH and water PAH analysis, there does not appear to be a correlation with the PAH surface water values and the sediment values. See Table 4-6 for the PAH concentrations in river sediment, based on the March 2007 sampling event.

Table 4-5: Summary of PAHs, BTEX, TDS and TSS in Red River Water Samples – Results for 3 of 25 samples collected (PAHs were below detection limits in the other 22 samples).

Concentrations in µg/L unless stated otherwise.

Sample Location	MDL	Canadian (CCME) Water Quality Guideline for Freshwater Life Protection (µg/L)	T3-W1A	T6-W1A	T7-W1A
Sample Date			12-Mar-07	12-Mar-07	13-Mar-07
Benzene	0.5	370	<0.5	<0.5	<0.5
Toluene	0.5	2.0	<0.5	<0.5	<0.5
Ethylbenzene	0.5	90.0	<0.5	<0.5	<0.5
Xylenes	0.5	--	<0.5	<0.5	<0.5
T V H	100	--	<100	<100	<100
T E H	100	--	<100	<100	<100
		PAH			
1-Methyl Naphthalene	0.05	--	<0.05	<0.05	<0.05
2-Methyl Naphthalene	0.05	--	<0.05	<0.05	<0.05
Acenaphthene	0.05	5.8	<0.05	<0.05	<0.05
Acenaphthylene	0.05	--	<0.05	<0.05	<0.05
Anthracene	0.01	0.012	<0.01	<0.01	<0.01
Benzo(a)anthracene	0.01	0.018	0.06	0.03	0.01
Benzo(a)pyrene	0.01	0.015	0.02	<0.01	<0.01
Benzo(b)fluoranthene	0.01	--	0.06	0.02	<0.01
Benzo(ghi)perylene	0.01	--	0.04	<0.01	<0.01
Benzo(k)fluoranthene	0.01	--	0.06	0.02	<0.01
Chrysene	0.05	--	0.08	<0.05	<0.05
Dibenzo(ah)anthracene	0.01	--	0.06	0.02	<0.01
Fluoranthene	0.01	0.04	0.13	0.06	0.03
Fluorene	0.05	3.0	<0.05	<0.05	<0.05
Indeno(1,2,3 cd)pyrene	0.01	--	0.05	0.01	<0.01
Naphthalene	0.05	1.1	<0.05	<0.05	<0.05
Phenanthrene	0.01	0.4	0.03	0.03	0.02
Pyrene	0.01	0.025	0.08	0.04	0.02
Quinoline	0.05	3.4	<0.05	<0.05	<0.05
Acridine	0.01	4.4	<0.01	<0.01	<0.01
Total Dissolved Solids	5 mg/L	700 – 1000 mg/L*	660 mg/L	650 mg/L	650 mg/L
Total Suspended Solids	5 mg/L	5 – 25 mg/L*	50 mg/L	33 mg/L	26 mg/L

Notes: Concentrations in yellow highlight exceed Canadian Water Quality Guidelines for Freshwater Life Protection and Manitoba Water Quality Standards, Objectives and Guidelines..

To place these results in perspective, it is important to note that virtually all of the 25 water samples exhibited concentrations of aluminum, copper, iron, selenium and/or zinc that were in excess of their respective Canadian Water Quality Guideline for Freshwater Life Protection.

Table 4-6: Summary of PAH in River Sediment Former Sutherland MGP, Winnipeg, MB

Sample Location Sample Date	MDL	CCME Sediment Criteria (mg/kg)	T2-1	T2-2	T2-3	T2-4	T3-2	T3-3	T3-4	T4-1
			29-Jan-07	29-Jan-07	29-Jan-07	29-Jan-07	29-Jan-07	29-Jan-07	29-Jan-07	31-Jan-07
Acenaphthene	0.01	**0.0889**	<0.01	<0.01	<0.01	<0.01	**0.68**	0.08	<0.01	<0.01
Acenaphthylene	0.01	**0.128**	<0.01	<0.01	<0.01	<0.01	**0.62**	0.03	<0.01	<0.01
Anthracene	0.01	**0.245**	<0.01	<0.01	<0.01	<0.01	**1.9**	0.05	<0.01	<0.01
Benzo (a) anthracene	0.01	**0.385**	<0.01	<0.01	<0.01	<0.01	**2.3**	<0.01	<0.01	<0.01
Benzo (a) pyrene	0.01	**0.782**	<0.01	<0.01	<0.01	<0.01	**1.8**	<0.01	<0.01	<0.01
Benzo (b) fluoranthene	0.01	--	<0.01	<0.01	<0.01	<0.01	2.0	<0.01	<0.01	<0.01
Benzo (g,h,i) perylene	0.01	--	<0.01	<0.01	<0.01	<0.01	1.0	<0.01	<0.01	<0.01
Benzo (k) fluoranthene	0.01	--	<0.01	<0.01	<0.01	<0.01	0.74	<0.01	<0.01	<0.01
Chrysene	0.01	**0.862**	<0.01	<0.01	<0.01	<0.01	**2.2**	<0.01	<0.01	<0.01
Dibenzo (a,h) anthracene	0.01	**0.135**	<0.01	<0.01	<0.01	<0.01	**0.24**	<0.01	<0.01	<0.01
Fluoranthene	0.01	**2.355**	<0.01	<0.01	<0.01	<0.01	**6.2**	0.03	<0.01	<0.01
Fluorene	0.01	**0.144**	<0.01	<0.01	<0.01	<0.01	**1.1**	0.03	<0.01	<0.01
Indeno (1,2,3-cd) pyrene	0.01	--	<0.01	<0.01	<0.01	<0.01	1.6	<0.01	<0.01	<0.01
Naphthalene	0.01	**0.391**	<0.01	<0.01	<0.01	<0.01	0.38	**2.4**	0.07	<0.01
1-Methyl naphthalene	0.01	--	<0.01	<0.01	<0.01	<0.01	0.12	0.08	<0.01	<0.01
2-Methyl naphthalene	0.01	**0.201**	<0.01	<0.01	<0.01	<0.01	0.06	0.10	<0.01	<0.01
Phenanthrene	0.01	**0.515**	<0.01	<0.01	<0.01	<0.01	**6.2**	0.05	<0.01	<0.01
Pyrene	0.01	**0.875**	<0.01	<0.01	<0.01	<0.01	**5.1**	0.03	<0.01	<0.01
Quinoline	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acridine	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Notes:
CCME, Interim Sediment Quality Guidelines (PEL) for Freshwater, Update 2002.
-- indicates no criteria
BOLD or shaded indicates exceeded parameter

Table 4-6 (continued)

Sample Location Sample Date	MDL	CCME Sediment Criteria (mg/kg)	T5-2 31-Jan-07	T6-1 31-Jan-07	T6-2 31-Jan-07	T6-3 31-Jan-07	T6-4 31-Jan-07	T7-1 7-Feb-07	T7-2 7-Feb-07	T7-3 7-Feb-07
Acenaphthene	0.01	**0.0889**	<0.01	<0.01	0.02	<0.01	0.03	<0.01	<0.01	<0.01
Acenaphthylene	0.01	**0.128**	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	0.01	**0.245**	<0.01	<0.01	0.19	<0.01	0.03	<0.01	<0.01	<0.01
Benzo (a) anthracene	0.01	**0.385**	<0.01	<0.01	0.02	<0.01	0.03	<0.01	<0.01	<0.01
Benzo (a) pyrene	0.01	**0.782**	<0.01	<0.01	0.02	<0.01	0.03	<0.01	<0.01	<0.01
Benzo (b) fluoranthene	0.01	--	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo (g,h,i) perylene	0.01	--	<0.01	<0.01	0.02	<0.01	0.03	<0.01	<0.01	<0.01
Benzo (k) fluoranthene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	0.01	**0.862**	<0.01	<0.01	0.02	<0.01	0.03	<0.01	<0.01	<0.01
Dibenzo (a,h) anthracene	0.01	**0.135**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	0.01	**2.355**	<0.01	<0.01	0.10	<0.01	0.08	<0.01	<0.01	<0.01
Fluorene	0.01	**0.144**	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno (1,2,3-cd) pyrene	0.01	--	<0.01	<0.01	0.02	<0.01	0.03	<0.01	<0.01	<0.01
Naphthalene	0.01	**0.391**	0.08	<0.01	0.38	0.02	**0.53**	0.02	<0.01	<0.01
1-Methyl naphthalene	0.01	--	<0.01	<0.01	0.02	<0.01	0.03	<0.01	<0.01	<0.01
2-Methyl naphthalene	0.01	**0.201**	<0.01	<0.01	0.07	0.02	0.03	<0.01	<0.01	<0.01
Phenanthrene	0.01	**0.515**	<0.01	<0.01	0.14	<0.01	0.10	<0.01	<0.01	<0.01
Pyrene	0.01	**0.875**	<0.01	<0.01	0.07	<0.01	0.05	<0.01	<0.01	<0.01
Quinoline	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acridine	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Notes:
CCME, Interim Sediment Quality Guidelines (PEL) for Freshwater, Update 2002.
-- indicates no criteria
BOLD or shaded indicates exceeded parameter

Table 4-6 (continued)

Sample Location Sample Date	MDL	CCME Sediment Criteria (mg/kg)	T7A-1 7-Feb-07	T8-2 7-Feb-07	T8A-1 7-Feb-07	T9A-1 21-Feb-07	T9A-2 21-Feb-07	T10-1 21-Feb-07	T10-2 21-Feb-07	T11-1 21-Feb-07
Acenaphthene	0.01	**0.0889**	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	0.01	**0.128**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	0.01	**0.245**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo (a) anthracene	0.01	**0.385**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo (a) pyrene	0.01	**0.782**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo (b) fluoranthene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo (g,h,i) perylene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo (k) fluoranthene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	0.01	**0.862**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo (a,h) anthracene	0.01	**0.135**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	0.01	**2.355**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	0.01	**0.144**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno (1,2,3-cd) pyrene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	0.01	**0.391**	<0.01	<0.01	0.13	<0.01	<0.01	<0.01	<0.01	<0.01
1-Methyl naphthalene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2-Methyl naphthalene	0.01	**0.201**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenanthrene	0.01	**0.515**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	0.01	**0.875**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Quinoline	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acridine	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Notes:
CCME, Interim Sediment Quality Guidelines (PEL) for Freshwater, Update 2002.
-- indicates no criteria
BOLD or shaded indicates exceeded parameter

All of the surface water sample results for BTEX, TVH and TEH were below the minimum laboratory detection limits and CCME Guidelines. Relatively high levels of TDS and TSS were recorded in all of the samples when compared with the Manitoba Water Quality Objectives (WQO). All of the TDS results for the water samples submitted are within the WQO range while all of the TSS values exceed the WQO range (see Appendix B). Concentrations of aluminum exceeded the applicable guideline in all of the surface water samples. With the exception of surface water sample T9-W1A, all of the surface water samples exceeded or were at the applicable guideline for copper. Concentrations of iron in the surface water samples exceeded the applicable guideline for iron with the exception of sample T8-W1B. Concentrations of selenium were in excess of the applicable guideline in three (3) of the water samples and one (1) water sample exceeded the zinc guideline (Appendix B).

The results of the surface water analysis indicate that aluminum, copper and iron concentrations are consistently higher than the applicable guidelines and a number of water samples were just above the selenium water quality guideline. Manitoba Water Stewardship quarterly water sample data for the St. Norbert South Flood Gate routinely exceed the applicable guidelines for aluminum, copper, iron and selenium.

In summary, water samples collected from 15 to 30 cm from the river bed of the Red River adjacent to the Sutherland Site did not contain detectable concentrations of PAHs (UMA, 2007). A subset of PAHs was detected in three water samples collected approximately 1 m below the ice surface. The overall data show no evidence of a correlation between with PAH surface water concentrations and the sediment PAH levels, and that the presence of PAHs in surface water may be as a result of other upriver sources such as urban drainage. Environment Canada reports that PAHs also find their way directly into the aquatic environment through discharges from various human activities, including: industrial and domestic sewage effluents; spills and leaks of PAH-containing materials such as oils: and run-off from paved roads, parking lots, and the grounds of wood preservative plants. MH will conduct future river water quality analysis for PAHs as part of its river sediment monitoring activities

4.5 Spatial Distribution and Depth in Sediment of Coal Tar Contamination

A large number of investigations have been completed to characterize the magnitude and distribution of coal tar contamination in sediments in the Red River adjacent to the Site. Sediment PAH data are available from the following studies:

- CH2M Hill (January, 1995). *Environmental, Health and Safety Assessment of the Sutherland Avenue Operation Facility in Winnipeg, Manitoba. Phase II: Detailed Site Characterization.*
- Agassiz North Associates Ltd. (1996). *Surficial Sediment Plume Study – 1996. Phase II Biological Impact Assessment, Red River, Manitoba.*
- Agassiz North Associates Ltd. (1997). *Surficial Sediment Plume Study – 1997, Red River, Manitoba.*
- Agassiz North Associates Ltd. (1999). *Surficial Sediment Plume Study – 1998, Red River, Manitoba.*
- Agassiz North Associates Ltd. (2000). *Surficial Sediment Plume Study – 1999, Red River, Manitoba.*
- Morrow Environmental Consultants (2001). *Environmental Site Assessment: Red River Sediments Adjacent to the Former Sutherland Avenue Manufactured Gas Plant, Winnipeg, MB.*
- UMA (2003). *Manitoba Hydro Former Manufactured Gas Plant, 35 Sutherland Ave., Winnipeg, MB, Supplementary Environmental Site Investigation.*
- UMA (2006). *Comprehensive Environmental Management Plan.*

The different studies appear to provide disparate pictures of riverbed contamination; however, much of the confusion and uncertainty almost certainly arises from the different methods employed for each study. As will be discussed further on in the document, the data cumulatively indicate that shallow surficial sediments in the Red River adjacent to the site exhibit very steep vertical gradients in PAH concentration. Perceptions about the spatial distribution of coal-tar derived PAHs, as well as upper range PAH concentrations, are likely to be influenced by the sampling and analytical methods employed. Relevant past studies are reviewed in chronological order below:

4.5.1 CH2M Hill, 1995

CH2M Hill Engineering Limited conducted a detailed Phase II Environmental Site Assessment at the former Sutherland MGP site in 1994. The assessment included the collection of 32 sediment samples along eight transects. The sediment sampling program was conducted in March 1994 to facilitate sediment collection by split-spoon sampler using a Pionjar drill from the ice surface. Twenty–six shallow samples (0.5 to 1.0 m depth) and six deep samples (3.3 m depth) were collected. Eighteen samples were sent to CANVIRO Analytical Laboratories Ltd. in Waterloo, Ontario. Sediment quality was evaluated by comparison to the draft 1994 Environment Canada guidelines (CCME Sediment Quality Guidelines), the unpublished Quebec 1992 sediment guidelines, the 1993 Ontario sediment guidelines and the background conditions defined in the river based on background samples. The laboratory analytical data were used only secondarily, however, to define the spatial extent of sediment contamination, which was estimated based on visual observation of coal tar residues and the estimated extent of PAHs greater than background concentrations that were derived from samples collected upstream of the impacted area. The coal tar contaminated sediment plume was estimated to be approximately 9,000 m^2, including a 1,250 m^2 area of visible coal tar residues at sediment surface. There is a high probability that the lateral and downriver extent of the plume was under-estimated based on the limited available data.

4.5.2 Agassiz North, 1995, 1996, 1997, 1999, 2000

Agassiz North Associates Ltd. conducted a reconnaissance survey of the surficial river sediments in 1995 as part of the Phase IIB Biological Impact Assessment. A series of transects were established along a 400 m reach of shoreline and sediment samples collected at about 10 m intervals along each transect to a depth of 5 cm using an Ekman dredge. Visual evidence of PAH contamination was found along the 200, 250 and 300 m transects. Surficial sediment samples of sediment were sent to Canviro Laboratories Ltd. in Mississauga, Ontario for analysis of PAHs.

Agassiz conducted additional Surficial Sediment Plume Studies commencing in 1996 and ending in 1999. Sampling was undertaken in the fall of each year by boat. An Ekman dredge was used to collect surficial sediment samples that were visually assessed for coal tar residues in the field. Laboratory measurements of PAHs in sediments were only obtained for a small subset of the samples collected in each of 1998 and 1999. The results were compared to the CCME Sediment Quality Guidelines.

The aerial extent of the surficial coal tar sediment contamination for all of the studies (1995 to 1999) was estimated based only on visual coal tar residues and odour assessment of the sediments.

Agassiz North (2000, Table 7 and accompanying discussion) discuss annual changes in the aerial extent of the plume based on examination of the top ~5 cm of sediment and visual/olfactory observations only. Aerial extent estimates from the Agassiz North Reports, based on both lines of evidence, were –

- 1994: 3,435 m^2 (data from CH2M Hill, 1995)
- 1995: 3,800 m^2
- 1996: 2,865 m^2

- 1997: 9,245 m^2
- 1998: 6,805 m^2
- 1999: 12,800 m^2

Of particular concern was the increased inferred extent of contamination between 1996 and 1997, as well as indications of an increase in extent over longer periods, possibly indicating an ongoing source to the river. Agassiz North (1999) attributed the increase in inferred plume size between 1996 and 1997 to the extreme spring flood of 1997. Three possible mechanisms were discussed in association with the flood event:

- Promotion of loading from an external source
- Redistribution of existing deposits by riverbed scour
- Erosion of overlying sediments to uncover existing deposits.

The report discusses the possible role of subsurface, man-made conduits (especially the existing high-pressure gas main and trench and two abandoned sewer lines that previously serviced the MGP site) in probably supplying coal tar to the river on an ongoing basis. This was concluded to be less likely than the other two explanations, but was not ruled out.

With regard to the second and third mechanisms, Agassiz North (1999) wrote –

> "The erosion of overlying sediments to uncover existing deposits cannot be ruled out as a partial contributor to the 1997 plume expansion. However, this explanation seems less likely given the considerable variation in downstream plume geometry from 1997 to 1999, and the evident extension, displacement and dispersion of the downstream plume, particularly in 1999. Based on this trend, and barring the occurrence of flood conditions comparable to 1997 in the next several years, further dispersal of the plume downstream of the 300 to 350 m transects should be expected over the next several years as well."

Agassiz North (1999) also noted that there was no indication that surficial PAH concentrations (based on laboratory data) had increased between 1995 and 1999. The average PAH concentrations within the plume were statistically similar in 1995, 1998 and 1999. The minimum, mean, and maximum observed concentration of total PAHs (PAH16 plus 2- and 1-methylnaphthalene) was 0.67 mg/kg, 1,900 mg/kg, and 12,460 mg/kg, respectively (n = 8).

4.5.3 Morrow, 2001

Morrow Environmental Consultants Inc. conducted an Environmental Site Assessment of the Red River sediments adjacent to the former Sutherland MGP site in 2001. Sediment sampling was conducted between February and March 2001 using a drill rig and hollow stem augers. Sample locations were based on the previous studies conducted by Agassiz North. Boreholes were drilled to depths ranging from 1.8 to 6.4 m below river bottom and sediment samples were collected from 0 to 2.9 m below river bottom. Each borehole was advanced 0.75 m to 1.5 m intervals along the transect. Boreholes were surveyed by Morrow with assistance from UMA Engineering Ltd., and UTM coordinates and reference points were established. Samples were collected in polyethylene bags and sent to Philip Analytical Services in Mississauga, Ontario. The sediment sample results were compared to the CCME Sediment Quality Guidelines. The extent of the sediment PAH plume for this assessment was based on visual assessment of the sediments containing coal tar residues and trace PAH contaminant levels. Morrow (2001) noted that –

> "Liquid and/or plastic coal tar was observed in some boreholes located up to 700 m downstream of the bridge at depths ranging from 0 m to 1.2 m below river bottom.

A drawing showing the inferred spatial extent of coal tar contamination was provided; however, the delineation was constrained by limited sampling intensity lateral to the direction of current flow. The lateral extent of the plume, therefore, was likely under-estimated.

4.5.4 UMA, 2003

UMA Engineering Ltd. conducted a Supplemental Environmental Site Investigation of the former MGP site that included investigation of the river sediments in February 2002. Based on the work conducted by Agassiz North and Morrow Environmental, eight additional transects consisting of five test holes per transect were established. The final program included thirty-six test holes along twelve transects. Test hole drilling was conducted using a skid mounted auger rig. A long cellulose butyrate sleeve sampler was inserted into hollow stem augers to obtain a full depth, intact core for visual description, field sampling and sample selection for laboratory analysis. Particularly when looking for evidence of DNAPL, it is important to examine intact as opposed to highly mixed soils and sediment, since DNAPL migration can occur along very fine, thin permeable seems that are typically obliterated by some types of drilling equipment.

Sample depths ranged from 0.2 to 5.7 m below the river bed. Sediment samples were retained within the sampler in the sleeve, and the intact sediment cores were subsequently transported to an on-site laboratory for logging and core extraction. Samples were divided for field screening using photo-ionization detection (PID), PetroFLAG® and fluorometric quantification. Selected samples (n = 55) were sent to Philip Analytical Services in Mississauga, Ontario for laboratory analysis. The results were compared to the CCME Sediment Quality Guidelines. The extent of the sediment PAH plume was based on the worst-case scenario by applying the highest naphthalene/naphthalene equivalent concentrations. Naphthalene equivalents were calculated from the PetroFLAG® and fluorometric data using a regression relationship between lab results and field screening values. Plan view drawings of the aerial extent of coal tar contamination adjacent to the Site as previously provided to the TAC are based on analysis of the UMA (2003) data.

4.5.5 Reconciliation of Different Observational Methods and Studies

Since the completion of the Agassiz North (1999) study, it has become evident that interpretations of the aerial extent of the coal tar contaminated sediment plume are highly influenced by the methods used. CH2M Hill, Morrow Environmental and UMA all employed similar sediment sampling protocols, using drill rigs through the river ice during winter months. An advantage of this approach is that the depth of contamination is determined, along with the aerial extent (based on multiple boreholes). A major disadvantage, however, is that use of drill rigs and some types of coring apparatus tend to result in failure to capture poorly consolidated sediments at the sediment water interface. These sediments represent the most recent deposition (sediment deposits over the last few months, years, and perhaps decades) that overlies historically contaminated sediments.

Agassiz North used an Ekman grab throughout their studies from 1995 to 1999 during the fall months. Grab sampling is better equipped to preserve the integrity of sediments at the sediment water interface, for subsequent chemical characterization, but is not useful for defining the highest local contaminant concentration unless the most contaminated zone coincides with the uppermost sediment layers. Another limitation of grab samples is that there is greater uncertainty about the depth over which a sediment sample is obtained for subsequent chemical analysis. An Eckman grab tends to result in less sediment deformation during the time of deployment than samplers such as a Ponar or Petite Ponar grab (as used by North/South in 2003 or UMA in 2007; see below), since the four walls of the Eckman grab are vertical and grab closure relies less on squeezing the sediment mass between two opposing jaws. Considerable uncertainty is introduced during grab sampling arising to differing sediment penetration depths at each location and based on limited rigour when a subset of the captured grab is removed for subsequent analysis. While practitioners may try to standardize the sampled depth of sediment collected (e.g. to the top 5 or 10 cm), there is likely to be a high degree of variability between grabs and especially between field personnel in the depth of sediment that is actually captured, and in the relative proportion of sediments from different depths in the final sample. This becomes a critically important issue when sampling sediments that exhibit very steep chemical gradients within the top decimetre or less.

Table 4-7 provides a summary of data on concentrations of total unsubstituted PAHs (PAH16) based on the re-sampling in 2003 and twice in 2007 of the UMA 2002 sediment sample sites (UMA, 2003). It was previously noted in the ecological risk assessment included in the CEMP that sediment samples collected by North/South (2003) at the same time that five additional replicate samples were collected for benthos analysis contained much lower PAH concentrations on average than encountered during the UMA (2003) drilling/coring program. The 2002 drilling/coring data comprise PAH data from different depths in the river bed.

Table 4-7 lists the upper-most sample from each coring location for which laboratory PAH data are available. The depth listed is the middle of the integrated depth samples, generally collected over a vertical range of approximately 10 cm.

Site TH3-3 (Table 4-7) has been re-sampled at the surface of the riverbed on three occasions since the 2002 UMA drilling program. A sample collected from ~30 cm depth in 2002 exhibited a PAH16 concentration of 38,700 mg/kg, while a surface sediment sample collected with a Petite Ponar grab by North/South in 2003 exhibited a concentration of only 56 mg/kg. UMA re-sampled surface sediments in the spring of 2007, also using a Petite Ponar grab, and observed a PAH16 concentration of only 2.7 mg/kg; however, this location was then sampled in August of 2007 for the purpose of assessing sediment-pore water PAH partitioning and estimated PAH bioavailability, and the observed PAH16 concentration was 11,400 mg/kg. Similar, highly variable results between sampling events since 2002 are evident for virtually every location that have been sampled on more than one occasion.

Table 4-7: Results of Repeated Sampling of the Same River Bed Location Using Different Methods and Field Personnel

	2002 UMA Data (UMA 2003)		**2003 North/South Data** (see CEMP)	**March 2007 UMA** (Appendix A herein)	**August 2007 Bioavailability Study** (Section 4.11 herein)
Sampling Depth	**Sample Specific (see below)**		**0 to ~5 cm**	**0 to ~10 cm**	**0 to ~10 cm**
Sample Location	**Depth (cm)**	**TPAH$_{16}$ (mg/kg)**	**TPAH$_{16}$ (mg/kg)**	**TPAH$_{16}$ (mg/kg)**	**TPAH$_{16}$ (mg/kg)**
T0-1	20 cm	28.9			
T1-1	10 cm	2.47			
T2-1	70 cm	7.02		<0.01	
T2-2	60 cm	6,570	0.88	<0.01	
T2-3	50 cm	1,270		<0.01	
T2-3				<0.01	
T2-4			0.08	<0.01	
T2-5			0.05		
MH16					17,900
MH18					7,890
T3-2/MH19				34.1	2,540
T3-3/MH14	30 cm	38,700	55.7	2.7	11,400
T3-4/MH02			211	0.07	9.18
MH20					8,480
T4-1	10 cm	0.11		<0.01	
T4-2	200 cm	<0.05	0.47		
T4-3	20 cm	0.08			
T5A-1	30 cm	12.1			
T5-2	300 cm	7.07	163	0.08	
MH03					20.4
MH11					247
T6-1	50 cm	0.75		<0.01	
T6-2	30 cm	41,800	117	1.04	
T6-3	20 cm	5.53		0.02	
T6-4				0.97	
MH04					285
MH10					66
T7A-1	30 cm	21.5		<0.01	
T7-1	20 cm	<0.05		0.02	
T7-2	75 cm	0.32	7.18	<0.01	
T7-3	40 cm	<0.05	0.21	<0.01	
T8-1	30 cm	0.47	1.72	0.15	
T8-2	55 cm	<0.05	1.03	<0.01	
T8-3	45 cm	<0.05			
T9A-1				<0.01	
T9A-2				<0.01	
T10-1				<0.01	
T10-2				<0.01	
T11-1				<0.01	

In all of the studies where sediment samples were analyzed, the results were compared with the CCME Sediment Quality Guidelines. However, the aerial extent of the PAH plumes were estimated based on different methodologies for all of the studies. The estimated aerial extent of the surficial PAH sediment plume by Agassiz North for all of their studies was based on visual identification of surficial (0.05 m) coal tar residues and odours to estimate areas of trace contamination in surface sediments. CH2M Hill estimated the aerial extent of the plume based on visual identification of surficial (<0.8 m) coal tar residues and through comparison with background concentrations. Morrow Environmental estimated the extent of the sediment PAH plume based on visual assessment of the sediments containing coal tar residues and trace PAH contaminant levels at depths ranging from 0 to 3.7 m. UMA (2003) estimated the PAH sediment plume by plotting the naphthalene (lab data)/naphthalene equivalent (field data) sediment concentrations at depths ranging from 0 to >5.7 m.

Based on the differences in sample collection and plume estimation methodologies, caution should be exercised in comparing the estimated aerial extent of the PAH sediment plume. However, all of the studies support the conclusion that the surficial distribution of PAHs is strongly dependent on river currents and sediment deposition versus scouring. This is particularly evident when comparing the estimated aerial extent of coal tar contaminated surficial sediment prior to and after the 1997 extreme flood event.

As discussed in Section 4.5.2 above, Agassiz North (1999) discussed two possible mechanisms that might account for the observed distribution of coal tar contaminated sediment: (i) down river transport of coal tar contaminated sediments, followed by re-deposition, especially during the flood event in 1997; and (ii) scouring of surface sediments to expose more highly contaminated historical coal tar deposits. While these two phenomena are not mutually exclusive, it is clear that the second mechanism has been the major influence on the overall distribution of coal-tar contaminated sediments in recent years. Down river transport and re-settling of coal tar contaminated sediments could not account for the observed depth of coal tar contamination in areas beyond the original depositional area, especially for the down river area that is partially disconnected from the more highly contaminated sediment plume directly adjacent to the former MGP Site. Rather, scouring and re-deposition would result in a thin surface coating of the contaminated sediment, mixed and co-deposited with other uncontaminated sediment originating farther upriver.

Evidence in support of scouring as the major recent influence on coal tar distribution in the post-operational era of the MGP is also provided by observations on sediment stratigraphy. The lateral limits of the sediment contamination at the western edge of the plume coincides with the presence of glacial till at or near the sediment surface (UMA, 2003), whereas closer to the east river bank and within the contaminated zone, there is substantial depth of recent sediment overlying compacted, blue-green glacial tills. This indicates that the river bed adjacent to the western edge of the plume is routinely scoured, with little net deposition of sediments originating within the last century or more. Conversely, sediment zones with higher levels of coal tar contamination exhibit deeper accumulations of more recent sediments overlying glacial till.

The relatively uncontaminated area between two more contaminated zones in a down river direction may have resulted from deposition of free phase coal tar during the operation of the MGP, followed by massive scouring in the years following decommissioning of the MGP. The construction of bridge footings for the Disraeli Bridge around 1965, in particular, may have played a role in altering the hydrodynamic regime at the sediment – water interface in the downriver section of river bed, which happens to be adjacent to the former MGP site. The bridge abutments would tend to disrupt laminar flow and lead to more turbulent flows. Potential for sediment re-suspension and erosion increases with the degree of turbulent as opposed to laminar flow.

Scouring events are expected to be episodic, with periods of annual net deposition over top of the historically contaminated sediments punctuated by very high energy, extreme flood events. Evidence for the presence of a surficial layer of minimally contaminated sediment overlying coal tar contaminated sediment is provided by the March 2007 sampling data, the North/South 2003 data and observations of plume extent prior to 1998, based on surface sediment samples and observations. It is likely that there is an annual net accumulation of sediment on the riverbed adjacent to the Site in most years, with some atypical years for which there is net scouring and removal to downriver areas. Within a year, it is also expected that there will be a dynamic equilibrium of deposition and removal, such that the localized depth of recent sediments over top of historically contaminated sediments may vary.

Finally, recent and past field sampling has also indicated that – in addition to vertical variations - fine scale distribution of coal tar in sediments tends to be heterogeneous. This is attributed to the presence of coal tar in more highly contaminated zones as droplets, blebs, poorly miscible coal tar pitch, and perhaps small coal particles. This is in contrast to some PAH contaminated sediments affected by petroleum product releases, wherein PAHs are more uniformly distributed based on sorption to the external surfaces of sediment particles.

In summary, the evidence from approximately 12 years of studies on the extent of coal tar contamination in Red River sediments adjacent to the site indicates –

- The 1997 extreme flood event (>100 year flood event) increased the apparent aerial extent of coal tar contaminated sediment in the Red River adjacent to the Site by resulting in scouring of more recent sediments at the surface to expose historical deposits discharged directly to the riverbed during the MGP operational era.

- Since 1997-98, a thin accumulation of recent sediments has been re-deposited over top of historical coal tar contamination. The depth and spatial variability of this newer sediment accumulation has not been fully evaluated.

- The presence of a fine veneer of recent sediments results in steep concentration gradients that are challenging to adequately characterize based on sampling with either grabs or cores/drilling. This has resulted in substantial variation in the measured PAH concentration in surface sediments at a given site on the riverbed.

- There is a high degree of fine-scale spatial heterogeneity of PAH contamination in the sediments based on the nature of the deposited material. Between-sample variability, even within a single sampling event, has been relatively high.

4.6 3-D Visualization of the Contaminated Sediment Plume

TAC members requested the development of three-dimensional visualizations of the coal-tar contaminated sediment plume within the Red River to assist with planning exercises. Visualizations were prepared based on a re-interpretation of the UMA (2003) drill core PAH data, based on both naphthalene and PAH16 concentrations.

3D visualization work was done using EVS-Pro software (C Tech Development Corp. http://www.ctech.com). The visualization is performed in two steps. First, the stratigraphy is modeled to bound the region and to provide layers of distinct material. Second, the sampling results are processed to estimate the distribution of various contaminants through the region.

Representative static drawings of the visualization are provided in Appendix D. The 3-D visualizations illustrate the limited area of higher PAH concentrations that have the potential to become bioavailable and pose a potential risk to aquatic organisms.

4.6.1 *Stratigraphy*

Stratigraphic data from the cores taken in November 2002 was used to produce estimated continuous surfaces to represent the following layers, listed in increasing depth: Ice, Water, Sediment, Organic, Sandy, Till. The bottom of the Till layer was arbitrarily set for each core close to the depth of the lowest sample from all cores, at 8.53 m below the ice surface.

The layers are determined by independently kriging of each surface to a dense 2D grid, with the variogram chosen by the EVS-Pro expert system. The horizontal grid extents are determined by the convex hull of the data plus a very small incremental boundary. The stratigraphic layers were used to bound the region for work with sediment concentration data, by excluding the Ice and Water layers.

4.6.2 *Sampling results*

Sediment sampling analytical results from two separate programs were considered: the November 2002 cores, and the August 2007 surface grabs. Each sample was located in 3D space based on its reported Universal Transverse Mercator (UTM: Easting and Northing) coordinates, and the mid-point of the depth below the sediment surface.

The contaminant considered was total unsubstituted PAHs (PAH16). For each sample, either a total of the 16 individual PAH results was used (for those samples fully analyzed in the lab), or PAH16 was estimated using field collected data of a more semi-quantitative nature.

- **For November 2002 data**, a PAH16 value was determined from laboratory analytical data for 55 sediment samples and for another 159 sediment samples from field fluorescence data. See UMA (2003) for a complete description of the technique. Briefly, the concentration of unsubstituted and alkyl-substituted PAHs was analyzed at a CAEAL-certified laboratory in 55 sediment samples, comprising 25 different cores, and samples collected from multiple depths in the range of 0.09 to 5.65 m beneath the top of the river bed. Alkyl-substitued PAHs have a number of alkyl groups such as methyl, ethyl and propyl on their aromatic ring structures. In order to provide a more detailed picture of spatial coal tar distribution in sediment, a total of 214 individual sediment samples were analyzed in the same cores, including the 55 samples analyzed in the laboratory.

  For fluorometric quantification, small masses of sediment (0.5 – 1 g) were extracted in 1:1 hexane:acetone in clean, disposable glass scintillation vials and the fluorescence measured using a portable Turner Fluorometer using an excitation wavelength of 250-260 nm and a measured emission and 380 nm. The magnitude of fluorescence was converted to mg of coal tar/kg extracted sediment by prior construction and reference to standard curves developed using an authentic coal tar sample collected previously from the Sutherland Site.

  The statistical relationship between coal-tar equivalent concentrations based on fluorometric analysis and PAH16 and concentration based on laboratory analysis of the same 55 samples (

  Figure 4-8), was used to estimate expected naphthalene and benzo[a]pyrene concentrations in the remaining 159 samples. Using the best least-squares linear fit of log10-transformed data, the relationship between PAH16 and coal tar concentrations was estimated based on the following equation:

$$\mathrm{Log}_{10}[\mathrm{PAH16}] = 1.15\ \mathrm{Log}_{10}[\text{coal tar equiv.}] - 3.25 \qquad (1)$$

The degree of agreement between predicted and actual measured (laboratory analysis) PAH16 concentrations in bulk sediment is illustrated in

Figure 4-8. As can be seen from both

Figure 4-8 and Figure 4-9, the use of field fluorometric data to estimated actual PAH16 concentrations in sediment is limited, and the true concentration might be under- or over-predicted by an order of magnitude or more. Departures in a linear relationship between fluorescence at 380 nm of sediment extracts and the concentration of unsubstituted PAHs might be attributed to a number of issues:

- At very high coal tar concentrations, the observed fluorescence intensity does not linearly increase with increasing concentration; rather, a quenching effect occurs, such that increased coal tar concentrations result in progressively lower fluorescence measurements. The technique, therefore, is of limited value outside of the linear response range on the standard curves.
- Fluorescence of substances in the acetone/hexane sediment extracts, following excitation, might be attributed to not just PAHs, but also methylphenols or other monoaromatics present in coal tar, other polyaromatics, and a wide range of biogenic substances present in sediments with resonant double bonds. The extent of fluorescence by non-PAH16 substances is likely influenced by sediment texture and sediment organic carbon content, which was variable across Red River sediment samples.
- The PAHs in sediment are heterogeneously distributed, and relatively small mass subsamples extracted in the field for fluorometric analysis or in the laboratory for extraction and analysis by GC-MS may exhibit different concentrations of coal tar.

In spite of the limited predictive power of the field analytical data, we note from Figure 4-9 that predicting bulk sediment PAH16 concentration from field fluorometric data might have resulted in mis-classification of 4 of 55 sediment samples, with regard to risk potential (see Section 4.11).

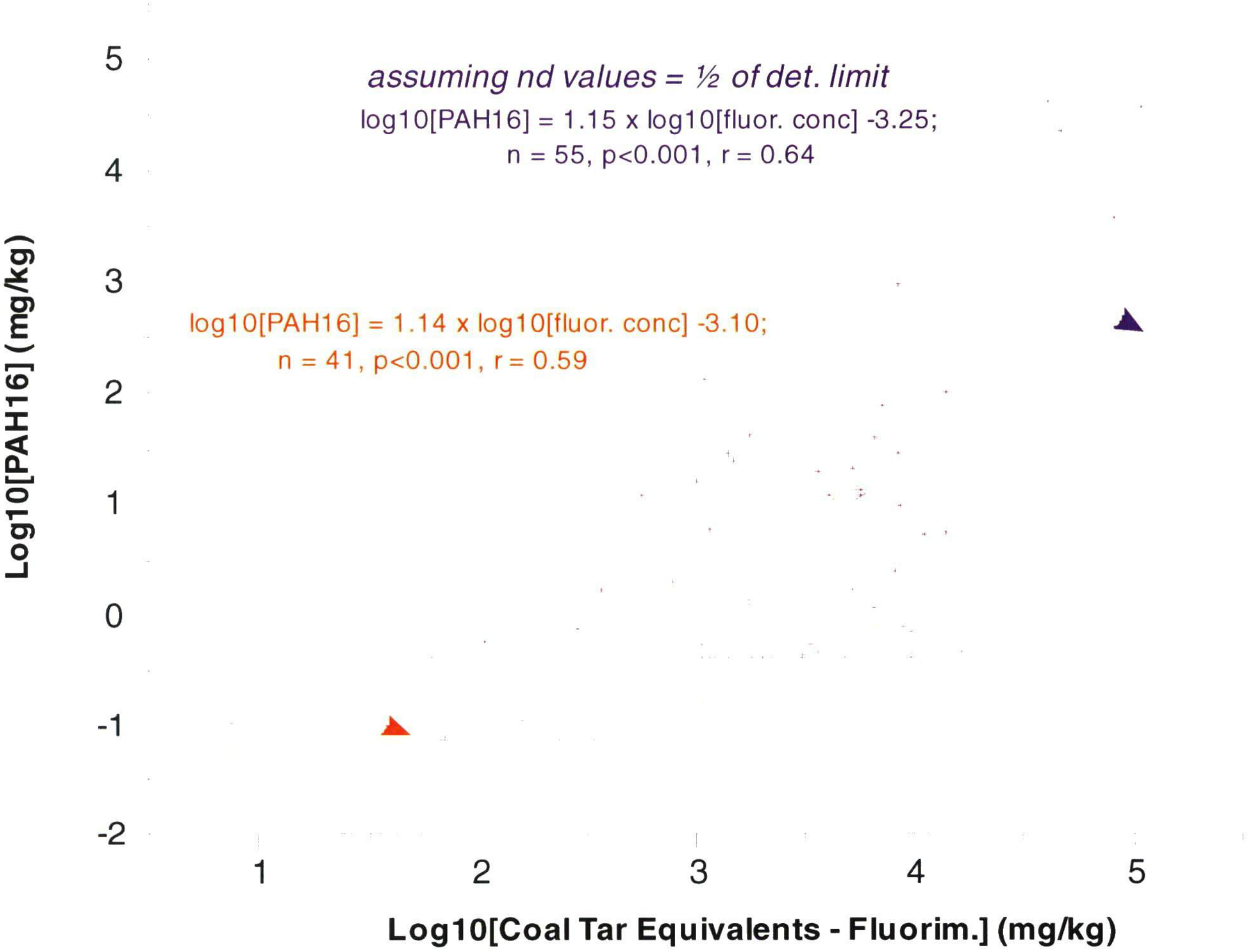


Figure 4-8: Statistical Relationship Between Coal Tar Concentrations in 2002 Sediment Samples Estimated by Field Fluorometric Analysis and Laboratory-Derived PAH Data

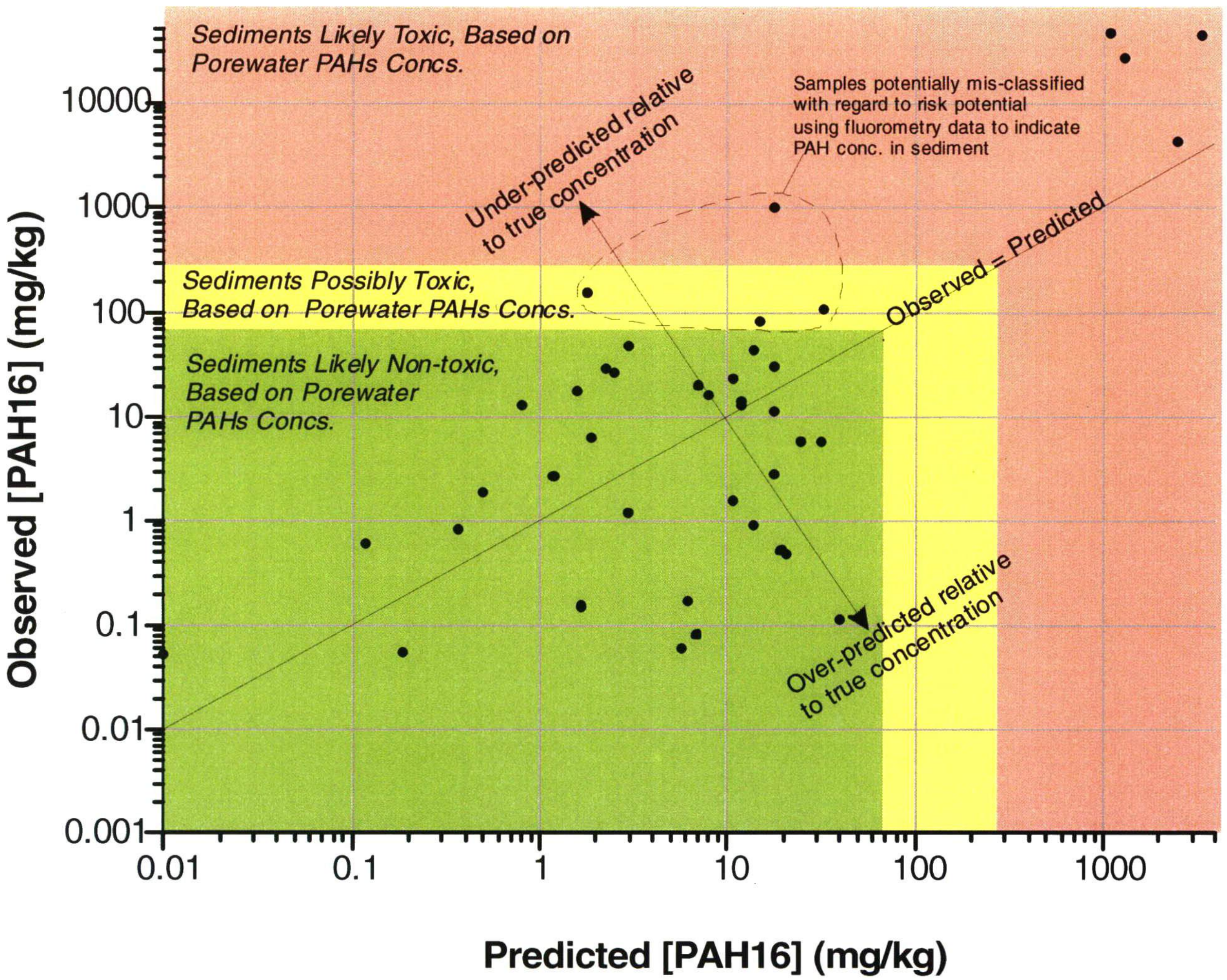


Figure 4-9: Degree of Concurrence Between Predicted and Actual Concentrations of Unsubstituted PAHs in 55 Red River Sediment Samples

Given the marked change in concentration of coal tar concentrations and synoptic trend at the plume edge, bottom, and in the upper several cm of sediment, an order of magnitude error in predicting the PAH16 concentration in bulk sediments would influence calculated volumes of highly contaminated sediments to a relatively smaller degree.

- **August 2007** sediment **data** (top 10 cm) were collected in support of the coal tar bioavailability assessment as described in Appendix E, and Section 4.11. The lab screening value was used for PAH16 concentrations, since data were available for all 20 surface collected samples. *Note that these screening-level measurements were made using sonication to provide a rapid assessment of PAH concentrations used to sub-select samples for detailed characterization.

To produce a continuous estimate of the contaminant distribution from the data, kriging was done in three dimensions, with the variogram chosen by the EVS-Pro expert system. The data was kriged to a grid that had the same horizontal structure as the 2D grid from the stratigraphy, and had vertical nodes distributed through the stratigraphic layers with a minimum of 2 nodes per layer. Because the samples from the cores were often taken at multiple depths spaced close together, a horizontal to vertical anisotropy of 20 was used during the kriging to help preserve in the gridded results the vertical variability found in the samples.

4.6.3 Visualization

The 3D data can be visualized in multiple ways. For each display, some processing is done:

- Limit the horizontal extent to a closely following polygon (convex) to limit extrapolation beyond the limits of sampling
- Set a vertical exaggeration, usually of 10 times the horizontal.

4.7 Screening Criteria for Sediment Quality

It was noted by the TAC that delineation of contaminated sediment made reference to the Canadian Council of Ministers of the Environment (**CCME**) Probable Effects Level (**PEL**) guideline, but not the more sensitive Interim Sediment Quality Guideline (**ISQG**).

The CCME is the intergovernmental forum in Canada for discussion and joint action on environmental issues of national and international concern. The CCME provides guidance that can be followed by individual jurisdictions or departments voluntarily. The guidance is intended to facilitate individual jurisdictional environmental clean-up or protection goals by providing tools, shared resources, and some standardization. The CCME takes responsibility for the development and dissemination of Canadian Environmental Quality Guidelines, including guidelines for soil, sediment and water quality (for drinking water, irrigation or livestock source water, and aquatic life protection), and tissue residue guidelines (for a small suite of persistent, bioaccumulative, toxic substances).

CCME sediment quality guidelines were developed in the mid 1990s in two categories: the Interim Sediment Quality Guidelines (**ISQG**), and the Probable Effects Level (**PEL**) sediment quality guidelines. The ISQG are contaminant thresholds for possible effects on sensitive organisms, and are generally much lower than the PEL for a given substance. The PEL sediment quality guidelines are intended to provide concentration thresholds above which impacts to aquatic life in or near sediments are likely.

The CCME ISQG and PEL sediment guidelines are conceptually similar to the United States National Oceanographic and Atmospheric Administration (**NOAA**) sediment “Effects Range - Low” (**ER-L**) and “Effects Range – Median” (**ER-M**) sediment values for contaminants. Initially, the NOAA Sediment Quality Guidelines (**SQGs**) (Long and Morgan, 1990) were developed specifically to enable the ranking of a suit of marine coastal sites in the Unites States for further investigation and action (such action potentially includes better focus on source control). The original authors of the SQGs initially held that that they should not be regarded as thresholds of acceptable versus unacceptable concentrations (E.R. Long, *pers. com.*; Annual meeting, Pacific Northwest Chapter, Society of Environmental Toxicology and Contamination, Victoria, BC, 1992). The NOAA SQGs have since been further developed and popularized for use in guidance of site-specific coastal assessments, risk assessments, and remediation. Some of the earlier cautions regarding appropriate or inappropriate use, however, have been lost in the intervening years.

The NOAA, CCME and British Columia (BC) Contaminated Sites Regulation (CSR) sediment quality guidelines or criteria share a common derivation methodology and even the same underlying sediment toxicity data, with some variations. Long and Morgan (1990) introduced SQGs based on compilations of data from reports where bulk chemical concentrations in sediment were quantified along with a measure of biological response. The responses were typically laboratory-based whole sediment or (rarely) pore water elutriate bioassays (e.g., using bivalve larvae), where the toxicant-response relationship was dominated by data from multiple sites on a few standardized test organisms, such as the amphipod *Rhepoxynius abronius* for marine sediments. A smaller portion of the underlying concentration-response data were based on benthic community response in field populations. The interpretation of effects versus no-effects in these field studies is highly complicated, is dependent on the power of the experimental design, and may be highly subjective. Long and Morgan (1990) based the initial NOAA SQGs only on cases within their database where a biological effect was noted. The concentrations of a substance (most often co-occurring with other contaminants) associated with a biological effect were ranked from lowest to highest. The 10th percentile among those concentrations was designated the ER-L and the 50th designated as the ER-M.

The CCME sediment quality guidelines were developed using a similar ranks-based approach to the NOAA SQGs, except that both the "no-effects" data and "effects" data from the database are used in derivation of the "Threshold Effects Levels" (**TELs**), which are then nominated as ISQGs provided certain data quality requirements are met. The TEL is defined as the geometric mean of the 15th percentile of the concentration ranked effects data and the 50th percentile of the ranked no-effects data (CCME, 1995). The use of no-effects concentrations to establish a potential effect threshold is particularly contentious among ecotoxicologists.

O'Connor (2002) points out various shortcomings of the NOAA ER-L and ER-M (and by extension CCME) approaches. He states –

> "Originally, an exceedance of any one ERM was considered a likely indication that a sample was toxic. However, upon examination of large data sets Long and MacDonald (1998) categorized the likelihood of toxicity as low, medium, or high if 1 to 5, 6 to 10, or more than 10 chemical concentrations, respectively, exceeded an ERM. As an alternative to multiple exceedances they introduced the ERM Quotient (ERMQ), which is the mean among ratios of chemical concentrations to ERMs. An ERMQ >1 would imply a medium likelihood of toxicity."

Empirical tests of the validity of the NOAA SQG have been undertaken both by those involved in their original derivation (Long et al., 1995; Long and Macdonald, 1998) and by others (O'Connor, 2002; O'Connor and Paul, 2000). The results of validation studies by O'Connor (2002) show that –

> "generally less than half of the samples with chemical concentrations above any of the SQGs were actually toxic. A few did better than 50%, but at the price of excluding many samples. For example SQGs requiring 6 or more ERM exceedances or an ERMQ >1 were about 60% accurate in identifying toxic samples, but that increase in accuracy caused the SQG to apply to ten times fewer samples than the simple single-ERM exceedance SQG."

The CCME sediment quality guidelines would likely have an even lower predictive capability, in light of the inclusion of the no-effects data distribution for their derivation. It has been noted that ER-L SQGs are relatively good for predicting the non-toxicity of sediment samples; however, exceedance of the ER-L concentrations is not a good predictor of toxicity. O'Connor (2002) concluded that the connection between sediment bulk chemistry and biological toxicity is sufficiently tenuous across a wide range of sediment and ecosystem types to have little predictive value. He further noted that there is a certain gamesmanship in validating chemistry-based thresholds of biological toxicity: Whereas the absolute concentrations of chemicals in the sediment are static, the co-occurrence of other substances is highly variable, and operationally defined assertions about toxic versus non-toxic can be highly fluid. One can classify a sediment sample as toxic versus non-toxic, for example, based on a pass or fail of one test or multiple tests within a battery of laboratory-based toxicity tests, or based on level of response (EC_{20} versus other response levels), the choice of which is somewhat arbitrary, and may be less than objective. When dealing with benthic community data, it is even more challenging to dichotomize into an effects versus no-effects scheme what is often a continuous and synoptic concentration-response relationship without break-points, depending on whether the response of interest is macroinvertebrate densities, taxon richness, feeding guild or functional shifts, or other types of responses.

Many of the Canadian ecological risk assessment practitioners have found that the CCME ISQGs are not good predictors of benthic community effects, and that the ISQG values are often so low that in many cases virtually all sediments in urban setting or even based on natural mineralization exceed one or more ISQGs.

Beyond the concerns summarized above, there are at least four other major criticisms of the CCME sediment quality guidelines for use in establishing environmental protection goals:

(i) The CCME sediment quality guidelines are derived from a set of matched data on toxicity and bulk sediment chemistry; however, the mechanics of the derivation automatically assign the toxicity to the chemical of interest in spite of the co-occurrence of a large suite of substances that might be more directly connected to the observed biological response(s). There is a large possibility that the chemical of interest was not the causative agent, so that the pseudo- dose response assignation is erroneous and misleading.

(ii) The CCME sediment quality guidelines were not derived in consideration of other aspects of porewater chemistry in the field collected samples. Important influences on biological exposures and responses relative to bulk sediment concentrations include the sediment/pore water concentrations in a eutrophied sediment in an urbanized or industrialized water body of ammonia and other by-products of decomposition of organic detritus, redox conditions, and rate of advective and diffusive exchange with surface water at the sediment water interface (which is in turn related to sediment particle size and degree of sorting).

(iii) Especially for PAHs, the underlying database for the CCME sediment quality guidelines is dominated by studies of sediments wherein metals/metalloids are major co-contaminants with PAHs, and the PAHs are substantially derived from environmental releases of petroleum-based products (petrogenic PAHs). Petrogenic PAH mixtures are typified by a dominance of alkyl-substituted PAHs over unsubstituted or parent PAHs. The alkyl-substituted forms, however, are seldom measured, and the biological response is assigned to the measured PAHs. Coal-tar, creosote, and many pyrogenic PAH mixtures, however, are comprised primarily of unsubstituted PAHs, and there is less potential for biological risks from an unmeasured alkyl-PAH component. In general, it has been experienced that generic sediment quality criteria for PAHs tend to seriously over-predict toxicity of PAHs released to sediments from coal tar or creosote inputs, relative to the observed toxicity.

(iv) The CCME sediment quality guidelines are based on an amalgamation of data that are then ranked and the lower ranks of effects and no-effects concentrations used to derive the ISQGs. The data falling at the lower end of the ranked effects data very likely represent sediments where the contaminants exhibit a very high degree of availability (i.e., are among the lower 20th %ile of sites ranked from higher to lower bioavailability). This will over-estimate the toxicity relative to actual bioavailability and exposures at the vast majority of sites.

In light of general reservations about the high degree of conservatism of CCME ISQGs, UMA (2003) elected to compare sediment PAH data to PELs. It should be noted, however, that many of the issues associated with derivation of the CCME ISQGs also apply to the derivation of PELs. The comparison, therefore, was simply intended to show relative degree of contamination within different areas of the riverbed. Above all, a site-specific ecological risk assessment has been completed for the Red River adjacent to the Sutherland Site, and this is provided as a more proximate and more accurate assessment of the potential for ecological risks than the use of generic environmental quality criteria.

4.8 Individual PAH Surrogates of Coal Tar Contamination

In the UMA (2003) Supplemental Site Investigation, naphthalene (and benzo[a]pyrene) was used as surrogate PAH for delineation of contaminated sediment. We explain the rationale for this. In addition, the spatial extent of coal tar contamination in the river bed is described in this report (Section 4.5, 4.9 and 4.11) in terms of the concentration of total unsubstituted PAHs (PAH16).

An evaluation of the composition of PAHs in Sutherland Site samples was included in UMA (2003), using descriptive as well as multivariate pattern analysis techniques. A major conclusion of this analysis was that the PAH-contaminated sediment in the riverbed had a PAH composition that was not distinguishable from highly coal tar contaminated soils in the subsurface environment beneath the Site. The implication is that the PAH composition in the river is consistent with the historic direct deposition of free-phase coal tar into the river during the operation.

Figure 4-10 shows the average proportion of various PAHs in Red River sediment samples based on the 2002 coring program (UMA, 2003). The "total" PAH concentration is based on the sum of the 16 unsubstituted PAHs, and various alkyl-substituted PAHs measured either as individual PAH compounds (e.g., 2-methylnaphthalene) or alky-PAH homologue groups (e.g., dimethylnaphthalenes: all naphthalene compounds with two methyl groups attached in any position). Also indicated in Figure 4-9 are those PAHs that are suspected or known carcinogens.

Unsubstituted PAHs in coal tar contaminated sediment comprise about 60 to 80% of the total PAH concentration (see Appendix E, Table 3). In addition, naphthalene is the most abundant individual PAH in coal tar contaminated sediment samples (17% of total PAHs on average, including alkyl forms as analyzed in 2002), followed by phenanthrene (12% on average). Among the eight potentially carcinogenic unsubstituted PAHs, benzo(a)pyrene, benzo(a)anthracene, and benzo(b)fluoranthene were the dominant contributors to total PAH concentrations (2.8 to 3.1% on average).

In conclusion, naphthalene is considered a good surrogate of coal tar distribution since it is the individual PAH occurring in the highest proportion in coal tar contaminated sediments. Benzo(a)pyrene was secondarily used as a chemical surrogate of coal tar distribution based on its proportional concentration, known mode of action as a cancer-causing substance, and based on the large amount of scientific information available regarding the environmental fate and effects.

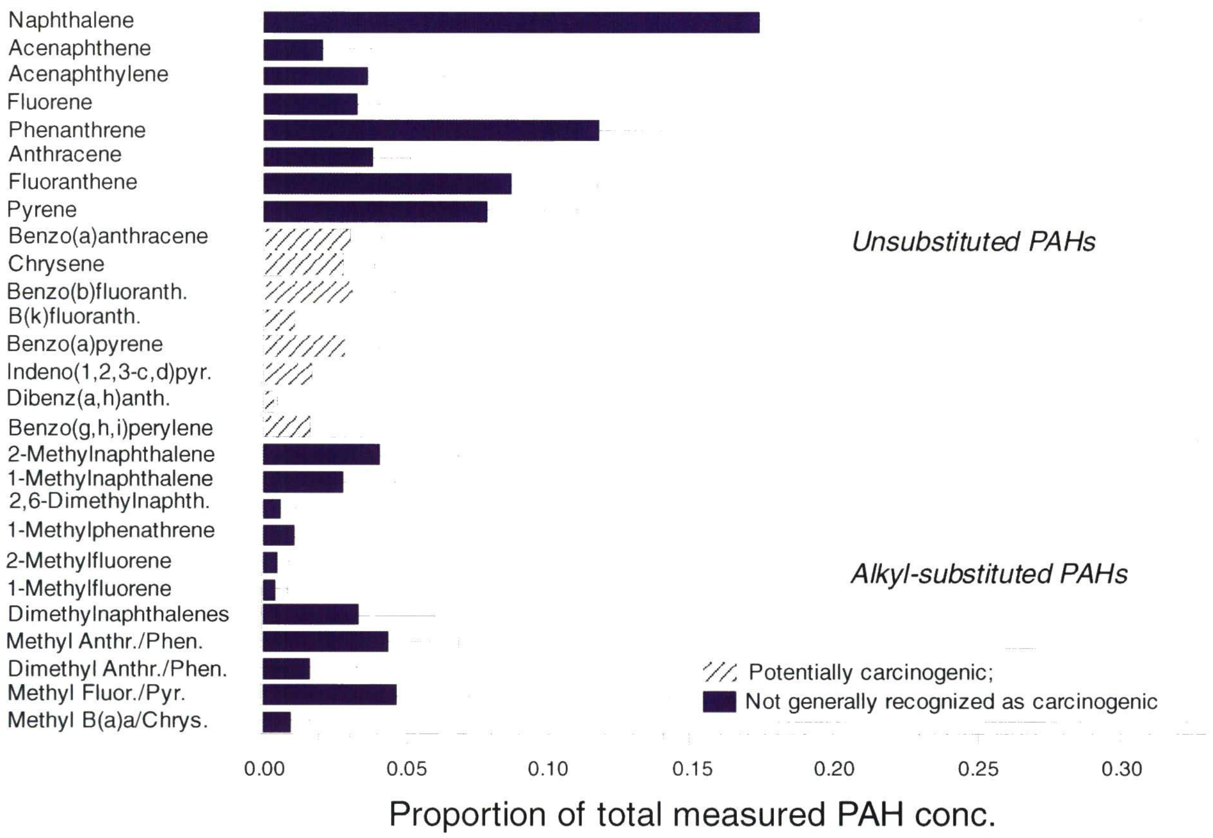


Figure 4-10: Relative Proportion of Different PAHs in Coal Tar Contaminated Sediment, Sutherland MGP Site

4.9 Spatial Variation in Sediment PAHs and Benthos

TAC provided the following query:

> "The risk assessment report indicated that there was a significant difference in macroinvertebrate density between various station groupings, but did not indicate whether there was a significant difference in sediment PAH concentration between the five groups (low, medium, high PAH levels; up-river reference; down-river reference)."
>
> "Sediment samples from downstream reference stations exhibited much lower PAH concentrations than sediments from the areas adjacent to the Sutherland Site, although these samples exhibited PAH concentrations that were more than two fold higher on average than the upstream stations. Are these differences in PAH contamination significant?"

The aquatic risk assessment described in the CEMP makes reference to a possible influence of PAHs on reference station sediments down river from the Site. In particular, we note that the concentrations of PAHs (sum of 16 unsubstituted PAHs) in five down river reference samples was significantly different from the samples from the five up river reference sites (Figure 4-11):

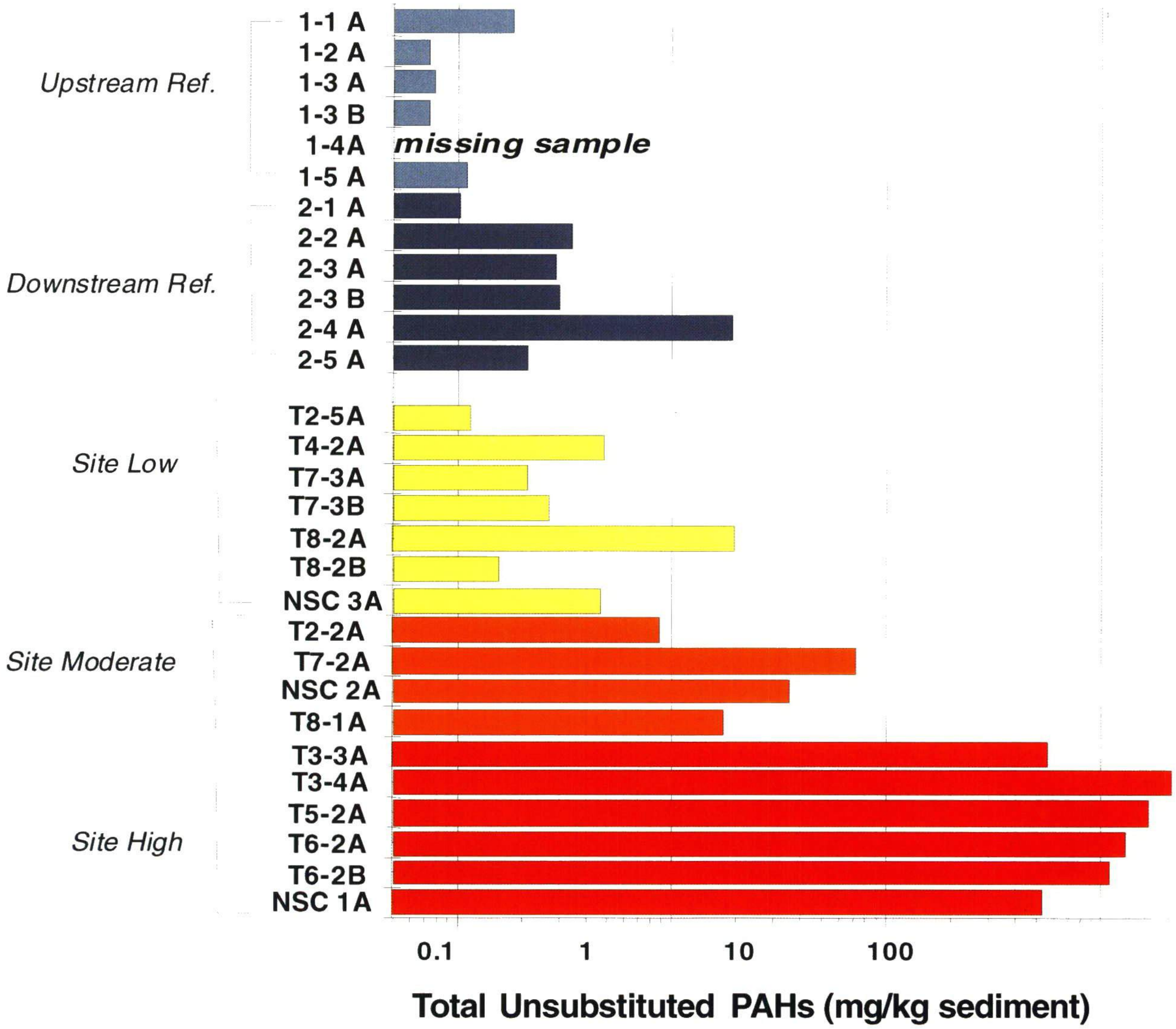


Figure 4-11: Concentrations of PAHs in Surface Sediment Samples from Benthos Risk Assessment Sites (2003) (non-detected PAHs assumed present at ½ d.l.)

Figure 4-11 also shows the statistically significant differences between site categories, based on a one-way ANOVA and Tukey post-hoc test run on the untransformed data. A two-tailed t-test (non-paired) indicates that PAH16 concentrations at the downriver and upriver reference sites were not significantly different (df = 9, t = 1.15) using α=0.05. While the average downriver PAH concentration (0.46 mg/kg) was much higher than the upriver average (0.083 mg/kg), the high degree of between-site variability suggests that differences would be statistically significant with a higher number of sample replicates or perhaps if the assumption of normality were not violated for this data set. The log10-transformed PAH concentrations were marginally statistically different for upriver and downriver reference sites (df = 9, t = 2.23). A log-transformation is appropriate since the transformed data more closely approximate a normal distribution.

Given the slightly higher PAH16 concentrations in the downriver reference samples relative to the upriver reference samples, an obvious question is whether this might be attributable to past re-suspension and deposition of coal-tar contaminated sediments from the river bed adjacent to the Sutherland Site. Figure 4-12 shows that the PAH composition (i.e., relative abundance of the sixteen unsubstituted PAHs) was similar for upriver and downriver reference sites, and that the reference site PAH composition was dissimilar to the coal tar contaminated sediment samples. In particular, reference sediment samples from both upriver and downriver of the Site exhibited a much lower proportion of naphthalene and phenanthrene, as well as a much higher proportion of the higher molecular weight PAHs typically associated with deposition of combustion-derived fine particulates [benzo(a)anthracene, benzofluoranthenes, benzo(a)pyrene, indeno(1,2,3-c,d)pyrene, dibenzo(a,h)-anthracene, benzo(g,h,i)perylene]. As illustrated below, sediments collected within 30 cm of the surface at core location 3-3 exhibited about 30% of their PAH16 concentration as naphthalene.

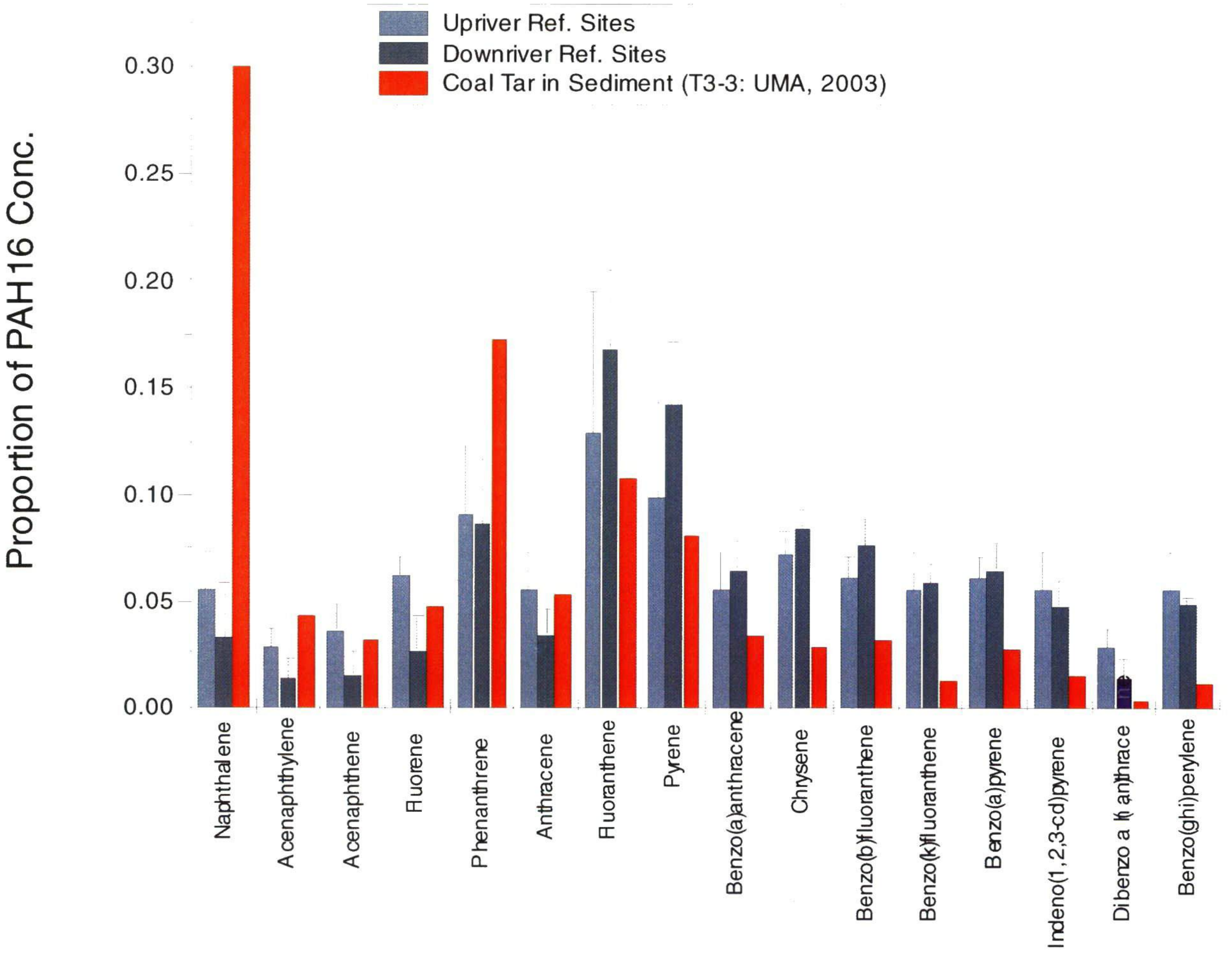


Figure 4-12: Comparative analysis of PAH composition of reference sediment samples from the urbanized Red River (collected in 2003) and a sample of coal-tar contaminated sediment from riverbed adjacent to the Sutherland Site (T3-3: PAH16 = 38,700 mg/kg)

There were much lower PAH16 concentrations in the reference site sediments relative to sample T3-3, collected 30 cm from riverbed surface, as illustrated in Figure 4-12. It might be hypothesized, therefore, that the compositional differences arose from differential rates of microbial decomposition over time of lower molecular weight PAHs, coupled with overall higher decomposition rates in areas of the river bed that have lower PAH concentrations (i.e., naphthalene and phenanthrene are being preferentially degraded, and the rate of loss is highest in minimally contaminated areas). In order to differentiate between the effects of post-depositional fate and urban-type inputs to the near-surface sediments, we examined minimally contaminated sediment samples collected from the bottom of cores that intersected major zones of coal tar contamination. Less contaminated sediments near the bottom of several cores would be expected to contain only coal-tar derived PAHs. For the sediment sample collected from T3-3 at a depth of 3.5 m below the surface (PAH16 = 6.0 mg/kg), naphthalene and phenanthrene accounted for 13.2% and 20.5% respectively of the PAH16 concentration, which is not consistent with the proportion of these PAHs in downriver reference sediments. Therefore, differential biodegradation does not appear to account for the compositional differences observed between the downriver sediment samples and coal tar contaminated sediment plume.

Finally, it is noted that the PAH16 concentrations in reference sediment samples 2-1 through 2-5 (Figure 4-11) do not decrease synoptically with downriver distance from the Sutherland Site. In particular, the reference site 2-5 was located an estimated 2.2 km downriver from the Site. The observed PAH16 sediment concentration, however, was approximately an order of magnitude higher at site 2-4 located approximately 5 km downriver from the site. The concentration at site 2-3 was also an order of magnitude lower that sample 2-4 in spite of the fact that collection sites 2-3 and 2-4 were less than 200 m apart.

Overall, it is concluded that while the downriver reference sites contained average PAH16 concentrations that were five-fold higher than the upriver reference sites, such differences do not appear to be a result of downriver mobilization of coal-tar contaminated sediments from the riverbed adjacent to the former MGP site. Rather, the PAH composition of all reference site samples is consistent with expectations based on stormwater inputs from urbanized areas in other North American communities.

4.10 Other Possible Sources of PAH Contamination to the Urbanized Red River

The UMA (2003) report suggests that there is a separate PAH source affecting the sediment samples at the downstream sites. PAHs are widely known to be contributed to the aquatic environment through at least two major source types:

(i) Release of new and used petroleum-based products (motor gas, diesel-range distillates, lubricating oils, heavy residuals) (petrogenic PAHs); and

(ii) *De novo* production and release during lower temperature combustion (automotive exhaust, garbage incineration, wood-burning, *et cetera*) (pyrogenic PAHs).

Coal tar PAH constituents are a special case, wherein the PAHs originated from production over geological timescales from the long-term diagenesis of organic matter to produce coal, and the PAHs have subsequently been modified to a more pyrogenic PAH type as a result of the coal gasification process.

Petrogenic sources such as crankcase oil in cars, trucks and machinery with 2-stroke engines (lawnmowers, for example) can take on a progressively pyrogenic characteristic with extended use.

Within the Winnipeg environment, major expected sources of PAH loading to the Red River might include (in possible order of priority) –

- Stormwater runoff;
- Discharge of treated sewage effluent;
- Direct discharge from adjacent industrial and historically contaminated sites and/or petroleum spills;

- Direct atmospheric deposition of combustion-derived fine particulates containing PAHs.

Stormwater runoff in particular has been shown to be an important PAH source to receiving waters in a large number of cities, owing to the large number of combustion sources including automobiles and trucks, high percentage of impervious surfaces (building roofs, parking lots, roadways, sidewalks), and aerial extent of the overall catchment drained by various stormwater collection networks. Two good review articles include Wren et al. (1997) and Makepeace et al. (1995).

PAHs in stormwater are contributed by both combustion-derived fine particulate deposition to impervious surfaces and the direct spillage of petroleum products to impervious surfaces. For example, oil leaks from vehicles can comprise a major PAH source to stormwater and subsequently to aquatic receiving environments. In fact, "Waste Crankcase Oil" (WCO) was re-assessed in 2002 under the Canadian Environmental Protection Act (CEPA) and was concluded to be a "CEPA toxic" substance. According to Environment Canada (2002):

> "Studies on roadway runoff provide a link between release of WCO from vehicles and effects on benthic organisms, which also include changes in the biodiversity of sediment fauna. As a result, this new information was used as a surrogate for the dust suppressant and land disposal scenarios to show possible effects on sediment biota and change in species diversity that can result from exposure to WCO."

In any urban environment, the relative importance of sewage effluent inputs versus stormwater inputs will depend on (i) whether the stormwater and sanitary flows are segregated or combined, (ii) efficacy of the sewage treatment process to either sequester PAHs in biosolids or result in microbial breakdown, and (iii) industrial, commercial and residential make-up of properties serviced by either the stormwater or sanitary sewer collection systems.

Chambers *et al.* (1997) reported that discharge of treated municipal sewage effluent in Montreal contributed approximately 1.2 kg/d (440 kg/y) of PAHs (including 21 individual PAH). Current estimated PAH loading of dissolved naphthalene to the Red River via groundwater is 0.37 kg/y (Section 4.2). No similar mass loading estimates are available for the City of Winnipeg based on either stormwater, or treated sanitary wastewater inputs; however, the presence of PAHs in surficial sediments in the Red River is not surprising in light of studies that have been conducted in other cities.

4.11 Effects on Sediment Associated Fauna: Relationship Between PAH Bioavailability and Observed Ecological Response

The CEMP for the Site is based on an ecological risk assessment completed in 2003/04. The risk assessment, based on the investigation of field occurrences of benthic macroinvertebrates, demonstrated that there is a very limited impact on benthos from PAH contamination in the Red River adjacent to the Site. While there was a statistically significant negative correlation between the $\log_{10}$ PAH concentration and macroinvertebrate abundance, this relationship accounted for only ~5% of the between-site variability in macrobenthos abundance:

$$\text{Log}_{10}[\text{Macroinvertebrate density}] = 1.42 - 0.001 \bullet [\text{total PAHs}] \tag{2}$$
$$(p = 0.013;\ R^2_{(adj)} = 0.052\ [5.2\%])$$

This is illustrated in Figure 4-13, which is reproduced from the ecological risk assessment.

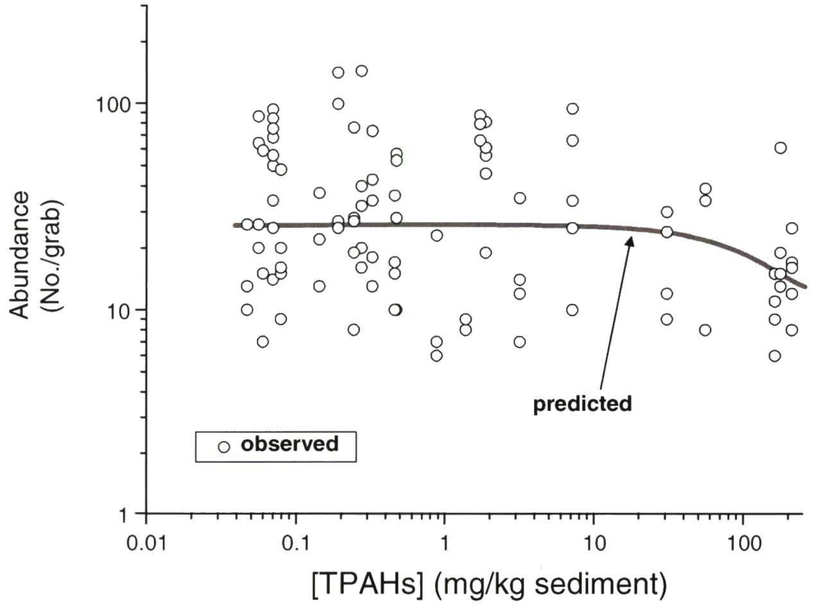


Figure 4-13: Relationship Between Macroinvertebrate Density and PAH Concentrations

It was noted that measures of sediment particle size (% clay), sediment organic carbon content and various geological origin metals were at least as strongly correlated with benthos abundance as the sediment PAH concentration, in spite of the fact that PAHs in sediment samples from the sites assessed exhibited a concentration range spanning four orders of magnitude. The abundance of infaunal clams, caddis fly larvae and stone fly larvae was found to be significantly negatively correlated with sediment PAH concentration, but - as for total macroinvertebrate abundance - the co-variation between biological variation and PAH concentration in sediment accounted for 10% or less of the overall between-site variability in abundance.

None of the other taxonomic groups (ephemeroptera, diptera, lumbriculids, tubificids, or gastropods) exhibited a discernible relationship with levels of PAH sediment concentrations. Ephemeropteran density increased significantly with sediment gravel content ($p = 0.016$; $r^2 = 0.05$). Lumbriculid density was positively associated with sediment silt content, but negatively associated with organic carbon content ($p = 0.037$, $r^2 = 0.05$). No relationship between biodiversity, measured as species richness, and sediment PAH levels was evident. Finally, it was demonstrated that the total macroinvertebrate abundance, biodiversity, and species composition (evaluated using multivariate analytical techniques) in highly PAH contaminated sediment adjacent to the Site were in the range of observations for other sites within the urbanized Red and Assiniboine Rivers.

The apparent lack of major toxicological response of sediment-associated fauna to coal tar contamination bears further scrutiny from mechanistic/causal perspective. In particular, it was speculated that limited bioavailability of PAHs in the coal tar contaminated sediments could account for the observed benthos data.

A follow-up study was completed in August - October, 2007. In order to evaluate the apparent lack of bioavailability and hence toxicity of PAHs, the dissolved concentration of PAHs in porewater extracted from sediment samples was determined using recently published ASTM standard methods and guidance prepared by the U.S. Environmental Protection Agency for predicting the toxicity of PAH mixtures (ASTM, 2007; US EPA 2003). Complete documentation of the bioavailability study is provided in Appendix E, while a summary of the methods and major findings is provided herein.

Sediment grab samples (top ~10 cm) were collected using a stainless steel Petite Ponar grab from 20 sites in the Red River within the coal tar contaminated sediment plume. These sites were selected based on the existing (2002) sediment data showing elevated coal-tar related PAH concentrations and for which previous data existed on macroinvertebrates. The concentration of total PAHs in bulk sediments was determined semi-quantitatively using a rapid chemical assessment method based on PAH extraction through sonication. The screening concentration of PAH16 in the 20 sediments ranged from 0.2 to 2,700 mg/kg (wet weight basis). The ratio of parent (unsubstituted) to parent + alkyl PAHs ranged from 0.40 to 0.82, indicating that parent PAHs represented a significant proportion of the aromatic hydrocarbons in the sediment samples, which is typical for PAH mixtures observed at MGP sites. Samples with lower parent:parent+alkyl PAHs likely reflect a greater relative contribution of PAHs from urban runoff. These samples exhibited a lower overall PAH concentration.

Using the screening data, 10 samples having a range in PAH concentrations were selected for detailed analysis of dissolved PAHs in extracted porewater. The concentration of dissolved PAHs was used to estimate the potential toxicity of each sediment sample.

When referring to the concentration of dissolved PAHs or bioavailable PAHs present in sediment porewater, the term PAH_{34} is used which is expressed in units of μmol/g lipid. The bioavailability PAH_{34} concentration expressed as μmol/g lipid represents the predicted internal concentration or body burden of PAHs that is expected in benthic aquatic organisms if they are exposed to the sediment and based on equilibrium partitioning between porewater and biological lipids. The measurement of PAH_{34} is the sum of 18 parent PAH compounds and 16 groups of alkylated PAH compounds, which represents thousands of individual PAHs. The exposure and internal body burden of sediment-dwelling invertebrates is predicted using equilibrium portioning theory, and the analysis of PAH_{34} is conducted to provide a better estimate of the potential toxicity resulting from complex mixtures of PAHs and as a result of non-polar narcosis. This approach is based upon recently published guidance prepared by the U.S. EPA for characterizing the toxicity of PAH mixtures to benthic macroinvertebrates (U.S. EPA 2003).

Mean concentrations of dissolved PAH_{34} measured in extracted porewater ranged from 0.42 to 4,630 μg/L. When expressed in terms of potential exposure to benthic life, the concentrations of dissolved PAHs in porewater ranged from 0.05 to 128 μmol/g lipid. In contrast to the variability observed in bulk sediment PAH_{34} concentrations, there were much smaller differences between the replicate analyses of dissolved PAH_{34} in sediment porewater.

4.11.1 Expected Versus Observed Sediment-Pore Water Partitioning of PAHs

Using the measured concentrations of dissolved PAHs in sediment porewater, the concentrations of PAHs in bulk sediment, and the total organic carbon (TOC) measured in bulk sediment, the apparent organic carbon-water partitioning coefficient (K_{OC} value) for each PAH was calculated for each of the ten sediment samples. These K_{OC} values provide an estimate of the PAH bioavailability to benthic aquatic life. The mean and range of the measured log K_{OC} values is shown for the parent PAHs in Figure 4-14. In all cases, the measured K_{OC} value exceeded the literature based values based on natural organic matter and used by various risk assessment models [U.S. EPA, 2003]. Higher K_{OC} values indicate lower PAH bioavailability; therefore, the PAHs in these surface sediments are less bioavailable than would be assumed by the current risk assessment models. In some sediment samples, the log K_{OC} values exceeded the literature derived K_{OC} values by more than two log units (100 times).

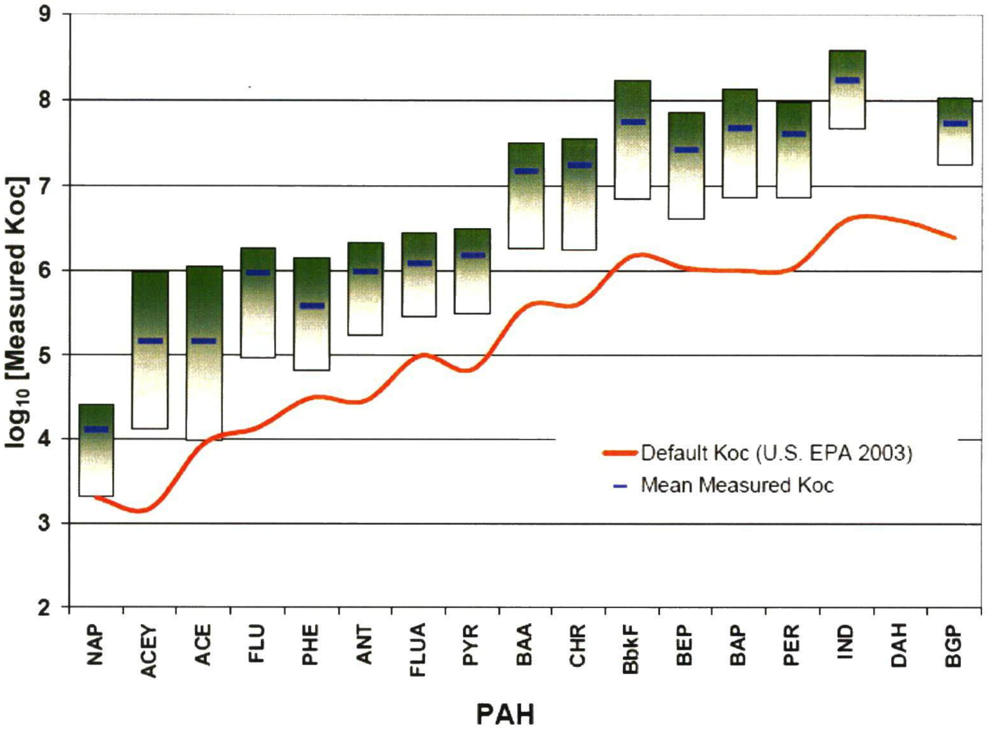


Figure 4-14: Observed versus USEPA Published Sediment-Water Partition Co-efficients for Ten Red River Sediment Samples. The Average and Range of Observed Values is Indicated by the Bars.

4.11.2 Bioavailability Assessment and Predictions of Sediment Toxicity

The concentration of bioavailable PAHs generated for the Red River sediment samples was compared to the *Sediment Contaminant Bioavailability Alliance* (SCBA) sediment database of previously collected PAH bioavailability and *Hyalella azteca (H. azteca)* laboratory toxicity data. A total of 133 freshwater sediments are included in the database, from 7 MGP and 2 aluminum smelter sites across North America. Aluminum smelters are included in the data set because of the use of coal tar pitch as a binding agent for electrodes in the Soderberg aluminum smelting process. *H. azteca* was selected as the test organism for assessing sediment toxicity in the SCBA database because it is considered to be highly sensitive to hydrocarbon contaminants and its survival and growth test endpoints have good precision (U.S. EPA 2000, 2003).

Data previously developed from freshwater sediment samples (SCBA database) indicate that porewater samples having less than 15 μmol/g lipid PAH_{34} are not anticipated to result in significantly reduced survival of *H. azteca* (i.e., *H. azteca* survival should be >85%) and samples having more than 75 μmol/g lipid PAH_{34} are expected to have near 100% mortality (i.e., *H. azteca* survival should be <15%) [Hawthorne et al., 2007]. The concentrations of dissolved PAH_{34} in sediment porewater from the 10 selected samples were evaluated against this set of results (Figure 4-15).

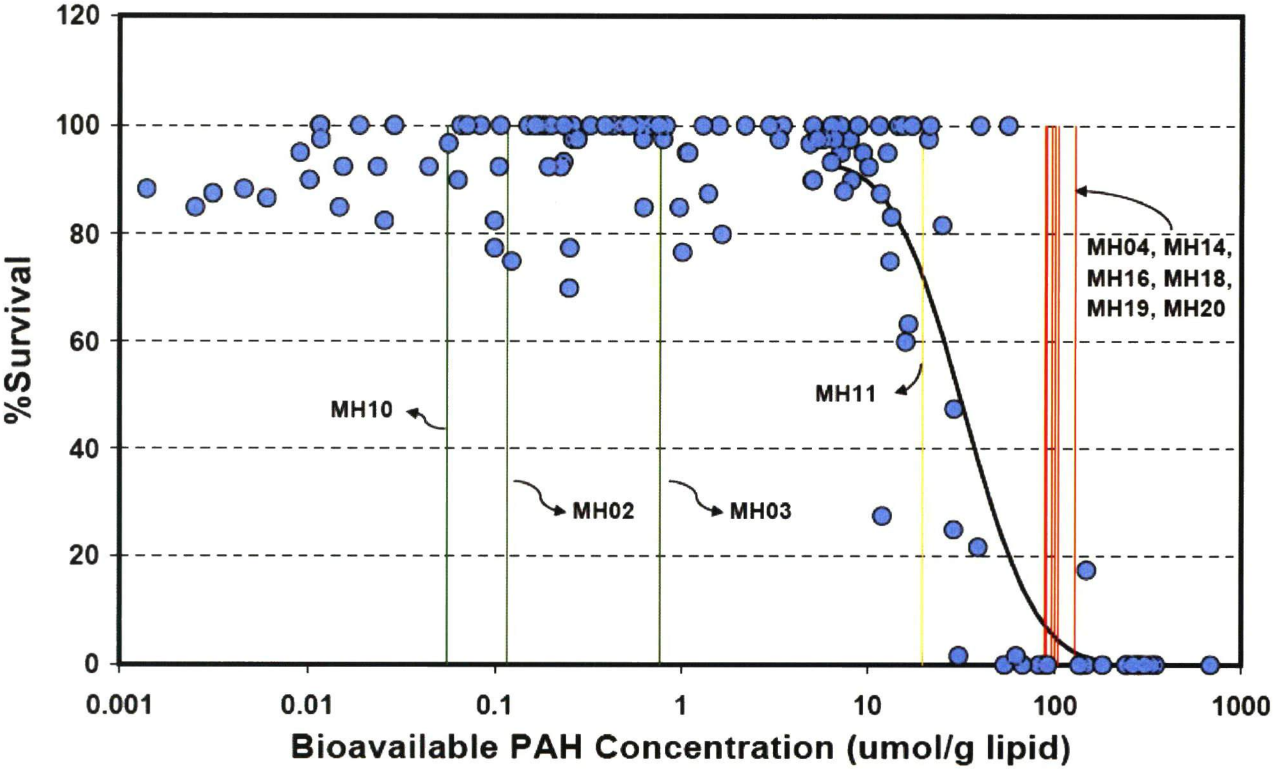


Figure 4-15: Bioavailable PAH (μmol/g lipid) concentrations for Red River sediment samples compared to *H. azteca* survival (28-day) and bioavailable PAH (μmol/g lipid) concentrations for 133 sediment samples from the SCBA database.

Based on these comparisons –

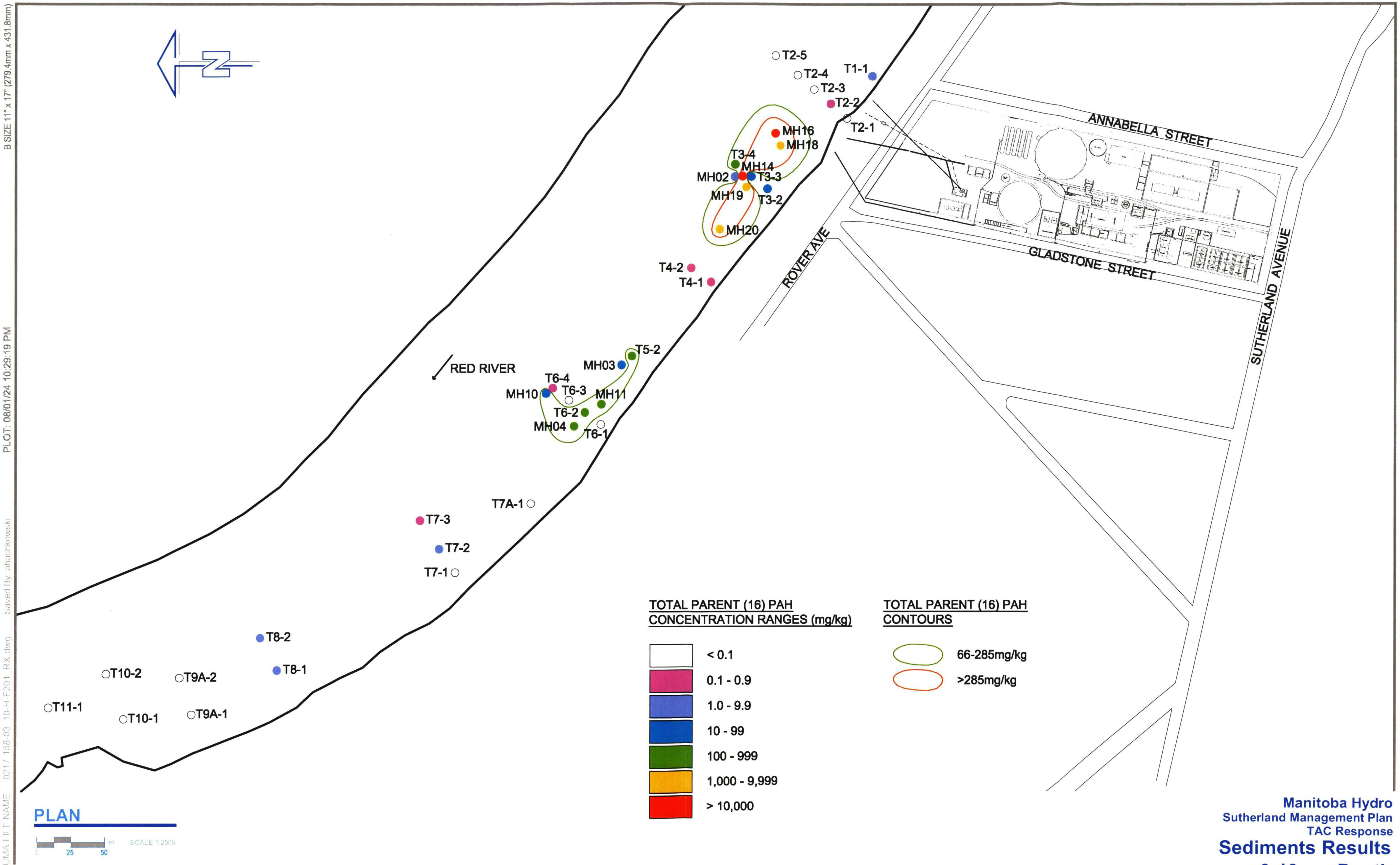
- Sutherland Site sediment samples MH02, MH03, and MH10 are not predicted to be toxic to aquatic invertebrates such as *H. azteca*. Samples MH02, MH03 and MH10 were determined to have 0.12, 0.78, and 0.06 µmol/g lipid PAH_{34} (9.18, 20.4 and 66 mg/kg PAH16) respectively.
- Sample MH11 was determined to have a dissolved PAH_{34} concentration of 19.9 µmol/g lipid (sediment concentration 247 mg/kg PAH16) and toxicity cannot be predicted at the 95% confidence level.
- The dissolved concentration of PAHs in porewater extracted from samples MH04, MH14, MH16, MH18, MH19, and MH20 exceeded 75 µmol/g lipid PAH_{34} and these samples are expected to be toxic to *H. azteca* (Fig 4-15). These samples ranged in sediment PAH16 concentration from 285 to 17,900 mg/kg.

Though samples MH04, MH10, and MH11 came from the same vicinity, they ranged in bioavailable PAH concentrations from less than 1 µmol/g lipid to more than 90 µmol/g lipid indicating that the chemistry of sediments in this area appears to be very heterogeneous. The other sediment samples exhibiting high concentrations of bioavailable PAHs were also found to be geographically centered in the area located just north of the bridge crossing the study area. Surface sediment samples collected downgradient (north) of sample MH04 and upgradient (south) of sample MH16 were found to have very low concentrations of total PAHs in the screening analysis and are also not expected to exhibit toxicity to benthic macroinvertebrates.

Overall, the site-specific bioavailability assessment indicated that sediment samples with PAH16 bulk sediment concentrations exceeding 285 mg/kg PAH_{16} are likely to be toxic to benthic aquatic organisms in laboratory toxicity tests, while sediments with <66 mg/kg PAH16 in bulk sediments are likely to be non-toxic.

Sediment samples exhibiting high concentrations of bioavailable PAHs and expected to be toxic were geographically centered in the area located just north of the bridge crossing the study area. Sediment samples further downgradient (approx 150 m north of the bridge) were highly variable in PAH concentrations, having a wide range when measured in both the bulk sediment and extracted sediment porewater.

The estimated aerial extent of coal tar contaminated sediment in the Red River with bulk sediment PAH concentrations in excess of 66 mg/kg and 285 mg/kg is illustrated in Figure 4-16 (top 10 cm) and Figure 4-17 (all sampling depths >10 cm). Especially the areas of sediment with PAH16 concentrations >285 mg/kg are likely to be toxic to benthic invertebrates if exposed at the sediment surface within the zone of benthos burrowing.



TOTAL PARENT (16) PAH CONCENTRATION RANGES (mg/kg)

- ☐ < 0.1
- 🟪 0.1 - 0.9
- 🟦 1.0 - 9.9
- 🟦 10 - 99
- 🟩 100 - 999
- 🟨 1,000 - 9,999
- 🟥 > 10,000

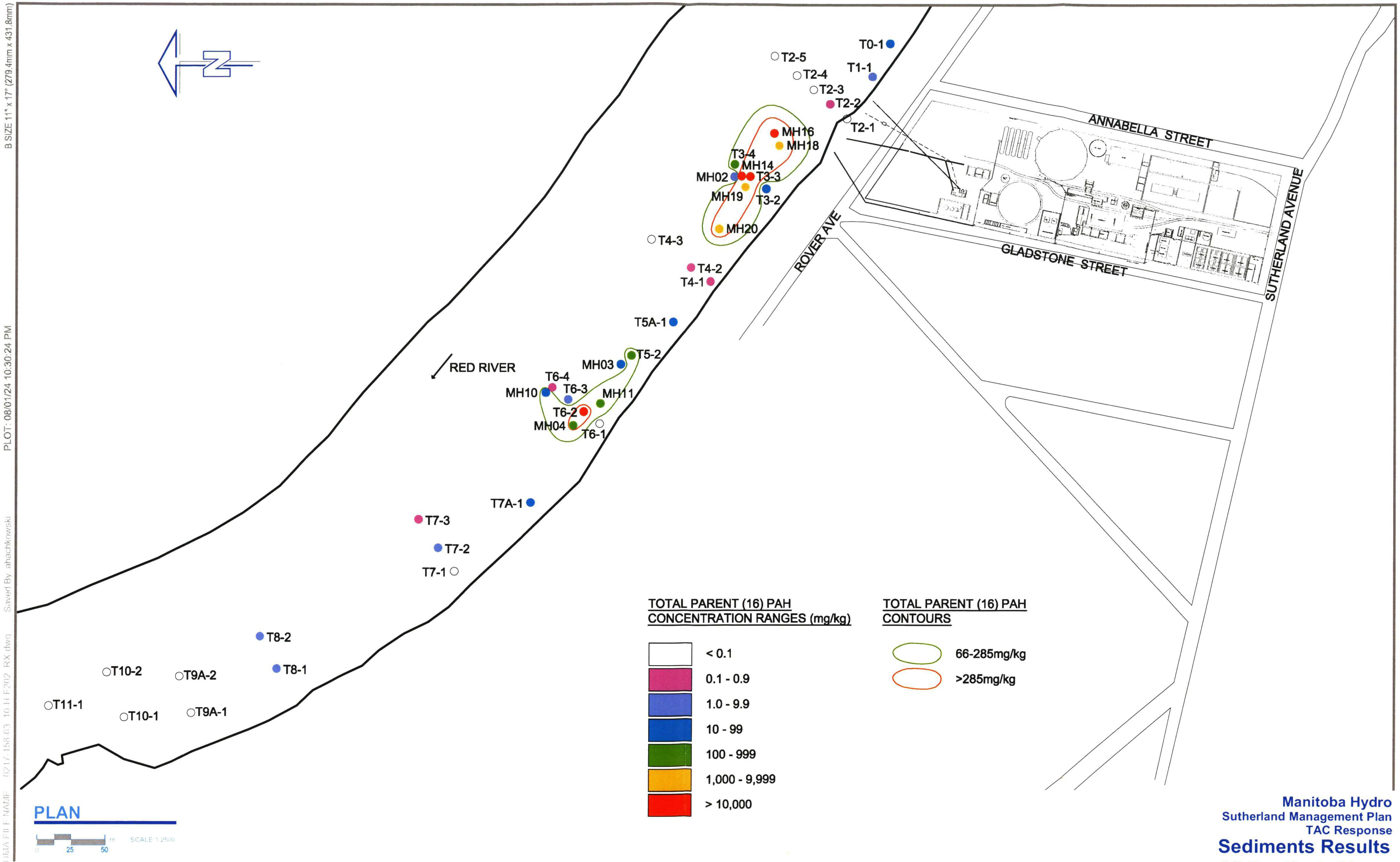
TOTAL PARENT (16) PAH CONTOURS

- ○ 66-285mg/kg
- ○ >285mg/kg

UMA | AECOM

Manitoba Hydro
Sutherland Management Plan
TAC Response

Sediments Results
0-10 cm Depth
Figure 4-16



TOTAL PARENT (16) PAH CONCENTRATION RANGES (mg/kg)

☐	< 0.1
🟪	0.1 - 0.9
🟦	1.0 - 9.9
🟦	10 - 99
🟩	100 - 999
🟨	1,000 - 9,999
🟥	> 10,000

TOTAL PARENT (16) PAH CONTOURS

⬭	66-285mg/kg
⬭	>285mg/kg

B SIZE 11" x 17" (279.4mm x 431.8mm)

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UMA | AECOM

Manitoba Hydro
Sutherland Management Plan
TAC Response

Sediments Results
All Depths > 10 cm
Figure 4-17

4.11.3 Reconciliation of Bioavailability Assessment and 2003 Benthos Observations

The categorization of samples as toxic - non-toxic through comparison of observed porewater PAH concentrations from Sutherland Site sediments with the available SCBA data for *Hyallela* responses to bioavailable PAHs helps to explain the 2003 benthic community data.

In particular, it was noted in the previously completed ecological risk assessment that surficial sediment samples collected by Petite Ponar grab (~top 5 cm) contained PAH concentrations that were lower on average than previously documented for the same riverbed locations. Assuming that a bulk sediment concentration of 285 mg/kg PAH16 is indicative of a high probability of adverse effects on benthic invertebrates, only one of 25 sites sampled for the ecological risk assessment (T6-2) exhibited PAHs at a concentration of ≥285 mg/kg PAH16. Table 4-8 shows the sediment data used in the 2003 ecological risk assessment, ranked according to PAH16 concentration.

Table 4-8: 2003 Sediment Data for Benthos Sites Ranked According to Observed PAH16 Concentrations

Site Location	Site ID	PAH16 (mg/kg)
Plume: High Level Area	T6-2A	366
Plume: Moderate Level Area	T3-4A	211
Plume: High Level Area	T5-2A	163
Plume: High Level Area	T6-2A	127
Plume: High Level Area	T6-2B	108
Plume: High Level Area	T3-3A	56
Plume: Moderate Level Area	NSC 1A	53
Plume: Moderate Level Area	NSC 1A	8.8
Plume: High Level Area	T7-2A	7.2
Plume: Moderate Level Area	NSC 2A	3.5
Plume: Moderate Level Area	NSC 2A	2.9
Plume: Moderate Level Area	T8-2A	2.0
Downstream Reference: Area 2	2.4 A	1.9
Plume: Low Level Area	T8-1A	1.7
Plume: High Level Area	T2-2A	0.88
Plume: Low Level Area	T4-2A	0.47
Plume: Low Level Area	NSC 3A	0.46
Downstream Reference: Area 2	2.2 A	0.34
Downstream Reference: Area 2	2.3 B	0.29
Downstream Reference: Area 2	2.3 A	0.28
Plume: Low Level Area	T7-3B	0.26
Downstream Reference: Area 2	2.5 A	0.21
Plume: Low Level Area	T7-3A	0.21
Upstream Reference: Area 1	1.1 A	0.18
Plume: Low Level Area	T2-5A	0.11
Upstream Reference: Area 1	1.5 A	0.11
Downstream Reference: Area 2	2.1 A	0.10
Downstream Reference: Area 2	2.1 A	0.10
Upstream Reference: Area 1	1.3 A	0.078
Upstream Reference: Area 1	1.2 A	0.073
Upstream Reference: Area 1	1.3 B	0.073
Upstream Reference: Area 1	1.4A	0.000

Two additional sites (T3-4 and T5-2) exhibited PAH16 concentrations in the range for which toxicological response is possible, but is indeterminate. Note that T6-2B is a field duplicate of T6-2A while the two results tabulated for T6-2A are laboratory duplicate analyses.

The 2003 benthos data for Sites T6-2, T3-4 and T5-2 were scrutinized in light of expectations for toxicity arising from the PAH bioavailability study (Figure 4-18).

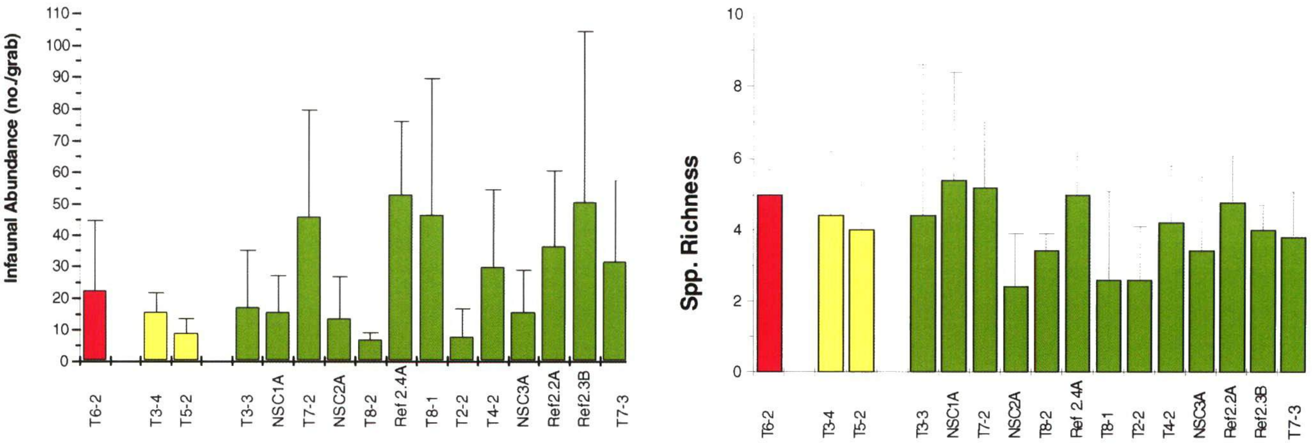


Figure 4-18: Relationship Between Benthic Community Abundance or Species Richness and Sediment Categorization as Likely Toxic (Pink Bars), Likely Non-Toxic (Green Bars) or Indeterminant (Yellow Bars) Based on Expected PAH Bioavailability.

Neither benthos abundance nor species richness were obviously lower in T6-2 than the other samples analyzed. It is likely, however, that benthos interact with much less than top 5 cm of sediment (e.g., top few cm of sediment for small bodied, shallow burrowing insect larvae, oligochaetes, amphipods, molluscs and other groups). This might also account for limited impact on benthos. The expected influence of highly variable PAH concentrations in the top several centimetres of sediment is discussed in more detail in Section 4.5.

Overall, assuming that the *Hyallela* laboratory-based toxicity test is a sensitive predictor of toxicity to aquatic animals, and that a bulk sediment concentration of 285 mg/kg PAH16 is an upper threshold for a high probability of toxicity, it can be seen that the previously observed status of the benthos is not substantially different than what would be predicted from the results of the bioavailability study. Risks to sediment-dwelling organisms are likely to be minimal based on the results of the 2003 ecological risk assessment, the 2007 river sediment and surface water monitoring program and the 2007 bioavailability study. The majority of the coal-tar impacted sediment plume appears to be covered by background sediment originating in upriver areas. Although scouring of surficial sediments appears to occur in two areas of the coal-tar impacted sediment plume that could result in toxicity to benthic invertebrates, these areas are limited in size as discussed in the previous section.

4.12 Human Health Risks Associated with River Water and Sediment Contact

We addressed possible risks to human health associated with PAH contamination of the sediments in the Red River adjacent to the Site. In particular, a quantitative evaluation was completed for scenarios involving dermal (skin) contact with the contaminated sediments as well as incidental sediment ingestion. Below is a summary of the human health risk assessment that can be found in entirety in Appendix F.

It cannot be absolutely precluded that humans could come in contact with contaminated sediment. In particular, there is some remote possibility that a person could come in contact with the sediment when walking or playing along the waters edge beneath the Site during low water periods. Contact might also occur as a result of the handling of anchors, fishing lures, or other objects that have come into contact with the contaminated sediment, and to which sediment adheres.

Such human exposure events are considered highly improbable, but not impossible. Given the low probability of occurrence, frequency or duration of such exposures would be very low; i.e., once to no more than ten times in a person's lifetime. If a person were to get PAH contaminated sediment on their skin, the potential for dermal uptake would remain until such time as the sediment were washed off, or until the PAH concentration in the adhering sediment is depleted in the microzone adjacent to the skin.

The calculated risk quotients and incremental lifetime cancer risks associated with exposure to sediment are tabulated below. Consistent with the recommendations of Health Canada (2004), the toddler receptor was used to evaluate non-cancer risks while the adult was used to evaluate cancer risks. The evaluation of exposure to recreational users also considered that all of the sediment ingestion occurred from the site (i.e., the 80 mg of soil that a typical child ingests on a daily basis was considered to be 100% from the site even though children would spend only a fraction of their time in such settings according to the assumptions used in the HHRA). In addition, it is noted that it was assumed that the sediment had a 10-fold greater soil adherence factor than typical soil (due to the moist nature of sediment as compared to soil). These are considered to be quite conservative factors that may tend to overestimate actual exposures and risks.

4.12.1 Non-Cancer Risks

A young child (Toddler: 0.5 to ~ 4 years of age) is a potentially maximally exposed individual, since sediment ingestion rates via hand to mouth contact are generally higher for this age group relative to other age groups and the expected body weight is lower than for older age groups. Infants less than six months of age are generally less exposed, since they are more closely supervised by their parents and are not as mobile.

Table 4-9 provides calculated risk quotients for non-cancer type effects, assuming an average of 2 days exposure per year, and based on the maximum observed surface versus subsurface PAH concentration in sediment, as discussed above.

All risk quotients were substantially lower than 1.0; therefore, it is concluded that non-cancer risks of exposures to sediments are acceptably low.

Table 4-9: Risk Quotients for Non-Cancer Type Effects

PAH	TDI (µg/kg d)	Based on Max. Observed Subsurface Conc.			Based on Max. Observed Surface Conc.		
		RQ_{Ing}	RQ_D	RQ_{Tot}	RQ_{Ing}	RQ_D	RQ_{Tot}
Naphthalene	16	1.4E-05	1.2E-07	**1.4E-05**	4.0E-06	3.4E-08	**4.0E-06**
Acenaphthylene	60	2.7E-06	2.4E-08	**2.8E-06**	2.7E-07	2.4E-09	**2.8E-07**
Acenaphthene	60	2.6E-06	2.2E-08	**2.6E-06**	3.0E-07	2.6E-09	**3.0E-07**
Fluorene	40	7.5E-06	6.5E-08	**7.6E-06**	7.3E-07	6.3E-09	**7.4E-07**
Phenanthrene	40	4.5E-06	3.9E-08	**4.5E-06**	4.1E-06	3.6E-08	**4.2E-06**
Anthracene	300	2.2E-06	1.9E-08	**2.2E-06**	1.7E-07	1.5E-09	**1.7E-07**
Fluoranthene	40	5.3E-06	4.6E-08	**5.3E-06**	4.1E-06	3.6E-08	**4.2E-06**
Pyrene	30	1.2E-05	1.0E-07	**1.2E-05**	4.5E-06	3.9E-08	**4.6E-06**
Benzo(a)anthracene	40	8.8E-06	7.6E-08	**8.9E-06**	1.5E-06	1.3E-08	**1.5E-06**
Chrysene	40	3.0E-06	2.6E-08	**3.0E-06**	1.5E-06	1.3E-08	**1.5E-06**
Benzo(b)fluoranthene	40	2.8E-06	2.4E-08	**2.8E-06**	1.3E-06	1.1E-08	**1.3E-06**
Benzo(k)fluoranthene	40	3.2E-06	2.7E-08	**3.2E-06**	4.9E-07	4.2E-09	**5.0E-07**
Benzo(a)pyrene	40	1.2E-06	1.0E-08	**1.2E-06**	1.2E-06	1.0E-08	**1.2E-06**
Indeno(1,2,3-cd)pyrene	40	2.9E-06	2.5E-08	**2.9E-06**	1.1E-06	9.2E-09	**1.1E-06**
Dibenzo(a,h)anthracene	40	1.8E-06	1.5E-08	**1.8E-06**	1.6E-07	1.4E-09	**1.6E-07**
Benzo(g,h,I)perylene	40	3.3E-07	2.8E-09	**3.3E-07**	6.6E-07	5.7E-09	**6.7E-07**

4.12.2 Cancer Risks

Table 4-10 shows the calculated incremental lifetime cancer risks for an adult exposed to either surface or subsurface coal-tar contaminated sediment. The estimates are based on a 70.7 kg adult who is exposed for up to 2 days per year, over 25 years of a 70 year lifespan.

Table 4-10: Calculated Incremental Lifetime Cancer Risks

PAH	Slope Factor $(\mu g/kg\ d)^{-1}$	$ILCR_{Ing}$	$ILCR_{D}$	$ILCR_{Tot}$	$ILCR_{Ing}$	$ILCR_{D}$	$ILCR_{Tot}$
Naphthalene	n/a						
Acenaphthylene	n/a						
Acenaphthene	n/a						
Fluorene	n/a						
Phenanthrene	1.5E-06	2.0E-11	1.7E-09	**1.8E-09**	5.1E-12	4.4E-10	**4.5E-10**
Anthracene	n/a						
Fluoranthene	n/a						
Pyrene	n/a						
Benzo(a)anthracene	2.3E-03	5.8E-09	4.9E-07	**5.0E-07**	2.9E-09	2.5E-07	**2.5E-07**
Chrysene	3.0E-05	7.0E-11	6.0E-09	**6.1E-09**	3.7E-11	3.1E-09	**3.2E-09**
Benzo(b)fluoranthene	2.3E-04	6.1E-10	5.2E-08	**5.3E-08**	2.5E-10	2.2E-08	**2.2E-08**
Benzo(k)fluoranthene	2.3E-04	2.3E-10	1.9E-08	**2.0E-08**	9.4E-11	8.1E-09	**8.2E-09**
Benzo(a)pyrene	2.3E-03	5.6E-09	4.7E-07	**4.8E-07**	2.3E-09	2.0E-07	**2.0E-07**
Indeno(1,2,3-cd)pyrene	2.3E-04	3.4E-10	2.9E-08	**3.0E-08**	2.0E-10	1.7E-08	**1.8E-08**
Dibenzo(a,h)anthracene	2.3E-04	6.3E-11	5.4E-09	**5.4E-09**	3.1E-11	2.6E-09	**2.6E-09**
Benzo(g,h,l)perylene	6.9E-05	9.7E-11	8.3E-09	**8.4E-09**	3.8E-11	3.3E-09	**3.3E-09**
ILCR for all potentially carcinogenic unsubst. PAH				**1.1E-06**			**5.1E-07**

An ILCR of less than 1 in 100,000 ($<1.0 \times 10^{-5}$) is considered to be *de minimus*, or acceptable. As shown in Table 4-9, cancer-related exposure risks are acceptably low for possible human exposures to surface sediment, based on current riverbed conditions adjacent to the Sutherland site.

In light of the risk characterization, and accounting for various types of uncertainty, it is concluded that risks to humans from exposures to coal tar contaminated sediments are unlikely.

5.0 Monitoring

5.1 Issues Identified

Issues identified include –

- Limited information on concentrations of PAHs or other coal tar constituents within the water column of the Red River;
- Expectations for temporal change in the extent and particulars of the coal-tar contaminated sediment plume in the Red River/ Possible mechanisms of and implications of contaminated sediment re-suspension and riverine fate;
- Consistency of the proposed monitoring program with the intent and elements of the Environmental Effects Monitoring (EEM) program for metal mines or pulp mills;
- Details regarding the frequency of proposed monitoring;
- Laboratory toxicity test species used;
- Trigger/response conditions for the monitoring program;
- Need for communications plans and risk management for other activities in/on the River.

These are addressed below in the order listed.

5.2 Surface Water Chemistry

This issue is discussed in detail in Section 4.4. In addition to this, it is the intention of MH to include sampling and analysis of riverine water in the ongoing monitoring program. The available information indicates that surface water quality in the Red River adjacent to or downstream from the Site has not been influenced by historical coal tar inputs.

5.3 Future Status of Coal Tar Contaminated Sediment in the Red River

A monitored natural recovery approach is appropriate for the Red River sediments adjacent to the Site in light of the limited ecological risks and absence of human health risks. From a risk management perspective, the longer term status of historically contaminated sediments is of significant interest. In particular, it is recognized that coal-tar contaminated sediment near the surface of the riverbed will continue to go through episodic burial with sediments originating from upriver sources, punctuated with scouring events during extreme floods. Questions that arise in light of a proposed monitored natural recovery approach include the following:

- Will the coal-tar derived PAHs degrade over time, and – of so – what are the expected timelines?
- Is the attenuation rate slower in more highly contaminated sediment zones?
- For coal tar contaminated sediments that become re-suspended, what are the expectations for sediment concentrations and sediment – water partitioning behaviour in downriver areas?
- What is the potential for riverbed – riverwater fluxes of PAHs?

Given the large number of MGP sites that have been investigated in North America and Europe, there is a reasonably large body of scientific knowledge on the fate of coal tar residuals in aquatic environments. A brief review of the scientific knowledge base is provided immediately below to assist TAC members with future scenarios.

5.3.1 Background on MGPs

MGPs in North America and Europe were one of the principal suppliers of energy in the 1800s and early 1900s (Jafvert et al, 2006). These plants manufactured gas from coal and oil and generated a variety of process wastes such as tars, spent oxides, ash, sludge, ammonia liquors and lampblack. Most of these plants closed in 1940s and 1950s due to the availability of natural gas; however, wastes generated at MGPs often remain in the soil and groundwater at these sites. The major waste product was coal tar, largely consisting of a mixture of mono- and polycyclic aromatic hydrocarbons (MAHs and PAHs). In the US, there are 1000 – 2000 contaminated MGP sites, making coal-tar contamination a significant environmental problem (Jafvert et al, 2006).

Term “tar” refers to the viscous residue from pyrolitic (in absence of oxygen) combustion of organic matter (Hatheway, 2002). Products and wastes derived from coal tar are mixtures composed of aromatic, hetero-aromatic and phenolic compounds within a wide range of molecular weights, from the monoaromatic (e.g. benzene, toluene, ethylbenzene, xylene (BTEX)) and phenolic compounds to the mid range, two-to four-ring polycyclic aromatic hydrocarbons (PAHs) and nitrogen, sulphur and oxygen (NSO) heteroatomics up to the larger PAHs with greater than four rings. PAHs of three or more benzene rings are dense, non-aqueous phase liquids (DNAPL). US EPA has identified 16 PAHs present in coal tar and creosote as priority pollutants (Rogers et al, 2007). Waste disposal practiced in the past resulted in the introduction of these mixtures to groundwater (King and Barker, 1999).

Creosote is a thin oily liquid that has density slightly higher than that of water and is composed of hydrophobic compounds and classified as a dense non-aqueous phase liquid (DNAPL). It may consist of up to 200 chemicals of with 85% PAHs by mass, 10% phenolic compounds and 5% oxygen-, sulphur-, and nitrogen-heteroaromatic compounds. Solubility of these compounds has a great range varying by several orders of magnitude. For example, solubility of phenol is up to tens of thousands of milligrams per litre, while chrysene, a four-ring PAH, has solubility in the order of a few micrograms per litre (King and Barker, 1999). Molecular weights and solubility in water of phenol and 16 priority pollutant PAHs are presented in Table 5-1.

Table 5-1: Molecular weight and pure compound aqueous solubility of phenol and 16 US EPA priority PAH pollutants (from Eberhardt and Grathwohl, 2002).

Compound	Molecular weight	Solubility at 25°C (mg/L)
Phenol	94.1	82,000
Naphthalene (Nap)	128.19	31.17
Acenaphthylene (Any)	154	9.804
Acenaphtene (Ace)	154.2	3.93
Fluorene (Fln)	166.2	1.98
Phenanthrene (Phe)	178.2	1.18
Anthracene (Ant)	178	0.05
Fluoranthene (Fth)	202.3	0.26
Pyrene (Py)	202.3	0.13
Benz(a)anthracene (BaA)	228	0.014
Chrysene (Chr)	228	0.002
Benzo(b)fluoranthene (BbF)	252	0.00323
Benz(k)fluoranthene (BkF)	252	0.00055
Ben(a)pyrene (BaP)	252	0.0038
Indeno(1,2,3-cd)pyrene (Indeno)	276	0.062
Dibenz(a,h)anthracene (DahA)	278	0.0005
Benzo(g,h,i)perylene (BghiP)	276	0.00026

5.3.2 What is Natural Attenuation/Natural Recovery?

Natural attenuation is a term used to describe naturally occurring processes that can reduce the mass, toxicity, mobility, volume or concentration of contaminants in soil, groundwater, or sediment. Processes that have a major influence on the fate of hydrophobic organic contaminants in soils include:

- dissolution of components at the source;
- mass transfer of the dissolved organics into groundwater;
- transport in groundwater by advection, dispersion and diffusion;
- sorption; and
- chemical and biological transformations.

Important attenuation processes in freshwater and marine sediments are similar; especially sediment – porewater partitioning rates (dissolution rates), followed by porewater transport (which is primarily upward through diffusion, and sometimes enhanced by advective flows). The residence time of porewater within a mass of sediment is often shortened near the sediment-water interface in areas where bivalves, various larval insects, or other invertebrates burrow into or otherwise disturb the sediment resulting in micro-scale advective flows and development of a "surface mixed layer". An important sediment attenuation process in aquatic environments that is seldom important in terrestrial/upland soil systems is the bulk transport of contaminated sediments either through bedload transport or sediment re-suspension and deposition in downcurrent areas. The presence of hydrophobic organic contaminants as free-phase accumulations versus as adsorbents to sediment, have a major influence on partitioning into water and chemical/biological transformations.

5.3.3 Mulitmedia Partitioning of Coal Tar Mixtures

Mixtures of organic compounds such as chlorinated solvents, aromatic (BTEX) and polycyclic aromatic hydrocarbons (PAHs) that constitute a major part of coal tar or creosote are very persistent in the subsurface environment; i.e. they have been observed routinely to be present in high concentrations tens or even hundreds of years after the contamination occurred. This persistence is mainly caused by slow dissolution rates of the compounds from the free-phase, or non-aqueous phase liquid (NAPL), and slow diffusion of the contaminants from low permeability deposits (those contained in fine-grained soil and sediment masses). Low dissolution rates and limited water-based transport also reduces the bioavailability of the easily biodegradable compounds, leading to their long-term persistence in the source zone, measured in geologic times (Hatheway, 2002).

Eberhardt and Grathwohl (2002) cite an experiment on BTEX and PAH dissolution kinetics from a 2.5 m long coal tar pool and 0.5 m long smear zone containing coal tar blobs distributed in a coarse sand. The researchers found that dissolution of the mono-aromatic compounds may take from decades to hundreds of years, while release rates of PAHs were predicted to be stable over several hundreds to thousands of years. Biodegradation was not considered.

Depending on solubility and composition of the NAPL phase, individual compounds slowly dissolve into the flowing groundwater. Raoult's Law states that the saturation concentration of a substance that occurs as part of a complex mixture in groundwater at equilibrium depends on molar fraction of that substance in the mixture and solubility of the compound, according to the following equation (Eberhardt and Grathwohl, 2002; Schirmer and Butler, 2004):

$$C_{i,sat} = x_{i,0} y_{i,0} S_i$$

where $C_{i,sat}$ is the saturation concentration of component i in water, $x_{i,0}$ is the molar fraction of the component i in the organic mixture, $y_{i,0}$ is the activity coefficient of i, and S_i is the aqueous solubility of the component i. The activity coefficient y_i describes the deviation from the ideal behaviour. Components with higher solubility are removed from the source zone preferentially, their mole fractions decrease over time and, subsequently, their concentrations emanating from the source into the groundwater decrease. Conversely, the mole fraction of less soluble compounds in the source increase over time, and their concentrations released into the groundwater increase as well (Schirmer and Butler, 2004). In general, the higher volumes of the groundwater flowing through the contaminant source, the larger amounts of NAPL are removed from the source (Schirmer and Butler, 2004).

Aquifer properties such as the organic carbon content affect transport of the dissolved compounds through the aquifer. Depending on their hydrophobic properties, the organic compounds become sorbed, which leads to their retardation. As a result, a complex of overlapping plumes may be present. These plumes move with different velocities, creating a situation where microbial communities are exposed to different environments over time and space (Schirmer and Butler, 2004).

To make a qualitative prediction of how the composition of source leachate may change over time, an extension of Raoult's Law to partitioning between an aqueous phase and organic mixture can be used. Components in the mixture display ideal behaviour if they partition linearly to the aqueous phase in proportion to the product of their mole fraction in the organic phase and their pure compound solubility. The following assumptions were used in this approach: (i) the activity coefficient in the organic phase is equal to unity and (ii) the inverse of the activity coefficient for the solute in water is equal to the mole fraction solubility of the component (MacKay et al., 1991). Based on these assumptions, Shiu et al. (1988) derived the following equation:

$$C^i = x^i S_L^i,$$

where C^i is the aqueous concentration of compound *i*, x^i is the mole fraction of *i* in the organic mixture and S_L^i is the pure compound liquid solubility. For compounds that are solid in pure form and at the temperature of the given systems, liquid phase solubility can be calculated with the following (Shiu et al., 1988):

$$S_L^i = S_L^i \exp[6.8(T_m^i / T - 1)],$$

where S_L^i is the solid solubility, T_M^i is the melting point (°K), and *T* is the system temperature. The calculated liquid solubility can be greater than the solid solubility but the dissolved concentration cannot exceed the latter (MacKay et al, 1991).

Coal tar NAPLs at lower temperatures (e.g., <5°C) tend to exist as semi-solids as opposed to semi-liquids depending on the specific composition, which varies between MGP sites.

Several studies have examined whether complex organic mixtures, such as PAHs in gasoline and diesel fuel mixtures, coal tars and creosote, conform to Raoult's law of ideal behaviour (King and Barker, 1999). These studies showed that the majority of the organic mixtures conform to Raoult's law.

King and Barker (1999) studied natural attenuation of a plume of coal tar creosote located below the water table. The study focused on seven compounds: phenol, *m*-xylene, naphthalene, phenanthrene, 1-methylnaphthalene, dibenzofuran and carbazole. Groundwater movement through the source led to the development of a dissolved organic plume, which was studied over a 4-year period. The study showed that, in general, trends in compound fluxes from the source were qualitatively consistent with predictions based on Raoult's law. The selected compounds showed a large spectrum of plume behaviour. For high solubility compounds (i.e. phenol), concentrations in the source zone decreased rapidly and dissolved completely within a relatively short time span. Migration of phenol in the subsurface environment as a discrete slug was consistent with that of chloride, which was used to indicate groundwater movement. Phenol was almost completely transformed at 626 days. The *m*-xylene plume migrated to a maximum distance at 626 days and then the leading edge of groundwater contamination receded back towards the source as the rate of flux into the plume decreased below the rate of plume transformation. The phenanthrene plume also receded although its flux continued to increase up until the end of the experiment. Movement of the carbazole plume decreased, or halted, at the last measurements and flux from the source also decreased probably due to depletion at the source. The dibenzofuran plume remained relatively constant during the last two years of the monitoring implying relatively constant rate of dissolution from the source matching the rate of plume transformation. Naphthalene and 1-methylnaphthalene continued to migrate outward despite apparent decreases in their input fluxes over time (King and Barker, 1999).

The general adherence of coal tar groundwater partitioning to Raoult's Law demonstrates that groundwater (and sediment porewater concentrations) are almost always lower than would be predicted from the organic carbon-water partition co-efficients and solubility estimates for individual substances within the complex mixture.

5.3.4 Biodegradation of Coal Tar and Creosote Compounds

In general, mass transformation was a major influence on plume behaviour for all observed compounds (King and Barker, 1999). It was found that even slow rates of transformation may impose significant limitations on the extent of plume migrations. The transformation of non-chlorinated organic compounds is mediated by naturally occurring microbes. Microbial degradation occurs by aerobic respiration, NO_3-

reduction, Mn(IV)-/Fe(III)-reduction, SO_4-reduction, methanogenesis and fermentation. In general, biodegradation of non-chlorinated organics, such as those comprising organic mixtures like creosote, is favoured under more oxidizing conditions (King et al, 1999; Thornton et al, 2001). Some studies (Bollag and Kaiser, 1991; Grbic-Galic, 1990) have shown that coal tar constituent can also be biodegraded under anaerobic conditions (denitrifying, sulphate-reducing, methanogenic and fermentative). The biodegradation processes lead to accumulation of their products and can be detected by changes of the redox-sensitive parameters (decrease in dissolved oxygen and SO_4^{2-} and increase in Fe^{2+}, Mn^{2+} and methane), microbial indicators (phospholipid fatty acids (PLFA)) and organic metabolites, such as aromatic acids (4-hydroxybenzaldehyde, 4-hydroxybenzoic acid) (King et al, 1999; Thornton et al, 2001).

Aerobic biodegradation of PAHs is considered the most important form of biodegradation of PAHs, and together with denitrification, accounted for up to 90% degradation of the total mass of PAHs (King et al, 1999; Thornton et al, 2001), Biodegradation rates of PAHs are limited by the supply of aqueous O_2 and NO_3 (Thornton et al, 2001; Broholm et al, 1999) which can be low in an aquifer due to low solubility of these compounds and low plume dispersion. Terminal electron acceptors such as oxygen for cellular respiration in microbes tend to be more readily re-supplied in sediments at the sediment-water interface in rivers, than in groundwater. Therefore, oxygen supply limits biodegradation rates only with increasing depth in the sediment, since re-supply of oxygen is limited by relatively slow downward diffusion rates (or advective transport) from the overlying water column.

PAHs, especially lower molecular weight PAHs, in contaminated harbour, estuarine, and aquifer sediments can also undergo anaerobic biodegradation (Schmitt et al., 1996; Rockne et al., 2000; Hayes and Lovley, 2002) but in this case the degradation processes proceed much more slowly (Thornton et al, 2001). Thornton et al. (2001) reported that due to the limited oxidant availability in an aquifer plume, the half-life of phenolic compounds from a former coal tar distillation plant was >140 years (Thornton et al, 2001).

It has been reported that PAH mineralization in soil and sediments globally is dominated by a limited number of bacterial taxonomic groups including nocardioforms, sphingomonads, *Burkholderia*, pseudomonads, and *Mycobacterium* (Johnsen et al., 2002). The following taxonomic clades and functional groups of microorganisms have been reported to play major role in removal of PAHs from contaminated aquifers under aerobic conditions: α-*Proteobacteria,* β-*Proteobacteria,* γ-*Proteobacteria, Actinobacteria, Flavobacteria,* and *Firmicutes.* Bacteria reported important for PAH biodegradation in anaerobic conditions included: β-*Proteobacteria,* γ-*Proteobacteria*, *Firmicutes* (denitrifying), δ-*Proteobacteria* (sulfate-reducing) and the *Firmicutes* (Rogers et al, 2007; Kaplan and Kitts, 2004; Rockne et al., 2000; Hayes and Loveley, 2002; Johnsen et al., 2002; Eriksson et al. 2003).

Contaminants in groundwater can be metabolized by microorganisms as primary substrates or via co-metabolism (Schirmer and Butler, 2004). Organics may serve as electron donors (e.g. benzene, toluene, ethylbenzene, xylene (BTEX), methyl-tertiary butyl ether (MtBE), alcohols or PAHs) or electron acceptors as for instance during reductive dechlorination of chlorinated solvents (e.g. tetra-, trichloroethene) (Schirmer and Butler, 2004). The biotransformation potential varies both spatially and temporally. Compounds can be re-mineralized in one environment and co-metabolized in another; and in the same environment can be co-metabolized at one concentration and re-mineralized at a different concentration (Alexander, 1994). Biotransformations of organics is primarily controlled by substrate concentrations and nutrient availability other factors such as substrate interactions, availability and utility of electron acceptors and microbial growth and decay dynamics (Schirmer and Butler, 2004).

Acclimation periods for indigenous microbial populations can vary from minutes to months. Short periods relative to groundwater flow rates can significantly influence the biodegradation. Indigenous microbial populations can be initially small and require time to grow to a size sufficient to cause detectable transformation. Linkage between microbial growth and contaminant biodegradation may be dependent on the relative contaminant concentration resulting from the location relative to the source (Schirmer and

Butler, 2004). At an historically contaminated site, it is expected that the bacterial consortia is already well adapted to the hydrophobic organic contaminants present.

Presence of several substrates in a mixture may either inhibit or accelerate the rate of transformation of individual chemicals. For instance, it was observed (Acton and Baker, 1992) that under anaerobic conditions, *m*-xylene degradation began only after ethylbenzene had degraded, and ethylbenzene biodegradation commenced only after all toluene had degraded. Biodegradation of benzene is inhibited by pyrrole and/or 1-methilpyrrole (Broholm et al, 1999). On the other hand, degradation of benzothiophene and benzofuran is stimulated by the presence of the BTEX or naphthalenes (Dyreborg et al., 1996c; Broholm et al, 1999). Biodegradation preferences may exist due to competition of microbial populations for available electron acceptors, compound specializations of microbes, toxic levels of one chemical that inhibit microbial degradation of another (Schirmer and Butler, 2004). Presence of multiple contaminants can also alter biodegradation rates more directly by influencing sediment/soil – porewater partitioning, as discussed above.

5.3.5 River Sediment – Water Partitioning

Many former MGP sites are located adjacent to creeks or rivers, and historical activities have resulted in contaminated sediments within the adjacent water body. A few studies have focused on sediments in water bodies adjacent to MGP sites that contain a non-aqueous phase liquid (NAPL). Jafvert et al. (2006) measured coal tar composition in sediment collected at five locations in a river adjacent to a former MGP and NAPL – aqueous phase concentrations of 16 MAH and PAH. The findings supported the notion that Raoult's law – based NAPL-water partitioning generally is sufficient to determine the non-reactive equilibrium pore water MAH and PAH concentrations in these sediments.

Transport of dissolved chemicals from the sediment to overlying water is mediated by the velocity and variability of water flow across the sediment-water interface. Groundwater discharge to the stream will occur when the hydraulic head in the sediment is greater than the total head of the stream. The water discharge rate is affected by this head difference and by properties that affect hydraulic conductivity of the sediment, including the heterogeneous pore size distribution of the sediment. This hydraulic conductivity of the sediment can be calculated with Darcy's Law from the measured seepage rate and the vertical hydraulic head gradient, measured with a sediment piezometer and stream gauge (Hyun et al., 2007).

5.3.6 Bioavailability

Bioavailability of PAH from sediments depends on a number of factors including faunal mobility, feeding and metabolism, degree to which PAHs are incorporated into sediment, and the physical and chemical properties of each individual compound (Law et al, 2002; Oug et al., 1998; Thorsen et al, 2004). Tissue burdens of coal tar constituents in sediment-dwelling organisms are a reflection of the relative rates of uptake and elimination (usually following biotransformation to more polar compounds (Thorsen et al, 2004). Bivalve molluscs are frequently used to indicate bioaccumulation and an impact from PAHs because of their low capacity to metabolize PAHs and sessile character (Thorsen et al, 2004; James, 1989). Law et al (2002) reported that PAH concentrations in mussels were higher than those found in crustacean collected from the same contaminated site at the former coal gas site by Shoreham Harbour, UK.

Some authors have reported that PAHs in sediments, particularly in forms of coal tar showed relatively low biological and chemical availability (Paine et al., 1996; Neff, 1979; Thorsen et al, 2004). The total PAH concentration in sediments is only one aspect of evaluation of bioavailability, which depends on availability of each individual compound in the mixture. High total PAH concentration in sediment may not be as highly toxic if individual compounds are sequestered or tightly sorbed and are unavailable for desorption and biological uptake (Thorsen et al, 2004). One of the models to assess bioavailability of

PAHs is by comparing individual PAH concentrations in an organism to individual PAH concentrations in sediments as described by the biota-sediment accumulation factor (BSAF) equation:

$$\mathrm{BSAF} = (C_m/f_L)/(C_s/f_{OC})$$

where C_m is the individual PAH concentration in mollusc tissue (ng of PAH/g of mollusc dry weight), f_L is the organism lipid fraction (g of lipid/g of mollusc dry weight), C_s is the individual PAH concentration in sediment (ng of PAH/g of sediment dry weight), and f_{OC} is the mass fraction of organic carbon (g of organic C/g of sediment dry weight (Thorsen et al, 2004). This equation represents partitioning between hydrophobic (sorptive) phases in the benthic organism and sediment. These sorptive phases are the lipid fraction in the tissue and organic carbon fraction in sediment.

Thomas et al. (2007) studied mussels and clams at the Exxon Valdez spill site 13 years after the spill for exposure to PAH and DNA damage and found out that: PAH were still bio-available; there was correlation between DNA damage and PAH concentrations in mussel tissues; the level of damage was low indicating chronic but not acute exposure; and damage to mussels was higher than for clams. The difference in effect between mussels and clams was probably due to differences in exposure (clams are buried, and occur much lower in the intertidal zone than mussels), and/or differences in biology (metabolism, feeding, retention capabilities of PAHs) (Thomas et al., 2007).

Increased accumulation of PAHs (along with PCBs and DDTs) in tissue was shown to be negatively correlated to the size of benthic amphipods in the River Po with greater concentrations of PAHs found in smaller organisms (Vigano et al, 2007).

5.3.7 Synthesis

Based on observations at other MGP and creosote release sites, it is expected that concentrations of coal-tar constituents and subsurface soils will decrease only very slowly (over decadal time periods) in highly contaminated areas of subsurface soils and sediment. Slow biodegradation or removal rates would be expected from limits to solubility and lower redox conditions in deeper areas. The current status of coal tar contamination, therefore, is likely a reflection of past inputs during the MGP operational area along with limited movement of NAPL, especially along the surface of the riverbed (i.e. based on bedload transport). At the edges of the coal tar contaminant plume, the proportion of mass that partitions into porewater from soils/sediments and biodegradation rates should be much higher than in more contaminated zones. Thus, attenuation rates are likely to be enhanced in areas with lower concentrations of coal tar constituents along major transport pathways.

It is expected that there will be future re-suspension of coal tar contaminated sediments during high energy flood events. Depending on the energy and turbulence of river bottom flows, coal tar materials might be transported both as sorbents to sediment particles and as small free-based droplets and as coal tar pitch. Re-distribution would invariably result in deposition intermixed with sediments from other areas of the Red River. Therefore, either the concentration in downriver areas will decrease sufficiently to facilitate accelerated attenuation, or fine masses of concentrated PAHs will be intermixed with a much larger mass of less contaminated sediment.

5.3.8 Contingencies

Changes in land use and construction activities along the river bank and the Disraeli Bridge could result in the release of coal-tar contaminants to the local environment and the potential for increases in human and ecological exposures. It is anticipated, however, that a screening level study of these construction activities, which could potentially impact fish habitat and therefore potentially involve the federal *Fisheries* Act, would be undertaken in accordance with the *Canadian Environmental Assessment Act* (CEAA). Any such activities, therefore, will need to consider whether the previous evaluations of human health or ecological risks have adequately accounted for new conditions that may arise as a result of the proposed project. Such a formal analysis will be an important pre-requisite to the establishment of appropriate risk management strategies; for example, avoidance or engineered controls. To facilitate such future planning, it will be important that the MH's CEMP and underlying information on site characteristics are adequately communicated to relevant parties, and are available for future review.

A screening level environmental assessment of proposed construction activities would assess the scope of the construction activities; environmental setting; environmental effects of the construction activities; mitigation measures; and follow-up monitoring activities.

5.4 Ongoing Monitoring Program in the Context of the Federal Environmental Effect Monitoring (EEM) Programs

Environmental Effects Monitoring (EEM) is a science-based tool that is designed to detect and measure changes in aquatic ecosystems potentially affected by human activity (i.e., effluent discharges). EEM is currently a requirement for regulated mills and mines under the *Regulations Amending the Pulp and Paper Effluent Regulations* and the *Metal Mining Effluent Regulations*, both under the authority of the *Federal Fisheries Act*. The objective of both regulatory EEM programs is prevent the discharge of deleterious substances to fish bearing waters, per the definitions in the *Federal Fisheries* Act, and ultimately to limit the potential for the effects of active effluent discharges on fish, fish habitat and the use of fisheries resources by humans. EEM provides a nationally consistent approach, based on the "polluter pays" principle, to determine if effluents are causing effects on ecosystems.

The federal EEM program is discussed herein at the request of TAC, based on an interest in whether the monitoring program proposed for the Sutherland Site, including adjacent riverine environment, is consistent with standardized and peer-reviewed EEM approaches. It should be noted, however, that the federal EEM program is focussed around active aqueous discharges into fish-bearing waters from continuing industrial operations (metal mining, pulp and paper production) while the monitoring at the Sutherland Site is focussed on an historical release, and has a slightly different objective.

The overall objective of the Sutherland Site environmental monitoring program is to -

- Ascertain whether MGP-derived contaminants in the Red River and in upland areas might cause wider environmental impacts in the future relative to the baseline conditions documented in the CEMP (CEMP) and supporting documents (UMA, 2003; this TAC response document).

The components and triggers of the Sutherland Site Monitoring Program are not explicitly tied to the *Federal Fisheries Act.* Rather, the need to monitor arises out of the current understanding of environmental risks, and the conclusion that monitored natural recovery is consistent with risk management needs. In particular, the Sutherland Site Monitoring Program will address whether there have been changes in environmental conditions or other important components that indicate the possibility of a broader scale or higher magnitude environmental impact than is currently understood, and to shape future responses should there be substantial change for current "baseline" conditions.

5.4.1 Overview of the federal EEM programs

Regardless of their differences in intent, the Sutherland Site Monitoring Program and EEM programs share a common set of scientific tools, including use of chemical tracers to establish the aerial influence, laboratory toxicity tests to predict toxicity to fish in the receiving environment, and benthic infaunal analysis.

The EEM program is tiered to allow for more extensive monitoring where there are effects and less monitoring where there are not, building upon the information obtained from successive studies. An effect is a statistically significant difference in fish or benthic invertebrate community indicators taken in an exposure area and reference area, or an exceedance of the Health Canada tissue guidelines in fish exposed to the effluent. The key elements of the EEM program include:

- Effluent characterization
- Water quality monitoring
- Site characterization
- Survey of fish
- Monitoring of the benthic invertebrate community

Under the Fisheries Act, the Metal Mining Effluent Regulations (SOR/2002-222) apply to mines and recognized closed mines that exceed an effluent flow rate of 50 m^3 per day, based on effluent deposited from all the final discharge points of the mine and deposit of a deleterious substance in any water. The regulations specify parameters for effluent characterization and require sub-lethal toxicity testing of a fish species, a plant species and algal species, in the case of effluent deposited into freshwaters. A summary of the metal mining EEM program is provided in Table 5-2.

Specific sub-lethal test methodologies are prescribed in the regulations. Water quality monitoring requirements are prescribed based on specific parameters (pH, hardness and alkalinity) and sample frequency (4 times per calendar year and not less than one month apart). Site Characterization must include a description of the manner in which the effluent mixes within the exposed area, including an estimate of the concentration of effluent in water at 250 m from each final discharge point; description of the reference and exposure areas where biological studies will be conducted (geological, hydrogeological, limnological, chemical and biological features); and a description of anthropogenic, natural or other factors that are not related to the effluent under study and that may reasonably be expected to contribute to any observed effect. A study respecting fish population is required if the concentration of effluent in the exposure area is greater than one percent in the area located within 250 m of a final discharge point. Benthic invertebrate studies are required to include the sampling areas selected, taking into account the benthic invertebrate diversity and the area most exposed to effluent; the sample size selected; the sampling season selected; and the field and laboratory methodologies selected. Reporting requirements are specified in the regulations.

Table 5-2: Example of Metal Mining EEM Program Details

Sample Type	Parameter	Frequency	Location
Effluent discharge (immediately prior to point of discharge into fish-bearing waters)			
Grab sample or composite sample of runoff/ discharge water	pH, Schedule 4 substances***	Once a week*	Each final discharge point
Grab sample or composite sample of runoff/ discharge water	Rainbow trout fry acute lethality test	Once a month or if a deposit is out of the normal course of events**	Each final discharge point
Grab sample or composite sample of runoff/ discharge water	*Daphnia magna* acute lethality test	Same time as acute lethality test	Each final discharge point
Monthly volume of runoff/ discharge water	Cubic meters	Monthly	Final discharge point
Effluent and water quality monitoring studies			
Effluent characterization	MMER Sched. 5 part 1, 4(1)(a) to (g)	4 times a year	Final discharge point
Sub-lethal toxicity test	Fish, invertebrate, plant, algal species.	4 times a year	Final discharge point
Water Quality	Temp., DO, pH, hardness, alkalinity, MMER Sched. 5 part 1, 4(1)(a) to (g), Sched. 4	4 times a year	Receiving environment
Biological Monitoring Studies			
First biological study	Site characterization Fish population Fish tissue Benthic invertebrates	Within 18 month after beginning of the project	Receiving environment
Subsequent biological study	Site characterization Fish population Fish tissue Benthic invertebrates	Report submitted not later than 36 months after the report of the previous biological study was required to be submitted.	Receiving environment
Final biological study	Site characterization Fish population Fish tissue Benthic invertebrates	12 month after notice of mine closure	Receiving environment

*If any of substance's monthly mean concentration is less than 10% of Schedule 4 for a 12 month period, frequency of testing for such substance may be reduced to not less than one in each calendar quarter.

**If, during a 12 month testing period, the effluent is determined to be not acutely lethal, frequency of acute lethality testing may be reduced to once each calendar year.

***Frequency of testing for Radium 226 may be reduced to not less than once in each calendar quarter if Radium 226 concentration in the effluent is less than 0.037 Bg/L in 10 consecutive tests.

Under the Fisheries Act, the Pulp and Paper Effluent Regulations (SOR/92-269) apply to all pulp mills except Port Alberni Mill and off-site treatment facilities at which during the preceding year 20% or more of the average BOD of the BOD matter in the effluent that was treated originated from one or more mills or 5,000 kg or more of the average BOD of the BOD matter in the effluent that was treated originated from a single mill. The key elements of the EEM program are consistent with those described in the Metal Mining Effluent Regulations (MMER). The effluent characterization must include monitoring of the presence of acutely lethal effluent and the effect on Daphnia magna; the BOD of the BOD matter; the quantity of suspended solids; volume and pH levels and conductivity. Specific sampling methodologies are prescribed in the regulations. The EEM requirements are the same as those in the MMER and reported requirements are specified in the regulations.

Each EEM cycle includes a study design, field studies and interpretive reports. They are submitted to the Authorization Officer identified in the regulations at least six months before planned field studies. Environment Canada has published the Metal Mining Guidance Document for Aquatic Environmental Effects Monitoring (June 2002) to assist in the development of EEM programs.

5.4.2 Components of the federal EEM programs that are not applicable to the Sutherland Site

Much of the Metal Mining or Pulp and Paper EEM programs would not be applicable to the Sutherland Site for the simple reasons that there is not an active discharge, and two such components would not advance the objective of detecting a wider-area influence relative to current documented conditions. In addition, the EEM programs assume that fish population status, individual fish health and benthic community structure in the receiving environment near an active discharge should not deviate from the natural reference condition. Most pulp and paper and metal mining discharges occur in non-urbanized areas where there are few confounding anthropogenic influences. An open question for the Sutherland Site is whether the appropriate reference condition is the state of the adjacent areas of the urbanized Red River, or more pristine areas.

A detailed comparison between the Sutherland Site Monitoring Program and Metal Mining EEM is provided below:

- **Effluent discharge volumes and quality:** routine groundwater monitoring and soil vapour monitoring at the Site provide equivalent information to requirements under the EEM. Groundwater toxicity testing using rainbow trout or fathead minnow fry is equivalent the EEM effluent toxicity testing requirement. No testing has been proposed to date at the Sutherland Site using *Daphnia magna*.

- **Biological monitoring studies:** The metal mining EEM program requires evaluation of both fish and benthic assemblages, while the latter is the focus of the Sutherland Site Monitoring Program. Monitoring (or ecological risk assessment) using fish was discounted for the Sutherland Site since the local riverine habitat would favour neither spawning nor extended bouts of foraging or residence time. The monitoring of fish, therefore, is likely to have very low power to detect ecological effects relative to benthos surveys. Even for EEM studies, it has been necessary at several sites to replace the fish monitoring component with alternative biota such as bivalves, owing to challenges with effective use of fish to achieve monitoring objectives.

5.5 Proposed Sutherland Site Remedial Monitoring Program

Similar to the EEM program, the proposed RM program builds upon information from successive studies. Information from previous studies conducted since 1994 was used in the development of the RM program. The RM program incorporates elements of the EEM program including sub-lethal testing of the groundwater; chemical characterization of the groundwater; water quality monitoring of the Red River; site characterization (contaminant plumes in soil, groundwater flow and soil vapours); and monitoring of the benthic invertebrate community in accordance with the methodologies prescribed in the EEM program. The RM program proposes to conduct annual monitoring of the river sediment, groundwater, and soil vapours, including re-assessment of the benthic community every five years. The RM program may be modified similar to the EEM approach, based on successive monitoring events to provide the appropriate information required to detect and measure changes in aquatic ecosystems potentially affected by contaminants from the former MGP site.

The proposed Sutherland Site Remedial Monitoring Program (RM program) established as part of the CEMP for Residuals from Historic Operations at the Sutherland Avenue Former Manufactured Gas Plant is based on a remedial strategy that is divided into two broad categories, human health and the physical environment. In evaluating human health and environmental risks associated with residual coal-tar and related products from the former MGP site, the sources of residual coal tar contaminants should be monitored and important transport pathways evaluated. Direct exposures of humans to PAH-contaminated soils is precluded at the Sutherland site owing to the lack of contamination of surface, accessible soils and the ground surface is typically hard surface pavement. The proposed Remedial Monitoring program (RM) includes the following:

- Upland Groundwater
- Upland Vapour, and
- River Sediments, Water Quality and Biota.

Table 5-3 provides a summary of the proposed program:

Table 5-3: Proposed Remedial Monitoring Program – Sutherland Site, MB

Sample Type	Parameter	Frequency	Locations
Uplands – Groundwater			
Groundwater	PAHs, BTEX, depth to groundwater, DO, ORP	Annual Reduced frequency in future once seasonal variability is established and sufficient evidence that groundwater contaminant plume is stable or shrinking	• BD-01A/B • MW-23A/B/C/D, • MW-24A/B/C/D, • MW-29A/B/C, • MW-41A/B/C, • MW-42A/B/C, • MW-27A/B/C, • MW-28A/B, • MW-46, • MW-47, • MW-48 (25 piezometers total)
	PAHs, BTEX, depth to groundwater, DO, ORP	Quarterly in 2008 to establish shorter term variability	• MW41C • MW29B/C • MW23C/D • MW24D • MW42C • MW-46, • MW-47, • MW-48
	7-d toxicity to fish fry (fathead minnow. If stock not available, use rainbow trout).	*Existing studies:* 2005 (Jun): UMA, 2005 2006 (May): UMA, 2006 2006 (Oct.): UMA, 2007 *Future:* • Annual	• MW-46, • MW-47, • MW-48
Uplands – Soil Vapour			
Subsurface soil vapour	%LEL, CWS F1, BTEX, naphthalene	*Existing studies:* 1995: CH2M Hill, 1995 2006 (Jan.): UMA, 2006 2007 (Jan.): UMA, 2007 *Future:* • Quarterly % LEL, One Annual Vapour Characterization • Reduced frequency in future once seasonal variability is established and sufficient evidence that groundwater contaminant plume is stable or shrinking	• MW-50 through MW-61
Riverine Environment			
Surface sediments and water quality	Grab samples by weighted Eckman or box core: PAHs, sediment particle size, f_{OC} (0 – 2 cm depth;	*Existing studies:* 1995: CH2M Hill 1996 – 1999: Agassiz North	UMA (2003) transect locations, augmented with fill-in areas and additional lateral and downriver areas

Sample Type	Parameter	Frequency	Locations
	2 – 5 cm depth; 5 – 10 cm depth) Collect water column samples immediately above sediment surface and below ice	2001: Morrow, 2001 2002: UMA, 2003 2007 (March): UMA, 2007a 2007 (Aug.): This report *Future:* • Annually (through ice: Jan. – Feb. period); or • Within 60 days following major flood (>100 year) or other sediment disturbance event. • Reduced frequency after 5 years, if no significant change or if reduction in aerial extent demonstrated.	(n = 15 additional sites initially)
Subsurface sediments	Core/intact drill samples: PAHs, sediment particle size, f_{OC} (~ 25 cm intervals beneath surface intervals as described above). Calculation of PAH16, naphthalene, benzo[a]pyrene mass estimates in riverbed	• Every 10 years; or • Within 8 months following major flood (>100 year) event.	As above.
Bioavailable PAHs (porewater analysis: ASTM method D7363-07)	Porewater PAHs, f_{OC}, toxicity to *Hyalella azteca*	2009, 2012, 2017, every 10 years thereafter	Subset of 20 surface sediment sampling locations.
Benthic invertebrates	Benthic fauna from top ~5 cm of sediment (5 replicate samples/site)	• Jan. – Feb. 2012 (5 yr) • Additional monitoring events contingent on observation from bioavailability study of increased aerial extent of surficial sediments with potentially toxic porewater PAH concentrations.	2003 North-South sampling locations, augmented with locations from bioavailability study.

From a human health and environmental risk assessment perspective, the RM program is designed to assess contaminant concentrations along major transport pathways for coal tar constituents, as well as important potential exposure areas (Humans: indoor air; Aquatic life: surface water; surface sediments). In particular, the RM program should be sufficiently sensitive to allow the detection of potential changes in magnitude of exposure (and hence magnitude of potential risks) for each relevant set of receptors and exposure pathways.

The Upland Groundwater work involves the monitoring of existing piezometers within the overburden soils and one bedrock monitoring well, and the installation of additional piezometers along Annabella Street, Gladstone Street and the north portion of the former MGP site. Although the EEM was developed as a scientific approach to help determine the effects in aquatic ecosystems caused by industrial effluents and the effectiveness of environmental protection measures, elements of the program are applicable to assessing effects to the aquatic ecosystem as a result of historic contamination from contaminated sites. Environmental assessments and studies have confirmed that there is no direct discharge or effluent at the former Sutherland MGP site. However, it has been determined based on environmental investigations that dissolved contaminants in the groundwater continue to be released to the Red River. It has been estimated that groundwater migrating from the former MGP site contributes approximately 0.33 kg of naphthalene to the riverine environment each year. Therefore, laboratory toxicity testing of groundwater from wells across the top of the river bank is a component of the Remedial Monitoring program.

The Upland Vapour work involves the installation of dedicated shallow vapour probes on the east and west sides of the former Sutherland MGP site that will allow monitoring of the shallow unsaturated zone along the perimeter of the site and off-site near residences for potential vapour migration. The initial vapour monitoring will involve the characterization of the soil vapours with on-going monitoring of vapours.

The River Baseline work is directed at re-sampling the original sediment locations and establishing new sediment sampling locations. It is also directed at detecting any future increase in the aerial extent of biological impact associated with sediment coal tar contamination.

5.5.1 Proposed Monitoring Frequency

The monitoring frequency of sediments, aquatic biota, groundwater and soil vapours (Table 5-3) has been established based on previous studies conducted since 1994.

The *Closure Report* prepared by AMEC Earth and Environmental Limited (AMEC, 2000) documented that while significant PAH contamination is present at the river's edge and throughout the river bed, there does not appear to be any evidence of significant on-going migration of coal tar from the site to the river. The Supplemental Environmental Site Investigation (UMA, 2003) concluded that the impacts within the river sediments are a result of direct discharge into the river during the historical plant operation. The spatial extent and PAH concentrations of the river sediments studies since 1994 have indicated re-distribution of the PAH river sediment plume. Studies since 1998 indicate the spatial extent of PAH in sediments remain relatively the same.

Based on the results of the previous studies, it was felt that a greater emphasis for monitoring should be placed on the biologically active zone and that annual monitoring of surficial sediments should be conducted to assess potential impacts to the ecological environment.

The results of the 2002 – 2003 benthic study that was undertaken as a component of the Supplemental Environmental Site Investigation (UMA, 2003) indicate "no effect" as interpreted by the EEM program protocol. The general rule for the second and subsequent EEM interpretive reports is 36 months or 72 months where no effects levels have been observed after two consecutive studies. North South Consultants conducted extensive studies between 1998 and 2000 for the City of Winnipeg that included assessment of the benthic community in the Red River. Based on the results of these benthic studies and on-going chemical assessment of river sediments, a 5 year frequency was recommended. The benthic community monitoring frequency will be re-assessed based on the results of the bioavailability study.

CH2M Hill conducted groundwater monitoring at selected monitoring wells at the former Sutherland MGP site and along the river bank north of the site in October 1993, June 1994 and August 1994. AGRA (AMEC) Earth and Environmental sampled two of the monitoring wells located at the north end of the former MGP site during December 1996, March 1997, May 1997, June 1997 and October 1999 and selected monitoring wells during October 1999. In 2002, 2005 and 2006, UMA installed additional monitoring wells and collected groundwater samples from selected historic monitoring wells and the new monitoring wells. Table 4-1provides a summary of the groundwater monitoring field data and Table 4-2 provides a summary of the groundwater monitoring naphthalene results.

In most cases, naphthalene groundwater results show a high degree of variability between sampling periods with no apparent correlation to monitoring frequency. This may be attributable to the rate of PAH release to groundwater that is influenced by the complexity of the subsurface soil conditions, changes in the water table and the flow rate of the groundwater. However, the estimated mass loading of naphthalene to the riverine environment has remained relatively constant over a period of approximately three years. The management plan proposes to monitor groundwater annually to provide a continuing assessment of groundwater quality and estimates of the mass loading of naphthalene into the river environment.

An off-site soil vapour survey was conducted as part of the *Environmental, Health and Safety Assessment of the Sutherland Avenue Operations Facility in Winnipeg, Manitoba* (CH2M Hill, 1995). Six boreholes (0.85 m depth) and one borehole (3.25 m depth) were installed along the boulevard of Gladstone Street and nine boreholes (0.85 m depth) and two (3.25 m depth) were installed along the boulevard of Annabella Street. A field vapour screening was completed using a Gastech Model 1238 and soil vapour samples were collected based on the screening results from five of the boreholes using special canisters. The results were compared to other urban centres, ambient air quality criteria and workplace air quality standards. The comparison with other urban centres suggests that although the soil gas levels are above ambient, they are not unusual relative to typical values in large urban environments. Soil gas concentrations were detected below the ambient air quality criteria and workplace air quality standards using Time Weighted Average (CH2M Hill, 1995). MH has undertaken a number of indoor air studies to assess workplace safety and health concerns.

Seven dedicated vapour probes (6.1 m depth) were installed, three along the east side of the Hydro property and four along the west side of the Hydro property to assess soil vapours on the Hydro property (UMA, 2006). Field screening was conducted using a Gastech Model 1238 and soil vapour samples were collected from all of the vapour probes using calibrated pumps and Carbotrap tubes. The soil vapour results were compared to ambient air quality criteria and available guidelines and reference values. Benzene values for all of the wells including the ambient air sample exceeded the air quality criteria and guidelines. The naphthalene and toluene results in all but one of the wells exceeded the criteria and guidelines.

Six dedicated vapour probes (6.1 m depth) were installed, three along the boulevard of Gladstone street and three along the boulevard of Anabella street to assess off-site soil vapours (UMA, 2007). The same sampling protocols and assessment criteria as the 2006 study were applied. The soil vapour results from all of the vapour probes were either at or below the laboratory minimum detection limits or below the applicable criteria, guidelines and reference values.

The results of the soil vapour characterization studies confirm that although soil vapour concentrations within the property boundaries of the former Sutherland MGP site exceed criteria, guidelines and reference concentrations, there does not appear to be any off-site migration of soil vapour that would pose any public health risk or safety risk. Quarterly monitoring of combustible vapour is proposed in the Remedial Monitoring program for the former Sutherland MGP site. Combustible vapour results from recent monitoring events were compared to the soil vapour characterization studies and it was concluded that another study should be conducted using a photo-ionization detector (PID) and soil vapour characterization to correlate field results with laboratory soil vapour values to establish a quantitative relationship between total volatile organic compounds (TVOC) and the concentrations of individual volatile hydrocarbon constituents of concern.

5.6 Response Triggers for Future Risk Management Decisions

Based on the assessment of site conditions and the evaluation of human health and environmental risks, it is concluded that:

- The currently available information indicates no unacceptable human health risks associated with either contaminated soil vapour intrusion into buildings or off-site exposures to soils or sediment;
- The major portion of the mass of contaminants in the Red River arose from historical direct deposition during the MGP operational era, and ongoing inputs of either dissolved-phase or free-phase contaminants is a very minor contributor to riverine sediment and water-borne concentrations. Ongoing off-site transport is not considered to be a significant source of contamination to the Red River.
- The benthic invertebrates in sediments adjacent to the former MGP site are not obviously impoverished relative to other areas of the Red River within Winnipeg. This is attributed to (i) the limited bioavailability of PAHs from coal-tar contaminated sediments, (ii) relatively small aerial extent of the zone of coal-tar contamination at concentrations in porewater that would be expected to elicit toxic responses, and (iii) burial of the most contaminated sediments by a layer of minimally contaminated sediments originating from farther up river.

A proposed monitoring program (Remedial Monitoring Program: Section 5.5) has been established as part of the CEMP for Residuals from Historic Operations at the Sutherland Avenue Former Manufactured Gas Plant.

As stated above, the overall objective of the Sutherland Site Remedial Monitoring program is to -

- Ascertain whether MGP-derived contaminants in the Red River and in upland areas might cause wider environmental impacts in the future relative to the baseline conditions documented in the CEMP and supporting documents (UMA, 2003; this TAC response document).

Furthermore, the Remedial Monitoring (RM) program will:

- provide on-going assurance that residual conditions do not pose a threat to human health or the environment;
- detect and measure any potential changes in conditions on or off the site in a time frame to allow appropriate response; and
- trigger additional remedial actions, as warranted.

The RM program is based on a remedial strategy that is divided into two broad categories: Human health, and the aquatic environment. In evaluating human health and environmental risks associated with residual coal-tar and related products from the former MGP site, the sources of residual coal tar contaminants should be monitored and pathways evaluated. The primary sources of residual coal tar contaminants are the impacted sub-surface soils at the former Sutherland MGP site and river sediment. Direct exposures of humans to PAH-contaminated soils is precluded at the Sutherland site owing to the lack of contamination of surface, accessible soils and the ground surface is typically hard surface pavement. However, there is the potential for human exposure to soil vapour as a result of vapour migration from the sub-surface impacted soils. Aquatic organisms may be exposed to PAH contamination as a result of direct exposure to impacted river sediment.

Figures 5-1 to 5-3 illustrate the RM program and proposed response triggers.

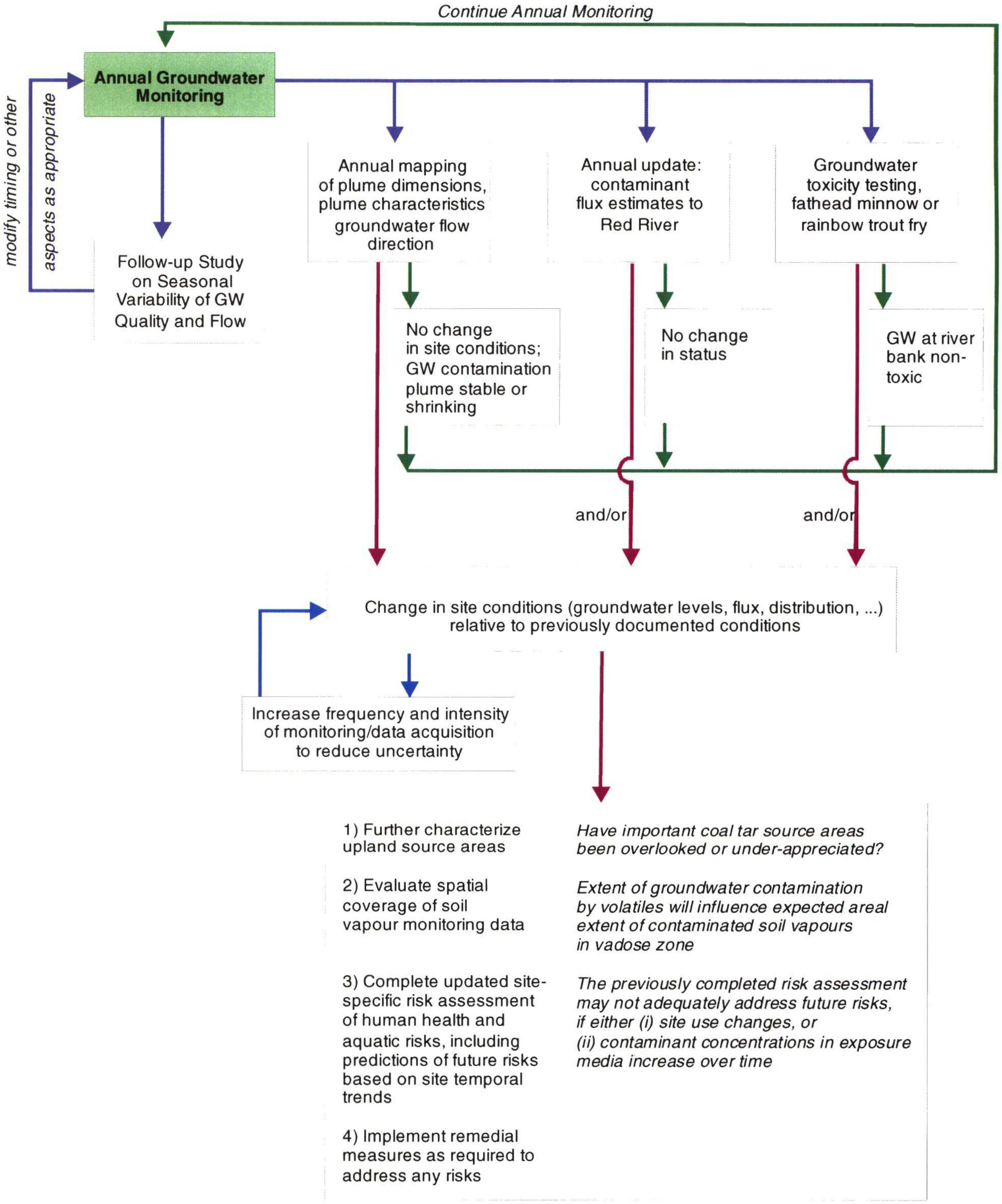


Figure 5-1: Summary of Proposed Actions Associated with Remedial Monitoring Program-Groundwater

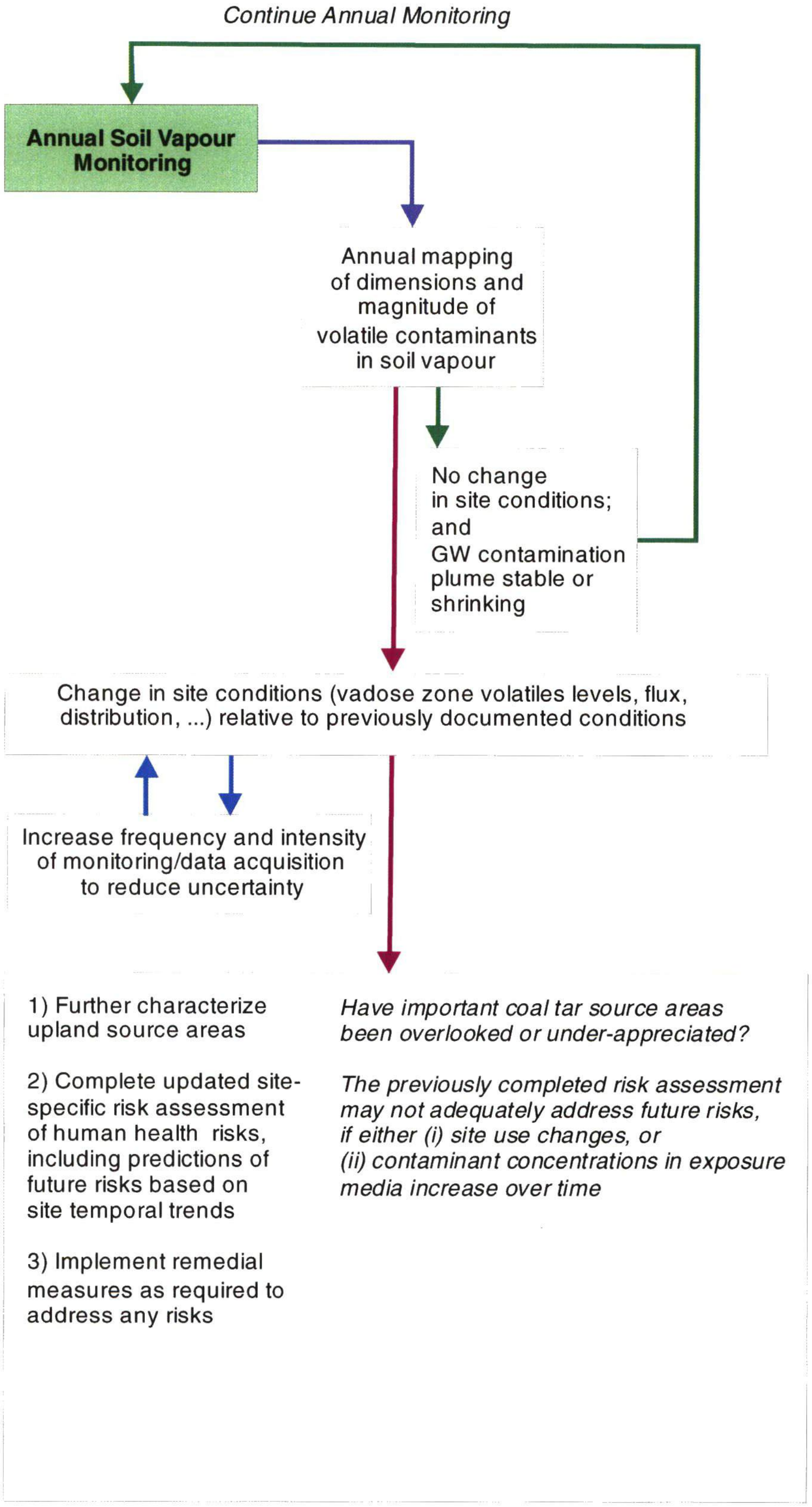


Figure 5-2: Summary of Proposed Actions Associated with Remedial Monitoring Program–Contaminants in Soil Vapour

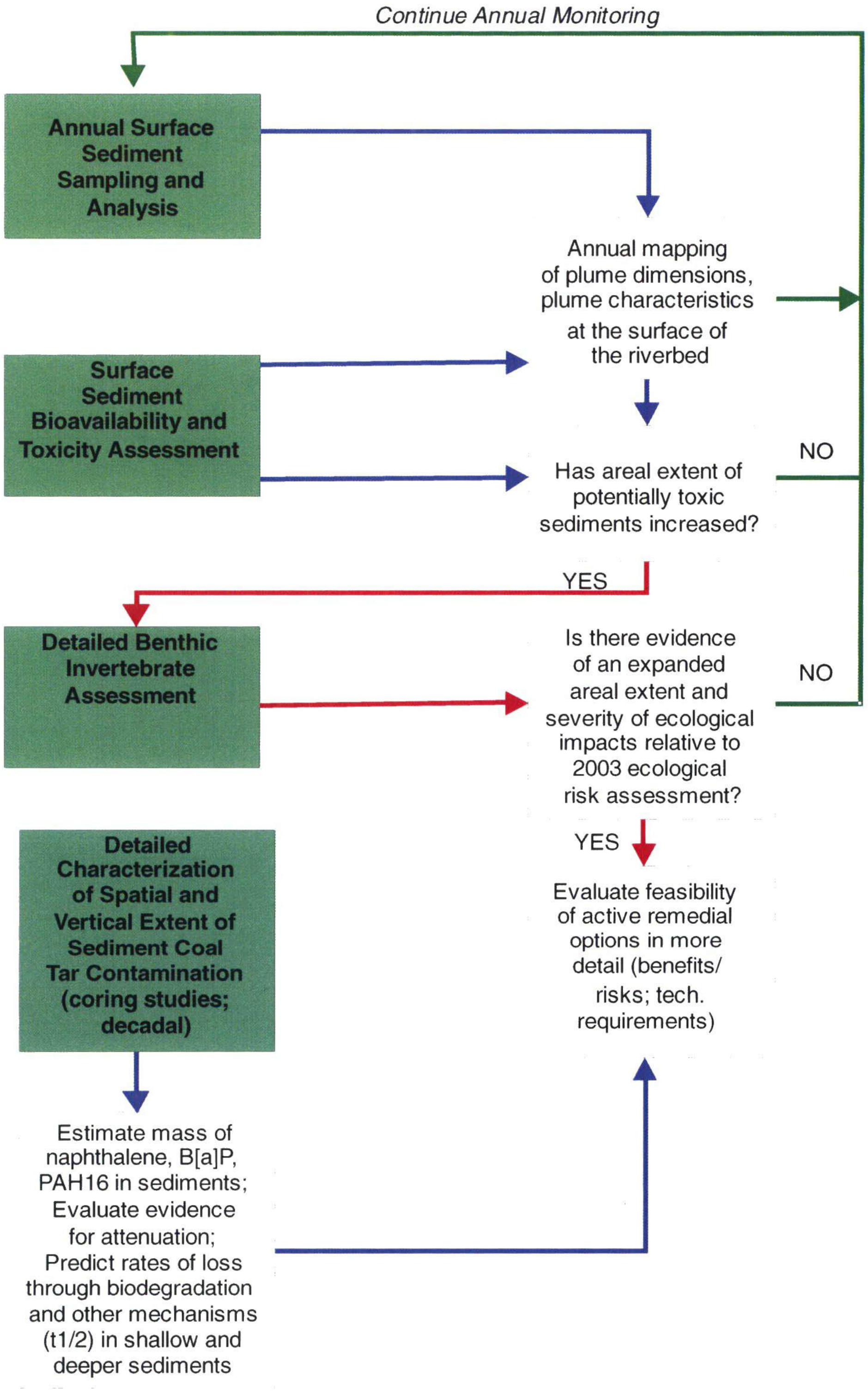


Figure 5-3: Summary of Proposed Actions Associated with Remedial Monitoring Program–River Sediments

5.7 Communication and Reporting Plan

Since 1993, MH (formerly Centra Gas) commissioned a number to studies to assess potential human health and environmental risks associated with the residual coal tar residues from the former Sutherland MGP site located at 35 – 38 Sutherland Avenue in Winnipeg, Manitoba. The results of these studies were provided to a number of agencies including MC (formerly Manitoba Environment), Consumer and Corporate Affairs, Public Utilities Board, Environment Canada, City of Winnipeg and Department of Fisheries and Oceans. In addition, MH has met with the MH Health and Safety Committee and informed Sutherland staff of investigation activities and the results of the studies. Notices were provided to residents around the former MGP site, the local City of Winnipeg Councillor and MH Sutherland staff informing them of investigation activities. In 1995 a News Release on the on-going environmental investigations was issued.

In 1997, MC designated the former Sutherland MGP site as a contaminated site and placed pertinent environmental investigation reports in their public registry located at 123 Main Street, Winnipeg, Manitoba. In 2006, MH developed and provided to MC a proposed Management Plan to address the residuals from the historical operations at the former Sutherland MGP. MC in discussions with MH indicated that upon acceptance of the Management Plan, a Director's Order will be issued to MH pursuant to the Contaminated Sites Remediation Act to implement the plan. The Management Plan includes the preparation of an annual report describing all field activities, monitoring results and recommendations for further remedial actions if required. A TAC consisting of representatives from MC, Manitoba Water Stewardship, Manitoba Health, Manitoba Justice, City of Winnipeg, Winnipeg Regional Health Authority and Department of Fisheries and Oceans has been created to review the Management Plan and supporting technical reports.

In addition to the reporting requirements that will be specified by MC in the Director's Order, MH will implement a communications plan that will keep stakeholders (regulatory agencies, public representatives, the local community and MH Sutherland staff) informed of the management plan, current site investigation and monitoring activities, site conditions and future investigation/monitoring activities and remedial actions. The regulatory agencies identified in the communications plan include the TAC members, Environment Canada, Fisheries and Oceans Canada, and the Public Utilities Board. The City of Winnipeg Councillor for Point Douglas Ward, MLA for Point Douglas Constituency, Minister of Conservation, Minister of Water Stewardship and Minster responsible for MH have been identified as the public representative stakeholders. The local community around the former Sutherland MGP site has been identified as the general public stakeholder. Additional agencies, groups and individuals may be added to the currently identified stakeholders based on the response to communications or specific requests received by MH. MH Sutherland staff has also been identified as a stakeholder.

Upon the approval of the Management Plan, MH will prepare a summary document providing the background history of the former Sutherland MGP site, investigation studies, the Management Plan and Director's Order. MH will conduct an Open House for the local community. The summary document will also be provided to MH Sutherland staff and the MH Management Team for the former MGP site, will meet with staff to address their concerns or questions. The annual report on the monitoring activities and results of the Remedial Monitoring program provided to MC will also be provided to the regulatory stakeholders. A summary of the annual report will be prepared and provided to the public representatives and made available through MH to local residents and Sutherland staff. Notices for specific site activities that include installation of new monitoring wells/vapour probes or soil excavation that are conducted outside of the MH property boundary will be provided to regulatory authorities, public representatives, local residents and Sutherland staff.

6.0 Alternative Remedial Options

6.1 Issues Identified

The monitored natural recovery (MNR) remedy has been selected for the Sutherland Site and adjacent environment primarily on the evidence provided by the ecological risk assessment, showing no obvious impacts of the contaminated sediment on sediment-dwelling faunal communities.

Remedial options other than MNR for sediments were not described in detail in the CEMP. The potential benefits and drawbacks of dredging, capping, and in-situ sediment treatment are discussed in Section 6.2. Section 6.3 assesses active remediation of impacted soils and groundwater on the upland portion of the site, including measures to mitigate the potential movement of dissolved-phase or non-aqueous phase liquids (NAPL) from the upland portion of the site into the Red River.

6.2 Evaluation of Remediation Options for Coal-tar Contaminated Sediments in the Red River

6.2.1 Dredging

Dredging is the removal of sediment from a waterway. Figure 6-1 provides some facts about dredging including some advantages and disadvantages of this technology. A typical sequence of dredging steps identified by the U.S.EPA (2005) includes:

- Debris removal
- Sediment removal
- Transport
- Staging
- Pretreatment/dewatering
- Water treatment and disposal
- Sediment transport, treatment, and disposal.

This Section summarizes approaches to removing and disposing of contaminated sediments at the site, if removal is performed. Removal is accomplished by dredging using mechanical, hydraulic, or dry-dredging techniques. Mechanical and hydraulic dredging uses electronic locational and depth guidance tools to position the dredge and remove the target sediments. Contaminated sediment, and approximately 15 to 30 centimetres of material below the contaminated layer (overdredge), are usually targeted. Due to residual contaminated sediment left after dredging, additional dredging, capping, or monitored natural attenuation are commonly necessary. Dry dredging would involve re-routing the Red River or otherwise isolating the contaminated sediments from the flow of the river, and performing the removal like a soil excavation.

Dredged sediment disposal typically involves a local aquatic or terrestrial disposal cell or, more likely at this site, off-site treatment and/or landfill disposal. Aquatic dredge disposal sites have been used to contain contaminated sediments at several coastal and lacustrine sites in the United States, but no such disposal option has ever been attempted in Canada.

6.2.1.1 Physical Setting

The Sutherland MGP Site is located in metropolitan Winnipeg (660,000 population) located 100 kilometres upstream of Lake Winnipeg on the banks of the Red River. The land in this part of Manitoba slopes northwards from North Dakota at approximately 10 centimetres per kilometre. The Red River meanders northward with a slow current through a channel that varies from 60 to 150 metres in width, and has an average depth at the banks-full stage of from 3 to 10 metres. At the Sutherland Site in Winnipeg the river channel is about 150 metres in width, and approximately 10 metres in depth at the banks-full stage. In summer there is about a 3 metre depth of water in the channel.

The Assiniboine River flows into the Red River at the Forks in downtown Winnipeg. Under normal conditions, it contributes approximately twenty percent of the water flowing through Winnipeg.

Historic flood events prompted the construction of the Red River Floodway to divert a portion of the excess river flow around Winnipeg. The floodway minimized damage during a major flood in 1997 and is now undergoing expansion. The Floodway is designed to keep the maximum flow in the Red River channel below the level of the dikes through Winnipeg. At the Sutherland Site the dike is formed by Rover Avenue, and the estimated flow in 1997 was approximately 75,000 cubic feet (2100 cubic metres) per second (Manitoba Historical Society, 2002).

The available physical data for the Red River sediments indicates that most of the sediments at the site are fine grained silts or clays. These data are based on numerous samples taken throughout the area as reported in Table 3-5 of the UMA December 2003 Supplemental Environmental Site Investigation. Also, North South Consultants, Inc. (2003) mapped medium silt and clay substrate throughout the sediment investigation area adjacent to the Sutherland Site, except for a small area of cobbles along the shoreline at Transect 3. As explained in Section 4.5, sediment deposition in the Red River has resulted in a cleaner recent layer of sediments overlying much of the MGP contaminated sediments.

A natural gas pipeline crosses the Red River just upstream from the Disraeli Bridge, adjacent to the Sutherland Site. Tires and other typical urban debris are expected to be present in the Red River.

6.2.1.2 Possible Removal Approaches

The physical properties of the sediments and of the river setting in which they are found will determine the details of equipment choices, dredging techniques, the time required, and ultimately the cost for dredging. For the purpose of this report we can assume the information needed to evaluate dredging, but further data collection may be needed to actually design a dredging remedy. Given the physical properties of the sediments, the physical features of the site, and the elevated PAH concentrations, diverting the river and excavating the contaminated sediment is not likely feasible, and dredging would probably be limited to certain mechanical and hydraulic removal equipment and approaches.

Based on the description in Section 4.5, the estimated total volume of contaminated sediments is 50,000 cubic metres contained in an area up to 80 metres wide and 700 metres long. The actual volume of sediment to be dredged is potentially greater than 50,000 cubic metres because some clean sediment must be removed to access the contaminated sediment (i.e., the overdredge material). During the removal action, the dredging area would be excluded from boat traffic and silt curtains would be deployed to reduce suspended sediment migration. It may be possible to dredge 1,000 to 1,500 cubic metres of sediment per day; which would allow the dredging phase to be completed within one season (May to October). Dredging operations also need to consider windows of time during non-spawning periods for important fish species, as well, and this typically further constrains the available time periods available annually for the conduct of remedial activities.

Upstream and downstream water quality monitoring would be conducted to evaluate impacts to the river and provide feedback for modification to the dredging activity to reduce pollution. Air monitoring would be conducted to protect worker safety and public health.

Debris removal would be accomplished with a barge mounted crane with appropriate debris recovery equipment. The Sutherland property would be used for staging the debris, some of which may require decontamination prior to disposal in a landfill.

Dredging would be designed to efficiently remove the contaminated sediment while minimizing the amount of residual contaminated sediments left at the sediment surface after dredging. Residual contaminants would likely be left in the river due to the proximity of the Disraeli Bridge piers and the natural gas pipeline. Residual material is also caused by a number of other factors including:

- **Mixing of contaminated material into the underlying clean material during the dredging process.** The act of placing mechanical or hydraulic dredging equipment onto the riverbed can contribute to mixing of contaminated sediment with the clean underlying material. The soft, fine grained, low strength nature of the dredge material can also compound this effect. Material on the edges of the dredge cut can slough into the dredged area. Debris in the sediments can disrupt dredging operations leaving residuals as well.

- **Fallout of the re-suspended sediment during the dredging process.** As the sediment is agitated, material can re-suspend into the water column. This re-suspended material can fall out of the water column and redeposit on the recently dredged surface. Also, contaminants retained in the water column can have short term adverse effects on aquatic biota. It has been estimated that as much as 10% of the mass of removed sediments is routinely lost during environmental dredging, and is re-suspended in downstream areas.

- **Location Control.** Survey control and equipment location during dredging affects the completeness of the dredging depth and proper lateral coverage. Also, if the designed dredging depth was not deep enough to adequately remove the material identified during the pre-dredge sampling and analyses, elevated levels of contaminated sediment can be left behind.

According to the National Academy of Sciences (2007) dredging projects have systematic difficulties associated with residual contaminated sediments and contaminants released during dredging. These side effects of dredging are termed "inevitable" by NAS.

The ecological damage caused by residual contaminated sediments is due to their location in the bioactive zone in surficial sediment and at the sediment – water interface. The chemical quality of the residuals is usually an average of the concentrations of the dredged sediments. Thus, the recently deposited cleaner sediments would be replaced by residual contaminated sediments containing higher concentrations of PAH.

Mechanical Removal

Mechanical dredging would involve the use of an enclosed bucket to minimize the mixing and resuspension of contaminated sediment. The enclosed bucket is a wire supported, sealed bucket with the capability of producing a level cut through the sediments (See Appendix G: Photos 1 and 2). The watertight nature of the bucket attempts to minimize the amount of resuspension.

The enclosed bucket would remove the relatively clean overlying sediment as well as the target contaminated sediment layer. To ensure removal of the contaminated material the design would call for overdredging an additional one foot of clean sediment below the contaminated layer. A dredging pattern would be established to methodically remove sediments and provide a sloping sidewall that would avoid problems with sediments slumping into the dredged area. The amount of slope would be determined based on the physical properties of the sediments. For example, at a maximum dredging depth of approximately three metres, a 1:3 slope would involve excavating approximately nine metres beyond the edge of contamination.

A barge-mounted crane would be used to operate the enclosed bucket (see Appendix G: photos 3, 4, and 5) and place the dredged material into haul barges or into a hopper for transportation to the staging area via pipeline. The use of haul barges would also require a clamshell for offloading the barges at the staging area (Appendix G: Photo 6). The pipeline method uses water to convey the sediment to the staging area as a slurry with a typical solids content of 30% to 40% or more. If the sediments were transported via pipeline, dewatering would be required prior to disposal, and water treatment would be required as discussed below for hydraulic removal.

Hydraulic Removal

Various sizes and designs of hydraulic dredges exist to handle a range of sediment removal conditions. One hydraulic dredge design is shown in Appendix G: Photos 7 and 8. In general, larger dredges move more sediment faster, but also release more contaminants to the water column and create more residual contaminated sediment and more water that requires treatment. A barge mounted hydraulic dredge would convey sediments to the staging area via pipeline for geotube or filter press dewatering. This layout is shown in Appendix G: Photo 9.

Once sediment is removed and transported to the staging area, the water must be removed and treated. Dewatering can be accomplished using geotextile fabric tubes that will retain the sediment and allow water to drain from the sediment and pass through the fabric (i.e., geotubes). At the Fox River in Wisconsin, the sediment is conveyed via pipeline and placed in geotubes for dewatering (Appendix G: Photo 10). Geotubes require a large staging area with drainage collection and water treatment (Appendix G: Photo 11). After an adequate dewatering period (typically one to three months) the sediment would be loaded for off-site shipment to a disposal facility (Appendix G: Photos 12 and 13). Sediment pretreatment may involve removal of the sand fraction to reduce the volume of contaminated sediments if it could be shown that the PAHs are only associated with the silt and clay fractions.

A typical water treatment system would consist of sediment removal in a settling pond with flocculation chemicals, followed by sand filtration, granular activated carbon filtration (Appendix G: Photo 14), and discharge back into the Red River. Appendix G: photos 15, 16, and 17 show construction activities at the water treatment plant built for the Fox River dredging project. Flocculants can also be added to the geotubes to speed the dewatering time and help clarify the water. Metals removal via a sand filter would likely be needed to avoid rapid fouling of the carbon filtration units.

The dewatered sediment would then be loaded into trucks for transport to a treatment and/or disposal facility. A truck cleaning station will be established on site to ensure that liners and tarps are in place and trucks a clean prior to traveling on public roads. A truck route will be established for all truck traffic going to and from the landfill facility.

6.2.2 Capping

Capping is commonly used at contaminated sediment sites to mitigate risks to human health and the environment. The U.S. Army Corps of Engineers (USACE) has experience with this technique dating back to the 1960s (Palermo and Reible, 2007). Capping involves placing a layer of cleaner dredged material, or geologic materials from upland borrow sources, over contaminated sediments to isolate contamination from the aquatic environment. Figure 6-2 is a fact sheet that identifies some advantages and disadvantages of capping.

Cap design includes the following:

- **Site characterization.** This includes an assessment of the site's features (water depths, bathymetry, currents, wave energies, and ice), site uses (navigational and recreational), geotechnical (subsurface and groundwater flow), and institutional constraints associated with a cap.

- **Sediment characterization.** This includes an assessment of the contaminated sediment's physical, chemical, and biological characteristics.

- **Cap design and construction techniques.** The cap design and its intended function may require certain approaches to cap construction that need to be considered.

- **Monitoring and cap maintenance plans.** This step involves short- and long-term monitoring plans for critical features of the cap design, construction, and performance. Also, conceptual maintenance programs are identified based on the results of the monitoring.

Section 6.2.1.1 described the site features and physical characteristics of the Red River and its sediments. The water in the Red River is generally deep enough that the bottom sediment is not disturbed by ice, boating, or other human activities. However, the current in the Red River, especially during storm events, would be a major factor in the design of a cap. During normal and low-flow conditions, the site area is depositional. A layer of relatively clean naturally deposited sediment is presently capping most of the contaminated sediments.

The contaminated sediments are located in an area up to 80 metres wide and 700 metres long. The estimated area to be capped is approximately five hectares. The river bed slopes from the banks to the center of the river at a slope of approximately 10% and it slopes downstream at less than 1%.

The sediments are mostly silt and clay with up to 40% coarser material. A cap should be designed with similar sized materials to minimize intermixing with the river bed sediments. Additional geotechnical data to ensure that the sediment has sufficient strength to support a cap would be needed for a final cap design. However, a typical cap design that may be appropriate for the Sutherland site is described below.

6.2.2.1 Typical Cap Design

Caps are designed as a series of layers that function to physically isolate the contaminated sediments from the aquatic environment, stabilize the cap and protect it from erosion, and to achieve chemical isolation for contaminant migration through the cap. Figure 6-3 is reproduced from USEPA's Contaminated Sediment Remediation Guidance (2005) and shows caps with a variety of layers for specific purposes. It is possible to accomplish all three functions with a single thick layer cap in certain conditions; however, most caps are designed to minimize the thickness, and the associated cost, of the cap. The three functional cap layers are discussed below.

Biological Isolation Component

One concern with the *in* situ contaminated sediments at the Sutherland site is exposure of aquatic organisms directly to contaminated sediments or by burrowing organisms that move buried contaminants to the surface (i.e., bioturbation). To provide physical isolation from benthic organisms, the cap must provide a buffer between the organisms and underlying contaminated sediments. The estimated average depth of bioturbation in the Red River is limited to the top 5 to 10 centimetres. Therefore, the minimum thickness for biological isolation is assumed to be 10 centimetres. The current natural cap is approximately 10 centimetres thick.

The weight of the cap material will compress underlying sediment and the cap layer itself will consolidate as well. Therefore, the design thickness of the cap must account for consolidation. When the contaminated sediments compress under the weight of a cap, pore water is expelled through the cap into the water column. This represents a short term impact that requires design consideration and monitoring during and after cap placement.

Long-term Durability Component

Caps are designed to stabilize the contaminated sediment, minimize resuspension and contaminant transport, and make the cap itself resistant to erosion. EPA guidance (2005) recommends designing caps to withstand a 100-year flood event. However, the Manitoba Floodway Authority effectively regulates the size of the floods in Winnipeg by diverting water around the city. Therefore, a cap for the Sutherland site sediments can be designed to minimize erosion from the floodwaters that do not bypass Winnipeg.

Stabilization

As summarized previously, the sediment to be capped at the Sutherland site is mostly fine grained with some sand. Therefore, to stabilize the sediments and to prevent resuspension, the capping material needs to be of similar grain size. For instance, a coarse grained material such as gravel or cobble sized, without any finer material or a separation geotextile, would penetrate the soft sediment during placement. In addition, the coarse grained material would not be able to prevent the migration of the finer grained sediment up through the cap with time. A fine to medium sand or silty sand applied at a slow rate would confine the underlying sediments and prevent upward migration of the contaminated sediments. A finer grained cap has less void spaces to be filled by the underlying smaller grain sized contaminated sediment than a coarser grained cap material. The density of finer grained capping material will also more closely match the natural capping sediments, increasing the stability of the cap.

The rate and method of placement of cap material also have a significant impact on the stability of a cap. Cap material placed too fast and unevenly (such as from a clamshell bucket, see Appendix G: Photos 18, 19, and 20) could cause a temporary increase in pore pressure reducing the strength of the sediment in that area (Palermo et. al. 1996). This reduction in strength and the addition of load could lead to isolated pockets of bearing failure, resulting in a mixed layer of cap material and sediment. In addition, long-term deformation and mixing of the cap could occur if an uneven distribution of cap material is placed over the soft sediment. If the capping material is placed slowly and evenly (see discussion in Section 6.2.2.2 below), the confined sediment will build up pore pressure more evenly avoiding pockets of lower strength. In addition, with a more evenly applied sediment layer the load applied to the sediment is also more evenly distributed reducing the potential for isolated bearing failures. With time, as the pore pressure dissipates, the confined sediment becomes denser through consolidation, and gains strength.

Resistance to Disturbance

The main forces that could disturb the sediment cap are the river currents, especially from flood events. Cap damage due to ice contact is likely to be a factor in those areas where the contaminated sediments are in shallow water close to shore. Vessel propeller wash or other turbulence from vessels are not likely to cause river bed erosion.

The current velocity in the Red River in the vicinity of Winnipeg during a 25-year flood event is in the range of 3 to 5 fps. In general, the current is fastest at the water surface and slowest at the bottom along the bed. Flooding can create turbulent flow that directs higher velocity currents into the banks and bed of the river. Armoring the cap with a layer of gravel would minimize the potential for cap erosion during floods.

Chemical Isolation Component

Contaminant migration associated with the movement of sediment particulates should be controlled if the cap is properly designed for stabilization. However, the potential for a cap to resist the possible vertical movement of dissolved contaminants by advection and the inevitable movement (long term) of contaminants by molecular diffusion needs to be assessed. Advection can occur while the cap is being placed and the underlying sediments consolidate, thus forcing water up into the cap. It can also occur over the long-term, as groundwater flows up through the contaminated sediment into the cap. Also, a cap will have some sorptive capacity that will retard contaminant flux through the cap. The ability of the cap materials to reduce contaminant flux can be enhanced with amendments such as carbon for PAH adsorption.

The bulk sediment and pore water PAH analyses conducted for the bioavailability study indicate that neither advection nor diffusion is resulting in high concentrations of dissolved PAH in existing sediment pore water. New capping material added on top of the existing sediment profile can be expected to further reduce the flux of contaminants into the aquatic environment. Due to the lack of impacts from advection and diffusion, a cap can be designed for stabilization and physical isolation of the contaminated sediments, without additional design considerations for chemical isolation.

In the Red River there is limited vertical groundwater flow through the contaminated sediments. Without the driving force of the groundwater, the dissolved and/or colloidally facilitated transport from the contained sediments due to advection is not a concern.

Diffusion is apparently being mitigated by natural recovery processes. These processes include biodegradation of PAHs as well as sediment accumulation occurring on top of the contaminated sediments at the Sutherland site.

6.2.2.2 Cap Construction and Monitoring

Capping relatively soft sediments can best be accomplished by applying a uniform load over the site in a slow, even manner. One likely option is hydraulic placement of capping material using a diffuser system at the end of the discharge pipe to slow the rate of discharge and allow a more even distribution of capping material. Appendix G: Photos 21, 22, and 23 show examples of diffuser systems used to spread capping materials.

The most cost effective capping scenario would be to operate a hydraulic dredge in nearby, non-impacted, portions of the Red River. This could be done to hydraulically obtain, transport, and place the cap materials. Another option would be to obtain the cap materials from upland borrow sources; perhaps from the excavation work on the expansion of the Manitoba Floodway should this alternative be considered during the timeframe of the floodway expansion. Upland material brought to the site via trucks could be mixed with water and pumped in the form of a slurry to the capping site via pipeline for placement. The physical and chemical characteristics of the cap material would need to be assessed.

If geotextiles are used as part of the cap, they are typically installed as a single sheet over the entire area to be capped. This requires a laydown area on land to weld seams together, and barge-mounted equipment to drag the geotextiles into place. Perimeter weights are then used to hold the fabric in place while additional capping layers are added.

The capping area would be separated from the river using silt curtains and oil booms, as necessary. A monitoring program would be implemented to evaluate cap construction, assess short-term contaminant release and impacts to surface water, and the long-term performance of the cap. Long-term monitoring will evaluate the integrity of the cap, recolonization by biota, and evidence of contaminant migration.

6.2.3 In-situ Sediment Treatment

A limited number of *in-situ* treatment options have been used for sediment remediation. Sediments containing organic contaminants can be treated biologically, however, as a practical matter this has only been done in small ponds or lagoons where the entire water body is used as a 'reaction vessel'. For example, the French Limited Superfund Site near Houston, Texas was a lagoon that was treated by mixing the bottom sediments into the water column and injecting oxygen. A similar approach for the Sutherland site would require isolating the treatment area from the Red River, most likely with a sheet pile wall, and conducting the mixing and treatment inside the wall. Biological treatment of PAH compounds can effectively reduce the PAH concentrations by perhaps as much as 50 to 75 percent. However, it is not practical to expect to reduce PAH concentrations to the low part per million range that currently exists over much of the sediment plume area.

Other *in-situ* approaches such as solidification/stabilization and chemical oxidation have recently been used to treat upland soils, but are unproven for sediment treatment. Again, complete isolation of the treatment area from the rest of the Red River would be necessary.

One proprietary in-situ method called Limnofix uses a combination of chemical oxidation and biological degradation to reduce contaminant concentrations in sediments. Limnofix has been used to destroy over 99% of sulfide contaminants in sediments (i.e., through increased transfer to overlying waters and oxidative conversion to sulfate), but has not been proven to be efficacious in destroying PAHs. Limnofix or other *in-situ* techniques have not been used to treat sediments at MGP sites. Limnofix was used on a pilot scale at an industrial boat slip in Hamilton Ontario. The concentrations of PAH in sediment were reduced by 64% from a starting concentration of 730 mg/kg. No data were provided for the Hamilton site regarding short term impacts from turbidity,re-suspension of contaminated sediments from the Limnofix injection boom, or enhanced solubilization and transfer to the overlying water. However, it may be necessary to isolate the treatment area from the rest of the Red River using this technology as well.

The Sutherland Site has sediment PAH concentrations over 17,000 mg/kg that would likely require multiple treatments using Limnofix. Assuming a 64% reduction at Sutherland, the treated sediment would still contain up to 6,120 mg/kg of PAH after Limnofix treatment.

6.3 Evaluation of Other Remedial Technologies to Address Contaminant Transport from Upland to the Red River

Prior analysis (UMA 2006) has indicated that low concentrations of dissolved PAH compounds migrate with groundwater from the Sutherland site to the Red River. An annual flux of ~0.33 to 0.37 kilograms of naphthalene has been calculated for the groundwater flow. Another potential concern for off-site migration is DNAPL that may migrate independently from groundwater. Although DNAPL has not been measured at the site, visual descriptions of test holes in the northwest corner of the site are consistent with the presence of a limited amount of DNAPL. The relatively high concentrations of PAH in wells MW-23 and MW-24 may indicate DNAPL in the vicinity of these wells.

The CEMP (UMA, 2006) suggests a barrier system such as a cut-off trench equipped with a French drain to collect dissolved phase contaminants and, if present, LNAPL and DNAPL, if it becomes necessary to intercept groundwater flow to the Red River. A cut-off trench has an advantage over an impermeable barrier because it allows for the collection of groundwater, not just its deflection. Another option might be a funnel and gate system that deflects groundwater through a narrow opening in an impermeable wall where permeable reactive media, such as granular activated carbon, removes MGP constituents from the groundwater. The carbon media would need to be installed via a cassette system that would allow for its periodic replacement. If DNAPL is present, the carbon system would be very expensive to maintain. A system of pumping wells could also be used to intercept groundwater from the site, but wells must rely on a zone of influence that can vary in three dimensions depending on local geology. Wells would be less effective than the cut-off trench which intercepts the entire cross-sectional area of groundwater flow independent of soil heterogeneity.

A conceptual interceptor trench is shown in Figure 6-4. The trench would be approximately 300 metres long, running from well MW-42 to west of MW-41,(Figure 3-1) and located between the dike and the river bank. The trench would be keyed in to the till layer approximately 15 metres below the ground surface. The bottom of the trench would contain perforated piping and would be sloped to one or more sumps where DNAPL could collect for recovery. The subsurface drain would be installed in one continuous vertical trench approximately one metre wide. Biopolymers would be used to support the open trench during construction. The installation would take approximately two months, depending on ease of access and the potential need for specialty equipment to excavate beneath the Disraeli Overpass.

Vertical risers in the trench would also allow for the recovery of groundwater, and the entire trench would be filled with coarse granular materials such as sand or pea gravel. Groundwater interception would require pumping approximately 300,000 litres per year based on the cross-sectional area (300m by 11m) and the average linear groundwater velocity of 2.8×10^{-8} metres per second.

After installation the sumps in the interceptor trench should be checked for accumulation of DNAPL. A separate DNAPL pump could be used to remove the DNAPL and keep it separate from groundwater. If DNAPL does not accumulate in the sumps, a decision could be made regarding the need to pump groundwater. A water treatment system would be needed to treat recovered groundwater to surface discharge standards. This would likely include iron removal and carbon filtration for organic compounds prior to discharge to the Red River.

FACT SHEET:

Dredging

Description:

Excavation of sediment from a waterway. Removed sediment will require subsequent management. Typical process options include hydraulic (e.g., cutterhead, horizontal auger, dust pan, matchbox, plain suction); mechanical (e.g., clamshell bucket, backhoe, bucket ladder, dipper, dragline); and specialty (e.g. PNEUMA® Pump, Dry Dredge™, SoliFlo℠).

Scale of Implementation:

Full-Scale

Precedence (full-scale):

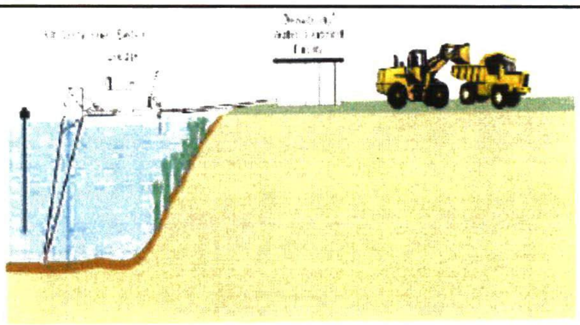
- ✓ Sheboygan River and Harbor (WI)
- ✓ Grasse River (NY)
- ✓ St. Lawrence River (NY)
- ✓ New Bedford Harbor (MA)
- ✓ Manistique River and Harbor (MI)
- ✓ Marathon Battery (NY)
- ✓ Shiawassee River (MI)
- ✓ Williamette River (OR)
- ✓ Duwamish Waterway (WA)
- ✓ Waukegan Harbor (IL)
- ✓ River Raisin (MI)
- ✓ Monguagon Creek (MI)
- ✓ Willow Run Creek (MI)
- ✓ Lake Jarnsjon (Sweden)

Documented Effectiveness Toward Risk Reduction:

- ✓ permanently removes sediment from aquatic environment

For More Information:

- ✓ National Research Council. *Contaminated Sediments in Ports and Waterways: Cleanup Strategies and Technologies.* National Academy of Sciences. 1997
- ✓ USEPA ARCS Program. *Remediation Guidance Document.* EPA-905-R94-003. October 1994.
- ✓ Herbich, J.B. *Handbook of Dredging Engineering.* McGraw Hill, Inc. 1992



Typical Dredging Components

Critical Engineering Design Issues Influencing Effectiveness:

- ✓ desired solids concentration
- ✓ desired production rate
- ✓ dredging accuracy
- ✓ sediment/dredging depth
- ✓ ability to handle debris
- ✓ water depth
- ✓ water velocity
- ✓ navigational traffic
- ✓ access constraints
- ✓ the presence of boulders/debris
- ✓ bottom conditions
- ✓ disposal requirements
- ✓ weather
- ✓ location, configuration, and extent of targeted sediment

Short-/Long-Term Issues:

- ✓ residual sediment due to mixing of constituent-containing material with underlying material or surrounding sediment during dredging
- ✓ areas missed by dredge
- ✓ sediment resuspension/downstream migration
- ✓ elevated chemical levels in residual sediments
- ✓ long- or short-term increases in chemical bioavailablity
- ✓ alteration or destruction of benthic community
- ✓ achieving low chemical cleanup levels unlikely
- ✓ presence of boulders/debris
- ✓ exposure of more highly contaminated sediments
- ✓ cannot achieve 100% removal; remaining residuals available for future exposure

Scale: 1:25,000

Reproduced from Paul Doody, Blasland, Bouck, & Lee. Pros & cons of various sediment management remedies. Sediment Work Group website

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Figure 6-1

FACT SHEET:

Engineered Capping

Description:

Controlled placement of various materials (e.g., sand, fill, gravel/cobbles, geotextile material, etc.) to physically isolate sediments from the overlying water column. Typical process options include: multi-media cap, sand cap, AquaBlok™, and revetments. Typical cap thicknesses range from 0.5-3 feet.

Scale of Implementation:

Full-Scale

Precedence (full-scale):

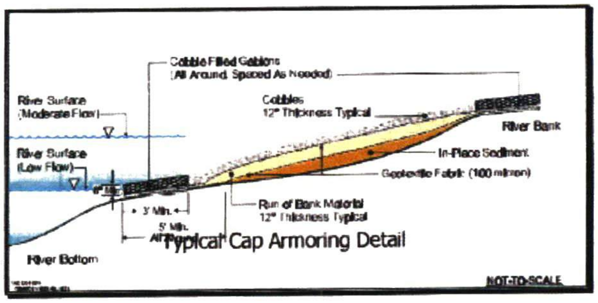
- ✓ Convair Lagoon (CA)
- ✓ Duwamish Waterway (WA)
- ✓ Puget Sound (WA)
- ✓ Hamilton Harbour (Ontario, Canada)
- ✓ St. Lawrence River (NY)
- ✓ Sheboygan River and Harbor (WI)
- ✓ Central Long Island Sound Disposal Site (NY)
- ✓ Mud Dump Site (NY)

Documented Effectiveness Toward Risk Reduction:

- ✓ reduces chemical bioavailability
- ✓ reduces water-column chemical concentrations
- ✓ can facilitate conditions conducive to natural degradation processes
- ✓ minimizes downstream migration of contaminated sediment
- ✓ can improve fish habitat areas

For More Information:

- ✓ **USEPA ARCS Program:** ***Guidance for In-Situ Subaqueous Capping of Contaminated Sediments.*** **EPA 905-B96-004. September 1998.**
- ✓ **Hazardous Substance Research Center and USEPA Great Lakes National Program Office. "Proceedings from: In-Situ Capping of Contaminated Sediments – A Seminar for Decision Makers." Chicago, IL. November 20-21, 1996.**



Typical Cap Armoring Detail

Critical Engineering Design Issues Influencing Effectiveness:

- ✓ cost/location of capping material source
- ✓ sediment surface topography
- ✓ flooding characteristics
- ✓ ground-water flow
- ✓ benthic activity
- ✓ water depths/velocity
- ✓ navigational traffic
- ✓ access constraints
- ✓ erosion potential
- ✓ sensitive/protective biologic environment

Short-/Long-Term Issues:

- ✓ chemical remains in-place
- ✓ resuspension and/or mixing of contaminants during placement
- ✓ chemical release in water column during placement
- ✓ benthic community alteration
- ✓ long-term diffusion/advection of chemicals through cap material
- ✓ long-term erosion
- ✓ cap surface recontamination
- ✓ alteration of river hydraulics
- ✓ disruption to recreational and commercial in-shore and near-shore activities
- ✓ placement may be challenging in deeper waters, areas with wave action, boat traffic or large targeted surface area
- ✓ navigational dredging requirements
- ✓ gas generation (sediment decomposition)

Scale: 1:25,000

Reproduced from Paul Doody, Blasland, Bouck, & Lee. Pros & cons of various sediment management remedies. Sediment Work Group website
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Figure 6-2

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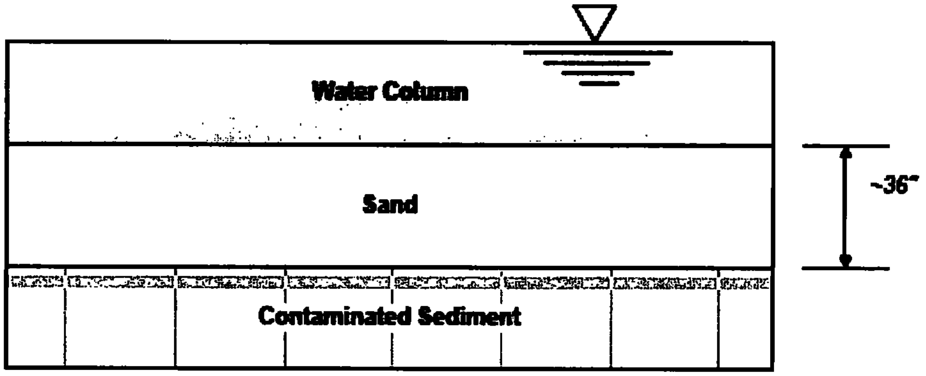
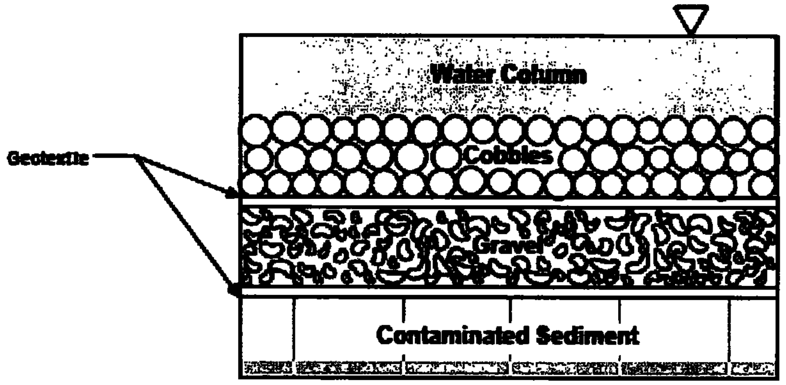
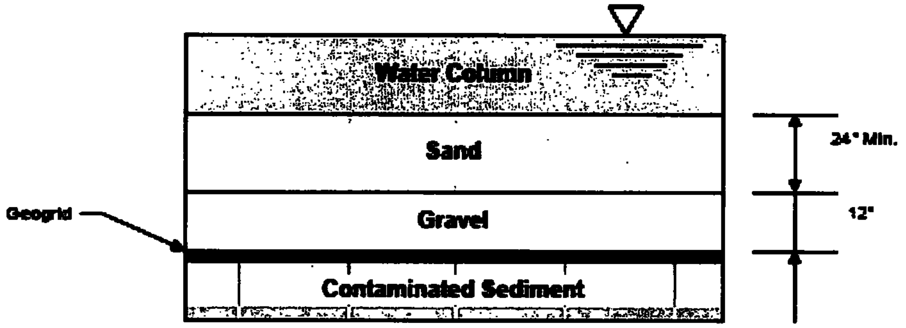


A. Eagle Harbor, WA



B. Sheboygan, WI



C. Convair Lagoon, CA

Scale: 1:25,000

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Figure 6-3

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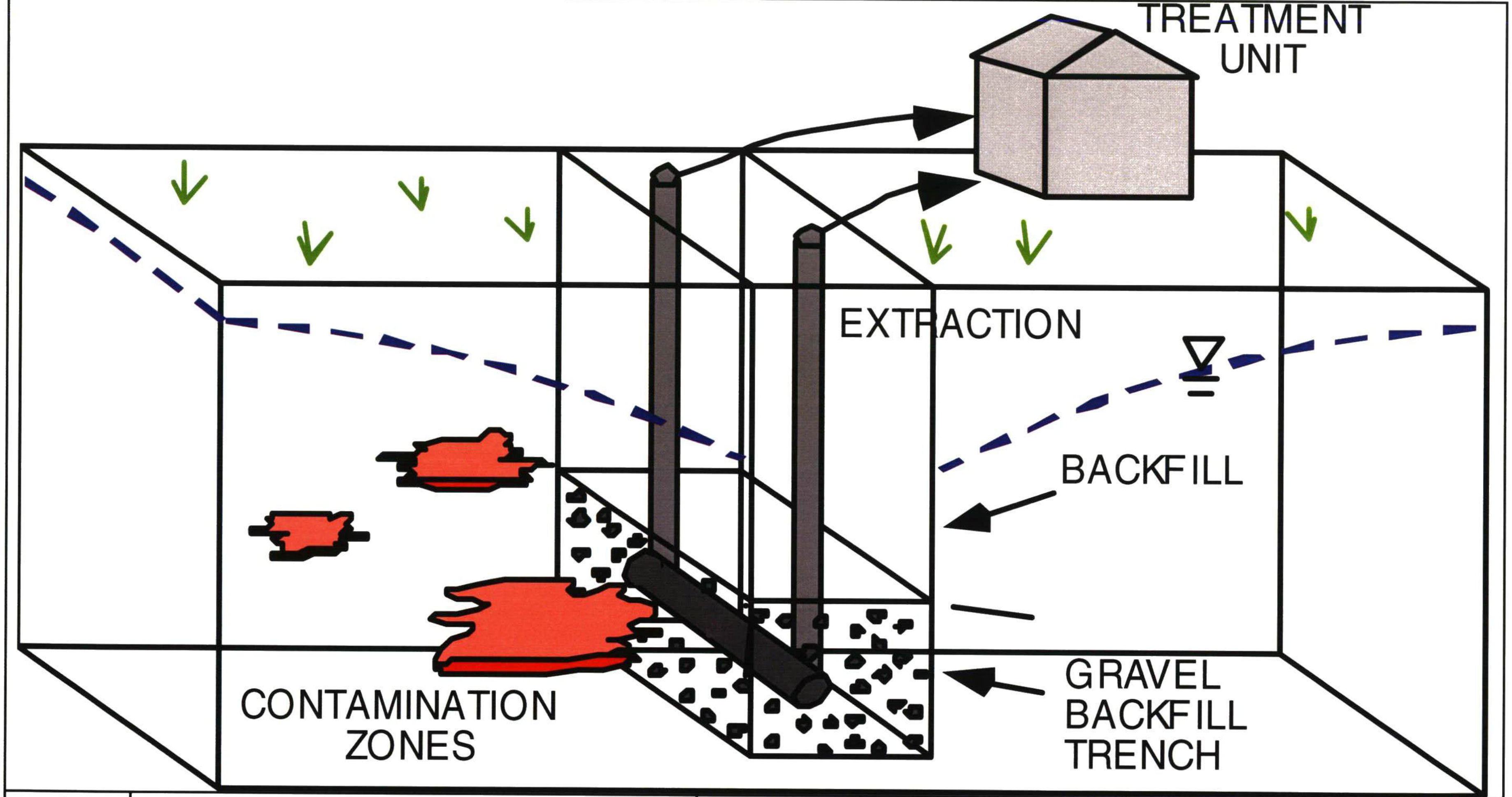

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Interceptor Trench for DNAPL

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Figure 6-4

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APPENDICES

APPENDIX A:
Comparative Toxicity of PAHs to Rainbow Trout and Fathead Minnow Larvae – Supporting Data

Table A1: Ecotox data for toxicity of PAHs to rainbow trout or fathead minnow

Chemical Name	Species Scientific Name	Endpoint	Effect Measurement	Exposure Duration (Days)	Exposure Type	Conc 1 (ug/L)	Author	Title	Source	Publication Year
1,3-Dimethylnaphthalene	*Oncorhynchus mykiss*	LC50	MORT	96 h	static	**1700**	Edsall, C.C.	Acute Toxicities to Larval Rainbow Trout of Representative Compounds Detected in Great Lakes Fish	Bull.Environ.Contam.Toxicol. 46(2):173-178	1991
1-Methylnaphthalene	*Oncorhynchus mykiss*	LD50	MORT	96 h	I	**20.5**	Hodson, P.V.	A Comparison of the Acute Toxicity of Chemicals to Fish, Rats and Mice	J.Appl.Toxicol. 5(4):220-226	1985
2-Methylnaphthalene	*Oncorhynchus mykiss*	LC50	MORT	24 h	static	**2443**	Kennedy, C.J.	Toxicokinetic Studies of Chlorinated Phenols and Polycyclic Aromatic Hydrocarbons in Rainbow Trout (Oncorhynchus mykiss)	Ph.D.Thesis, Simon Fraser Univ., Canada:188 p.(1990) / Diss.Abstr.Int.B Sci.Eng. 53(1):18	1992
2-Methylnaphthalene	*Oncorhynchus mykiss*	LC50	MORT	48 h	renewal	**2080**	Kennedy, C.J.	Toxicokinetic Studies of Chlorinated Phenols and Polycyclic Aromatic Hydrocarbons in Rainbow Trout (Oncorhynchus mykiss)	Ph.D.Thesis, Simon Fraser Univ., Canada:188 p.(1990) / Diss.Abstr.Int.B Sci.Eng. 53(1):18	1992
2-Methylnaphthalene	*Oncorhynchus mykiss*	LC50	MORT	72 h	renewal	**1694**	Kennedy, C.J.	Toxicokinetic Studies of Chlorinated Phenols and Polycyclic Aromatic Hydrocarbons in Rainbow Trout (Oncorhynchus mykiss)	Ph.D.Thesis, Simon Fraser Univ., Canada:188 p.(1990) / Diss.Abstr.Int.B Sci.Eng. 53(1):18	1992
2-Methylnaphthalene	*Oncorhynchus mykiss*	LC50	MORT	96 h	renewal	**1456**	Kennedy, C.J.	Toxicokinetic Studies of Chlorinated Phenols and Polycyclic Aromatic Hydrocarbons in Rainbow Trout (Oncorhynchus mykiss)	Ph.D.Thesis, Simon Fraser Univ., Canada:188 p.(1990) / Diss.Abstr.Int.B Sci.Eng. 53(1):18	1992
9H-Fluorene	*Oncorhynchus mykiss*	LC50	MORT	24 h	static	**>2000**	Kennedy, C.J.	Toxicokinetic Studies of Chlorinated Phenols and	Ph.D.Thesis, Simon Fraser Univ., Canada:188 p.(1990) /	1992

Chemical Name	Species Scientific Name	Endpoint	Effect Measurement	Exposure Duration (Days)	Exposure Type	Conc 1 (ug/L)	Author	Title	Source	Publication Year
								Polycyclic Aromatic Hydrocarbons in Rainbow Trout (Oncorhynchus mykiss)	Diss.Abstr.Int.B Sci.Eng. 53(1):18	
9H-Fluorene	*Oncorhynchus mykiss*	LC50	MORT	48 h	renewal	**>2000**	Kennedy, C.J.	Toxicokinetic Studies of Chlorinated Phenols and Polycyclic Aromatic Hydrocarbons in Rainbow Trout (Oncorhynchus mykiss)	Ph.D.Thesis, Simon Fraser Univ., Canada:188 p.(1990) / Diss.Abstr.Int.B Sci.Eng. 53(1):18	1992
9H-Fluorene	*Oncorhynchus mykiss*	LC50	MORT	72 h	renewal	**>2000**	Kennedy, C.J.	Toxicokinetic Studies of Chlorinated Phenols and Polycyclic Aromatic Hydrocarbons in Rainbow Trout (Oncorhynchus mykiss)	Ph.D.Thesis, Simon Fraser Univ., Canada:188 p.(1990) / Diss.Abstr.Int.B Sci.Eng. 53(1):18	1992
9H-Fluorene	*Oncorhynchus mykiss*	LC50	MORT	96 h	renewal	**>2000**	Kennedy, C.J.	Toxicokinetic Studies of Chlorinated Phenols and Polycyclic Aromatic Hydrocarbons in Rainbow Trout (Oncorhynchus mykiss)	Ph.D.Thesis, Simon Fraser Univ., Canada:188 p.(1990) / Diss.Abstr.Int.B Sci.Eng. 53(1):18	1992
9H-Fluorene	*Oncorhynchus mykiss*	LC50	MORT	96 h	static	**0.82**	Finger, S.E., E.F. Little, M.G. Henry, J.F. Fairchild, and T.P. Boyle	Comparison of Laboratory and Field Assessment of Fluorene - Part 1: Effects of Fluorene on the Survival, Growth, Reproduction, and Behavior of Aquatic Organisms in Laboratory Tests	In: T.P.Boyle (Ed.), Validation and Predictability of Laboratory Methods for Assessing the Fate and Effects of Contaminants in Aquatic Ecosystems, 1st Symposium, ASTM STP 865, Philadelphia, PA :120-133	1985
Acenaphthene	*Oncorhynchus mykiss*	LC50	MORT	24 h	flow-through	**1570**	Holcombe, G.W., G.L. Phipps, and J.T. Fiandt	Toxicity of Selected Priority Pollutants to Various Aquatic Organisms	Ecotoxicol.Environ.Saf. 7(4):400-409 (OECDG Data File)	1983
Acenaphthene	*Oncorhynchus mykiss*	LC50	MORT	48 h	flow-through	**1130**	Holcombe, G.W., G.L. Phipps, and	Toxicity of Selected Priority Pollutants to Various	Ecotoxicol.Environ.Saf. 7(4):400-409 (OECDG Data File)	1983

Chemical Name	Species Scientific Name	Endpoint	Effect Measurement	Exposure Duration (Days)	Exposure Type	Conc 1 (ug/L)	Author	Title	Source	Publication Year
							J.T. Fiandt	Aquatic Organisms		
Acenaphthene	*Oncorhynchus mykiss*	LC50	MORT	72 h	flow-through	**800**	Holcombe, G.W., G.L. Phipps, and J.T. Fiandt	Toxicity of Selected Priority Pollutants to Various Aquatic Organisms	Ecotoxicol.Environ.Saf. 7(4):400-409 (OECDG Data File)	1983
Acenaphthene	*Oncorhynchus mykiss*	LC50	MORT	96 h	flow-through	**670**	Holcombe, G.W., G.L. Phipps, and J.T. Fiandt	Toxicity of Selected Priority Pollutants to Various Aquatic Organisms	Ecotoxicol.Environ.Saf. 7(4):400-409 (OECDG Data File)	1983
Fluoranthene	*Oncorhynchus mykiss*	LC50	MORT	96 h	flow-through	**>12**	Spehar, R.L., S. Poucher, L.T. Brooke, D.J. Hansen, D. Champlin, and D.A. Cox	Comparative Toxicity of Fluoranthene to Freshwater and Saltwater Species Under Fluorescent and Ultraviolet Light	Arch.Environ.Contam.Toxicol. 37(4):496-502	1999
Fluoranthene	*Oncorhynchus mykiss*	LC50	MORT	96 h	flow-through	**91**	Spehar, R.L., S. Poucher, L.T. Brooke, D.J. Hansen, D. Champlin, and D.A. Cox	Comparative Toxicity of Fluoranthene to Freshwater and Saltwater Species Under Fluorescent and Ultraviolet Light	Arch.Environ.Contam.Toxicol. 37(4):496-502	1999
Fluoranthene	*Oncorhynchus mykiss*	LC50	MORT	96 h	flow-through	**7.7**	Spehar, R.L., S. Poucher, L.T. Brooke, D.J. Hansen, D. Champlin, and D.A. Cox	Comparative Toxicity of Fluoranthene to Freshwater and Saltwater Species Under Fluorescent and Ultraviolet Light	Arch.Environ.Contam.Toxicol. 37(4):496-502	1999
Fluoranthene	*Oncorhynchus mykiss*	LC50	MORT	96 h	static	**187**	Birge, W.J., J.A. Black, S.T. Ballard, and W.E. McDonnell	Acute Toxicity Testing with Freshwater Fish	In: J.D.Horne, M.A.Sirsky, T.A.Hollister, B.R.Oblad, and J.H.Kennedy (Eds.), Aquatic Toxicity Studies of Five Priority Pollutants, Rep.No.4398, NUS Corp, Houston, TX :47 p.	1982
Fluoranthene	*Oncorhynchus mykiss*	NR-LETH	MORT	72 h	static	**250**	Birge, W.J., J.A. Black, S.T. Ballard, and W.E.	Acute Toxicity Testing with Freshwater Fish	In: J.D.Horne, M.A.Sirsky, T.A.Hollister, B.R.Oblad, and J.H.Kennedy (Eds.), Aquatic Toxicity	1982

Chemical Name	Species Scientific Name	Endpoint	Effect Measurement	Exposure Duration (Days)	Exposure Type	Conc 1 (ug/L)	Author	Title	Source	Publication Year
							McDonnell		Studies of Five Priority Pollutants, Rep.No.4398, NUS Corp, Houston, TX :47 p.	
Fluoranthene	*Oncorhynchus mykiss*	NR-LETH	MORT	72 h	static	**250**	Birge, W.J., J.A. Black, S.T. Ballard, and W.E. McDonnell	Acute Toxicity Testing with Freshwater Fish	In: J.D.Horne, M.A.Sirsky, T.A.Hollister, B.R.Oblad, and J.H.Kennedy (Eds.), Aquatic Toxicity Studies of Five Priority Pollutants, Rep.No.4398, NUS Corp, Houston, TX :47 p.	1982
Naphthalene	*Oncorhynchus mykiss*	LC50	MORT	23 d	flow-through	**120**	Black, J.A., W.J. Birge, A.G. Westerman, and P.C. Francis	Comparative Aquatic Toxicology of Aromatic Hydrocarbons	Fundam.Appl.Toxicol. 3(9/10):353-358 (OECDG Data File)	1983
Naphthalene	*Oncorhynchus mykiss*	LC50	MORT	27 d	flow-through	**110**	Black, J.A., W.J. Birge, A.G. Westerman, and P.C. Francis	Comparative Aquatic Toxicology of Aromatic Hydrocarbons	Fundam.Appl.Toxicol. 3(9/10):353-358 (OECDG Data File)	1983
Naphthalene	*Oncorhynchus mykiss*	LC50	MORT	96 h	flow-through	**1600**	DeGraeve, G.M., R.G. Elder, D.C. Woods, and H.L. Bergman	Effects of Naphthalene and Benzene on Fathead Minnows and Rainbow Trout	Arch.Environ.Contam.Toxicol. 11(4):487-490	1982
Naphthalene	*Oncorhynchus mykiss*	LC50	MORT	96 h	flow-through	**2250**	Bergman, H.L., and A.D. Anderson	Effects of Aqueous Effluents from In Situ Fossil Fuel Processing Technologies on Aquatic Systems	Contract No.EY-77-C-04-3913, Univ.of Wyoming, Laramie, WY :73 p.	1977
Naphthalene	*Oncorhynchus mykiss*	LC50	MORT	96 h	static	**1800**	Edsall, C.C.	Acute Toxicities to Larval Rainbow Trout of Representative Compounds Detected in Great Lakes Fish	Bull.Environ.Contam.Toxicol. 46(2):173-178	1991
Naphthalene	*Oncorhynchus mykiss*	LC50	MORT	96 h	static	**2600**	Edsall, C.C.	Acute Toxicities to Larval Rainbow Trout of Representative Compounds Detected in Great Lakes	Bull.Environ.Contam.Toxicol. 46(2):173-178	1991

Chemical Name	Species Scientific Name	Endpoint	Effect Measurement	Exposure Duration (Days)	Exposure Type	Conc 1 (ug/L)	Author	Title	Source	Publication Year
								Fish		
Naphthalene	*Oncorhynchus mykiss*	LC50	MORT	96 h	static	**4400**	Edsall, C.C.	Acute Toxicities to Larval Rainbow Trout of Representative Compounds Detected in Great Lakes Fish	Bull.Environ.Contam.Toxicol. 46(2):173-178	1991
Naphthalene	*Oncorhynchus mykiss*	LC50	MORT	96 h	static	**4500**	Edsall, C.C.	Acute Toxicities to Larval Rainbow Trout of Representative Compounds Detected in Great Lakes Fish	Bull.Environ.Contam.Toxicol. 46(2):173-178	1991
Naphthalene	*Oncorhynchus mykiss*	LC50	MORT	96 h	static	**5500**	Edsall, C.C.	Acute Toxicities to Larval Rainbow Trout of Representative Compounds Detected in Great Lakes Fish	Bull.Environ.Contam.Toxicol. 46(2):173-178	1991
Naphthalene	*Oncorhynchus mykiss*	LC50	MORT	96 h	static	**6100**	Edsall, C.C.	Acute Toxicities to Larval Rainbow Trout of Representative Compounds Detected in Great Lakes Fish	Bull.Environ.Contam.Toxicol. 46(2):173-178	1991
Naphthalene	*Oncorhynchus mykiss*	LC50	MORT	27 d	flow-through	**120**	Millemann, R.E., W.J. Birge, J.A. Black, R.M. Cushman, K.L. Daniels, P.J. Franco, J.M. Giddings, J.F. McCarthy, and A.J.	Comparative Acute Toxicity to Aquatic Organisms of Components of Coal-Derived Synthetic Fuels	Trans.Am.Fish.Soc. 113(1):74-85	1984
Phenanthrene	*Oncorhynchus mykiss*	LC50	MORT	23 d	flow-through	**40**	Black, J.A., W.J. Birge, A.G. Westerman, and P.C. Francis	Comparative Aquatic Toxicology of Aromatic Hydrocarbons	Fundam.Appl.Toxicol. 3(9/10):353-358 (OECDG Data File)	1983

Chemical Name	Species Scientific Name	Endpoint	Effect Measurement	Exposure Duration (Days)	Exposure Type	Conc 1 (ug/L)	Author	Title	Source	Publication Year
Phenanthrene	*Oncorhynchus mykiss*	LC50	MORT	27 d	flow-through	**40**	Black, J.A., W.J. Birge, A.G. Westerman, and P.C. Francis	Comparative Aquatic Toxicology of Aromatic Hydrocarbons	Fundam.Appl.Toxicol. 3(9/10):353-358 (OECDG Data File)	1983
Phenanthrene	*Oncorhynchus mykiss*	LC50	MORT	96 h	static	**3200**	Edsall, C.C.	Acute Toxicities to Larval Rainbow Trout of Representative Compounds Detected in Great Lakes Fish	Bull.Environ.Contam.Toxicol. 46(2):173-178	1991
Phenanthrene	*Oncorhynchus mykiss*	LC50	MORT	60 d	flow-through	**0.0002**	Passino-Reader, D.R.	Rainbow Trout Larvae Compared with Daphnia pulex Response in Contaminant Bioassays. Copy of a Research Information Bulletin (RIB). Draft (Personal Communication)	October 19 Letter to R.Spehar, U.S.EPA, Duluth, MN :5 p.	1993
Phenanthrene	*Oncorhynchus mykiss*	LC50	MORT	27 d	flow-through	**30**	Millemann, R.E., W.J. Birge, J.A. Black, R.M. Cushman, K.L. Daniels, P.J. Franco, J.M. Giddings, J.F. McCarthy, and A.J.	Comparative Acute Toxicity to Aquatic Organisms of Components of Coal-Derived Synthetic Fuels	Trans.Am.Fish.Soc. 113(1):74-85	1984
Pyrene	*Oncorhynchus mykiss*	LC50	MORT	24 h	static	**2000**	Kennedy, C.J.	Toxicokinetic Studies of Chlorinated Phenols and Polycyclic Aromatic Hydrocarbons in Rainbow Trout (Oncorhynchus mykiss)	Ph.D.Thesis, Simon Fraser Univ., Canada:188 p.(1990) / Diss.Abstr.Int.B Sci.Eng. 53(1):18	1992
Pyrene	*Oncorhynchus mykiss*	LC50	MORT	48 h	renewal	**2000**	Kennedy, C.J.	Toxicokinetic Studies of Chlorinated Phenols and Polycyclic Aromatic Hydrocarbons in Rainbow	Ph.D.Thesis, Simon Fraser Univ., Canada:188 p.(1990) / Diss.Abstr.Int.B Sci.Eng. 53(1):18	1992

Chemical Name	Species Scientific Name	Endpoint	Effect Measurement	Exposure Duration (Days)	Exposure Type	Conc 1 (ug/L)	Author	Title	Source	Publication Year
								Trout (Oncorhynchus mykiss)		
Pyrene	*Oncorhynchus mykiss*	LC50	MORT	72 h	renewal	**2000**	Kennedy, C.J.	Toxicokinetic Studies of Chlorinated Phenols and Polycyclic Aromatic Hydrocarbons in Rainbow Trout (Oncorhynchus mykiss)	Ph.D.Thesis, Simon Fraser Univ., Canada:188 p.(1990) / Diss.Abstr.Int.B Sci.Eng. 53(1):18	1992
Pyrene	*Oncorhynchus mykiss*	LC50	MORT	96 h	renewal	**2000**	Kennedy, C.J.	Toxicokinetic Studies of Chlorinated Phenols and Polycyclic Aromatic Hydrocarbons in Rainbow Trout (Oncorhynchus mykiss)	Ph.D.Thesis, Simon Fraser Univ., Canada:188 p.(1990) / Diss.Abstr.Int.B Sci.Eng. 53(1):18	1992
1-Methylnaphthalene	*Pimephales promelas*	LC50	MORT	0.04 d	static	**39000**	Mattson, V.R., J.W. Arthur, and C.T. Walbridge	Acute Toxicity of Selected Organic Compounds to Fathead Minnows	EPA-600/3-76-097, U.S.EPA, Duluth, MN :12 p.	1976
1-Methylnaphthalene	*Pimephales promelas*	LC50	MORT	24 h	static	**9000**	Mattson, V.R., J.W. Arthur, and C.T. Walbridge	Acute Toxicity of Selected Organic Compounds to Fathead Minnows	EPA-600/3-76-097, U.S.EPA, Duluth, MN :12 p.	1976
1-Methylnaphthalene	*Pimephales promelas*	LC50	MORT	48 h	static	**9000**	Mattson, V.R., J.W. Arthur, and C.T. Walbridge	Acute Toxicity of Selected Organic Compounds to Fathead Minnows	EPA-600/3-76-097, U.S.EPA, Duluth, MN :12 p.	1976
1-Methylnaphthalene	*Pimephales promelas*	LC50	MORT	72 h	static	**9000**	Mattson, V.R., J.W. Arthur, and C.T. Walbridge	Acute Toxicity of Selected Organic Compounds to Fathead Minnows	EPA-600/3-76-097, U.S.EPA, Duluth, MN :12 p.	1976
1-Methylnaphthalene	*Pimephales promelas*	LC50	MORT	96 h	static	**9000**	Mattson, V.R., J.W. Arthur, and C.T. Walbridge	Acute Toxicity of Selected Organic Compounds to Fathead Minnows	EPA-600/3-76-097, U.S.EPA, Duluth, MN :12 p.	1976
2,3,5-Trimethyl naphthalene	*Pimephales promelas*	LC50	MORT	96 h	static	**6400**	Mayer, F.L.Jr., and M.R. Ellersieck	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	1986

Chemical Name	Species Scientific Name	Endpoint	Effect Measurement	Exposure Duration (Days)	Exposure Type	Conc 1 (ug/L)	Author	Title	Source	Publication Year
2,3,6-Trimethylnaphthalene	*Pimephales promelas*	LC50	MORT	96 h	static	**>6700**	Mayer, F.L.Jr., and M.R. Ellersieck	Manual of Acute Toxicity: Interpretation and Data Base for 410 Chemicals and 66 Species of Freshwater Animals	Resour.Publ.No.160, U.S.Dep.Interior, Fish Wildl.Serv., Washington, DC :505 p. (USGS Data File)	1986
9H-Fluorene	*Pimephales promelas*	LC50	MORT	96 h	static	**>100000**	Finger, S.E., E.F. Little, M.G. Henry, J.F. Fairchild, and T.P. Boyle	Comparison of Laboratory and Field Assessment of Fluorene - Part 1: Effects of Fluorene on the Survival, Growth, Reproduction, and Behavior of Aquatic Organisms in Laboratory Tests	In: T.P.Boyle (Ed.), Validation and Predictability of Laboratory Methods for Assessing the Fate and Effects of Contaminants in Aquatic Ecosystems, 1st Symposium, ASTM STP 865, Philadelphia, PA :120-133	1985
Acenaphthene	*Pimephales promelas*	LC50	MORT	72 h	flow-through	**1700**	Holcombe, G.W., G.L. Phipps, and J.T. Fiandt	Toxicity of Selected Priority Pollutants to Various Aquatic Organisms	Ecotoxicol.Environ.Saf. 7(4):400-409 (OECDG Data File)	1983
Acenaphthene	*Pimephales promelas*	LC50	MORT	96 h	flow-through	**1600**	Holcombe, G.W., G.L. Phipps, and J.T. Fiandt	Toxicity of Selected Priority Pollutants to Various Aquatic Organisms	Ecotoxicol.Environ.Saf. 7(4):400-409 (OECDG Data File)	1983
Acenaphthene	*Pimephales promelas*	LC50	MORT	96 h	flow-through	**1730**	Geiger, D.L., C.E. Northcott, D.J. Call, and L.T. Brooke	Acute Toxicities of Organic Chemicals to Fathead Minnows (Pimephales promelas), Volume 2	Ctr.for Lake Superior Environ.Stud., Univ.of Wisconsin-Superior, Superior, WI :326 p.	1985
Acenaphthene	*Pimephales promelas*	LC50	MORT	96 h	flow-through	**608**	Cairns, M.A., and A.V. Nebeker	Toxicity of Acenaphthene and Isophorone to Early Stages of Fathead Minnows	Arch.Environ.Contam.Toxicol. 11(6):703-707	1982
Anthracene	*Pimephales promelas*	LT50	MORT	7 h	renewal	**19.1**	Oris, J.T., A. Tilghman Hall, and J.D. Tylka	Humic Acids Reduce the Photo-Induced Toxicity of Anthracene to Fish and Daphnia	Environ.Toxicol.Chem. 9(5):575-583	1990
Anthracene	*Pimephales promelas*	LT50	MORT	15.8 h	renewal	**5.4**	Oris, J.T.Jr.	The Photo-Induced Toxicity of Polycyclic Aromatic Hydrocarbons to Larvae of the Fathead Minnow (Pimephales promelas)	Chemosphere 16(7):1395-1404	1987

Chemical Name	Species Scientific Name	Endpoint	Effect Measurement	Exposure Duration (Days)	Exposure Type	Conc 1 (ug/L)	Author	Title	Source	Publication Year
Benz[a]anthracene	*Pimephales promelas*	LT50	MORT	65 h	renewal	**1.8**	Oris, J.T.Jr.	The Photo-Induced Toxicity of Polycyclic Aromatic Hydrocarbons to Larvae of the Fathead Minnow (Pimephales promelas)	Chemosphere 16(7):1395-1404	1987
Benzo(a)pyrene	*Pimephales promelas*	LT50	MORT	40 h	renewal	**5.6**	Oris, J.T.Jr.	The Photo-Induced Toxicity of Polycyclic Aromatic Hydrocarbons to Larvae of the Fathead Minnow (Pimephales promelas)	Chemosphere 16(7):1395-1404	1987
Fluoranthene	*Pimephales promelas*	LC50	MORT	30 d	renewal	**7.1**	Gendusa, A.C.	Toxicity of Chromium and Fluoranthene from Aqueous and Sediment Sources to Selected Freshwater Fish	Ph.D.Thesis, University of North Texas:138 p.(Publ in Part As 9393, 5091)	1990
Fluoranthene	*Pimephales promelas*	LC50	MORT	96 h	flow-through	**>17**	Spehar, R.L., S. Poucher, L.T. Brooke, D.J. Hansen, D. Champlin, and D.A. Cox	Comparative Toxicity of Fluoranthene to Freshwater and Saltwater Species Under Fluorescent and Ultraviolet Light	Arch.Environ.Contam.Toxicol. 37(4):496-502	1999
Fluoranthene	*Pimephales promelas*	LC50	MORT	96 h	flow-through	**>212**	Spehar, R.L., S. Poucher, L.T. Brooke, D.J. Hansen, D. Champlin, and D.A. Cox	Comparative Toxicity of Fluoranthene to Freshwater and Saltwater Species Under Fluorescent and Ultraviolet Light	Arch.Environ.Contam.Toxicol. 37(4):496-502	1999
Fluoranthene	*Pimephales promelas*	LC50	MORT	96 h	flow-through	**12.2**	Spehar, R.L., S. Poucher, L.T. Brooke, D.J. Hansen, D. Champlin, and D.A. Cox	Comparative Toxicity of Fluoranthene to Freshwater and Saltwater Species Under Fluorescent and Ultraviolet Light	Arch.Environ.Contam.Toxicol. 37(4):496-502	1999
Fluoranthene	*Pimephales promelas*	LC50	MORT	96 h	flow-through	**6.83**	Diamond, S.A.	Characterization of Acute and Chronic Toxicity of Fluoranthene and the	Ph.D.Thesis, Miami University, Oxford, OH :151	1995

Chemical Name	Species Scientific Name	Endpoint	Effect Measurement	Exposure Duration (Days)	Exposure Type	Conc 1 (ug/L)	Author	Title	Source	Publication Year
								Potential for Acquisition Enhanced Tolerance in Fathead Minnows (Pimephales promelas)		
Fluoranthene	*Pimephales promelas*	LC50	MORT	96 h	static	**95**	Horne, J.D., and B.R. Oblad	Aquatic Toxicity Studies of Six Priority Pollutants	Rep.No.4380, NUS Corp., Houston Environ.Center, Houston, TX:99 p./ Appendix A, J.D.Horne, M.A.Swirsky, T.A.Hollister, B.R.Oblad, and J.H.Kennedy (Eds.), Acute Toxicity Studies of Five Priority Pollutants, NUS Corp.Rep.No.4398, Houston, TX :47 p.	1983
Fluoranthene	*Pimephales promelas*	LC50	MORT	96 h	static	**95**	Horne, J.D., and B.R. Oblad	Aquatic Toxicity Studies of Six Priority Pollutants	Rep.No.4380, NUS Corp., Houston Environ.Center, Houston, TX:99 p./ Appendix A, J.D.Horne, M.A.Swirsky, T.A.Hollister, B.R.Oblad, and J.H.Kennedy (Eds.), Acute Toxicity Studies of Five Priority Pollutants, NUS Corp.Rep.No.4398, Houston, TX :47 p.	1983
Fluoranthene	*Pimephales promelas*	LC50	MORT	6 d	flow-through	**6.83**	Diamond, S.A., J.T. Oris, and S.I. Guttman	Adaptation to Fluoranthene Exposure in a Laboratory Population of Fathead Minnows	Environ.Toxicol.Chem. 14(8):1393-1400	1995
Naphthalene	*Pimephales promelas*	LC50	MORT	96 h	flow-through	**9930**	Bio Dynamics, Inc.	A Flow-Through Acute Fish Toxicity Test of Naphthalene	EPA/OTS Doc.#86-870000910 :26p.(NTIS/OTS 0515348)	1987
Naphthalene	*Pimephales promelas*	LC50	MORT	24 h	flow-through	**7760**	Holcombe, G.W., G.L. Phipps, M.L. Knuth, and T. Felhaber	The Acute Toxicity of Selected Substituted Phenols, Benzenes and Benzoic Acid Esters to Fathead Minnows Pimephales promelas	Environ.Pollut.Ser.A 35(4):367-381 (OECDG Data File)	1984
Naphthalene	*Pimephales promelas*	LC50	MORT	48 h	flow-through	**6350**	Holcombe, G.W., G.L. Phipps, M.L.	The Acute Toxicity of Selected Substituted	Environ.Pollut.Ser.A 35(4):367-381 (OECDG Data File)	1984

Chemical Name	Species Scientific Name	Endpoint	Effect Measurement	Exposure Duration (Days)	Exposure Type	Conc 1 (ug/L)	Author	Title	Source	Publication Year
							Knuth, and T. Felhaber	Phenols, Benzenes and Benzoic Acid Esters to Fathead Minnows Pimephales promelas		
Naphthalene	*Pimephales promelas*	LC50	MORT	72 h	flow-through	**6080**	Holcombe, G.W., G.L. Phipps, M.L. Knuth, and T. Felhaber	The Acute Toxicity of Selected Substituted Phenols, Benzenes and Benzoic Acid Esters to Fathead Minnows Pimephales promelas	Environ.Pollut.Ser.A 35(4):367-381 (OECDG Data File)	1984
Naphthalene	*Pimephales promelas*	LC50	MORT	96 h	flow-through	**6140**	Broderius, S.J., M.D. Kahl, and M.D. Hoglund	Use of Joint Toxic Response to Define the Primary Mode of Toxic Action for Diverse Industrial Organic Chemicals	Environ.Toxicol.Chem. 14(9):1591-1605 (Author Communication Used)	1995
Naphthalene	*Pimephales promelas*	LC50	MORT	96 h	flow-through	**7900**	DeGraeve, G.M., R.G. Elder, D.C. Woods, and H.L. Bergman	Effects of Naphthalene and Benzene on Fathead Minnows and Rainbow Trout	Arch.Environ.Contam.Toxicol. 11(4):487-490	1982
Naphthalene	*Pimephales promelas*	LC50	MORT	96 h	flow-through	**6080**	Holcombe, G.W., G.L. Phipps, M.L. Knuth, and T. Felhaber	The Acute Toxicity of Selected Substituted Phenols, Benzenes and Benzoic Acid Esters to Fathead Minnows Pimephales promelas	Environ.Pollut.Ser.A 35(4):367-381 (OECDG Data File)	1984
Naphthalene	*Pimephales promelas*	LC50	MORT	96 h	flow-through	**6140**	Geiger, D.L., C.E. Northcott, D.J. Call, and L.T. Brooke	Acute Toxicities of Organic Chemicals to Fathead Minnows (Pimephales promelas), Volume 2	Ctr.for Lake Superior Environ.Stud., Univ.of Wisconsin-Superior, Superior, WI :326 p.	1985
Naphthalene	*Pimephales promelas*	LC50	MORT	96 h	flow-through	**4900**	Bergman, H.L., and A.D. Anderson	Effects of Aqueous Effluents from In Situ Fossil Fuel Processing Technologies on Aquatic Systems	Contract No.EY-77-C-04-3913, Univ.of Wyoming, Laramie, WY :73 p.	1977

Chemical Name	Species Scientific Name	Endpoint	Effect Measurement	Exposure Duration (Days)	Exposure Type	Conc 1 (ug/L)	Author	Title	Source	Publication Year
Naphthalene	*Pimephales promelas*	LC50	MORT	96 h	static	**1990**	Millemann, R.E., W.J. Birge, J.A. Black, R.M. Cushman, K.L. Daniels, P.J. Franco, J.M. Giddings, J.F. McCarthy, and A.J.	Comparative Acute Toxicity to Aquatic Organisms of Components of Coal-Derived Synthetic Fuels	Trans.Am.Fish.Soc. 113(1):74-85	1984
Pyrene	*Pimephales promelas*	LT50	MORT	3.2 h	renewal	**25.6**	Oris, J.T.Jr.	The Photo-Induced Toxicity of Polycyclic Aromatic Hydrocarbons to Larvae of the Fathead Minnow (Pimephales promelas)	Chemosphere 16(7):1395-1404	1987

APPENDIX B:
UMA Engineering Ltd. 2007. River Sediment and Surface Water Monitoring Report Prepared for Manitoba Hydro

UMA | AECOM

Manitoba Hydro
Remedial Monitoring Program
River Sediment and Surface Water Monitoring

Prepared by:
UMA Engineering Ltd.
1479 Buffalo Place
Winnipeg, MB R3T 1L7

UMA Project No. 0217 158 03 (4.6.1.4)

August 2007

UMA | AECOM

UMA Engineering Ltd.
1479 Buffalo Place
Winnipeg, Manitoba R3T 1L7
T 204.284.0580 F 204.475.3646 www.uma.aecom.com

August 7, 2007

UMA Project: 0217 158 03 (4.6.1.4)

Mr. Bob Gill, M.N.R.M.
Senior Environmental Specialist
Manitoba Hydro/Centra Gas
820 Taylor Avenue
Winnipeg, Manitoba
R3C 2P4

Dear Bob:

Re: Remedial Monitoring Program
River Sediment and Surface Water Monitoring

UMA Engineering Ltd. (UMA) is pleased to provide three (3) copies of this report documenting the sediment monitoring at twenty four locations and surface water sampling at thirteen locations from the Red River opposite the Sutherland Avenue former Manufactured Gas Plant (MGP) site. This work was undertaken between January and March 2007.

Thank you for the opportunity to provide our services on this project. Please do not hesitate to call Mr. Edwin Yee, B.Sc. at (204) 284-0580 should you have any questions regarding this report.

Sincerely,

UMA Engineering Ltd.

Tom Wingrove, P.Eng.
Senior Vice President
Earth and Water
tom.wingrove@uma.aecom.com

T. R.
WINGROVE
4/08/07

Disclaimer

The attached Report (the "Report") has been prepared by UMA Engineering Ltd. ("UMA") for the benefit of Manitoba Hydro ("Client") in accordance with the agreement between UMA and Client for the services described in the Report (the "Agreement"), and is subject to the budgetary, time and other constraints and limitations set forth in the Agreement.

The information and data contained in the Report, including without limitation the results of any inspections, sampling, testing and analyses and any conclusions or recommendations of UMA (the "Information"), represent UMA's professional judgement in light of the knowledge and information available to it at the time of preparation of the Report. UMA has not updated the Report since the date that the Report was prepared. Further, UMA has relied upon the accuracy of the information provided to it by Client in order to prepare the Report and UMA has not independently verified the accuracy of such information, nor was it required to do so. Thus, UMA shall not be responsible for any events or circumstances that may have occurred since the date on which the Report was prepared which may affect the information contained therein, or for any inaccuracies contained in information that was provided to UMA by Client.

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1.0 Background

The Sutherland former manufactured gas plant (MGP) site at 35-38 Sutherland Avenue, Winnipeg, exhibits residual contamination of subsurface soils with substances associated with coal tar. Beginning in 1993 extensive investigation of the soil, groundwater, air and riverbed sediments have been undertaken at the site of the former manufactured gas plant on Sutherland Avenue in Winnipeg. The investigations have identified the presence of polycyclic aromatic hydrocarbons (PAHs), monocyclic aromatic hydrocarbons (BTEX), and aliphatic hydrocarbons – petroleum hydrocarbons (PHC), total volatile hydrocarbons (TVH) and total extractable hydrocarbons (TEH) at concentrations in excess of the CCME Tier I guidelines in soil, groundwater and sediment.

UMA completed the *Comprehensive Environmental Management Plan for Residuals from Historical Operations at the Sutherland Avenue Former Manufactured Gas Plant* in May, 2006. The Environmental Management Plan proposes a remedial monitoring program. The objectives of the monitoring program are:

- provide on-going assurance that residual conditions do not pose a threat to human health or the environment;
- detect and measure any potential changes in conditions on or off site in a time frame to allow appropriate response;
- implement additional remedial actions, if warranted.

The monitoring program is based on a remedial strategy that is divided into two broad categories, human health and the physical environment. In evaluating human health and environmental risks associated with residual coal-tar and related products from the former MGP site, the sources of residual coal tar contaminants should be monitored and pathways evaluated. Direct exposures of humans to PAH-contaminated soils is precluded at the Sutherland site owing to the lack of contamination of surface, accessible soils and the ground surface is typically hard surface pavement.

The proposed Remedial Monitoring program includes the following:

- River Baseline;
- Upland Groundwater; and
- Upland Vapour.

The River Baseline work is directed at re-sampling the original sediment locations. The Upland Groundwater work will involve monitoring the existing piezometers within the overburden soils and one bedrock monitoring well, and the installation of additional piezometers along Annabella Street and Gladstone Street. The Upland Vapour work will involve the installation of dedicated shallow vapour probes on the east and west sides of the former Sutherland MGP site that will allow monitoring of the shallow unsaturated zone along the perimeter of the site for potential vapour migration. The initial vapour monitoring will involve the characterization of the soil vapours with on-going monitoring of combustible vapours.

2.0 Scope of Work

Manitoba Hydro requested that UMA undertake the River Sediment Sampling as a component of the Remedial Monitoring Program to determine if there is any change to the contaminant plume and potential risk to the aquatic life in the Red River. Previous investigations of the riverbed did not provide total delineation of the horizontal and vertical distribution of the contaminant plume. UMA undertook the drilling of an additional eight transects within the river channel consisting of five test holes per transect as part of the 2003 Supplemental Site Investigation. The site investigation work was carried out in accordance with Manitoba Guideline 98-01 Environmental Site Investigations in Manitoba. The river sediment monitoring program follows the above guidelines. Some of the sampling locations established during the 2003 investigation work were re-sampled and additional sampling locations down stream were established and sampled to ensure complete coverage of the contaminant plume. The objective of this sediment monitoring event is to assess the biologically active zone of the sediments (0 – 10 cm). Delineation of the aerial extent and depth of the sediment contaminant plume and assessment of temporal plume changes is planned for a future investigation.

Twenty four (24) sediment samples were collected from the Red River around the Disraeli Bridge and downstream approximately 800 m. In addition, twenty-five (25) surface water samples including two (2) duplicate water samples were collected at approximately one (1) metre below the ice level and approximately 0.15 to 0.30 metres above the Red River bottom. The water samples were added to the monitoring program in response to a request from the Manitoba Conservation Technical Advisory Committee (TAC) to assess whether the PAHs in the river sediments were influencing water quality. The locations of the sediment and surface water samples, which were based on the 2002 drilling investigation, are shown on Figures 01 and 02 respectively. The scope of work included the following:

- Collect sediment samples from select locations that coincide with the 2002 drilling investigation where possible with the addition of new sampling locations further downstream. Due to low river levels, some sediment locations had to be moved along the river's edge.
- Collect surface water samples above the river sediment and near the water surface to determine water chemistry and assess whether any release of PAHs from the sediment is affecting water quality.
- Analyze the sediment samples for PAHs and surface water samples for metals and PAHs.
- Provide a report assessing the results of the sediment and surface water analysis.

3.0 Methodology

3.1 Sediment Sampling

The sediment sampling program was conducted on January 29th, 30th, February 1st and 21st, 2007, using a chain saw and Eckman Dredger. The following describes the sampling program:

- Twenty four (24) sediment sample locations were cut in the ice based on the forty (40) sample locations established in the 2003 Supplemental Environmental Site Investigation. Additional sample locations downstream of the 2002 sampling program were added (Figure 1). The study sampling protocol was undertaken in accordance with Manitoba Guideline 98-01.
- A sampling port was cut through the river ice using a chain saw. The sediment sample was collected using an Eckman Dredger.
- The sampler was lowered maintaining tension on the line to avoid drifting.
- The sample was retrieved slowly to minimize the potential loss or disturbance of the sediment sample.
- The closure mechanism was released and the sample was placed in a 125 mL glass jar and labelled according to the sample location.
- Nitrile gloves were worn and disposed of after the collection of each sample.
- All sample locations were individually barricaded using snow fencing and thin ice signs were placed along each transect for safety.
- All sediment samples were submitted to ALS Laboratories in Winnipeg, Manitoba with the appropriate chain of custody and within the required holding times.

Twenty four (24) sediment samples were submitted for laboratory analysis of polycyclic aromatic hydrocarbons (PAHs). Results of the sediment analysis are presented in Table 1 and discussed in Sections 4.0 and 5.0. The laboratory reports are provided in Appendix C.

3.2 Surface Water Sampling

The surface water sampling program was conducted on March 12 and 13, 2007. Test hole locations are shown on Figure 02. The following describes the sampling program:

- Twelve (12) sample locations were drilled through the ice based on the 2007 sediment sampling investigation (Figure 02).
- A sampling port was cut through the river ice using a Kanga drill equipped with a 1.5" auger.
- Depth to bottom and ice thickness was measured using a graduated steel rod. Once depth to bottom was established, a sampling tube was fixed to the rod and again lowered to the desired sampling depth.

- Samples were taken from two separate depths within the water column using a peristaltic low flow pump. Sample A was taken from approximately 1.0 m below ice level and sample B was taken from approximately 0.15 m to 0.30 m above river bottom. All sample handling was done using nitrile gloves.

- The samples were placed in the appropriate laboratory supplied bottles and labelled according to the sample location.

- All surface water samples were submitted to ALS Laboratories (formerly Enviro-Test) in Winnipeg, Manitoba with the appropriate chain of custody and within the required holding times.

Twenty-five (25) surface water samples including two duplicate water samples were submitted for laboratory analysis of benzene, toluene, ethylbenzene, xylenes (BTEX), total volatile hydrocarbons (TVH), total extractable hydrocarbons (TEH), polyaromatic hydrocarbons (PAHs) and metals. The analysis of metals was included to provide a more complete assessment of surface water quality. Results of the surface water analysis are discussed in Section 4.0 and presented in Table 2 and 3. The laboratory reports are provided in Appendix C.

4.0 Results

4.1 Assessment Criteria

The results of the sediment analysis have been compared with the Probable Effects Level, Canadian Council of Ministers of the Environment (CCME) Sediment Quality Guidelines, Probable Effects Level (PEL), Update 2002. The selected guidelines provide the probable effect range within which adverse biological effects frequently occur.

The results of the surface water samples have been compared to the CCME Canadian Water Quality Guidelines for the Protection of Aquatic Life, Freshwater Aquatic Life (FAL), Update 6.01, December 2006 and the Manitoba Water Quality Standards, Objectives and Guidelines, Final Draft November 2002.

4.2 Sediment Results

All sediment samples collected in the field were submitted to ALS Laboratories in Winnipeg for PAH analysis. A summary of the results is provided in Table 1 for PAHs. The detailed laboratory results are provided in Appendix C.

The majority of the results for PAHs were below the laboratory minimum detection limit and the CCME guidelines. There were however, parameters that did exceed the applicable guidelines. In sample T3-2, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, phenanthrene and pyrene exceeded the applicable CCME guidelines. Concentrations of naphthalene in excess of the applicable CCME guidelines were detected in T3-3, and T6-4.

All laboratory quality control criteria were met and the results of surrogate recoveries for PAHs were all within the laboratory measure of method efficiency.

4.3 Surface Water Results

Surface Water samples collected one (1) metre below the ice level are designated by the letter "A" and samples collected approximately 0.15 to 0.30 metres above the river bottom are designated by the letter "B". All of the surface water samples collected in the field were submitted to ALS Laboratories in Winnipeg for PAH, benzene, toluene, ethylbenzene and xylenes (BTEX), Total Volatile Hydrocarbons (TVH), Total Extractable Hydrocarbons (TEH), metals, Total Dissolved Solids (TDS) and Total Suspended Solids (TSS) analysis. A summary of the PAH/BTEX/TDS/TSS and metal results are provided in Tables 2 and 3 respectively. The detailed laboratory results are provided in Appendix C.

All of the surface water sample results for BTEX, TVH and TEH were below the minimum laboratory detection limits and CCME Guidelines. For PAHs, with the exception of surface water samples T3-W1A and T6-W1A collected 1 metre below the ice level, all of the surface water samples were either below the minimum laboratory detection limits or below the applicable guidelines. Surface water sample T3-W1A exceeded the applicable guidelines for benzo(a)anthracene, benzo(a)pyrene, fluoranthene and pyrene. Surface water sample T6-W1A exceeded the applicable guidelines for benzo(a)anthracene, fluoranthene and pyrene. Relatively high levels of TDS and TSS were recorded in all of the samples when compared with the Manitoba Water Quality Objectives (WQO). The Manitoba WQO range for TDS in surface and groundwater is 700 to 1000 mg/L and the TSS range is 5 to 25 mg/L. All of the TDS results for the water samples submitted are within the WQO range while all of the TSS values exceed the WQO range.

Concentrations of aluminum exceeded the applicable guideline in all of the surface water samples. With the exception of surface water sample T9-W1A collected 1 metre below the ice level, all of the surface water samples exceeded or were at the applicable guideline for copper. Concentrations of iron in the surface water samples exceeded the applicable guideline for iron with the exception of sample T8-W1B collected approximately 0.15 to 0.30 metres above the sediment surface. Concentrations of selenium were either in excess of or at the applicable guideline value in surface water samples T2-W1A, T2-W1B, T2-W2A, T2-W2B, T2-W3A, T3-W1A, T7-W1B and upstream samples UP1-W1A, UP1-W1B and UP2-W1A. Zinc concentrations in samples T2-W2A and T9-W1B, and upstream sample UP1-W1A were either in excess or at the applicable guideline.

The results for the duplicate water samples T2-W3A and T8-W2A for sample locations T2-W2B and T8-W1B respectively, are within the laboratory accepted 20 percent Relative Percent Difference (RPD) with the exception of T2-W3A for selenium and zirconium and T8-W2A for aluminum, arsenic, iron, nickel and thallium. It should be noted that deviation outside the acceptable RPD is permitted in cases where analytes with low detection limits and measured concentrations in the samples are less than five times the minimum laboratory detection limits (MDL). This would apply to the nickel, selenium and thallium parameters.

5.0 Discussion

The majority of the results for PAHs in the river sediments were below the minimum laboratory detection limits and the CCME guidelines. Three (3) of the twenty-four (24) sediment samples exceeded the applicable guidelines.

Concentrations of naphthalene in excess of the applicable CCME guidelines were detected in T3-3 and T6-4, and near the CCME guideline for T3-2. In sediment sample T3-2, acenaphthene, acenaphthylene, anthracene, benzo(a)anthracene, benzo(a)pyrene, chrysene, dibenzo(a,h)anthracene, fluoranthene, fluorene, phenanthrene and pyrene exceeded the applicable CCME guidelines.

In comparing the 2007 PAH sediment results to those obtained for the 2003 ecological risk assessment of the Red River adjacent to the Sutherland site which employed a similar sample collection methodology (North/South Consultants Inc., 2003), the 2007 PAH sediment results are lower. Additional sediment sampling locations were established further downstream of the 2002/2003 sample locations to address potential redistribution of the PAH sediment plume. The results of all of the new downstream sample locations were below minimum laboratory detection limits. The shallow river sediment sampling indicates a clean layer of recent sediment.

The results of all the water samples were below the minimum laboratory detection limits for BTEX, TVH and TEH. For the PAHs, surface water samples T3-W1A and T6-W1A collected at 1 metre below ice level exceeded the applicable guidelines for benzo(a)anthracene, fluoranthene and pyrene. The benzo(a)pyrene result for sample T3-W1A also exceeded the applicable guideline. Surface water sample T3-1WA was collected near the river bank above sediment sample location T3-3. The sediment sample exceeded the applicable guideline for naphthalene but not for the PAHs observed in the surface water sample. The surface water sample T6-W1A was collected near the river bank above the sediment sample location T6-1 where the concentrations of PAHs in the sediments were below the minimum laboratory detection limits. The results of all of the water samples collected just above the river sediment were below the minimum laboratory detection limits. There does not appear to be a correlation with the PAH surface water values and the sediment values as only two surface water samples collected at 1 metre below the ice level exceeded applicable guidelines while the samples collected at 0.15 to 0.30 m above the river bottom were below applicable guidelines.

The results of the surface water analysis indicate that aluminum, copper and iron concentrations are consistently higher than the applicable guidelines and a number of water samples were just above the selenium water quality guideline. Although the 2007 sediment samples were not analyzed for metals, high concentrations of aluminum were found in the 2003 sediment samples. However, similar values were obtained for aluminum, copper, iron and selenium for the upstream control water samples. Manitoba Water Stewardship collects monthly water samples at the St. Norbert South Flood Gate, one of their monitoring stations on the Red River located just south of the City of Winnipeg. The water quality results for this monitoring station show similar high values exceeding the applicable guidelines for aluminum, copper, iron and selenium. Relatively high levels of calcium and magnesium were obtained from the surface water samples indicating a relatively high hardness level for the Red River. Manitoba Water Stewardship results for Red River water quality at the St. Norbert South Flood Gate confirm the relatively high levels of calcium and magnesium present in Red River water entering the urban environment.

6.0 Conclusions and Recommendations

The results of the Red River sediment monitoring program were below the applicable PAH guidelines with the exception of samples T3-2, T3-3 and T6-4. Samples T3-3 and T6-4 exceeded the naphthalene guideline, while sample T3-2 exceeded a number of PAH guidelines. The 2007 PAH sediment results are lower than PAH sediment results from the benthic study (North/South Consultants Inc., 2003) that employed a similar sample collection methodology as described in Section 3 and in accordance with Manitoba Guideline 98-01. Spatial distribution of the plume could not be determined based on the results as the objective of this sediment monitoring event was the assessment of the biologically active zone of the sediments (0 – 10 cm). Delineation of the aerial extent and depth of the sediment contaminant plume and assessment of temporal plume changes is planned for a future investigation.

All of the surface water samples with the exception of T3-W1A and T6-W1A were below the applicable guidelines for PAHs. Both of these surface water samples were collected 1 metre below ice level and the water samples collected 0.15 to 0.30 metres above the river bottom at these sample locations were below the minimum laboratory detection limits. There does not appear to be a correlation with the PAH surface water values and the sediment values.

Concentrations of aluminum, copper and, iron were at or above the applicable water quality guidelines for all sample locations, including the upstream control samples. However, the study results are similar to Manitoba Water Stewardship water quality results for Red River water entering the urban environment. Some of the surface water samples exceeded the applicable guidelines for selenium and zinc. Although the 2007 sediment samples were not analyzed for metal content, the 2003 sediment sample results had high levels of aluminum. There is no applicable guideline for aluminum, but all of the 2003 sediment results for copper were below the applicable CCME guideline. The concentrations of metals in the water column above the impacted sediment are similar to values obtained by Manitoba Water Stewardship at their upstream monitoring station located at the St. Norbert South Flood Gate.

Based on the results, the following is recommended:

- In addition to surface sediment monitoring, core sampling should be undertaken to assess the spatial distribution of the PAH contaminant plume; and
- Surface water samples above the sediment monitoring locations should be collected and analyzed for PAHs as part of the next scheduled river sediment monitoring event to identify if there are any PAH impacts to the river water quality and if there is a correlation to the underlying impacted river sediments.

Respectfully Submitted,

UMA Engineering Ltd.	**Reviewed By:**
Kristiina Ferraz B.A., Grad Tech. Environmental Technologist Earth and Water	Edwin Yee, B.Sc Environmental Specialist Earth and Water

TABLES

Table 1. Summary of PAH in River Sediment
Former Sutherland Avenue MGP, Winnipeg, Manitoba

Sample Location Sample Date	MDL	CCME Sediment Criteria (mg/kg)	T2-1 29-Jan-07	T2-2 29-Jan-07	T2-3 29-Jan-07	T2-4 29-Jan-07	T3-2 29-Jan-07	T3-3 29-Jan-07	T3-4 29-Jan-07	T4-1 31-Jan-07
Acenaphthene	0.01	**0.0889**	<0.01	<0.01	<0.01	<0.01	**0.68**	0.08	<0.01	<0.01
Acenaphthylene	0.01	**0.128**	<0.01	<0.01	<0.01	<0.01	**0.62**	0.03	<0.01	<0.01
Anthracene	0.01	**0.245**	<0.01	<0.01	<0.01	<0.01	**1.9**	0.05	<0.01	<0.01
Benzo (a) anthracene	0.01	**0.385**	<0.01	<0.01	<0.01	<0.01	**2.3**	<0.01	<0.01	<0.01
Benzo (a) pyrene	0.01	**0.782**	<0.01	<0.01	<0.01	<0.01	**1.8**	<0.01	<0.01	<0.01
Benzo (b) fluoranthene	0.01	--	<0.01	<0.01	<0.01	<0.01	2.0	<0.01	<0.01	<0.01
Benzo (g,h,i) perylene	0.01	--	<0.01	<0.01	<0.01	<0.01	1.0	<0.01	<0.01	<0.01
Benzo (k) fluoranthene	0.01	--	<0.01	<0.01	<0.01	<0.01	0.74	<0.01	<0.01	<0.01
Chrysene	0.01	**0.862**	<0.01	<0.01	<0.01	<0.01	**2.2**	<0.01	<0.01	<0.01
Dibenzo (a,h) anthracene	0.01	**0.135**	<0.01	<0.01	<0.01	<0.01	**0.24**	<0.01	<0.01	<0.01
Fluoranthene	0.01	**2.355**	<0.01	<0.01	<0.01	<0.01	**6.2**	0.03	<0.01	<0.01
Fluorene	0.01	**0.144**	<0.01	<0.01	<0.01	<0.01	**1.1**	0.03	<0.01	<0.01
Indeno (1,2,3-cd) pyrene	0.01	--	<0.01	<0.01	<0.01	<0.01	1.6	<0.01	<0.01	<0.01
Naphthalene	0.01	**0.391**	<0.01	<0.01	<0.01	<0.01	0.38	**2.4**	0.07	<0.01
1-Methyl naphthalene	0.01	--	<0.01	<0.01	<0.01	<0.01	0.12	0.08	<0.01	<0.01
2-Methyl naphthalene	0.01	**0.201**	<0.01	<0.01	<0.01	<0.01	0.06	0.10	<0.01	<0.01
Phenanthrene	0.01	**0.515**	<0.01	<0.01	<0.01	<0.01	**6.2**	0.05	<0.01	<0.01
Pyrene	0.01	**0.875**	<0.01	<0.01	<0.01	<0.01	**5.1**	0.03	<0.01	<0.01
Quinoline	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acridine	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Notes:
CCME, Interim Sediment Quality Guidelines (PEL) for Freshwater, Update 2002.
-- indicates no criteria
BOLD or shaded indicates exceeded parameter

Table 1. Summary of PAH in River Sediment
Former Sutherland Avenue MGP, Winnipeg, Manitoba

Sample Location	MDL	CCME Sediment Criteria (mg/kg)	T5-2	T6-1	T6-2	T6-3	T6-4	T7-1	T7-2	T7-3
Sample Date			31-Jan-07	31-Jan-07	31-Jan-07	31-Jan-07	31-Jan-07	7-Feb-07	7-Feb-07	7-Feb-07
Acenaphthene	0.01	**0.0889**	<0.01	<0.01	0.02	<0.01	0.03	<0.01	<0.01	<0.01
Acenaphthylene	0.01	**0.128**	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	0.01	**0.245**	<0.01	<0.01	0.19	<0.01	0.03	<0.01	<0.01	<0.01
Benzo (a) anthracene	0.01	**0.385**	<0.01	<0.01	0.02	<0.01	0.03	<0.01	<0.01	<0.01
Benzo (a) pyrene	0.01	**0.782**	<0.01	<0.01	0.02	<0.01	0.03	<0.01	<0.01	<0.01
Benzo (b) fluoranthene	0.01	--	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo (g,h,i) perylene	0.01	--	<0.01	<0.01	0.02	<0.01	0.03	<0.01	<0.01	<0.01
Benzo (k) fluoranthene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	0.01	**0.862**	<0.01	<0.01	0.02	<0.01	0.03	<0.01	<0.01	<0.01
Dibenzo (a,h) anthracene	0.01	**0.135**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	0.01	**2.355**	<0.01	<0.01	0.10	<0.01	0.08	<0.01	<0.01	<0.01
Fluorene	0.01	**0.144**	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno (1,2,3-cd) pyrene	0.01	--	<0.01	<0.01	0.02	<0.01	0.03	<0.01	<0.01	<0.01
Naphthalene	0.01	**0.391**	0.08	<0.01	0.38	0.02	**0.53**	0.02	<0.01	<0.01
1-Methyl naphthalene	0.01	--	<0.01	<0.01	0.02	<0.01	0.03	<0.01	<0.01	<0.01
2-Methyl naphthalene	0.01	**0.201**	<0.01	<0.01	0.07	0.02	0.03	<0.01	<0.01	<0.01
Phenanthrene	0.01	**0.515**	<0.01	<0.01	0.14	<0.01	0.10	<0.01	<0.01	<0.01
Pyrene	0.01	**0.875**	<0.01	<0.01	0.07	<0.01	0.05	<0.01	<0.01	<0.01
Quinoline	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acridine	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Notes:

CCME, Interim Sediment Quality Guidelines (PEL) for Freshwater, Update 2002.

-- indicates no criteria

BOLD or shaded indicates exceeded parameter

Table 1. Summary of PAH in River Sediment
Former Sutherland Avenue MGP, Winnipeg, Manitoba

Sample Location Sample Date	MDL	CCME Sediment Criteria (mg/kg)	T7A-1 7-Feb-07	T8-2 7-Feb-07	T8A-1 7-Feb-07	T9A-1 21-Feb-07	T9A-2 21-Feb-07	T10-1 21-Feb-07	T10-2 21-Feb-07	T11-1 21-Feb-07
Acenaphthene	0.01	**0.0889**	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Acenaphthylene	0.01	**0.128**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Anthracene	0.01	**0.245**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo (a) anthracene	0.01	**0.385**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo (a) pyrene	0.01	**0.782**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo (b) fluoranthene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo (g,h,i) perylene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo (k) fluoranthene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	0.01	**0.862**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Dibenzo (a,h) anthracene	0.01	**0.135**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	0.01	**2.355**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	0.01	**0.144**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Indeno (1,2,3-cd) pyrene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	0.01	**0.391**	<0.01	<0.01	0.13	<0.01	<0.01	<0.01	<0.01	<0.01
1-Methyl naphthalene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
2-Methyl naphthalene	0.01	**0.201**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Phenanthrene	0.01	**0.515**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	0.01	**0.875**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Quinoline	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acridine	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05

Notes:
CCME, Interim Sediment Quality Guidelines (PEL) for Freshwater, Update 2002.
-- indicates no criteria
BOLD or shaded indicates exceeded parameter

Table 2. Summary of PHC and PAH in River Water
Former Sutherland Avenue MGP, Winnipeg, Manitoba

Sample Location Sample Date	MDL	CCME Water Criteria (µg/L)	UP1-W1A[3] 12-Mar-07	UP1-W1B[4] 12-Mar-07	UP2-W1A 12-Mar-07	UP2-W1B 12-Mar-07	T2-W1A 12-Mar-07	T2-W1B 12-Mar-07	T2-W2A 12-Mar-07	T2-W2B 12-Mar-07	T2-W3A[1] 12-Mar-07	T3-W1A 12-Mar-07	T3-W2A 12-Mar-07	T3-W2B 12-Mar-07	T6-W1A 12-Mar-07
Benzene	0.5	**370**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	0.5	**2.0**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	0.5	**90.0**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylenes	0.5	--	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
T V H	100	--	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
T E H	100	--	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
PAH															
1-Methyl Naphthalene	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
2-Methyl Naphthalene	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acenaphthene	0.05	**5.8**	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acenaphthylene	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Anthracene	0.01	**0.012**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	0.01	**0.018**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.06**	<0.01	<0.01	**0.03**
Benzo(a)pyrene	0.01	**0.015**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.02**	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	<0.01	0.02
Benzo(ghi)perylene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	<0.01	0.02
Chrysene	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.08	<0.05	<0.05	<0.05
Dibenzo(ah)anthracene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.06	<0.01	<0.01	0.02
Fluoranthene	0.01	**0.04**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.13**	<0.01	<0.01	**0.06**
Fluorene	0.05	**3.0**	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Indeno(1,2,3 cd)pyrene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.05	<0.01	<0.01	0.01
Naphthalene	0.05	**1.1**	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Phenanthrene	0.01	**0.4**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	0.03
Pyrene	0.01	**0.025**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	**0.08**	<0.01	<0.01	**0.04**
Quinoline	0.05	**3.4**	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acridine	0.01	**4.4**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Dissolved Solids	5	**700 - 1000***	610	610	620	610	630	630	640	630	640	660	650	650	650
Total Suspended Solids	5	**5 - 25***	32	35	29	39	36	47	42	42	33	50	41	42	33

Notes:

CCME, Water Guidelines for the Protection of Freshwater Aquatic Life, Update 2006.

* Manitoba Water Quality Objective (mg/L)

[1] Duplicate of T2-W2B

[2] Duplicate of T8-W1B

[3] A - Approximately 1.0 m below ice level.

[4] B - Approximately 0.15 m to 0.30 m above sediment.

BOLD or shaded indicates exceeded parameter

Table 2. Summary of PHC and PAH in River Water
Former Sutherland Avenue MGP, Winnipeg, Manitoba

Sample Location Sample Date	MDL	CCME Water Criteria (µg/L)	T6-W1B 12-Mar-07	T6-W2A 12-Mar-07	T6-W2B 12-Mar-07	T7-W1A 13-Mar-07	T7-W1B 13-Mar-07	T7-W2A 13-Mar-07	T7-W2B 13-Mar-07	T8-W1A 13-Mar-07	T8-W1B 13-Mar-07	T8-W2A [2] 13-Mar-07	T9-W1A 13-Mar-07	T9-W1B 13-Mar-07
Benzene	0.5	**370**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Toluene	0.5	**2.0**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Ethylbenzene	0.5	**90.0**	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
Xylenes	0.5	--	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
T V H	100	--	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
T E H	100	--	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100
PAH														
1-Methyl Naphthalene	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
2-Methyl Naphthalene	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acenaphthene	0.05	**5.8**	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acenaphthylene	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Anthracene	0.01	**0.012**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)anthracene	0.01	**0.018**	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(a)pyrene	0.01	**0.015**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(b)fluoranthene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(ghi)perylene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Benzo(k)fluoranthene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Chrysene	0.05	--	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Dibenzo(ah)anthracene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluoranthene	0.01	**0.04**	<0.01	<0.01	<0.01	0.03	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Fluorene	0.05	**3.0**	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Indeno(1,2,3 cd)pyrene	0.01	--	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Naphthalene	0.05	**1.1**	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Phenanthrene	0.01	**0.4**	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Pyrene	0.01	**0.025**	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Quinoline	0.05	**3.4**	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Acridine	0.01	**4.4**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Total Dissolved Solids	5	**700 - 1000***	670	630	620	650	630	630	640	650	640	640	620	630
Total Suspended Solids	5	**5 - 25***	44	39	46	26	31	29	33	25	35	33	28	33

Notes:

CCME, Water Guidelines for the Protection of Freshwater Aquatic Life, Update 2006.

* Manitoba Water Quality Objective (mg/L)

[1] Duplicate of T2-W2B

[2] Duplicate of T8-W1B

[3] A - Approximately 1.0 m below ice level.

[4] B - Approximately 0.15 m to 0.30 m above sediment.

BOLD or shaded indicates exceeded parameter

Table 3. Summary of Metals in River Water
Former Sutherland Avenue MGP, Winnipeg, Manitoba

Sample Location	MDL	CCME Water Criteria (µg/L)	UP1-W1A[3]	UP1-W1B[4]	UP2-W1A	UP2-W1B	T2-W1A	T2-W1B	T2-W2A	T2-W2B	T2-W3A [1]	T3-W1A	T3-W2A	T3-W2B	T6-W1A
Sample Date			12-Mar-07	12-Mar-07	12-Mar-07	12-Mar-07	12-Mar-07	12-Mar-07	12-Mar-07	12-Mar-07	12-Mar-07	12-Mar-07	12-Mar-07	12-Mar-07	12-Mar-07
Silver	1	**0.1**	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Aluminum	20	**5 - 100**	**1510**	**2410**	**1220**	**1250**	**1240**	**1480**	**1430**	**1520**	**1430**	**930**	**1550**	**1480**	**1060**
Arsenic	0.5	**5.0**	3.8	4.1	3.6	3.6	3.6	3.7	3.8	3.6	3.5	3.4	3.7	3.7	3.6
Boron	30	--	100	110	110	110	110	110	120	110	110	110	110	110	110
Barium	0.3	--	88.9	99.8	85.7	87.5	87.7	89.8	90.1	88.1	88.7	83.5	86.40	87.6	83.8
Beryllium	1	--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bismuth	0.2	--	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Calcium	100	--	82300	81300	81500	78100	80000	81200	82600	78800	80500	78400	79400	78900	79400
Cadmium	0.2	**0.017**	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cobalt	0.2	--	0.6	0.8	0.4	0.6	0.5	0.6	0.5	0.5	0.5	0.5	0.7	0.6	0.5
Chromium	1	**9.9**	<1	2	<1	<1	<1	<1	<1	<1	<1	<1	<1	1	<1
Cesium	0.1	--	0.2	0.3	0.1	0.2	0.1	0.2	0.2	0.2	0.2	0.1	0.2	0.2	1
Copper	1	**2 - 4**	**4**	**5**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**
Iron	50	**300**	**1210**	**1970**	**960**	**1160**	**1010**	**1370**	**1200**	**1200**	**1170**	**730**	**1170**	**1170**	**850**
Potassium	100	--	10600	10800	10600	10100	10300	10700	10900	10200	10500	10600	10600	10300	10200
Magnesium	10	--	42000	42200	42500	42400	42800	42900	43200	42200	42100	42500	42300	42300	42800
Manganese	0.3	--	80.0	114	68.9	77.2	77.1	94.0	85.1	81.8	80.0	56.3	74.1	75.6	68.5
Molybdenum	0.2	**73.0**	2.6	2.6	2.7	2.7	2.7	2.8	2.8	2.7	2.6	2.6	2.7	2.7	2.6
Sodium	30	--	53100	53800	55000	52000	53200	54900	56600	52600	54000	57100	51900	52600	54200
Nickel	2	**25 - 150**	5	5	4	4	4	5	4	4	4	4	4	4	4
Phosphorus	50	--	290	310	270	290	300	290	300	280	280	280	290	290	290
Lead	0.5	**1 - 7**	0.6	1.0	0.5	0.7	0.5	0.7	0.6	0.6	0.5	0.5	0.6	0.6	0.6
Rubidium	0.2	--	5.0	6.5	4.6	4.8	4.6	5.4	5.0	5.0	5.1	4.0	5.0	5.0	4.2
Antimony	1	--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Selenium	1	**1.0**	**1**	**2**	**2**	<1	**2**	**2**	**1**	**1**	**2**	**1**	<1	<1	<1
Tin	0.6	--	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Strontium	0.1	--	312	323	322	315	321	327	329	321	315	308	312	320	308
Tellurium	1	--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Titanium	0.9	--	44.0	51.9	33.4	33.0	31.6	45.5	31.6	36.8	38.0	27.2	53.6	44.4	30.0
Thallium	0.1	**0.8**	0.2	0.2	0.2	0.3	0.5	0.3	0.3	0.2	0.2	0.4	0.3	0.3	0.3
Uranium	0.1	--	3.1	3.2	3.1	2.9	3.1	3.1	3.1	3.1	3.1	3	2.9	3	2.9
Vanadium	1	--	6	10	4	5	5	6	4	6	6	4	6	6	4
Tungsten	0.2	--	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Zinc	10	**30.0**	**30**	20	<10	<10	10	10	**30**	<10	<10	20	20	<10	<10
Zirconium	0.4	--	1.7	2.3	1.4	1.4	1.3	1.8	1.5	3.6	1.5	1.1	2.1	1.5	1.0

Notes:

CCME, Water Guidelines for the Protection of Freshwater Aquatic Life, Update 2006.

[1] Duplicate of T2-W2B

[2] Duplicate of T8-W1B

[3] A - Approximately 1.0 m below ice level.

[4] B - Approximately 0.15 m to 0.30 m above sediment.

BOLD or shaded indicates exceeded parameter

Table 3. Summary of Metals in River Water
Former Sutherland Avenue MGP, Winnipeg, Manitoba

Sample Location Sample Date	MDL	CCME Water Criteria (µg/L)	T6-W1B 12-Mar-07	T6-W2A 12-Mar-07	T6-W2B 12-Mar-07	T7-W1A 13-Mar-07	T7-W1B 13-Mar-07	T7-W2A 13-Mar-07	T7-W2B 13-Mar-07	T8-W1A 13-Mar-07	T8-W1B 13-Mar-07	T8-W2A [2] 13-Mar-07	T9-W1A 13-Mar-07	T9-W1B 13-Mar-07
Silver	1	**0.1**	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Aluminum	20	**5 - 100**	**1510**	**1370**	**1200**	**1190**	**1210**	**1100**	**1380**	**1280**	**1370**	**1100**	**1030**	**1450**
Arsenic	0.5	**5.0**	3.9	3.6	3.5	3.5	3.6	3.5	3.6	3.6	3.7	2.8	2.6	2.9
Boron	30	--	110	110	110	100	100	110	110	100	100	110	100	100
Barium	0.3	--	86.9	86.0	85.0	81.0	82.2	82.4	86.4	85.0	86.4	85.0	81.7	86.9
Beryllium	1	--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bismuth	0.2	--	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Calcium	100	--	82200	78100	76700	78000	78700	79000	80200	79200	80900	81000	75900	81800
Cadmium	0.2	**0.017**	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Cobalt	0.2	--	0.6	0.6	0.6	0.6	0.6	0.5	0.6	0.6	0.6	0.6	0.5	0.5
Chromium	1	**9.9**	1	1	<1	<1	<1	<1	<1	<1	1	<1	<1	<1
Cesium	0.1	--	0.2	0.1	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.1	0.2
Copper	1	**2 - 4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	**4**	3	**4**
Iron	50	**300**	**1200**	**1060**	**1090**	**890**	**970**	**850**	**1040**	**960**	110	**1000**	**840**	**1090**
Potassium	100	--	10900	10300	9900	10600	10300	10600	10600	10300	10600	10500	9800	10600
Magnesium	10	--	43900	42300	41900	42700	43000	41800	44400	43400	44200	43200	40800	42700
Manganese	0.3	--	78.5	72.1	75.3	65.2	66.2	65.8	70.1	66.7	76.3	74.0	63.2	74.4
Molybdenum	0.2	**73.0**	2.7	2.6	2.6	2.8	2.6	2.7	2.7	2.8	2.7	2.9	2.8	2.7
Sodium	30	--	58600	51900	50800	62000	61800	63800	64300	61600	62000	63100	58900	64200
Nickel	2	**25 - 150**	4	4	4	4	4	4	5	4	4	3	3	4
Phosphorus	50	--	300	310	290	260	300	270	300	290	280	250	220	250
Lead	0.5	**1 - 7**	1.0	0.6	0.6	0.7	0.7	0.7	0.7	0.7	0.8	0.8	0.8	0.8
Rubidium	0.2	--	4.9	4.6	4.6	4.5	4.5	4.3	4.6	4.6	4.6	5.3	4.9	5.5
Antimony	1	--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Selenium	1	**1.0**	<1	<1	<1	<1	**1**	<1	<1	<1	<1	<1	<1	<1
Tin	0.6	--	<0.6	<0.6	<0.6	<0.6	<0.6	0.8	<0.6	<0.6	<0.6	<0.6	<0.6	<0.6
Strontium	0.1	--	317	309	302	308	302	316	310	310	315	348	332	339
Tellurium	1	--	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Titanium	0.9	--	41.5	33.0	304	42.8	40.3	280	43.1	35.7	39.4	38.3	28.1	33.7
Thallium	0.1	**0.8**	0.3	0.2	0.3	0.3	0.3	0.3	0.3	0.2	0.2	0.3	0.2	0.3
Uranium	0.1	--	3	3	2.9	3	3	3	3	3	3.1	3.6	3.4	3.5
Vanadium	1	--	6	5	5	5	5	4	5	5	5	5	4	6
Tungsten	0.2	--	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
Zinc	10	**30.0**	10	10	20	10	10	10	20	10	10	10	10	**50**
Zirconium	0.4	--	1.5	1.5	1.4	1.3	1.3	1.2	1.4	1.3	1.4	1.5	1.3	1.5

Notes:

CCME, Water Guidelines for the Protection of Freshwater Aquatic Life, Update 2006.

[1] Duplicate of T2-W2B

[2] Duplicate of T8-W1B

[3] A - Approximately 1.0 m below ice level.

[4] B - Approximately 0.15 m to 0.30 m above sediment.

BOLD or shaded indicates exceeded parameter

FIGURES

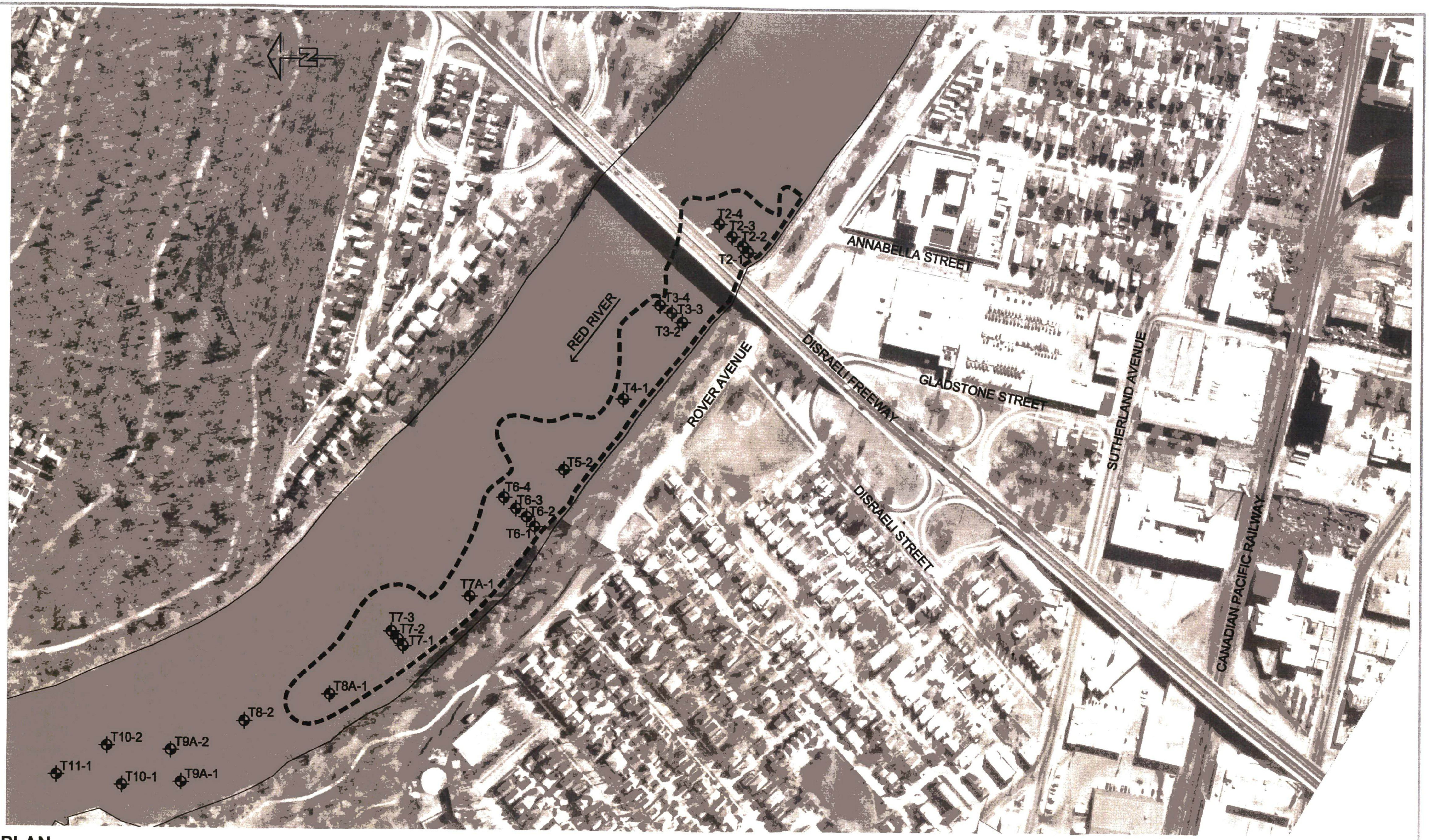
B SIZE 11" x 17" (279.4mm x 431.8mm)

PLOT: 07/06/18 9:55:31 AM

Saved By: stevensc

UMA FILE NAME 0217-158-03_08-H-F001_RX.dwg

ISS/REV: A



PLAN

0 30 60 m SCALE 1:3000

⌖ T3-2 SEDIMENT SAMPLE LOCATION

- - - 2002 SEDIMENT MONITORING AREA

UMA | AECOM

Manitoba Hydro
Sutherland Management Plan
Remedial Monitoring Plan

Sediment Sampling Locations
Figure - 01

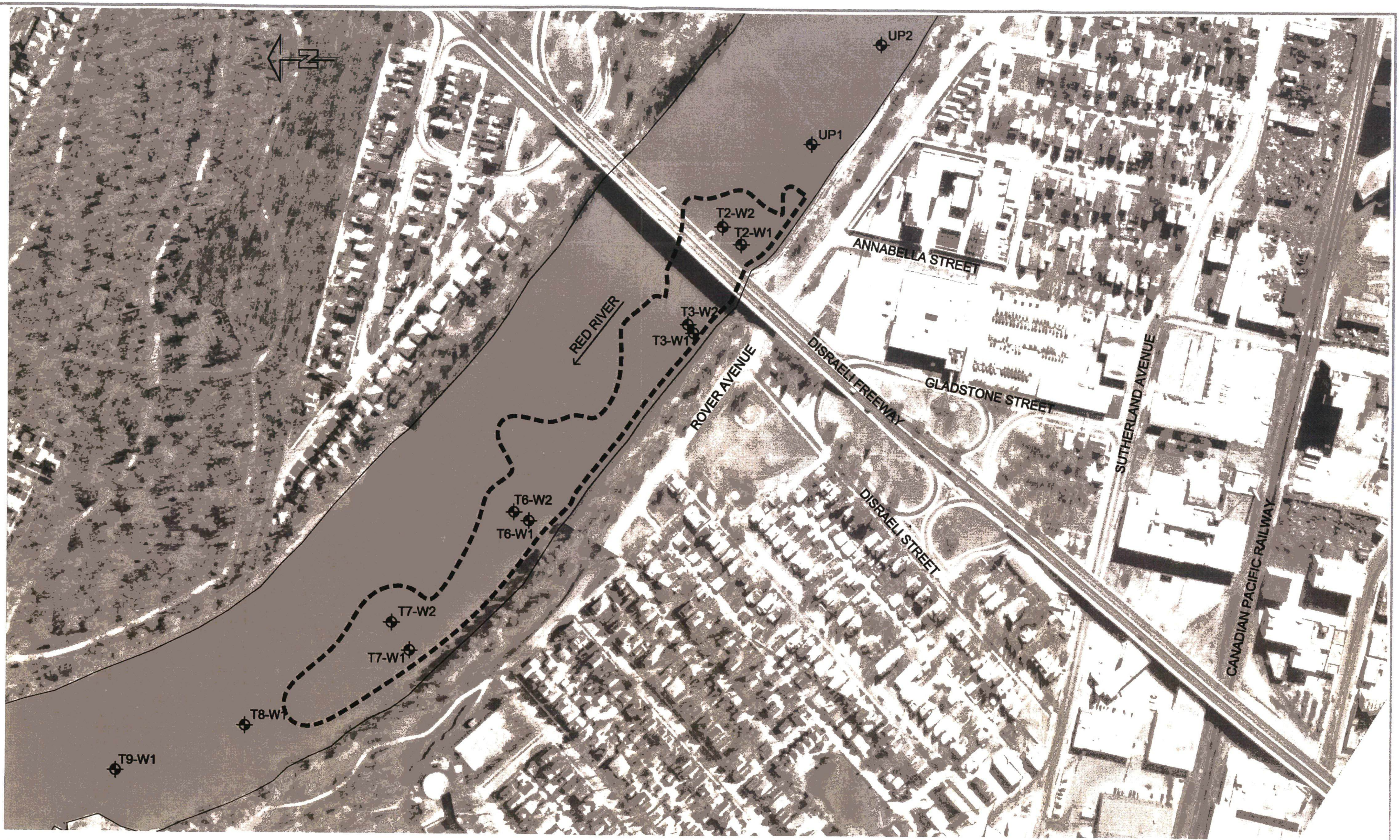
B SIZE 11" x 17" (279.4mm x 431.8mm)

PLOT: 07/06/18 9:53:44 AM

Saved By: ferrazk

UMA FILE NAME 0217-158-03_06-H-F002_RX.dwg

ISS/REV A



PLAN

0 30 60 m SCALE 1:3000

⊕ T9-W1 SURFACE WATER SAMPLE LOCATION

- - - 2002 SEDIMENT MONITORING AREA

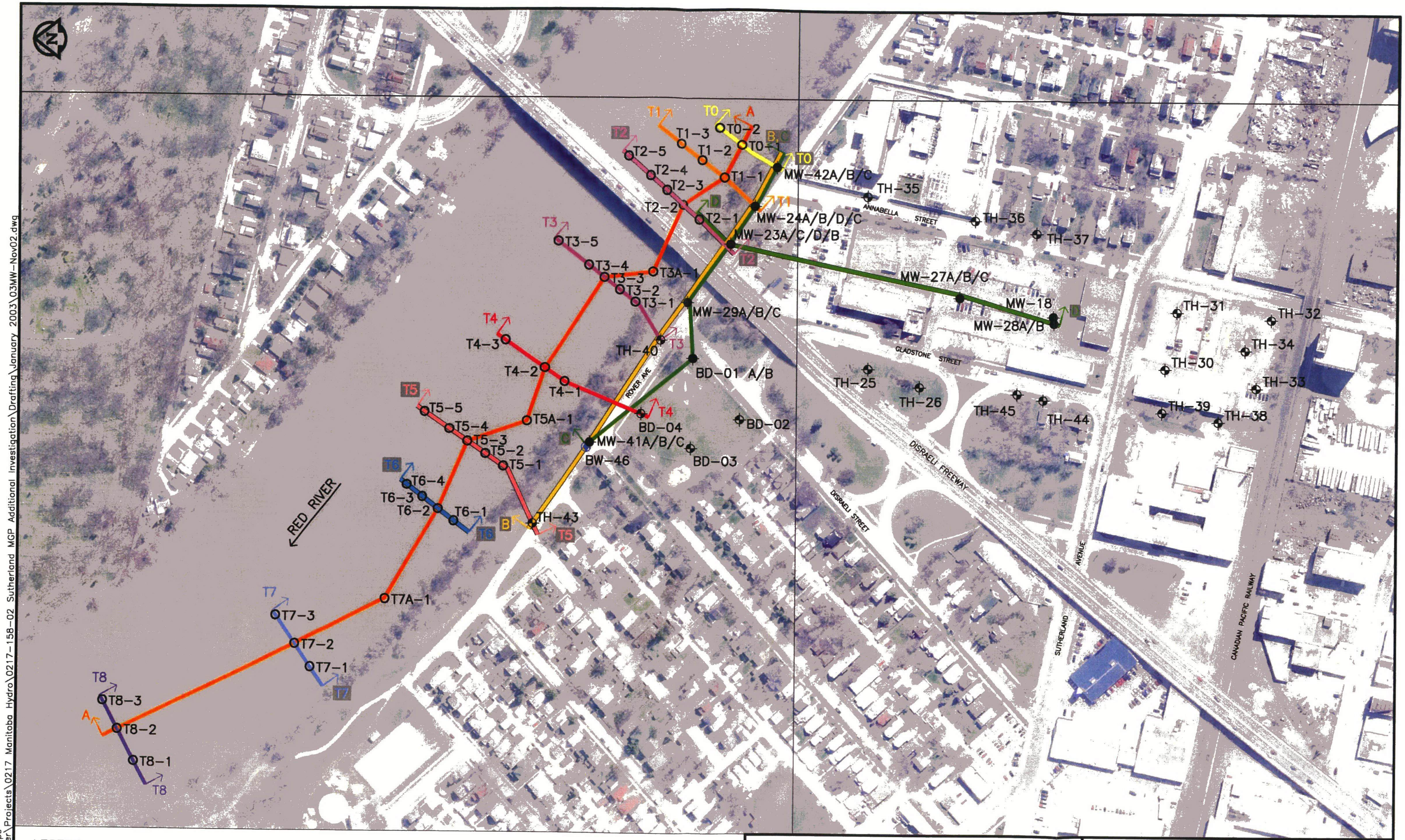
UMA | AECOM

Manitoba Hydro
Sutherland Management Plan
Remedial Monitoring Plan

Surface Water Sampling Locations

Figure - 02

Appendix A
2002 Sediment Sample Locations



LEGEND

○—○—○	–RIVER TESTHOLE LOCATIONS	●	–MONITORING WELL LOCATION	A ⌐——¬ A	–CROSS–SECTION REFERENCE LINE
⌖	–UPLAND TESTHOLE LOCATION	◈	–BEDROCK WELL LOCATION		

UMA Engineering Ltd.

· Consulting · Engineering · Construction · Management Services

MANITOBA HYDRO
35 SUTHERLAND AVENUE

TITLE:	TESTHOLE / MONITORING WELL LOCATIONS – 2002		
JOB No.	0217-158-02	DATE:	DECEMBER 2003
SCALE:	1:2,500	DWG. No.	03
CHECKED:	LB		

MAY 07, 2003
Plot Scale: 1:1 ps
L:\Earth & Water\Projects\0217 Manitoba Hydro\0217-158-02 Sutherland MGP Additional Investigation\Drafting\January 2003\03MW-Nov02.dwg

Appendix B
Site Photographs

Photo :	2089	**Description :**	View northeast at Disraeli Bridge and T2.
Date:	February 21, 2007		

Photo :	2090	**Description :**	View north of Disraeli Bridge.
Date:	February 21, 2007		

Appendix C
Laboratory Reports

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

ANALYTICAL REPORT

UMA ENGINEERING
ATTN: KRISTIINA FERRAZ
1479 BUFFALO PLACE

WINNIPEG MB R3T 1L7

Reported On: 04-APR-07 08:52 AM

Lab Work Order #: L473815 **Date Received:** 29-JAN-07

Project P.O. #:
Job Reference: 0217 158 03 08
Legal Site Desc:
CofC Numbers:

Other Information:

Comments:

APPROVED BY:
GERRY VERA
Project Manager

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L473815-1 T2 - 1								
Sampled By: KF on 29-JAN-07								
Matrix: SEDIMENT								
% Moisture	45		0.1	%	03-FEB-07	03-FEB-07	JAP	R489976
PAH								
Acenaphthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Acenaphthylene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Anthracene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Benzo(a)anthracene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Benzo(a)pyrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Benzo(b)fluoranthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Benzo(ghi)perylene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Benzo(k)fluoranthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Chrysene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Fluoranthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Fluorene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Naphthalene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
1-Methyl Naphthalene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
2-Methyl Naphthalene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Phenanthrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Pyrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Quinoline	<0.05		0.05	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Acridine	<0.05		0.05	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Surr: 2-Fluorobiphenyl Surr	60		25-175	%	02-FEB-07	03-FEB-07	JAP	R490385
Surr: Terphenyl Surr	90		25-175	%	02-FEB-07	03-FEB-07	JAP	R490385
L473815-2 T2 - 2								
Sampled By: KF on 29-JAN-07								
Matrix: SEDIMENT								
% Moisture	56		0.1	%	03-FEB-07	03-FEB-07	JAP	R489976
PAH								
Acenaphthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Acenaphthylene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Anthracene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Benzo(a)anthracene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Benzo(a)pyrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Benzo(b)fluoranthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Benzo(ghi)perylene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Benzo(k)fluoranthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Chrysene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Fluoranthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Fluorene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Naphthalene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
1-Methyl Naphthalene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
2-Methyl Naphthalene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Phenanthrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Pyrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Quinoline	<0.05		0.05	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Acridine	<0.05		0.05	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Surr: 2-Fluorobiphenyl Surr	64		25-175	%	02-FEB-07	03-FEB-07	JAP	R490385

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L473815-2	T2 - 2								
Sampled By:	KF on 29-JAN-07								
Matrix:	SEDIMENT								
PAH									
Surr:	Terphenyl Surr	86		25-175	%	02-FEB-07	03-FEB-07	JAP	R490385
L473815-3	T2 - 3								
Sampled By:	KF on 29-JAN-07								
Matrix:	SEDIMENT								
	% Moisture	58		0.1	%	03-FEB-07	03-FEB-07	JAP	R489976
PAH									
	Acenaphthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Acenaphthylene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Anthracene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(a)anthracene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(a)pyrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(b)fluoranthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(ghi)perylene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(k)fluoranthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Chrysene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Fluoranthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Fluorene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Naphthalene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	1-Methyl Naphthalene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	2-Methyl Naphthalene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Phenanthrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Pyrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Quinoline	<0.05		0.05	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Acridine	<0.05		0.05	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Surr:	2-Fluorobiphenyl Surr	70		25-175	%	02-FEB-07	03-FEB-07	JAP	R490385
Surr:	Terphenyl Surr	84		25-175	%	02-FEB-07	03-FEB-07	JAP	R490385
L473815-4	T2 - 4								
Sampled By:	KF on 29-JAN-07								
Matrix:	SEDIMENT								
	% Moisture	62		0.1	%	03-FEB-07	03-FEB-07	JAP	R489976
PAH									
	Acenaphthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Acenaphthylene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Anthracene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(a)anthracene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(a)pyrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(b)fluoranthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(ghi)perylene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(k)fluoranthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Chrysene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Fluoranthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Fluorene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Naphthalene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	1-Methyl Naphthalene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385

Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L473815-4	T2 - 4								
Sampled By:	KF on 29-JAN-07								
Matrix:	SEDIMENT								
PAH	2-Methyl Naphthalene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Phenanthrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Pyrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Quinoline	<0.05		0.05	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Acridine	<0.05		0.05	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Surr:	2-Fluorobiphenyl Surr	82		25-175	%	02-FEB-07	03-FEB-07	JAP	R490385
Surr:	Terphenyl Surr	90		25-175	%	02-FEB-07	03-FEB-07	JAP	R490385
L473815-5	T3 - 2								
Sampled By:	KF on 29-JAN-07								
Matrix:	SEDIMENT								
	% Moisture	54		0.1	%	03-FEB-07	03-FEB-07	JAP	R489976
PAH	Acenaphthene	0.68		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Acenaphthylene	0.62		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Anthracene	1.9		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(a)anthracene	2.3		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(a)pyrene	1.8		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(b)fluoranthene	2.0		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(ghi)perylene	1.0		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(k)fluoranthene	0.74		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Chrysene	2.2		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Dibenzo(ah)anthracene	0.24		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Fluoranthene	6.2		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Fluorene	1.1		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Indeno(1,2,3 cd)pyrene	1.6		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Naphthalene	0.38		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	1-Methyl Naphthalene	0.12		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	2-Methyl Naphthalene	0.06		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Phenanthrene	6.2		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Pyrene	5.1		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Quinoline	<0.05		0.05	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Acridine	<0.05		0.05	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Surr:	2-Fluorobiphenyl Surr	78		25-175	%	02-FEB-07	03-FEB-07	JAP	R490385
Surr:	Terphenyl Surr	92		25-175	%	02-FEB-07	03-FEB-07	JAP	R490385
L473815-6	T3 - 3								
Sampled By:	KF on 29-JAN-07								
Matrix:	SEDIMENT								
	% Moisture	62		0.1	%	03-FEB-07	03-FEB-07	JAP	R489976
PAH	Acenaphthene	0.08		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Acenaphthylene	0.03		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Anthracene	0.05		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(a)anthracene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(a)pyrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(b)fluoranthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(ghi)perylene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Benzo(k)fluoranthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
	Chrysene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L473815-6 T3 - 3								
Sampled By: KF on 29-JAN-07								
Matrix: SEDIMENT								
PAH								
Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Fluoranthene	0.03		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Fluorene	0.03		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Naphthalene	2.4		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
1-Methyl Naphthalene	0.08		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
2-Methyl Naphthalene	0.10		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Phenanthrene	0.05		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Pyrene	0.03		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Quinoline	<0.05		0.05	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Acridine	<0.05		0.05	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Surr: 2-Fluorobiphenyl Surr	74		25-175	%	02-FEB-07	03-FEB-07	JAP	R490385
Surr: Terphenyl Surr	92		25-175	%	02-FEB-07	03-FEB-07	JAP	R490385
L473815-7 T3 - 4								
Sampled By: KF on 29-JAN-07								
Matrix: SEDIMENT								
% Moisture	58		0.1	%	03-FEB-07	03-FEB-07	JAP	R489976
PAH								
Acenaphthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Acenaphthylene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Anthracene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Benzo(a)anthracene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Benzo(a)pyrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Benzo(b)fluoranthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Benzo(ghi)perylene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Benzo(k)fluoranthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Chrysene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Fluoranthene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Fluorene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Naphthalene	0.07		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
1-Methyl Naphthalene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
2-Methyl Naphthalene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Phenanthrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Pyrene	<0.01		0.01	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Quinoline	<0.05		0.05	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Acridine	<0.05		0.05	mg/kg	02-FEB-07	03-FEB-07	JAP	R490385
Surr: 2-Fluorobiphenyl Surr	62		25-175	%	02-FEB-07	03-FEB-07	JAP	R490385
Surr: Terphenyl Surr	76		25-175	%	02-FEB-07	03-FEB-07	JAP	R490385

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
PAH,PANH-WP	Soil	PAH		EPA SW846 8270B Sep 1994,3550A Sep 1994

Samples are ground into sodium sulfate and extracted with acetone/dichloromethane using a combination of high frequency sonication and shake using a wrist-action shaker. After extract concentration, samples are analyzed by GC/MS.

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
WP	ALS LABORATORY GROUP - WINNIPEG, MANITOBA, CANADA		

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency. The Laboratory control limits are determined under column heading D.L.
mg/kg (units) - unit of concentration based on mass, parts per million.
mg/L (units) - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

12 - 1329 Niakwa Road East
Winnipeg, Manitoba, Canada R2J 3T4
Tel: (204) 255-9720
Fax (204) 255-9721
Toll Free: 1-800-607-7555

CHAIN OF CUSTODY ANALYTICAL REQUEST FORM

L473815

DATE SUBMITTED: Jan 29/07 DATE REQUIRED:

SERVICE REQUESTED: [illegible]

PRICING (CHECK ONE):
AS PER QUOTE #: Q13469 ☐
AS PER LIST PRICE: ☐

ANALYSIS REQUESTED

LAB USE ONLY

SAMPLE ID	SAMPLED BY	DATE / TIME SAMPLED	SAMPLE TYPE	PAH	SAMPLE RECEIVED (Y OR N)	SAMPLE BROKEN (Y OR N)	LAB SAMPLE NO.
T2-1	KF	Jan 29/07	Sediment	X			1
T2-2	↓	↓	↓	X			2
T2-3				X			3
T2-4				X			4
T3-2				X			5
T3-3				X			6
T3-4	W876			X			7
			PRESERVED / FILTERED				

NOTES & CONDITIONS:

1. Quote number must be provided to ensure proper pricing.
2. All hazardous samples submitted must be labeled to comply with WHMIS regulations. This must include the nature of the hazard, as well as a contact name and phone number that the lab can contact for further information.
3. ALS's liability limited to cost of analysis.

NOTE: Failure to properly complete all portions of this form may delay analysis.

NOTE: Shaded areas MUST be completed in full by client for sample processing to begin.

CLIENT: [illegible]
CONTACT: [illegible]
REPORT ADDRESS: [illegible]
INVOICE ADDRESS: [illegible]

NO. SAMPLES SUBMITTED: 7
NO. BOTTLES/SAMPLES:
PHONE: [illegible]
FAX: [illegible]
E-MAIL: YES ☒ NO ☐
E-MAIL ADDRESS: [illegible]
P.O. NO.:
JOB NO.: 217158 0308

RELINQUISHED BY:	DATE Jan 29/07 TIME 3:00	RECEIVED BY: ALS LAB:	DATE JAN 29/07 TIME 14:45
RELINQUISHED BY:	DATE TIME	RECEIVED BY: ALS LAB:	DATE TIME

SAMPLE CONDITION UPON RECEIPT: ☐ ACCEPTABLE ☐ NON ACCEPTABLE

FROZEN: ______ COLD: ______ AMBIENT:

OTHER (BREAKAGE, LEAKAGE, ETC.):

WHITE - File Copy
GREEN - Final Report
PINK - Invoicing
BLUE - Client Support
YELLOW - Customer

REV. OCT. / 2006

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

ANALYTICAL REPORT

UMA ENGINEERING
ATTN: KRISTIINA FERRAZ
1479 BUFFALO PLACE
WINNIPEG MB R3T 1L7

Reported On: 04-APR-07 08:54 AM

Lab Work Order #: L475370 **Date Received:** 02-FEB-07

Project P.O. #:
Job Reference: 0217 158 03 08
Legal Site Desc:
CofC Numbers:

Other Information:

Comments:

APPROVED BY:
GERRY VERA
Project Manager

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L475370-1	T4-1								
Sampled By:	DS on 31-JAN-07								
Matrix:	SEDIMENT								
	% Moisture	51		0.1	%	07-FEB-07	07-FEB-07	JAP	R490977
PAH									
	Acenaphthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acenaphthylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(b)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(ghi)perylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(k)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Chrysene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluorene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	1-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	2-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Phenanthrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Quinoline	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acridine	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	2-Fluorobiphenyl Surr	72		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	Terphenyl Surr	94		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
L475370-2	T5-2								
Sampled By:	DS on 31-JAN-07								
Matrix:	SEDIMENT								
	% Moisture	52		0.1	%	07-FEB-07	07-FEB-07	JAP	R490977
PAH									
	Acenaphthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acenaphthylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(b)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(ghi)perylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(k)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Chrysene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluorene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Naphthalene	0.08		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	1-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	2-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Phenanthrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Quinoline	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acridine	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	2-Fluorobiphenyl Surr	88		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L475370-2	T5-2								
Sampled By:	DS on 31-JAN-07								
Matrix:	SEDIMENT								
PAH									
Surr:	Terphenyl Surr	94		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
L475370-3	T6-1								
Sampled By:	DS on 31-JAN-07								
Matrix:	SEDIMENT								
	% Moisture	59		0.1	%	07-FEB-07	07-FEB-07	JAP	R490977
PAH									
	Acenaphthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acenaphthylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(b)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(ghi)perylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(k)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Chrysene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluorene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	1-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	2-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Phenanthrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Quinoline	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acridine	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	2-Fluorobiphenyl Surr	104		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	Terphenyl Surr	100		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
L475370-4	T6-2								
Sampled By:	DS on 31-JAN-07								
Matrix:	SEDIMENT								
	% Moisture	62		0.1	%	07-FEB-07	07-FEB-07	JAP	R490977
PAH									
	Acenaphthene	0.02		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acenaphthylene	0.02		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Anthracene	0.19		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)anthracene	0.02		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)pyrene	0.02		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(b)fluoranthene	0.02		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(ghi)perylene	0.02		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(k)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Chrysene	0.02		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluoranthene	0.10		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluorene	0.02		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Indeno(1,2,3 cd)pyrene	0.02		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Naphthalene	0.38		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	1-Methyl Naphthalene	0.02		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556

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Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L475370-4	T6-2								
Sampled By:	DS on 31-JAN-07								
Matrix:	SEDIMENT								
PAH									
	2-Methyl Naphthalene	0.07		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Phenanthrene	0.14		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Pyrene	0.07		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Quinoline	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acridine	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	2-Fluorobiphenyl Surr	100		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	Terphenyl Surr	98		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
L475370-5	T6-3								
Sampled By:	DS on 31-JAN-07								
Matrix:	SEDIMENT								
	% Moisture	59		0.1	%	07-FEB-07	07-FEB-07	JAP	R490977
PAH									
	Acenaphthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acenaphthylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(b)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(ghi)perylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(k)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Chrysene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluorene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Naphthalene	0.02		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	1-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	2-Methyl Naphthalene	0.02		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Phenanthrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Quinoline	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acridine	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	2-Fluorobiphenyl Surr	96		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	Terphenyl Surr	110		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
L475370-6	T6-4								
Sampled By:	DS on 31-JAN-07								
Matrix:	SEDIMENT								
	% Moisture	61		0.1	%	07-FEB-07	07-FEB-07	JAP	R490977
PAH									
	Acenaphthene	0.03		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acenaphthylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Anthracene	0.03		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)anthracene	0.03		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)pyrene	0.03		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(b)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(ghi)perylene	0.03		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(k)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Chrysene	0.03		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L475370-6	T6-4								
Sampled By:	DS on 31-JAN-07								
Matrix:	SEDIMENT								
PAH									
	Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluoranthene	0.08		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluorene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Indeno(1,2,3 cd)pyrene	0.03		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Naphthalene	0.53		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	1-Methyl Naphthalene	0.03		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	2-Methyl Naphthalene	0.03		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Phenanthrene	0.10		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Pyrene	0.05		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Quinoline	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acridine	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	2-Fluorobiphenyl Surr	98		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	Terphenyl Surr	90		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
L475370-7	T7-1								
Sampled By:	DS on 01-FEB-07								
Matrix:	SEDIMENT								
	% Moisture	51		0.1	%	07-FEB-07	07-FEB-07	JAP	R490977
PAH									
	Acenaphthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acenaphthylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(b)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(ghi)perylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(k)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Chrysene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluorene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Naphthalene	0.02		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	1-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	2-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Phenanthrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Quinoline	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acridine	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	2-Fluorobiphenyl Surr	98		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	Terphenyl Surr	96		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
L475370-8	T7-2								
Sampled By:	DS on 01-FEB-07								
Matrix:	SEDIMENT								
	% Moisture	60		0.1	%	07-FEB-07	07-FEB-07	JAP	R490977
PAH									
	Acenaphthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acenaphthylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L475370-8	T7-2								
Sampled By:	DS on 01-FEB-07								
Matrix:	SEDIMENT								
PAH									
	Benzo(a)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(b)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(ghi)perylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(k)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Chrysene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluorene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	1-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	2-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Phenanthrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Quinoline	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acridine	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	2-Fluorobiphenyl Surr	100		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	Terphenyl Surr	96		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
L475370-9	T7-3								
Sampled By:	DS on 01-FEB-07								
Matrix:	SEDIMENT								
	% Moisture	57		0.1	%	07-FEB-07	07-FEB-07	JAP	R490977
PAH									
	Acenaphthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acenaphthylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(b)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(ghi)perylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(k)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Chrysene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluorene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	1-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	2-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Phenanthrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Quinoline	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acridine	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	2-Fluorobiphenyl Surr	94		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	Terphenyl Surr	92		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
L475370-10	T8A-1								
Sampled By:	DS on 01-FEB-07								
Matrix:	SEDIMENT								

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L475370-10	T8A-1								
Sampled By:	DS on 01-FEB-07								
Matrix:	SEDIMENT								
	% Moisture	39		0.1	%	07-FEB-07	07-FEB-07	JAP	R490977
PAH									
	Acenaphthene	0.02		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acenaphthylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(b)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(ghi)perylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(k)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Chrysene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluorene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Naphthalene	0.13		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	1-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	2-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Phenanthrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Quinoline	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acridine	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	2-Fluorobiphenyl Surr	76		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	Terphenyl Surr	94		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
L475370-11	T7A-1								
Sampled By:	DS on 01-FEB-07								
Matrix:	SEDIMENT								
	% Moisture	38		0.1	%	07-FEB-07	07-FEB-07	JAP	R490977
PAH									
	Acenaphthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acenaphthylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(b)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(ghi)perylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(k)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Chrysene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluorene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	1-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	2-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Phenanthrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Quinoline	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acridine	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	2-Fluorobiphenyl Surr	100		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L475370-11	T7A-1								
Sampled By:	DS on 01-FEB-07								
Matrix:	SEDIMENT								
PAH									
Surr:	Terphenyl Surr	104		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
L475370-12	T8-2								
Sampled By:	DS on 01-FEB-07								
Matrix:	SEDIMENT								
	% Moisture	59		0.1	%	07-FEB-07	07-FEB-07	JAP	R490977
PAH									
	Acenaphthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acenaphthylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(a)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(b)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(ghi)perylene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Benzo(k)fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Chrysene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluoranthene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Fluorene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	1-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	2-Methyl Naphthalene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Phenanthrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Pyrene	<0.01		0.01	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Quinoline	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
	Acridine	<0.05		0.05	mg/kg	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	2-Fluorobiphenyl Surr	102		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556
Surr:	Terphenyl Surr	100		25-175	%	05-FEB-07	06-FEB-07	JAP	R491556

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
PAH,PANH-WP	Soil	PAH		EPA SW846 8270B Sep 1994,3550A Sep 1994

Samples are ground into sodium sulfate and extracted with acetone/dichloromethane using a combination of high frequency sonication and shake using a wrist-action shaker. After extract concentration, samples are analyzed by GC/MS.

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
WP	ALS LABORATORY GROUP - WINNIPEG, MANITOBA, CANADA		

GLOSSARY OF REPORT TERMS

Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds. The reported surrogate recovery value provides a measure of method efficiency. The Laboratory control limits are determined under column heading D.L.

mg/kg (units) - unit of concentration based on mass, parts per million.

mg/L (units) - unit of concentration based on volume, parts per million.

< - Less than.

D.L. - The reporting limit.

N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

ANALYTICAL REPORT

UMA ENGINEERING
ATTN: KRISTIINA FERRAZ
1479 BUFFALO PLACE
WINNIPEG MB R3T 1L7

Reported On: 04-APR-07 08:51 AM

Lab Work Order #: L480407 **Date Received:** 21-FEB-07

Project P.O. #:
Job Reference: 0217 158 03 08
Legal Site Desc:
CofC Numbers:

Other Information:

Comments:

APPROVED BY:
GERRY VERA
Project Manager

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

12 - 1329 Niakwa Road East
Winnipeg, Manitoba, Canada R2J 3T4
Tel: (204) 255-9720
Fax (204) 255-9721
Toll Free: 1-800-607-7555

CHAIN OF CUSTODY ANALYTICAL REQUEST FORM

W172

DATE SUBMITTED: Feb 2/07

DATE REQUIRED:

SERVICE REQUESTED: [illegible]

PRICING (CHECK ONE):
AS PER QUOTE #: Q13469 ☒
AS PER LIST PRICE: ☐

ANALYSIS REQUESTED:

LAB USE ONLY

L475370

SAMPLE ID	SAMPLED BY	DATE / TIME SAMPLED	SAMPLE TYPE	PAH / CCME	SAMPLE RECEIVED (Y OR N)	SAMPLE BROKEN (Y OR N)	LAB SAMPLE NO.
T4-1	DS	Jan. 31/07	Sediment	X			1
T5-2				X			2
T6-1				X			3
T6-2				X			4
T6-3				X			5
T6-4				X			6
T7-1		Feb 1/07		X			7
T7-2				X			8
T7-3				X			9
T8A-1				X			10
~~T7A-1~~	T7A-1 (on Bottle)			X			11
T8-2				X			12
			PRESERVED / FILTERED				

NOTES & CONDITIONS:
1. Quote number must be provided to ensure proper pricing.
2. All hazardous samples submitted must be labeled to comply with WHMIS regulations. This must include the nature of the hazard, as well as a contact name and phone number that the lab can contact for further information.
3. ALS's liability limited to cost of analysis.

NOTE: Failure to properly complete all portions of this form may delay analysis.

NOTE: Shaded areas MUST be completed in full by client for sample processing to occur.

CLIENT: UMA
CONTACT: Kristina Ferrar
REPORT ADDRESS: 1479 Buffalo Pl
WPG R3T 1L7
BILLING ADDRESS:

NO. SAMPLES SUBMITTED: 12
NO. BOTTLES/SAMPLES: 1 Jar / Sample.
QUOTE: [illegible]

E-MAIL: YES ☒ NO ☐
E-MAIL ADDRESS: Kristina.ferraro@umaaecom.com
P.O. NO.:
JOB NO.: 0217-158-03-08

RELINQUISHED BY:	DATE: Feb. 2/07 TIME: 10:30am.	RECEIVED BY: ALS LAB:	DATE: TIME:
RELINQUISHED BY:	DATE: TIME:	RECEIVED BY: ALS LAB:	DATE: Feb 2/07 TIME: 1:50

SAMPLE CONDITION UPON RECEIPT: ☐ ACCEPTABLE ☐ NON ACCEPTABLE
FROZEN: ___ COLD: ✓ AMBIENT: ___
OTHER (BREAKAGE, LEAKAGE, ETC.):

WHITE - File Copy
GREEN - Final Report
PINK - Invoicing
BLUE - Client Support
YELLOW - Customer

REV. OCT. / 2006

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L480407-1	T9-1								
Sampled By:	DS/RS on 21-FEB-07								
Matrix:	SEDIMENT								
	% Moisture	64		0.1	%	23-FEB-07	23-FEB-07	THT	R496096
PAH									
	Acenaphthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Acenaphthylene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Anthracene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Benzo(a)anthracene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Benzo(a)pyrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Benzo(b)fluoranthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Benzo(ghi)perylene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Benzo(k)fluoranthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Chrysene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Fluoranthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Fluorene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Naphthalene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	1-Methyl Naphthalene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	2-Methyl Naphthalene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Phenanthrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Pyrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Quinoline	<0.05		0.05	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Acridine	<0.05		0.05	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Surr:	2-Fluorobiphenyl Surr	64		25-175	%	22-FEB-07	23-FEB-07	JAP	R496387
Surr:	Terphenyl Surr	86		25-175	%	22-FEB-07	23-FEB-07	JAP	R496387
L480407-2	T9-2								
Sampled By:	DS/RS on 21-FEB-07								
Matrix:	SEDIMENT								
	% Moisture	63		0.1	%	23-FEB-07	23-FEB-07	THT	R496096
PAH									
	Acenaphthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Acenaphthylene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Anthracene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Benzo(a)anthracene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Benzo(a)pyrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Benzo(b)fluoranthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Benzo(ghi)perylene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Benzo(k)fluoranthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Chrysene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Fluoranthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Fluorene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Naphthalene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	1-Methyl Naphthalene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	2-Methyl Naphthalene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Phenanthrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Pyrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Quinoline	<0.05		0.05	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
	Acridine	<0.05		0.05	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Surr:	2-Fluorobiphenyl Surr	66		25-175	%	22-FEB-07	23-FEB-07	JAP	R496387

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L480407-2 T9-2								
Sampled By: DS/RS on 21-FEB-07								
Matrix: SEDIMENT								
PAH								
Surr: Terphenyl Surr	92		25-175	%	22-FEB-07	23-FEB-07	JAP	R496387
L480407-3 T10-1								
Sampled By: DS/RS on 21-FEB-07								
Matrix: SEDIMENT								
% Moisture	66		0.1	%	23-FEB-07	23-FEB-07	THT	R496096
PAH								
Acenaphthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Acenaphthylene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Anthracene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Benzo(a)anthracene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Benzo(a)pyrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Benzo(b)fluoranthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Benzo(ghi)perylene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Benzo(k)fluoranthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Chrysene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Fluoranthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Fluorene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Naphthalene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
1-Methyl Naphthalene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
2-Methyl Naphthalene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Phenanthrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Pyrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Quinoline	<0.05		0.05	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Acridine	<0.05		0.05	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Surr: 2-Fluorobiphenyl Surr	74		25-175	%	22-FEB-07	23-FEB-07	JAP	R496387
Surr: Terphenyl Surr	86		25-175	%	22-FEB-07	23-FEB-07	JAP	R496387
L480407-4 T10-2								
Sampled By: DS/RS on 21-FEB-07								
Matrix: SEDIMENT								
% Moisture	66		0.1	%	23-FEB-07	23-FEB-07	THT	R496096
PAH								
Acenaphthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Acenaphthylene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Anthracene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Benzo(a)anthracene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Benzo(a)pyrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Benzo(b)fluoranthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Benzo(ghi)perylene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Benzo(k)fluoranthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Chrysene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Fluoranthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Fluorene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Naphthalene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
1-Methyl Naphthalene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L480407-4 T10-2								
Sampled By: DS/RS on 21-FEB-07								
Matrix: SEDIMENT								
PAH								
2-Methyl Naphthalene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Phenanthrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Pyrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Quinoline	<0.05		0.05	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Acridine	<0.05		0.05	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Surr: 2-Fluorobiphenyl Surr	70		25-175	%	22-FEB-07	23-FEB-07	JAP	R496387
Surr: Terphenyl Surr	94		25-175	%	22-FEB-07	23-FEB-07	JAP	R496387
L480407-5 T11								
Sampled By: DS/RS on 21-FEB-07								
Matrix: SEDIMENT								
% Moisture	64		0.1	%	23-FEB-07	23-FEB-07	THT	R496096
PAH								
Acenaphthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Acenaphthylene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Anthracene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Benzo(a)anthracene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Benzo(a)pyrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Benzo(b)fluoranthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Benzo(ghi)perylene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Benzo(k)fluoranthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Chrysene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Dibenzo(ah)anthracene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Fluoranthene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Fluorene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Indeno(1,2,3 cd)pyrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Naphthalene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
1-Methyl Naphthalene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
2-Methyl Naphthalene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Phenanthrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Pyrene	<0.01		0.01	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Quinoline	<0.05		0.05	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Acridine	<0.05		0.05	mg/kg	22-FEB-07	23-FEB-07	JAP	R496387
Surr: 2-Fluorobiphenyl Surr	68		25-175	%	22-FEB-07	23-FEB-07	JAP	R496387
Surr: Terphenyl Surr	80		25-175	%	22-FEB-07	23-FEB-07	JAP	R496387

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
PAH,PANH-WP	Soil	PAH		EPA SW846 8270B Sep 1994,3550A Sep 1994

Samples are ground into sodium sulfate and extracted with acetone/dichloromethane using a combination of high frequency sonication and shake using a wrist-action shaker. After extract concentration, samples are analyzed by GC/MS.

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
WP	ALS LABORATORY GROUP - WINNIPEG, MANITOBA, CANADA		

GLOSSARY OF REPORT TERMS

Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency. The Laboratory control limits are determined under column heading D.L.
mg/kg (units) - unit of concentration based on mass, parts per million.
mg/L (units) - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

12 - 1329 Niakwa Road East
Winnipeg, Manitoba, Canada R2J 3T4
Tel: (204) 255-9720
Fax (204) 255-9721
Toll Free: 1-800-607-7555

CHAIN OF CUSTODY
ANALYTICAL REQUEST FORM

DATE SUBMITTED: FEB 21/07 DATE REQUIRED:

[redacted]

PRICING (CHECK ONE):
AS PER QUOTE #: Q13469 ☐
AS PER LIST PRICE: ☐

ANALYSIS REQUESTED: LAB USE ONLY

L480107

SAMPLE ID	SAMPLED BY	DATE / TIME SAMPLED	SAMPLE TYPE	PAH CCME													SAMPLE RECEIVED (Y OR N)	SAMPLE BROKEN (Y OR N)	LAB SAMPLE NO.
T9-1	DS/RS	FEB 21/07	SEDIMENT	✓															1
T9-2	↓	↓	↓	✓															2
T10-1				✓															3
T10-2				✓															4
T11				✓															5
			PRESERVED / FILTERED																

NOTES & CONDITIONS:
1. Quote number must be provided to ensure proper pricing.
2. All hazardous samples submitted must be labeled to comply with WHMIS regulations. This must include the nature of the hazard, as well as a contact name and phone number that the lab can contact for further information.
3. ALS's liability limited to cost of analysis.

NOTE: Failure to properly complete all portions of this form may delay analysis.

[redacted]

NO. SAMPLES SUBMITTED: 5 JARS
NO. BOTTLES/SAMPLES: 1 JAR / SAMPLE

[redacted]

E-MAIL: YES ☐ NO ☐
E-MAIL ADDRESS:
P.O. NO.:
JOB NO.: 0217 158 03 08

RELINQUISHED BY:	DATE Feb 21/07 TIME	RECEIVED BY: ALS LAB:	DATE 15:10. TIME Feb 21/07
RELINQUISHED BY:	DATE TIME	RECEIVED BY: ALS LAB:	DATE TIME

SAMPLE CONDITION UPON RECEIPT: [✓ ☐ ACCEPTABLE] ☐ NON ACCEPTABLE
FROZEN: ____ COLD: ✓ AMBIENT:
OTHER (BREAKAGE, LEAKAGE, ETC.):

WHITE - File Copy
GREEN - Final Report
PINK - Invoicing
BLUE - Client Support
YELLOW - Customer

REV. OCT. / 2006

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

ANALYTICAL REPORT

UMA ENGINEERING
ATTN: EDWIN YEE
1479 BUFFALO PLACE
WINNIPEG MB R3T 1L7

Reported On: 19-APR-07 12:58 PM
Revision: 1

Lab Work Order #: L485862 **Date Received:** 13-MAR-07

Project P.O. #:
Job Reference: 0217 158 03
Legal Site Desc:
CofC Numbers:

Other Information:

Comments:

APPROVED BY: Paul Nicolas
PAUL NICOLAS
Project Manager

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-1 T2-W1A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.24		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0036		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.11		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0877		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	80.0		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0005		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0001		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Iron (Fe)-Total	1.01		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.3		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	42.8		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0771		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0027		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	53.2		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.30	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0005		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0046		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	0.002		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.321		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0316		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0005		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0031		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.005		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	0.01		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0013		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-1 T2-W1A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
PAH								
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	70		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	75		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	630		5	mg/L		19-MAR-07	BJL	R504860
Total Suspended Solids	39		5	mg/L		19-MAR-07	BJL	R504860
L485862-2 T2-W1B								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.48		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0037		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.11		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0898		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	81.2		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0006		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-2 T2-W1B								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
Metal scan								
Iron (Fe)-Total	1.37		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.7		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	42.9		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0940		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0028		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	54.9		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.005		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.29	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0007		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0054		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	0.002		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.327		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0455		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0003		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0031		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.006		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	0.01		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0018		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	82		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	85		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	630		5	mg/L		19-MAR-07	BJL	R504860
Total Suspended Solids	47		5	mg/L		19-MAR-07	BJL	R504860
L485862-3 T2-W2A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								

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Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-3 T2-W2A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.43		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0038		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.12		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0901		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	82.6		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0005		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Iron (Fe)-Total	1.20		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.9		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	43.2		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0851		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0028		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	56.6		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.30	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0006		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0050		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.329		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0316		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0003		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0031		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	0.03		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0015		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-3 T2-W2A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
PAH								
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	84		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	87		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	640		5	mg/L		19-MAR-07	BJL	R504860
Total Suspended Solids	42		5	mg/L		19-MAR-07	BJL	R504860
L485862-4 T2-W2B								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.52		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0036		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.11		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0881		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	78.8		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0005		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213

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Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-4 T2-W2B Sampled By: MR on 12-MAR-07 Matrix: WATER								
Metal scan								
Iron (Fe)-Total	1.20		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.2		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	42.2		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0818		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0027		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	52.6		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.28	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0006		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0050		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.321		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0368		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0031		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.006		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	<0.01		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0036		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	69		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	77		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	630		5	mg/L		19-MAR-07	BJL	R504860
Total Suspended Solids	42		5	mg/L		19-MAR-07	BJL	R504860
L485862-5 T2-W3A Sampled By: MR on 12-MAR-07 Matrix: WATER								
BTEX,TVH and TEH								

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-5 T2-W3A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.43		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0035		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.11		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0887		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	80.5		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0005		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Iron (Fe)-Total	1.17		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.5		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	42.1		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0800		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0026		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	54.0		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.28	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0005		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0051		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	0.002		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.315		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0380		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0031		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.006		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	<0.01		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0015		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136

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Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-5 T2-W3A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
PAH								
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	84		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	87		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	640		5	mg/L		19-MAR-07	BJL	R504860
Total Suspended Solids	33		5	mg/L		19-MAR-07	BJL	R504860
L485862-6 UP1-W1A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.51		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0038		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.10		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0889		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	82.3		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0006		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-6 UP1-W1A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
Metal scan								
Iron (Fe)-Total	1.21		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.6		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	42.0		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0800		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0026		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	53.1		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.005		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.29	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0006		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0050		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.312		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0440		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0031		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.006		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	0.03		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0017		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	80		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	84		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	610		5	mg/L		21-MAR-07	BJL	R505899
Total Suspended Solids	32		5	mg/L		19-MAR-07	BJL	R504860
L485862-7 UP1-W1B								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								

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Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-7 UP1-W1B								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	2.41		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0041		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.11		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0998		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	81.3		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0008		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	0.002		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0003		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.005		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Iron (Fe)-Total	1.97		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.8		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	42.2		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.114		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0026		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	53.8		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.005		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.31	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0010		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0065		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	0.002		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.323		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0519		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0032		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.010		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	0.02		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0023		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-7 UP1-W1B								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
PAH								
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	83		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	86		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	610		5	mg/L		21-MAR-07	BJL	R505899
Total Suspended Solids	35		5	mg/L		19-MAR-07	BJL	R504860
L485862-8 UP2-W1A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.22		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0036		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.11		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0857		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	81.5		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0004		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0001		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-8 UP2-W1A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
Metal scan								
Iron (Fe)-Total	0.96		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.6		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	42.5		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0689		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0027		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	55.0		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.27	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0005		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0046		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	0.002		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.322		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0334		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0031		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	<0.01		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0014		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	83		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	84		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	620		5	mg/L		21-MAR-07	BJL	R505899
Total Suspended Solids	29		5	mg/L		19-MAR-07	BJL	R504860
L485862-9 UP2-W1B								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								

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Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-9 UP2-W1B								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.25		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0036		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.11		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0875		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	78.1		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0006		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Iron (Fe)-Total	1.16		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.1		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	42.4		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0772		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0027		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	52.0		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.29	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0007		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0048		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.315		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0330		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0003		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0029		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.005		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	<0.01		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0014		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136

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Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-9 UP2-W1B								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
PAH								
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	88		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	88		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	610		5	mg/L		21-MAR-07	BJL	R505899
Total Suspended Solids	39		5	mg/L		19-MAR-07	BJL	R504860
L485862-10 T3-W1A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	0.93		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0034		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.11		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0835		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	78.4		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0005		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0001		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-10 T3-W1A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
Metal scan								
Iron (Fe)-Total	0.73		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.6		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	42.5		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0563		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0026		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	57.1		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.28	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0005		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0040		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.308		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0272		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0004		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0030		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	0.02		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0011		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	0.00006		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	0.00002		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	0.00006		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	0.00004		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	0.00006		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	0.00008		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	0.00006		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	0.00013		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	0.00005		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	0.00003		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	0.00008		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	81		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	86		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	660		5	mg/L		19-MAR-07	BJL	R504860
Total Suspended Solids	50		5	mg/L		19-MAR-07	BJL	R504860
L485862-11 T3-W2A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-11 T3-W2A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.55		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0037		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.11		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0864		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	79.4		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0007		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Iron (Fe)-Total	1.17		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.6		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	42.3		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0741		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0027		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	51.9		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.29	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0006		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0050		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.312		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0536		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0003		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0029		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.006		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	0.02		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0021		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-11 T3-W2A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
PAH								
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	78		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	87		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	650		5	mg/L		19-MAR-07	BJL	R504860
Total Suspended Solids	41		5	mg/L		19-MAR-07	BJL	R504860
L485862-12 T3-W2B								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.48		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0037		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.11		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0876		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	78.9		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0006		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213

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Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-12 T3-W2B Sampled By: MR on 12-MAR-07 Matrix: WATER								
Metal scan								
Iron (Fe)-Total	1.17		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.3		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	42.3		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0756		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0027		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	52.6		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.29	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0006		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0050		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.320		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0444		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0003		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0030		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.006		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	<0.01		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0015		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	67		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	82		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	650		5	mg/L		19-MAR-07	BJL	R504860
Total Suspended Solids	42		5	mg/L		19-MAR-07	BJL	R504860
L485862-13 T6-W1A Sampled By: MR on 12-MAR-07 Matrix: WATER								
BTEX,TVH and TEH								

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-13 T6-W1A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.06		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0036		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.11		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0838		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	79.4		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0005		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0001		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Iron (Fe)-Total	0.85		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.2		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	42.8		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0685		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0026		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	54.2		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.29	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0006		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0042		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.308		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0300		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0003		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0029		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	<0.01		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0010		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136

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Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-13 T6-W1A Sampled By: MR on 12-MAR-07 Matrix: WATER								
PAH								
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	0.00003		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	0.00002		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	0.00002		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	0.00002		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	0.00006		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	0.00003		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	0.00004		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	72		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	87		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	650		5	mg/L		19-MAR-07	BJL	R504860
Total Suspended Solids	33		5	mg/L		19-MAR-07	BJL	R504860
L485862-14 T6-W1B Sampled By: MR on 12-MAR-07 Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.51		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0039		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.11		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0869		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	82.2		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0006		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213

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Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-14 T6-W1B								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
Metal scan								
Iron (Fe)-Total	1.20		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.9		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	43.9		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0765		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0027		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	58.6		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.30	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0010		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0049		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.317		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0415		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0003		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0030		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.006		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	0.01		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0015		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	79		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	84		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	670		5	mg/L		19-MAR-07	BJL	R504860
Total Suspended Solids	44		5	mg/L		19-MAR-07	BJL	R504860
L485862-15 T6-W2A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								

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Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-15 T6-W2A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.37		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0036		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.11		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0860		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	78.1		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0006		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0001		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Iron (Fe)-Total	1.06		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.3		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	42.3		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0721		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0026		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	51.9		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.31	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0006		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0046		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.309		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0330		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0030		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.005		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	0.01		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0015		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-15 T6-W2A								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
PAH								
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	76		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	82		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	630		5	mg/L		19-MAR-07	BJL	R504860
Total Suspended Solids	39		5	mg/L		19-MAR-07	BJL	R504860
L485862-16 T6-W2B								
Sampled By: MR on 12-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.20		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0035		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.11		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0850		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	76.7		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0006		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L485862-16	T6-W2B								
Sampled By:	MR on 12-MAR-07								
Matrix:	WATER								
Metal scan									
	Iron (Fe)-Total	1.09		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Potassium (K)-Total	9.9		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Magnesium (Mg)-Total	41.9		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Manganese (Mn)-Total	0.0753		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Molybdenum (Mo)-Total	0.0026		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Sodium (Na)-Total	50.8		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Phosphorus (P)-Total	0.29	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Lead (Pb)-Total	0.0006		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Rubidium (Rb)-Total	0.0046		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Selenium (Se)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Strontium (Sr)-Total	0.302		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Titanium (Ti)-Total	0.0304		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Thallium (Tl)-Total	0.0003		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Uranium (U)-Total	0.0029		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Vanadium (V)-Total	0.005		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Zinc (Zn)-Total	0.02		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Zirconium (Zr)-Total	0.0014		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH									
	1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr:	2-Fluorobiphenyl Surr	70		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr:	Terphenyl Surr	84		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
	Total Dissolved Solids	620		5	mg/L		19-MAR-07	BJL	R504860
	Total Suspended Solids	46		5	mg/L		19-MAR-07	BJL	R504860

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Qualifiers for Individual Samples Listed:

Sample Number	Client ID	Qualifier	Description
L485862-1	T2-W1A	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485862-10	T3-W1A	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485862-11	T3-W2A	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485862-12	T3-W2B	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485862-13	T6-W1A	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485862-14	T6-W1B	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485862-15	T6-W2A	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485862-16	T6-W2B	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485862-2	T2-W1B	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485862-3	T2-W2A	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485862-4	T2-W2B	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485862-5	T2-W3A	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485862-6	UP1-W1A	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485862-7	UP1-W1B	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485862-8	UP2-W1A	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485862-9	UP2-W1B	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8

Sample Parameter Qualifier key listed:

Qualifier	Description
RAMB	Result Adjusted For Method Blank

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
BTX-WP	Water	BTEX		EPA SW846,5030,8015

Volatile organic compounds are extracted (purged) by bubbling nitrogen through a water sample. The purged sample components are trapped in a tube containing a sorbent material. When purging is complete, the tube is heated and back flushed with helium to desorb the trapped compounds onto a gas chromatographic column. The gas chromatograph is temperature programmed to separate the method analytes which are then detected with a photoionization detector (PID) followed by a flame ionization detector (FID).

MET-SCAN-TOT-LOW-WP	Water	Metal scan		EPA 200.8 Rev 5.4 May 1994
PAH,PANH-WP	Water	PAH		EPA SW846 8270B Sep 1994,3510B Sep 1992

Samples are stored in the dark at 4 degrees C until extraction. Samples are partitioned at basic and acidic pH with dichloromethane, concentrated and esterified (if run in conjunction with pentachlorophenol).
Extracts are analyzed by Gas Chromatography / Mass Spectrometry in the selected ion monitoring mode.

SOLIDS-TDS-WP	Water	Total Dissolved Solids		APHA 2540

The residue remaining in a prepared casserole after passing the sample through a 1.2 um Whatman GF/C glass microfibre filter and drying at 180 degrees C. Samples may be dried at 105 degrees C if the client specifically requests this drying temperature.

SOLIDS-TOTSUS-WP	Water	Total Suspended Solids		APHA 2540

The residue retained by a prepared 1.5 um Whatman 934-AH glass microfibre filter dried at 105 degrees C.

TEH-WP	Water	Tot. Extr. Hydrocarbons (C11-C30)		EPA SW846 3510, 8000

This is the semi-quantitative determination of total extractable hydrocarbons (TEH) C11-C30 in water, soil and sediment samples. A water sample volume of 240 mLs in a 250 mL glass amber bottle is shaken with 2-4 mL hexane for one hour on a wrist action shaker, then sonicated for 5 minutes. A soil/sediment sample of 25 grams is weighed out with sodium sulphate and extracted with 10 mLs hexane/acetone for one hour on a wrist action shaker, then sonicated for 5 minutes. After extraction, the solvent layer is drawn off and analysed against a calibrated diesel standard on a gas chromatograph equipped with a flame ionization detector. All results are reported on a dry weight basis. By special request, the result can be calculated on C10-C24 to

Reference Information

meet specific regulations.

TVH-WP	Water	TVH (C5-C10)	EPA SW846,5030,8015

Volatile organic compounds are extracted (purged) by bubbling nitrogen through a water sample. The purged sample components are trapped in a tube containing a sorbent material. When purging is complete, the tube is heated and back flushed with helium to desorb the trapped compounds onto a gas chromatographic column. The gas chromatograph is temperature programmed to separate the method analytes which are then detected with a photoionization detector (PID) followed by a flame ionization detector (FID).

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
WP	ALS LABORATORY GROUP - WINNIPEG, MANITOBA, CANADA		

GLOSSARY OF REPORT TERMS
Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds. The reported surrogate recovery value provides a measure of method efficiency. The Laboratory control limits are determined under column heading D.L.
mg/kg (units) - unit of concentration based on mass, parts per million.
mg/L (units) - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

CHAIN OF CUSTODY ANALYTICAL REQUEST FORM

12 - 1329 Niakwa Road East
Winnipeg, Manitoba, Canada R2J 3T4
Tel: (204) 255-9720
Fax (204) 255-9721
Toll Free: 1-800-607-7555

DATE SUBMITTED: March 13/07 DATE REQUIRED: ______

SERVICE REQUESTED: [illegible]

PRICING (CHECK ONE):
AS PER QUOTE #: ______ ☐
AS PER LIST PRICE: ☐

ANALYSIS REQUESTED: LAB USE ONLY

[illegible] L485862

SAMPLE ID	SAMPLED BY	DATE / TIME SAMPLED	SAMPLE TYPE	TDS	TSS	PAH	Total Metals	BTEX, TEH, T[illegible]	SAMPLE RECEIVED (Y OR N)	SAMPLE BROKEN (Y OR N)	LAB SAMPLE NO.
T6-W1B	MR	Mar. 12/07	water	X	X	X	X	X			14
T6-W2A	↓	↓	↓	X	X	X	X	X			15
T6-W2B	↓	↓	↓	X	X	X	X	X			16
			PRESERVED / FILTERED								

NOTES & CONDITIONS:

1. Quote number must be provided to ensure proper pricing.
2. All hazardous samples submitted must be labeled to comply with WHMIS regulations. This must include the nature of the hazard, as well as a contact name and phone number that the lab can contact for further information.
3. ALS's liability limited to cost of analysis.

NOTE: Failure to properly complete all portions of this form may delay analysis.

NOTE: [illegible]

CLIENT: UMA
CONTACT: Edwin Yeo
PHONE: [illegible]
FAX: [illegible]
REPORT ADDRESS: [illegible]
BILLING ADDRESS:

NO. SAMPLES SUBMITTED: 108
NO. BOTTLES/SAMPLES: 7 bottles / sample
E-MAIL: YES ☒ NO ☐
E-MAIL ADDRESS: edwin.yeo@umaaecom.com
P.O. NO.: ______
JOB NO.: 0217 158 03

RELINQUISHED BY:	DATE March 13/07 TIME 10am	RECEIVED BY: ALS LAB:	DATE TIME
RELINQUISHED BY:	DATE TIME	RECEIVED BY: ALS LAB:	DATE Mar 13/07 TIME 12:00

SAMPLE CONDITION UPON RECEIPT: ☐ ACCEPTABLE ☐ NON ACCEPTABLE
FROZEN: ______ COLD: ______ AMBIENT: ______
OTHER (BREAKAGE, LEAKAGE, ETC): T6-W2A - [illegible] of 12 ambers, use 500 ml poly for PAH

WHITE - File Copy
GREEN - Final Report
PINK - Invoicing
BLUE - Client Support
YELLOW - Customer

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[illegible]

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

12 - 1329 Niakwa Road East
Winnipeg, Manitoba, Canada R2J 3T4
Tel: (204) 255-9720
Fax (204) 255-9721
Toll Free: 1-800-607-7555

CHAIN OF CUSTODY ANALYTICAL REQUEST FORM

DATE SUBMITTED: March 13/07 DATE REQUIRED:

[redacted]

PRICING (CHECK ONE):
AS PER QUOTE #: ☐
AS PER LIST PRICE: ☐

ANALYSIS REQUESTED:
LAB USE ONLY

L485862

SAMPLE ID	SAMPLED BY	DATE / TIME SAMPLED	SAMPLE TYPE	TDS	TSS	PAH	Total Metals	BTEX TEH – [illegible]									SAMPLE RECEIVED (Y OR N)	SAMPLE BROKEN (Y OR N)	LAB SAMPLE NO.
T2-W1A	MR.	Mar. 12/07	water.	X	X	X	X	X											1
T2-W1B				X	X	X	X	X											2
T2-W2A				X	X	X	X	X											3
T2-W2B				X	X	X	X	X											4
T2-W3A				X	X	X	X	X											5
UP1-W1A				X	X	X	X	X											6
UP1-W1B				X	X	X	X	X											7
UP2-W1A				X	X	X	X	X											8
UP2-W1B				X	X	X	X	X											9
T3-W1A				X	X	X	X	X											10
T3-W2A				X	X	X	X	X											11
T3-W2B				X	X	X	X	X											12
T6-W1A			PRESERVED / FILTERED	X	X	X	X	X											13

NOTES & CONDITIONS:

1. Quote number must be provided to ensure proper pricing.
2. All hazardous samples submitted must be labeled to comply with WHMIS regulations. This must include the nature of the hazard, as well as a contact name and phone number that the lab can contact for further information.
3. ALS's liability limited to cost of analysis.

NOTE: Failure to properly complete all portions of this form may delay analysis.

[redacted]

NO. SAMPLES SUBMITTED: 108
NO. BOTTLES/SAMPLES: 7 bottles/sample

[redacted]

E-MAIL: YES ☒ NO ☐
E-MAIL ADDRESS: edwinyee@uma.aecom.com
P.O. NO.:
JOB NO.: 0217158.03

RELINQUISHED BY:	DATE March 13/07 TIME	RECEIVED BY: ALS LAB:	DATE TIME
RELINQUISHED BY:	DATE TIME	RECEIVED BY: ALS LAB:	DATE Mar 13/07 TIME 13:00

SAMPLE CONDITION UPON RECEIPT: ☐ ACCEPTABLE ☐ NON ACCEPTABLE
FROZEN: ____ COLD: ____ AMBIENT: ____
OTHER (BREAKAGE, LEAKAGE, ETC.): *All metals not preserved and filtered*

WHITE - File Copy
GREEN - Final Report
PINK - Invoicing
BLUE - Client Support
YELLOW - Customer

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ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

Environmental Division

ANALYTICAL REPORT

UMA ENGINEERING
ATTN: EDWIN YEE
1479 BUFFALO PLACE
WINNIPEG MB R3T 1L7

Reported On: 04-APR-07 08:55 AM
Revision: 1

Lab Work Order #: L485992 **Date Received:** 13-MAR-07

Project P.O. #:
Job Reference: 0217-158-03
Legal Site Desc:
CofC Numbers:

Other Information:

Comments:

APPROVED BY: Paul Nicolas
PAUL NICOLAS
Project Manager

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485992-1 T7-W2A								
Sampled By: M. RODDY on 13-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.10		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0035		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.11		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0824		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	79.0		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0005		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0001		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Iron (Fe)-Total	0.85		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.6		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	41.8		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0658		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0027		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	63.8		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.27	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0007		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0043		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	0.0008		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.316		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0280		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0003		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0030		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	0.01		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0012		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485992-1	T7-W2A								
Sampled By:	M. RODDY on 13-MAR-07								
Matrix:	WATER								
PAH									
	Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr:	2-Fluorobiphenyl Surr	70		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr:	Terphenyl Surr	77		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
	Total Dissolved Solids	630		5	mg/L		21-MAR-07	BJL	R505899
	Total Suspended Solids	29		5	mg/L		19-MAR-07	BJL	R504860
L485992-2	T7-W2B								
Sampled By:	M. RODDY on 13-MAR-07								
Matrix:	WATER								
BTEX,TVH and TEH									
BTEX									
	Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
	Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
	Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
	m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
	o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
	Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)									
	Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)									
	TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan									
	Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Aluminum (Al)-Total	1.38		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Arsenic (As)-Total	0.0036		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Boron (B)-Total	0.11		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Barium (Ba)-Total	0.0864		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Calcium (Ca)-Total	80.2		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Cobalt (Co)-Total	0.0006		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Cesium (Cs)-Total	0.0001		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485992-2	T7-W2B								
Sampled By:	M. RODDY on 13-MAR-07								
Matrix:	WATER								
Metal scan									
	Iron (Fe)-Total	1.04		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Potassium (K)-Total	10.6		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Magnesium (Mg)-Total	44.4		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Manganese (Mn)-Total	0.0701		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Molybdenum (Mo)-Total	0.0027		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Sodium (Na)-Total	64.3		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Nickel (Ni)-Total	0.005		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Phosphorus (P)-Total	0.30	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Lead (Pb)-Total	0.0007		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Rubidium (Rb)-Total	0.0046		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Selenium (Se)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Strontium (Sr)-Total	0.310		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Titanium (Ti)-Total	0.0431		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Thallium (Tl)-Total	0.0003		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Uranium (U)-Total	0.0030		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Vanadium (V)-Total	0.005		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Zinc (Zn)-Total	0.02		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Zirconium (Zr)-Total	0.0014		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH									
	1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr:	2-Fluorobiphenyl Surr	76		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr:	Terphenyl Surr	86		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
	Total Dissolved Solids	640		5	mg/L		21-MAR-07	BJL	R505899
	Total Suspended Solids	33		5	mg/L		19-MAR-07	BJL	R504860
L485992-3	T7-W1A								
Sampled By:	M. RODDY on 13-MAR-07								
Matrix:	WATER								
BTEX,TVH and TEH									

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485992-3 T7-W1A								
Sampled By: M. RODDY on 13-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.19		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0035		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.10		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0810		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	78.0		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0006		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0001		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Iron (Fe)-Total	0.89		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.6		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	42.7		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0652		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0028		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	62.0		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.26	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0007		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0045		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.308		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0428		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0003		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0030		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.005		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	0.01		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0013		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485992-3 T7-W1A								
Sampled By: M. RODDY on 13-MAR-07								
Matrix: WATER								
PAH								
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	0.00003		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	0.00002		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	0.00002		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	76		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	84		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	650		5	mg/L		21-MAR-07	BJL	R505899
Total Suspended Solids	26		5	mg/L		19-MAR-07	BJL	R504860
L485992-4 T7-W1B								
Sampled By: M. RODDY on 13-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.21		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0036		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.10		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0822		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	78.7		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0006		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0001		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485992-4 T7-W1B								
Sampled By: M. RODDY on 13-MAR-07								
Matrix: WATER								
Metal scan								
Iron (Fe)-Total	0.97		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.3		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	43.0		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0662		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0026		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	61.8		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.30	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0007		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0045		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.302		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0403		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0003		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0030		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.005		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	0.01		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0013		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	69		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	83		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	630		5	mg/L		21-MAR-07	BJL	R505899
Total Suspended Solids	31		5	mg/L		19-MAR-07	BJL	R504860
L485992-5 T8-W1A								
Sampled By: M. RODDY on 13-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L485992-5 T8-W1A								
Sampled By: M. RODDY on 13-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.28		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0036		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.10		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0850		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	79.2		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0006		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0001		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Iron (Fe)-Total	0.96		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.3		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	43.4		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0667		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0028		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	61.6		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.29	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0007		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0046		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.310		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0357		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0030		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.005		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	0.01		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0013		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136

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Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485992-5 T8-W1A								
Sampled By: M. RODDY on 13-MAR-07								
Matrix: WATER								
PAH								
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	<0.00001		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	72		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	82		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	650		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Suspended Solids	25		5	mg/L		21-MAR-07	BJL	R505899
			5	mg/L		19-MAR-07	BJL	R504860
L485992-6 T8-W1B								
Sampled By: M. RODDY on 13-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.37		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0037		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.10		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0864		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	80.9		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0006		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0001		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L485992-6	T8-W1B								
Sampled By:	M. RODDY on 13-MAR-07								
Matrix:	WATER								
Metal scan									
	Iron (Fe)-Total	1.10		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Potassium (K)-Total	10.6		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Magnesium (Mg)-Total	44.2		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Manganese (Mn)-Total	0.0763		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Molybdenum (Mo)-Total	0.0027		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Sodium (Na)-Total	62.0		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Phosphorus (P)-Total	0.28	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Lead (Pb)-Total	0.0008		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Rubidium (Rb)-Total	0.0046		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Selenium (Se)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Strontium (Sr)-Total	0.315		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Titanium (Ti)-Total	0.0394		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Thallium (Tl)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Uranium (U)-Total	0.0031		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Vanadium (V)-Total	0.005		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Zinc (Zn)-Total	0.01		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Zirconium (Zr)-Total	0.0014		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH									
	1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr:	2-Fluorobiphenyl Surr	70		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr:	Terphenyl Surr	89		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
	Total Dissolved Solids	640		5	mg/L		21-MAR-07	BJL	R505899
	Total Suspended Solids	35		5	mg/L		19-MAR-07	BJL	R504860
L485992-7	T8-W2A								
Sampled By:	M. RODDY on 13-MAR-07								
Matrix:	WATER								
BTEX,TVH and TEH									

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485992-7 T8-W2A								
Sampled By: M. RODDY on 13-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.10		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0028		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.11		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0850		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	81.0		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0006		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Iron (Fe)-Total	1.00		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.5		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	43.2		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0740		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0029		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	63.1		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.003		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.25	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0008		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0053		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.348		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0383		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0003		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0036		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.005		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	0.01		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0015		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485992-7	T8-W2A								
Sampled By:	M. RODDY on 13-MAR-07								
Matrix:	WATER								
PAH									
	Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr:	2-Fluorobiphenyl Surr	70		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr:	Terphenyl Surr	80		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
	Total Dissolved Solids	640		5	mg/L		21-MAR-07	BJL	R505899
	Total Suspended Solids	33		5	mg/L		19-MAR-07	BJL	R504860
L485992-8	T9-W1A								
Sampled By:	M. RODDY on 13-MAR-07								
Matrix:	WATER								
BTEX,TVH and TEH									
BTEX									
	Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
	Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
	Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
	m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
	o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
	Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)									
	Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)									
	TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan									
	Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Aluminum (Al)-Total	1.03		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Arsenic (As)-Total	0.0026		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Boron (B)-Total	0.10		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Barium (Ba)-Total	0.0817		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Calcium (Ca)-Total	75.9		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Cobalt (Co)-Total	0.0005		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Cesium (Cs)-Total	0.0001		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
	Copper (Cu)-Total	0.003		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213

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Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485992-8 T9-W1A Sampled By: M. RODDY on 13-MAR-07 Matrix: WATER								
Metal scan								
Iron (Fe)-Total	0.84		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	9.8		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	40.8		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0632		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0028		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	58.9		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.003		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.22	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0008		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0049		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.332		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0281		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0034		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	0.01		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0013		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr: 2-Fluorobiphenyl Surr	69		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr: Terphenyl Surr	85		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Total Dissolved Solids	620		5	mg/L		21-MAR-07	BJL	R505899
Total Suspended Solids	28		5	mg/L		19-MAR-07	BJL	R504860
L485992-9 T9-W1B Sampled By: M. RODDY on 13-MAR-07 Matrix: WATER								
BTEX,TVH and TEH								

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters	Result	Qualifier	D.L.	Units	Extracted	Analyzed	By	Batch
L485992-9 T9-W1B								
Sampled By: M. RODDY on 13-MAR-07								
Matrix: WATER								
BTEX,TVH and TEH								
BTEX								
Benzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Toluene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Ethylbenzene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
m+p-Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
o-Xylene	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
Xylenes	<0.0005		0.0005	mg/L		16-MAR-07	MDM	R504474
TVH (C5-C10)								
Total Volatiles	<0.1		0.1	mg/L		16-MAR-07	MDM	R504474
Tot. Extr. Hydrocarbons (C11-C30)								
TEH (C11-C30)	<0.1		0.1	mg/L	15-MAR-07	19-MAR-07	THT	R504135
Metal scan								
Silver (Ag)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Aluminum (Al)-Total	1.45		0.02	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Arsenic (As)-Total	0.0029		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Boron (B)-Total	0.10		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Barium (Ba)-Total	0.0869		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Beryllium (Be)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Bismuth (Bi)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Calcium (Ca)-Total	81.8		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cadmium (Cd)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cobalt (Co)-Total	0.0005		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Chromium (Cr)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Cesium (Cs)-Total	0.0002		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Copper (Cu)-Total	0.004		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Iron (Fe)-Total	1.09		0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Potassium (K)-Total	10.6		0.1	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Magnesium (Mg)-Total	42.7		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Manganese (Mn)-Total	0.0744		0.0003	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Molybdenum (Mo)-Total	0.0027		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Sodium (Na)-Total	64.2		0.03	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Nickel (Ni)-Total	0.004		0.002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Phosphorus (P)-Total	0.25	RAMB	0.05	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Lead (Pb)-Total	0.0008		0.0005	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Rubidium (Rb)-Total	0.0055		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Antimony (Sb)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Selenium (Se)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tin (Sn)-Total	<0.0006		0.0006	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Strontium (Sr)-Total	0.339		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tellurium (Te)-Total	<0.001		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Titanium (Ti)-Total	0.0337		0.0009	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Thallium (Tl)-Total	0.0003		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Uranium (U)-Total	0.0035		0.0001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Vanadium (V)-Total	0.006		0.001	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Tungsten (W)-Total	<0.0002		0.0002	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zinc (Zn)-Total	0.05		0.01	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
Zirconium (Zr)-Total	0.0015		0.0004	mg/L	15-MAR-07	15-MAR-07	DAG	R503213
PAH								
1-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
2-Methyl Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Acenaphthene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136

ALS LABORATORY GROUP ANALYTICAL REPORT

Sample Details/Parameters		Result	Qualifier*	D.L.	Units	Extracted	Analyzed	By	Batch
L485992-9	T9-W1B								
Sampled By:	M. RODDY on 13-MAR-07								
Matrix:	WATER								
PAH									
	Acenaphthylene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(a)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(a)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(b)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(ghi)perylene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Benzo(k)fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Chrysene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Dibenzo(ah)anthracene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Fluoranthene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Fluorene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Indeno(1,2,3 cd)pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Naphthalene	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Phenanthrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Pyrene	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Quinoline	<0.00005		0.00005	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
	Acridine	<0.00001		0.00001	mg/L	15-MAR-07	17-MAR-07	JAP	R504136
Surr:	2-Fluorobiphenyl Surr	67		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
Surr:	Terphenyl Surr	77		25-175	%	15-MAR-07	17-MAR-07	JAP	R504136
	Total Dissolved Solids	630		5	mg/L		21-MAR-07	BJL	R505899
	Total Suspended Solids	33		5	mg/L		19-MAR-07	BJL	R504860

* Refer to Referenced Information for Qualifiers (if any) and Methodology.

Reference Information

Qualifiers for Individual Samples Listed:

Sample Number	Client ID	Qualifier	Description
L485992-1	T7-W2A	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485992-2	T7-W2B	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485992-3	T7-W1A	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485992-4	T7-W1B	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485992-5	T8-W1A	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485992-6	T8-W1B	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485992-7	T8-W2A	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485992-8	T9-W1A	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8
L485992-9	T9-W1B	LPM	Laboratory Preserved for Metals. Total metals sample was preserved at the laboratory in accordance with EPA 200.8

Sample Parameter Qualifier key listed:

Qualifier	Description
RAMB	Result Adjusted For Method Blank

Methods Listed (if applicable):

ALS Test Code	Matrix	Test Description	Preparation Method Reference(Based On)	Analytical Method Reference(Based On)
BTX-WP	Water	BTEX		EPA SW846,5030,8015
Volatile organic compounds are extracted (purged) by bubbling nitrogen through a water sample. The purged sample components are trapped in a tube containing a sorbent material. When purging is complete, the tube is heated and back flushed with helium to desorb the trapped compounds onto a gas chromatographic column. The gas chromatograph is temperature programmed to separate the method analytes which are then detected with a photoionization detector (PID) followed by a flame ionization detector (FID).				
MET-SCAN-TOT-LOW-WP	Water	Metal scan		EPA 200.8 Rev 5.4 May 1994
PAH,PANH-WP	Water	PAH		EPA SW846 8270B Sep 1994,3510B Sep 1992
Samples are stored in the dark at 4 degrees C until extraction. Samples are partitioned at basic and acidic pH with dichloromethane, concentrated and esterified (if run in conjunction with pentachlorophenol). Extracts are analyzed by Gas Chromatography / Mass Spectrometry in the selected ion monitoring mode.				
SOLIDS-TDS-WP	Water	Total Dissolved Solids		APHA 2540
The residue remaining in a prepared casserole after passing the sample through a 1.2 um Whatman GF/C glass microfibre filter and drying at 180 degrees C. Samples may be dried at 105 degrees C if the client specifically requests this drying temperature.				
SOLIDS-TOTSUS-WP	Water	Total Suspended Solids		APHA 2540
The residue retained by a prepared 1.5 um Whatman 934-AH glass microfibre filter dried at 105 degrees C.				
TEH-WP	Water	Tot. Extr. Hydrocarbons (C11-C30)		EPA SW846 3510, 8000
This is the semi-quantitative determination of total extractable hydrocarbons (TEH) C11-C30 in water, soil and sediment samples. A water sample volume of 240 mLs in a 250 mL glass amber bottle is shaken with 2-4 mL hexane for one hour on a wrist action shaker, then sonicated for 5 minutes. A soil/sediment sample of 25 grams is weighed out with sodium sulphate and extracted with 10 mLs hexane/acetone for one hour on a wrist action shaker, then sonicated for 5 minutes. After extraction, the solvent layer is drawn off and analysed against a calibrated diesel standard on a gas chromatograph equipped with a flame ionization detector. All results are reported on a dry weight basis. By special request, the result can be calculated on C10-C24 to meet specific regulations.				
TVH-WP	Water	TVH (C5-C10)		EPA SW846,5030,8015
Volatile organic compounds are extracted (purged) by bubbling nitrogen through a water sample. The purged sample components are trapped in a tube containing a sorbent material. When purging is complete, the tube is heated and back flushed with helium to desorb the trapped compounds onto a gas chromatographic column. The gas chromatograph is temperature programmed to separate the method analytes which are then detected with a photoionization detector (PID) followed by a flame ionization detector (FID).				

** Laboratory Methods employed follow in-house procedures, which are generally based on nationally or internationally accepted methodologies.

Chain of Custody numbers:

The last two letters of the above test code(s) indicate the laboratory that performed analytical analysis for that test. Refer to the list below:

Reference Information

Laboratory Definition Code	Laboratory Location	Laboratory Definition Code	Laboratory Location
WP	ALS LABORATORY GROUP - WINNIPEG, MANITOBA, CANADA		

GLOSSARY OF REPORT TERMS

Surr - A surrogate is an organic compound that is similar to the target analyte(s) in chemical composition and behavior but not normally detected in environmental samples. Prior to sample processing, samples are fortified with one or more surrogate compounds.
The reported surrogate recovery value provides a measure of method efficiency. The Laboratory control limits are determined under column heading D.L.
mg/kg (units) - unit of concentration based on mass, parts per million.
mg/L (units) - unit of concentration based on volume, parts per million.
< - Less than.
D.L. - The reporting limit.
N/A - Result not available. Refer to qualifier code and definition for explanation.

Test results reported relate only to the samples as received by the laboratory.
UNLESS OTHERWISE STATED, ALL SAMPLES WERE RECEIVED IN ACCEPTABLE CONDITION.
UNLESS OTHERWISE STATED, SAMPLES ARE NOT CORRECTED FOR CLIENT FIELD BLANKS.
Although test results are generated under strict QA/QC protocols, any unsigned test reports, faxes, or emails are considered preliminary.

ALS Laboratory Group has an extensive QA/QC program where all analytical data reported is analyzed using approved referenced procedures followed by checks and reviews by senior managers and quality assurance personnel. However, since the results are obtained from chemical measurements and thus cannot be guaranteed, ALS Laboratory Group assumes no liability for the use or interpretation of the results.

ALS Laboratory Group
ANALYTICAL CHEMISTRY & TESTING SERVICES

12 - 1329 Niakwa Road East
Winnipeg, Manitoba, Canada R2J 3T4
Tel: (204) 255-9720
Fax (204) 255-9721
Toll Free: 1-800-607-7555

CHAIN OF CUSTODY ANALYTICAL REQUEST FORM

DATE SUBMITTED: Mar 13/07 DATE REQUIRED:

[illegible]

PRICING (CHECK ONE):
AS PER QUOTE #: ☐
AS PER LIST PRICE: ☐

ANALYSIS REQUESTED
LAB USE ONLY

L485912

SAMPLE ID	SAMPLED BY	DATE / TIME SAMPLED	SAMPLE TYPE	TSS	TDS	Total Metals	PAH's	BTEX TVH	SAMPLE RECEIVED (Y OR N)	SAMPLE BROKEN (Y OR N)	LAB SAMPLE NO.
T7-W2A	M. Roddy	MAR 13/07	water	X	X	X	X	X			1
T7-W2B				X	X	X	X	X			2
T7-W1A				X	X	X	X	X			3
T7-W1B				X	X	X	X	X			4
T8-W1A				X	X	X	X	X			5
T8 W1B				X	X	X	X	X			6
T8-W2A				X	X	X	X	X			7
T9-W1A				X	X	X	X	X			8
T9-W1B				X	X	X	X	X			9
			PRESERVED / FILTERED								

Metals Sampled Not filtered or preserved

NOTES & CONDITIONS:
1. Quote number must be provided to ensure proper pricing.
2. All hazardous samples submitted must be labeled to comply with WHMIS regulations. This must include the nature of the hazard, as well as a contact name and phone number, that the lab can contact for further information.
3. ALS's liability limited to cost of analysis.

NOTE: Failure to properly complete all portions of this form may delay analysis.

NOTE: Shaded areas MUST be completed in full by client for sample processing to occur.

CLIENT: UMA Eng. Ltd
CONTACT: Edwin Yee
REPORT ADDRESS: 1479 Buffalo Pl
Wpg MB
BILLING ADDRESS: Same as above

NO. SAMPLES SUBMITTED:
NO. BOTTLES/SAMPLES:
PHONE: [illegible]
FAX:
E-MAIL: YES ☒ NO ☐
E-MAIL ADDRESS: edwin.yee@uma.a[illegible]com
P.O. NO.:
JOB NO.: 0217-158-03

RELINQUISHED BY: M.R.	DATE March 13/07 TIME 2:06	RECEIVED BY: ALS LAB:	DATE TIME
RELINQUISHED BY:	DATE: TIME:	RECEIVED BY: AK ALS LAB:	DATE Mar 13/07 TIME 14:20

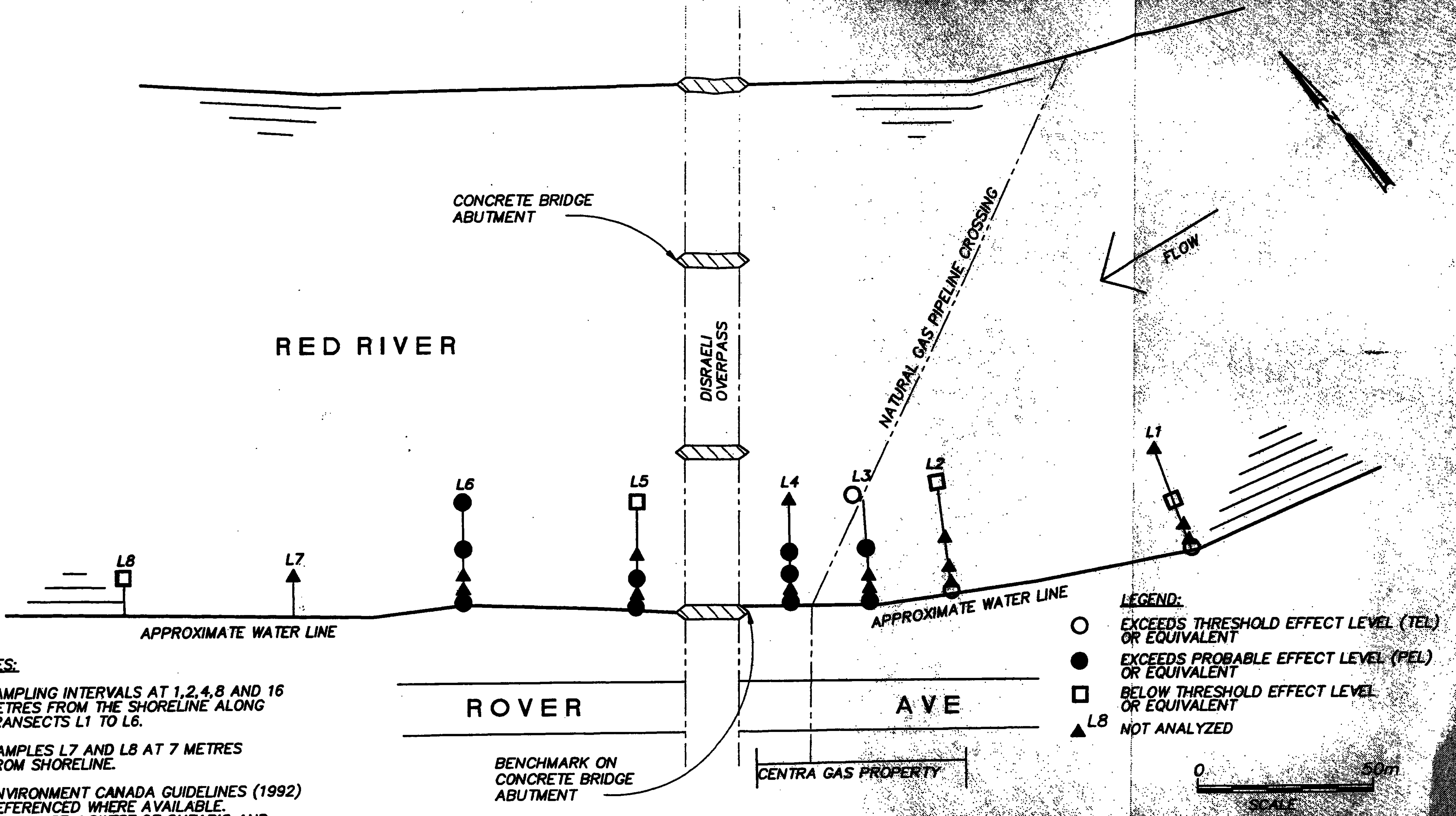
SAMPLE CONDITION UPON RECEIPT: ☐ ACCEPTABLE ☐ NON ACCEPTABLE
FROZEN: ______ COLD: ______ AMBIENT: ______
OTHER (BREAKAGE, LEAKAGE, ETC.): ______

WHITE - File Copy
GREEN - Final Report
PINK - Invoicing
BLUE - Client Support
YELLOW - Customer

REV. OCT / 2006

APPENDIX C:
Water Quality Sampling Program (CH2M Hill, 1995)

06/OCT/94



NOTES:

1. SAMPLING INTERVALS AT 1,2,4,8 AND 16 METRES FROM THE SHORELINE ALONG TRANSECTS L1 TO L6.
2. SAMPLES L7 AND L8 AT 7 METRES FROM SHORELINE.
3. ENVIRONMENT CANADA GUIDELINES (1992) REFERENCED WHERE AVAILABLE. OTHERWISE, LOWEST OF ONTARIO AND QUEBEC GUIDELINES USED.
4. CHEMICAL ANALYSIS OF SHALLOW SEDIMENT (TYPICALLY < 0.8m) USED TO COMPILE THIS FIGURE.

CH2M HILL ENGINEERING LTD.
WATERLOO ONTARIO
PROJECT No. ON129776.B0

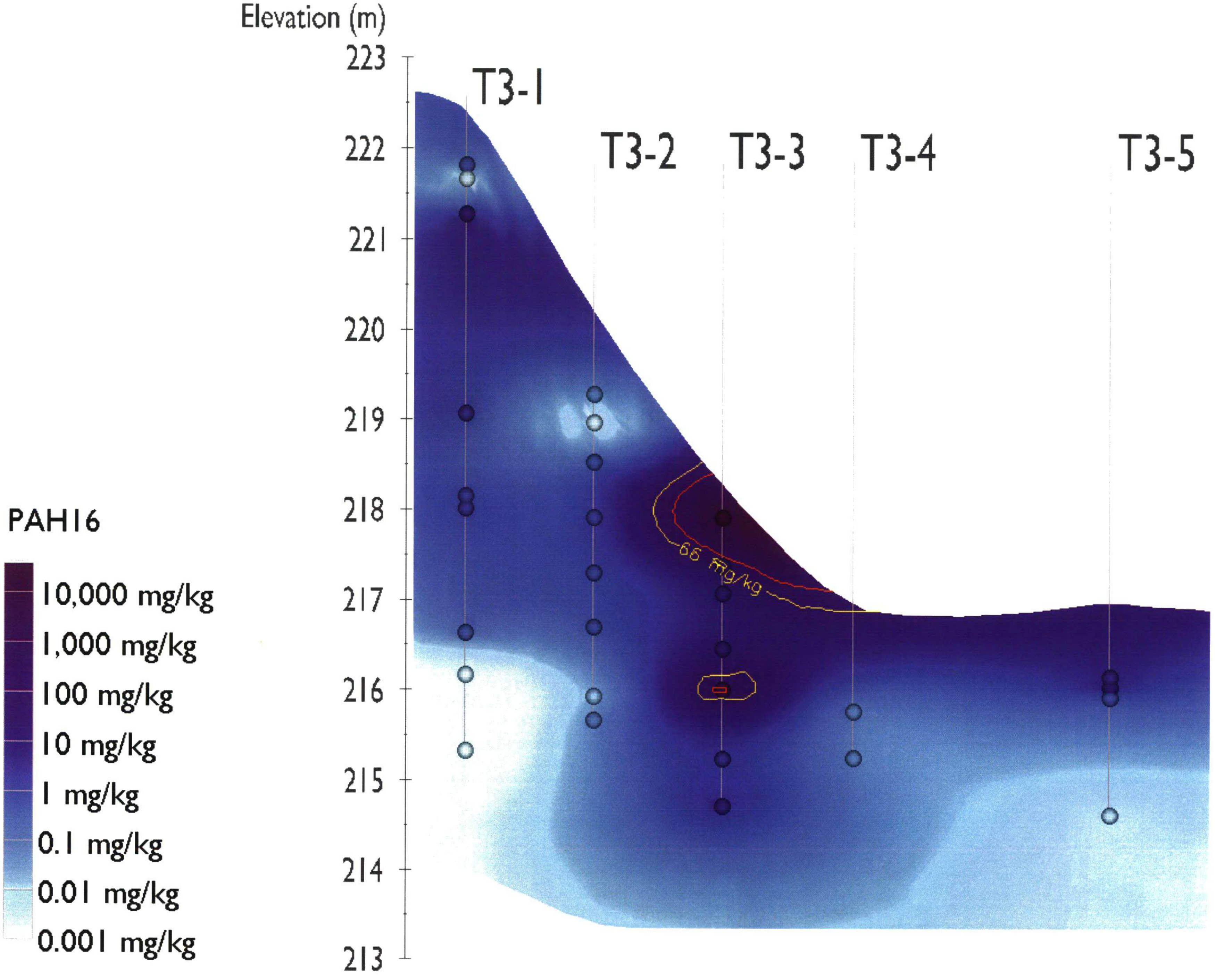
FIGURE 4-1:
SEDIMENT SAMPLE LOCATIONS IN THE RIVER INDICATING ANALYTICAL RESULTS

29776F17.DWG

APPENDIX D:
Three Dimensional Representation of Coal Tar Contaminated Sediment Plume, Red River (Based on Data from UMA, 2003)

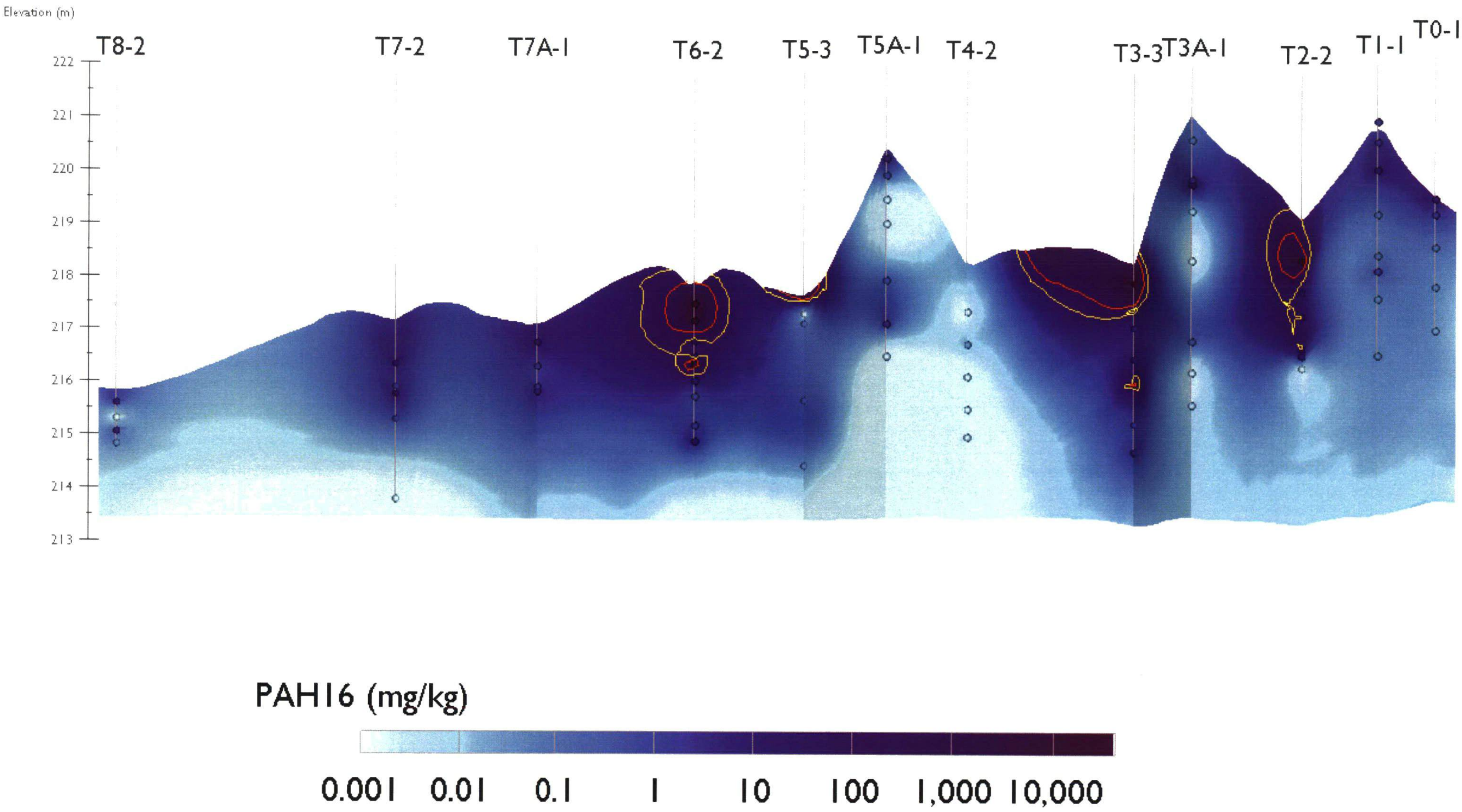
PAH16 at Transect 3: Contours at 66 & 285 ppm

Z = 10 X



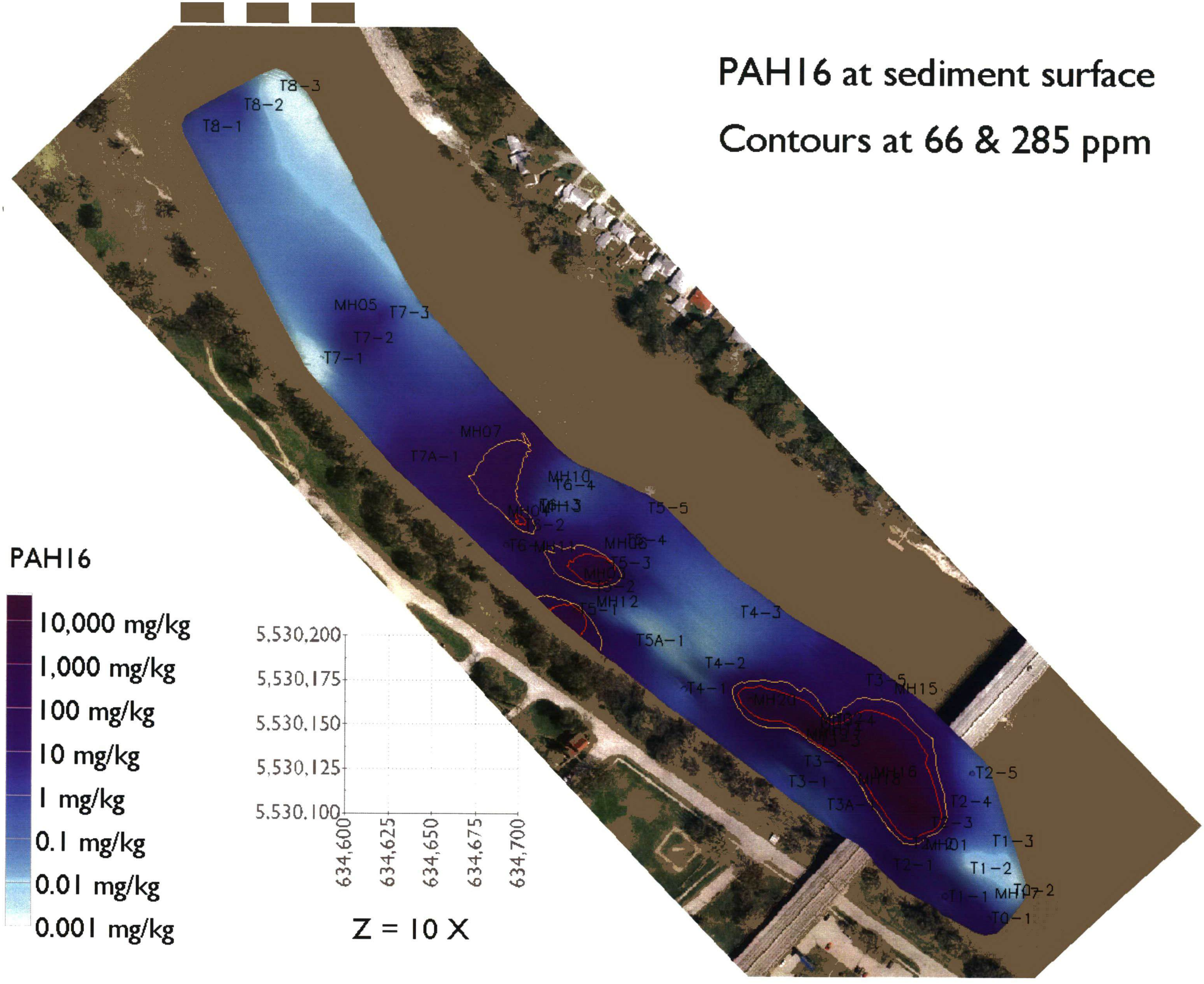
PAH16 at Transect 9: Contours at 66 & 285 ppm

Z = 25 X



PAH16 at sediment surface

Contours at 66 & 285 ppm



APPENDIX E:
Assessment of PAH Bioavailability and Toxicity in Sediments, Manitoba Hydro – Sutherland Avenue Site

ENSR | AECOM

The RETEC Group, Inc.
1001 W. Seneca Street, Suite 204
Ithaca, NY 14850
T 607-277-5716 F 607-277-9057 www.ensr.aecom.com

October 1, 2007

Edwin Yee
UMA Engineering Ltd.
1479 Buffalo Place,
Winnipeg, Manitoba R3T 1L7

Subject: Preliminary Assessment of PAH Bioavailability and Toxicity in Sediments, Manitoba Hydro – Sutherland Avenue Site

Dear Mr. Yee,

The following Technical Memorandum provides a preliminary assessment of polycyclic aromatic hydrocarbon (PAH) bioavailability in surface sediments located adjacent to the former manufactured gas plant (MGP) facility at Sutherland Avenue in Winnipeg, Manitoba. The following memorandum is designed to be incorporated into your final report for Manitoba Hydro.

1. PAH bioavailability and toxicity assessment

Previous investigations of benthic macroinvertebrate community structure and toxicity testing have indicated that there is apparently little or no impact to benthic aquatic life from sediments having PAH concentrations exceeding typical sediment quality guideline (SQG) screening values at the Sutherland Avenue Site. To confirm the apparent lack of bioavailability and toxicity of PAHs, the dissolved concentration of PAHs in porewater extracted from sediment samples was determined using recently published ASTM standard methods and guidance prepared by the U.S. Environmental Protection Agency for predicting the toxicity of PAH mixtures (ASTM, 2007; US EPA 2003).

Twenty surface sediment grab samples were collected from stations with previously observed elevated PAH concentrations and for which previous data existed on macroinvertebrate community structure. These samples were screened for the concentration of PAHs in the bulk sediment. Based on these screening data, 10 samples having a range in PAH concentrations were then selected for detailed analysis of dissolved PAHs in extracted porewater. The concentration of dissolved PAHs was used to estimate the potential toxicity of each sediment sample. For the duration of this report, when bulk sediment PAH concentrations are discussed, the term PAH_{16} mg/kg will be used which refers to the sum of 16 PAHs present in the bulk sediment expressed on a dry weight basis. The concentration of PAH_{16} in sediment is the PAH concentration that many regulatory screening values are based upon. When referring to the concentration of dissolved PAHs or bioavailable PAHs present in sediment porewater, the term PAH_{34} is used which is expressed in units of µmol/g lipid. The bioavailability PAH_{34} concentration expressed as µmol/g lipid represents the predicted internal concentration or body burden of PAHs that is expected in benthic aquatic organisms if they are exposed to the sediment. The measurement of PAH_{34} is the sum of 18 parent PAH compounds and 16 groups of alkylated PAH compounds, which represents thousands of individual PAHs. The exposure and internal body burden of sediment-dwelling invertebrates is predicted using equilibrium portioning theory, and the analysis of PAH_{34} is conducted to provide a better estimate of the potential toxicity resulting from complex mixtures of PAHs. This approach is based upon recently published guidance prepared by the U.S. EPA for characterizing the toxicity of PAH mixtures to benthic macroinvertebrates (U.S. EPA 2003).

The goal of this assessment was to provide an initial evaluation of the PAH bioavailability and to determine whether the toxicity of PAH impacted sediments adjacent to the Sutherland Avenue MGP site is likely to be lower than currently assumed by the bulk sediment screening criteria typically used to assess risk of PAHs to aquatic life. This assessment was designed to build upon the information and database that have been developed by the Sediment Contaminant Bioavailability Alliance (SCBA). The SCBA is a multi-industry group that has developed a new standard method for the site-specific characterization of PAH bioavailability and toxicity in sediments (ASTM 2007, see www.scbaweb.com). The data collected from the Sutherland Avenue site have been compared to the SCBA amphipod toxicity database to enhance the interpretation of the sediment quality data collected from the Red River.

1.1 Sample location

UMA collected 20 surface sediment grab samples (MH01 through MH20) on August 28-29, using a petit ponar, which were then prepared for shipment to the testing laboratories with support from ENSR. Samples were located in the field with a global positioning system (GPS) receiver and their latitude and longitude were determined to within sub-meter accuracy. At each station, approximately two liters of surface sediment (0 to 10 cm) was collected and a physical description of the sample and water depth was recorded (Table 1, Fig.1).

1.2 Station water quality assessment

Baseline measurements of water quality were measured with a YSI 556 MPS in the field prior to collection of sediment samples (Table 2). The water quality parameters measured in the field included temperature, dissolved oxygen, pH, and conductivity. Two measurements were collected from each location, one measurement was taken near the water surface (approx. ½ meter below the water surface) and a second measurement was taken near the bottom of the water column (approx. ½ meter above the sediment surface).

1.3 Sample handling procedures

Sediment samples were homogenized in the field which included screening (sieved through a #5 mesh [4 mm] screen) to remove twigs, shells, leaves, stones, pieces of wood, and vegetation so as to improve homogeneity of subsamples sent to the laboratory. Each sample was then placed into glass jars having Teflon-lined lids for submittal to the laboratory and labeled with the name of the study site, the station location designation, the time of collection, the date of collection, and name of collector. Jars were kept at 4 °C during shipment and chain-of-custody (COC) procedures were followed.

1.4 Sample screening and selection

Twenty surface sediment samples (MH01 through MH20) were submitted to the Energy and Environmental Research Center (EERC) located at the University of North Dakota in Grand Forks, ND for chemical characterization. EERC conducted an initial screening for the concentration of 34 PAHs specified by the U.S. National Oceanographic and Atmospheric Administration (NOAA), which includes 18 parent and 16 groups of alkylated PAHs. It is important to note that the 16 groups of alkylated PAHs actually represent thousands of individual PAH homologues. The 16 U.S. EPA-priority pollutant PAHs (PAH_{16}) are a subset of the 18 parent PAHs specified by NOAA.

The screening concentration of PAH_{16} in the 20 sediments ranged from 0.2 to 2,700 mg/kg (wet weight basis) (Table 3). The ratio of parent to parent + alkyl PAHs (PAH_{16}/PAH_{34}) ranged from 0.40 to 0.82, indicating that parent PAHs represented a significant proportion of the aromatic hydrocarbons in the sediment samples which is typical for PAH mixtures observed at MGP sites. Based on this screening analysis, the ten samples having a bulk sediment concentration greater than 1.6 mg/kg (wet wt) PAH_{16} were selected for detailed analysis of PAHs dissolved in sediment porewater. The samples selected for detailed chemical characterization included MH02, MH03, MH04, MH10, MH11, MH14, MH16, MH18, MH19, and MH20 (Table 3).

1.5 Sample analysis

1.5.1 Sediment PAH analysis

Samples selected for detailed chemical characterization were analyzed for PAH_{34} concentrations in bulk sediment using Soxhlet extraction and GC/MS analysis (Hawthorne *et. al.*, 2006).

The mean concentration of total PAH_{16} (determined on a dry wt. basis) for the selected samples ranged from 9.18 to 17900 mg/kg (Table 4, Fig 1). The ratio of PAH_{16}/PAH_{34} was consistent, ranging from 0.41 to 0.63, indicating that both alkyl and parent PAHs are represented in the PAH mixture present in the sediment samples. The standard U.S. EPA method 8270 for determination of semi-volatile analytes does not include measurements of alkylated PAHs. Therefore, the typical standard method for determination of PAHs in sediment would not accurately characterize sediment toxicity because it does not include measurement of alkylated PAHs.

Several samples (MH10, MH14 and MH16) were found to have large differences (> 50 relative percent difference) between duplicate PAH analysis. These samples were also found to have relatively high concentrations of low molecular weight PAHs suggesting that blebs of coal tar NAPL may be present in these samples contributing to sample heterogeneity. The analytical lab, EERC, chose to analyze MH14 four times (2 sets of duplicate analyses) for quality control purposes due to the observed variation between the initial duplicate tests. The mean, standard deviation, and number of replicates are presented for this sample in the data table (Table 4).

1.5.2 Porewater PAH analysis

The concentration of dissolved PAHs in sediment porewater using solid phase micro-extraction (SPME) in combination with GC/MS analysis of PAH_{34} was determined using ASTM method D7363-07 for the detailed chemical characterization of PAH bioavailability in the 10 selected samples (ASTM 2007, Hawthorne et al, 2005).

Mean concentrations of dissolved PAH_{34} measured in extracted porewater ranged from 0.42 to 4,630 µg/L. When expressed in terms of potential exposure to benthic life, the concentrations of dissolved PAHs in porewater ranged from 0.05 to 128 µmol/g lipid (Table 5). In contrast to the variability observed in bulk sediment PAH_{34} concentrations, there were much smaller differences between the replicate analyses of dissolved PAH_{34} in sediment porewater. Sample MH10 was analyzed twice more for quality control purposes because of the lack of variation seen in its porewater concentrations between duplicates. High variability was observed between duplicate analyses of bulk sediment PAH concentrations in this sample. The mean, standard deviation, and number of replicates are presented in the data table (Table 5).

1.5.3 Total organic carbon (TOC), soot carbon (SOC), and dissolved organic carbon (DOC)

The concentration of TOC, SOC, and DOC were determined using the methods of Hawthorne 2001, Gustafsson et al. 1997, and APHA, 1998 SM 5310C respectively. SOC, or heat stabile carbon, is determined by heating the sediment sample to 375°C for 24 hours in the presence of excess oxygen prior to determining TOC. The TOC content of the sediment samples ranged from 1.2 to 17%. The ratio of SOC/TOC ranged from 0.10 to 0.20 (Table 4). These data indicate that 10% to 20% of the organic carbon in the sediment is heat stable and likely to be anthropogenic in origin consisting of soot, coke, etc. This is significant since soot and these other forms of anthropogenic carbon bind PAHs more tightly than natural organic matter. The dissolved organic carbon present in extracted porewater ranged from 6.0 to 24 mg/L. DOC data are collected to show whether unusually large amounts of dissolved carbon are present in porewater, which may modify the interpretation of the bioavailability of high molecular weight PAHs

1.5.4 PAH organic carbon – water partitioning (Koc) values

Using the measured concentrations of dissolved PAHs in sediment porewater, the concentrations of PAHs in bulk sediment, and the TOC measured in bulk sediment, the apparent organic carbon-water partitioning coefficient (Koc value) for each PAH was calculated for each sediment sample. These Koc values provide an estimate of the PAH bioavailability to benthic aquatic life. The mean and range of the measured log Koc values is shown for the parent PAHs in Figure 2. In all cases the measured Koc value exceeded the literature based values based on natural organic matter and used by risk assessment models [U.S. EPA, 2003]. Higher Koc values indicate lower PAH bioavailability; therefore, the PAHs in these surface sediments are less bioavailable than would be assumed by the current risk assessment models. In some sediment samples the log Koc values exceeded the literature derived Koc values by more than two log units (100 times).

In Figure 3, the measured Koc values for naphthalene and phenanthrene are shown for each sediment sample and plotted against the concentration of naphthalene and phenanthrene measured in the bulk sediment. With the exception of sample MH03, the measured log Koc value for naphthalene increases as the concentration of naphthalene increases in the bulk sediment. These data indicate that naphthalene is sorbed more strongly to the sediment organic carbon as the concentration of naphthalene in the bulk sediment increases. These data suggest that the relative bioavailability of naphthalene apparently decreases as the concentration of naphthalene increases in the bulk sediment. However, this trend is not present for the larger molecular weight PAH compound phenanthrene.

To estimate the bioavailability for a mixture of PAHs present in sediment, the concentration of PAH_{34} measured in sediment porewater is compared to the predicted concentration of PAH_{34} using the default literature derived sediment organic carbon-water partitioning coefficients (Koc). This analysis is provided in Figure 4, where PAH bioavailability is expressed as a percent of the predicted value using the formula

$$\textit{PAH Bioavailability (\%)} = \frac{PAH_{34}\ \textit{measured porewater}}{PAH_{34}\ \textit{predicted porewater}} \times 100$$

where the PAH_{34} concentration is expressed as µmol/g lipid. As can be seen from Figure 4, the expected bioavailability of PAHs in sediment samples is expected to be less than 10% for five samples (MH02, MH03, MH10, MH14 and MH18). Higher PAH bioavailability (10-100%) is expected in the other five samples tested (MH04, MH11, MH16, MH19 and MH20).

1.5.5 Bioavailability assessment and predictions of sediment toxicity

The concentration of bioavailable PAHs generated for the Red River sediment samples were compared to the SCBA sediment database of previously collected PAH bioavailability and *Hyalella azteca (H.*

azteca) laboratory toxicity data (133 freshwater sediments were collected from 7 MGP and 2 aluminum smelter sites across North America). Aluminum smelters are included in the data set because of their use of coal tar pitch as a binding agent for their electrodes. *H. azteca* was selected as the test organism for assessing sediment toxicity in the SCBA database because it is considered to be highly sensitive to hydrocarbon contaminants and it's survival and growth test endpoints have good precision (U.S. EPA 2000, 2003). Data developed from freshwater sediment samples indicate that porewater samples having less than 15 μmol/g lipid PAH_{34} are not anticipated to result in significantly reduced survival of *H. azteca* (i.e., *H. azteca* survival should be >85%) and samples having more than 75 μmol/g lipid PAH_{34} are expected to have near 100% mortality (i.e., *H. azteca* survival should be <15%) [Hawthorne et al., 2007]. The concentrations of dissolved PAH_{34} in sediment porewater from the 10 selected samples were evaluated against this database (Fig 5). Based on these comparisons, the sediment samples MH02, MH03, and MH10 are not predicted to be toxic to aquatic invertebrates such as *H. azteca*. Samples MH02, MH03 and MH10 were determined to have 0.12, 0.78, and 0.06 μmol/g lipid PAH_{34} (9.18, 20.4 and 66 mg/kg PAH_{16}) respectively. Sample MH11 was determined to have a dissolved PAH_{34} concentration of 19.9 μmol/g lipid (sediment concentration 247 mg/kg PAH_{16}) and toxicity cannot be predicted at the 95% confidence level. The dissolved concentration of PAHs in porewater extracted from samples MH04, MH14, MH16, MH18, MH19, and MH20 exceeded 75 μmol/g lipid PAH_{34} and are expected to be toxic to *H. azteca* (Fig 2). These samples ranged in sediment PAH_{16} concentration from 285 to 17900 mg/kg.

Though samples MH04, MH10, and MH11 came from the same vicinity, they ranged in bioavailable PAH concentrations from less than 1 μmol/g lipid to more than 90 μmol/g lipid indicating that the chemistry of sediments in this area appears to be very heterogeneous (Fig 1). The bulk sediment concentration of PAHs among duplicate analyses of sample MH10 illustrates the point (66 and 2660 mg/kg PAH_{16}). The other sediment samples exhibiting high concentrations of bioavailable PAHs were also found to be geographically centered in the area located just north of the bridge crossing the study area. Surface sediment samples collected downgradient (north) of sample MH04 and upgradient (south) of sample MH16 were found to have very low concentrations of total PAHs in the screening analysis and are also not expected to exhibit toxicity to benthic macroinvertebrates.

Summary

Twenty surface sediment samples collected adjacent to the Sutherland Avenue MGP site contained a wide range of PAH concentrations. Ten of the 20 sediment samples collected were determined to have very low PAH concentrations in screening level analyses for PAHs, such that additional characterization of PAH bioavailability was not conducted for these samples. Ten sediment samples having a wide range in total PAH concentrations were selected for characterization of PAH bioavailability and potential toxicity to sensitive benthic invertebrates such as the fresh water amphipod *H. azteca*. The samples tested ranged in PAH_{16} from 9.2 to 17,900 mg/kg. Characterization of bioavailable PAHs determined by measuring the dissolved concentrations of 34 PAHs in porewater extracted from the sediment indicated that samples having PAH_{16} concentrations exceeding 285 mg/kg PAH_{16} are likely to be toxic to benthic aquatic organisms in laboratory toxicity tests. One sample, MH11, was determined to have a dissolved PAH concentration in an intermediate range for which a prediction of toxicity is uncertain. This sample was observed to have a sediment PAH_{16} concentration of 247 mg/kg. Three sediment samples, all having less than 66 mg/kg PAH_{16}, were predicted to be nontoxic to *H. azteca*. Sediment samples exhibiting high concentrations of bioavailable PAHs and expected to be toxic were geographically centered in the area located just north of the bridge crossing the study area. Sediment samples further downgradient (approx 500 feet north of the bridge) were highly variable in PAH concentrations, having a wide range when measured in both the bulk sediment and extracted sediment porewater.

If you have any questions regarding the information presented in this report, please do not hesitate to contact me at (607) 277-5716.

Sincerely yours,

Joseph Kreitinger, Ph.D.
Toxicologist
JKreitinger@ensr.aecom.com

Helen Jones by [illegible]

Helen Jones
Geochemist
HJones@ensr.aecom.com

Attachments: Tables 1, 2, 3, 4, and 5. Figures 1, 2, 3, 4, and 5.

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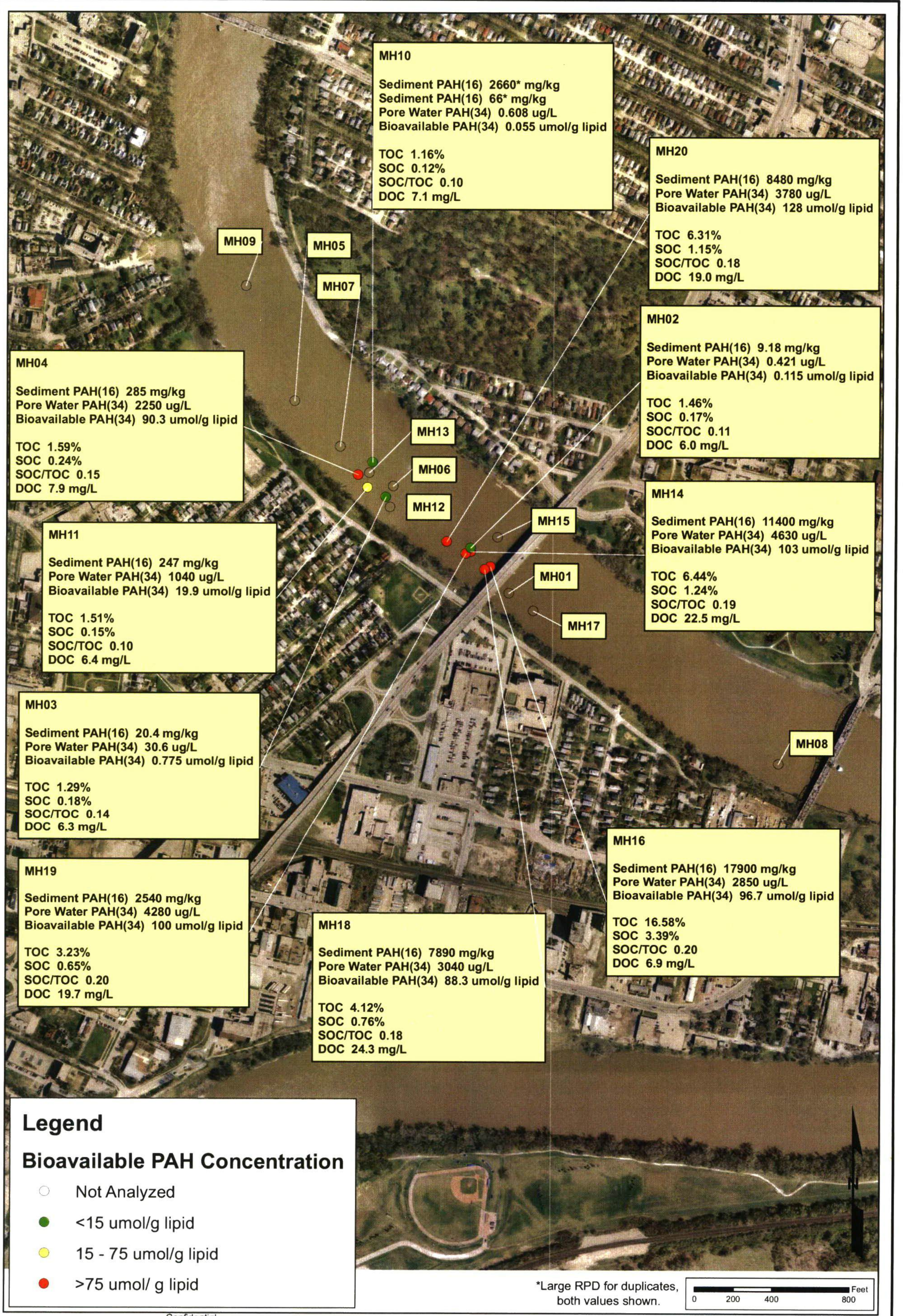
U.S. EPA. 2003. Equilibrium partitioning sediment guidelines (ESGs) for the protection of benthic organisms: PAH mixtures. U.S. Environmental Protection Agency Office of Science and Technology and Office of Research and Development.

Figures



MH10

Sediment PAH(16) 2660* mg/kg
Sediment PAH(16) 66* mg/kg
Pore Water PAH(34) 0.608 ug/L
Bioavailable PAH(34) 0.055 umol/g lipid

TOC 1.16%
SOC 0.12%
SOC/TOC 0.10
DOC 7.1 mg/L

MH20

Sediment PAH(16) 8480 mg/kg
Pore Water PAH(34) 3780 ug/L
Bioavailable PAH(34) 128 umol/g lipid

TOC 6.31%
SOC 1.15%
SOC/TOC 0.18
DOC 19.0 mg/L

MH02

Sediment PAH(16) 9.18 mg/kg
Pore Water PAH(34) 0.421 ug/L
Bioavailable PAH(34) 0.115 umol/g lipid

TOC 1.46%
SOC 0.17%
SOC/TOC 0.11
DOC 6.0 mg/L

MH04

Sediment PAH(16) 285 mg/kg
Pore Water PAH(34) 2250 ug/L
Bioavailable PAH(34) 90.3 umol/g lipid

TOC 1.59%
SOC 0.24%
SOC/TOC 0.15
DOC 7.9 mg/L

MH14

Sediment PAH(16) 11400 mg/kg
Pore Water PAH(34) 4630 ug/L
Bioavailable PAH(34) 103 umol/g lipid

TOC 6.44%
SOC 1.24%
SOC/TOC 0.19
DOC 22.5 mg/L

MH11

Sediment PAH(16) 247 mg/kg
Pore Water PAH(34) 1040 ug/L
Bioavailable PAH(34) 19.9 umol/g lipid

TOC 1.51%
SOC 0.15%
SOC/TOC 0.10
DOC 6.4 mg/L

MH03

Sediment PAH(16) 20.4 mg/kg
Pore Water PAH(34) 30.6 ug/L
Bioavailable PAH(34) 0.775 umol/g lipid

TOC 1.29%
SOC 0.18%
SOC/TOC 0.14
DOC 6.3 mg/L

MH16

Sediment PAH(16) 17900 mg/kg
Pore Water PAH(34) 2850 ug/L
Bioavailable PAH(34) 96.7 umol/g lipid

TOC 16.58%
SOC 3.39%
SOC/TOC 0.20
DOC 6.9 mg/L

MH19

Sediment PAH(16) 2540 mg/kg
Pore Water PAH(34) 4280 ug/L
Bioavailable PAH(34) 100 umol/g lipid

TOC 3.23%
SOC 0.65%
SOC/TOC 0.20
DOC 19.7 mg/L

MH18

Sediment PAH(16) 7890 mg/kg
Pore Water PAH(34) 3040 ug/L
Bioavailable PAH(34) 88.3 umol/g lipid

TOC 4.12%
SOC 0.76%
SOC/TOC 0.18
DOC 24.3 mg/L

Legend

Bioavailable PAH Concentration

- ○ Not Analyzed
- 🟢 <15 umol/g lipid
- 🟡 15 - 75 umol/g lipid
- 🔴 >75 umol/ g lipid

*Large RPD for duplicates,
both values shown.

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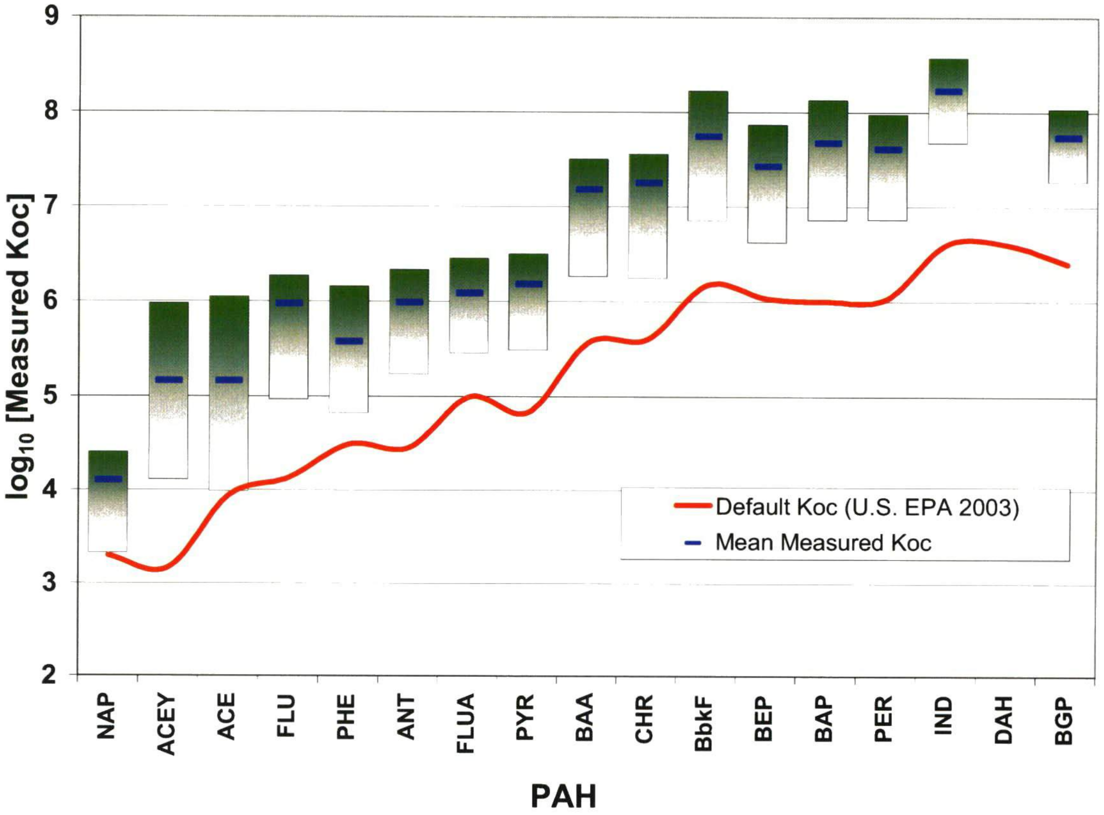
and/or Work Product Doctrines

ENSR | AECOM

Merged with ENSR in 2007
RETEC

Sutherland Avenue Red River Manitoba Hydro, Winnipeg, MB	Total PAH 16, Pore Water PAH, and Carbon Data
DATE: 9/24/07 | DRWN: HAJ/lth | Revision: 0	FIGURE 1

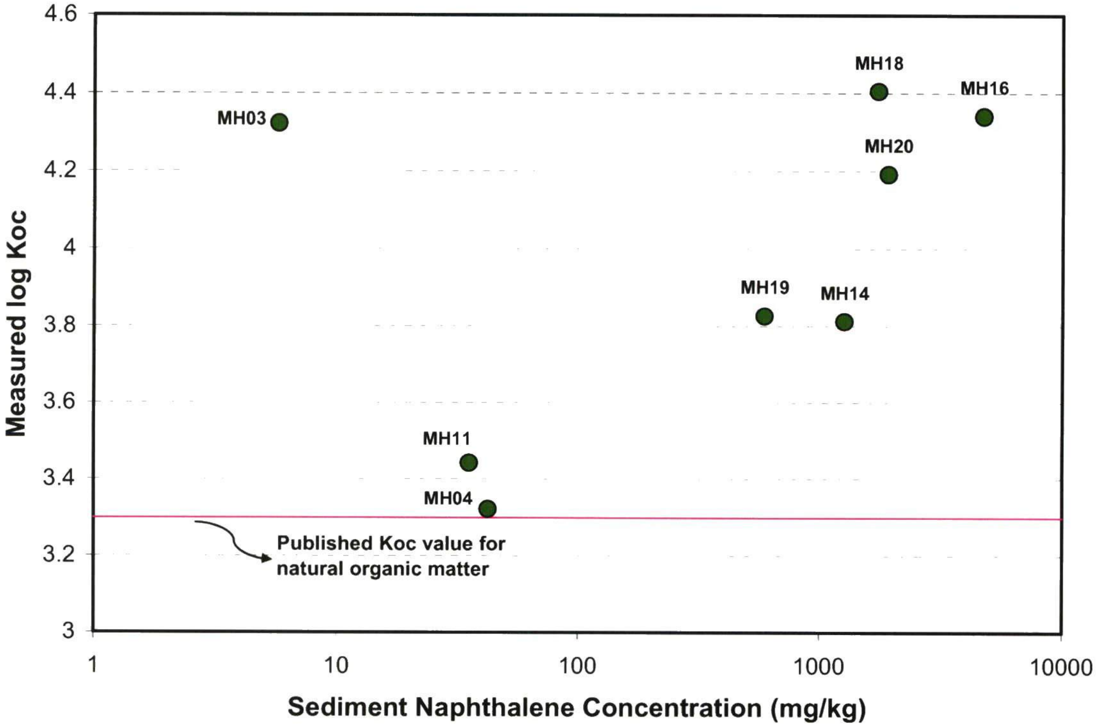
Figure 2: Measured organic carbon-water partitioning coefficients (Koc) for Red River sediment samples compared to default values generally used for estimating risk to benthic macroinvertebrates. Bars represent the minimum to maximum measured Koc values for each PAH.



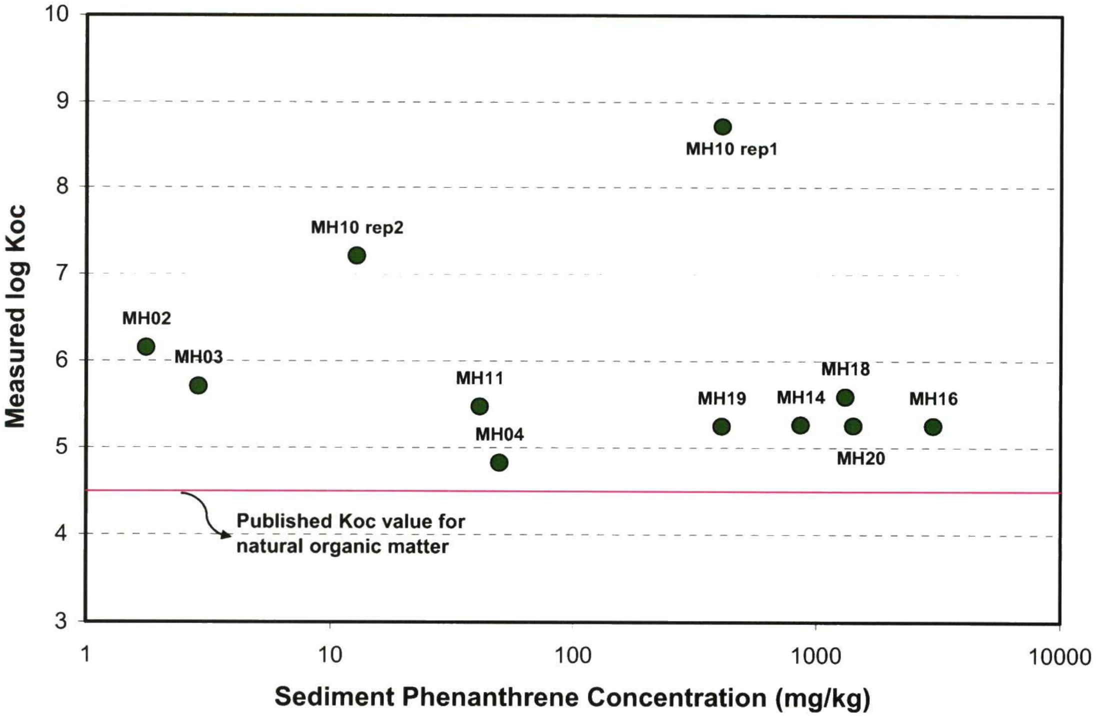
Note: MH10 was not included in the calculation of Koc values due to sample heterogeneity.

Figure 3: Measured organic carbon-water partitioning coefficients (Koc) for naphthalene and phenanthrene compared to default U.S. EPA values (U.S. EPA, 2003)[1].

a. Naphthalene



b. Phenanthrene



[1] U.S. EPA. 2003. Equilibrium partitioning sediment benchmarks (ESBs) for the protection of benthic organisms: PAH mixtures. U.S. Environmental Protection Agency Office of Science and Technology and Office of Research and Development.

Figure 4: Expected % bioavailability compared to Total sediment PAH_{16} concentrations.

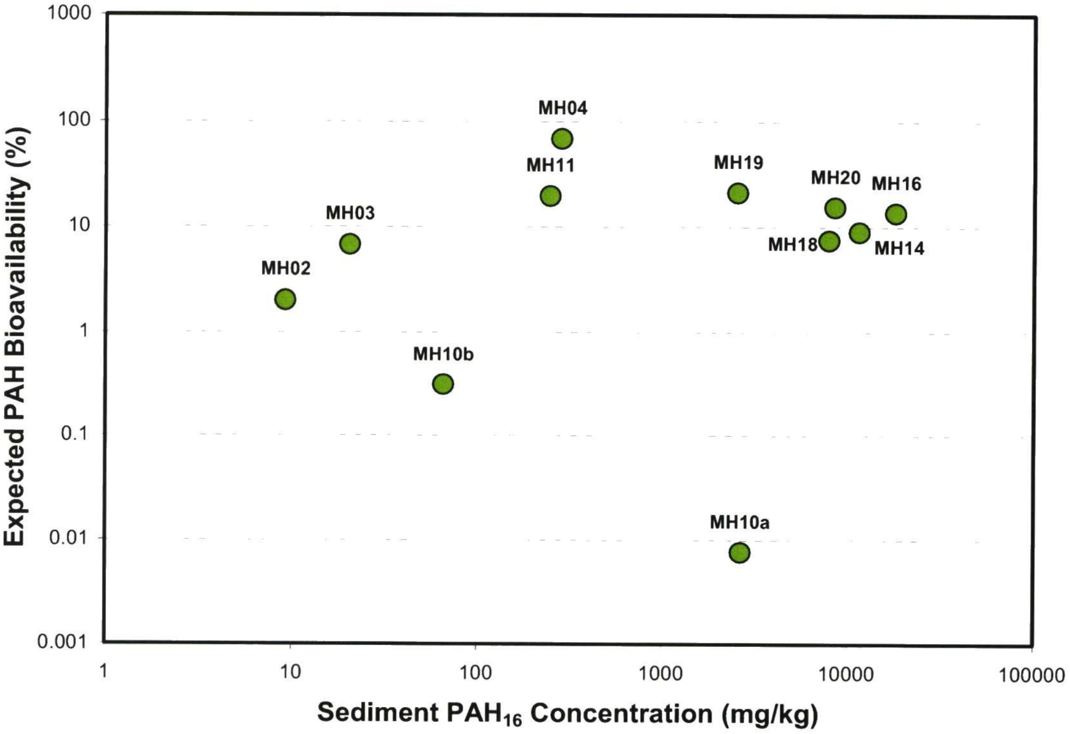
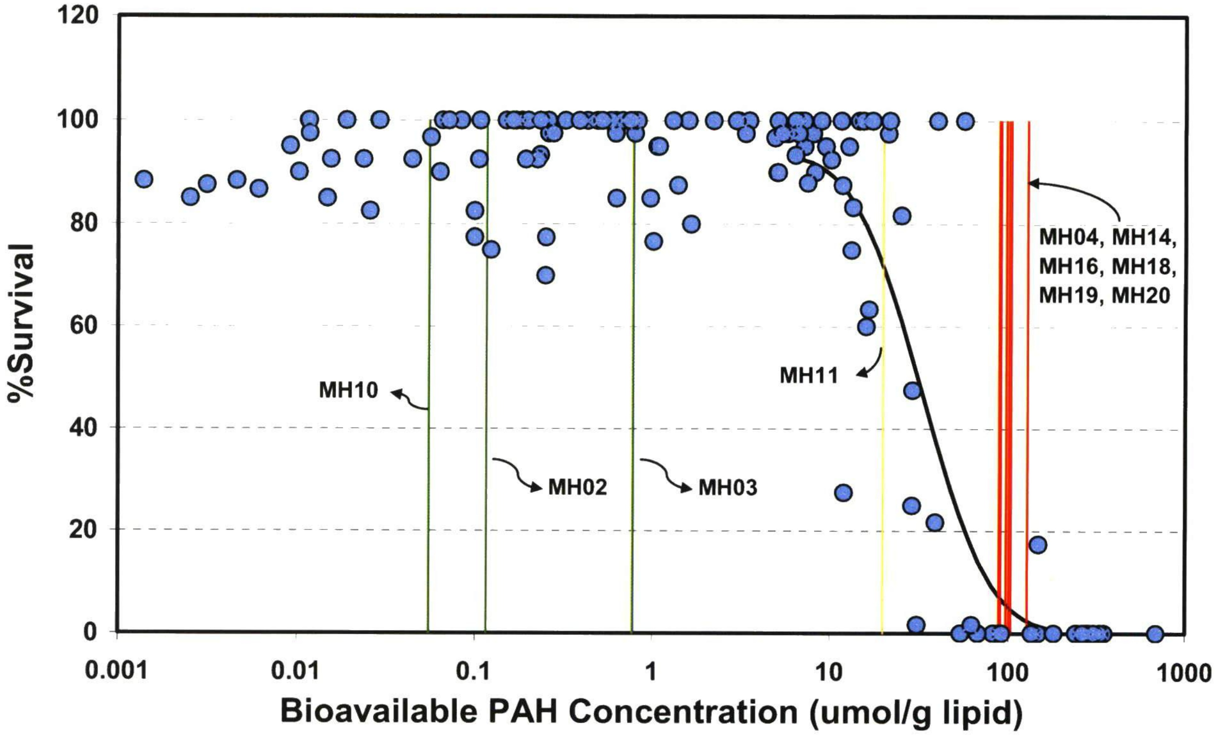


Figure 5: Bioavailable PAH (µmol/g lipid) concentrations for Red River sediment samples compared to *H. azteca* survival (28-day) and bioavailable PAH (µmol/g lipid) concentrations for 133 sediment samples from the SCBA database.



Tables

Table 1
Sediment Sample Locations
Manitoba Hydro
Sutherland Avenue MGP Site

Sample ID	Database ID	Selected for Detailed Chemical Analysis	Latitude(1)	Longitude(1)	Water Depth (m)	Field Description
SED-0807-T2.2-A	MH01		49 54 28.41120	-97 7 14.86829	4.6	Brown-grey fine SILT and gravel, no odor, no sheen
SED-0807-3.4-A	MH02	✔	49 54 30.75767	-97 7 17.78561	6.2	Grey-brown SILT, trace gravel, trace sheen, no odor
SED-0807-5.2-A	MH03	✔	49 54 33.48867	-97 7 24.44876	5.4	Grey-brown SILT, trace gravel, no sheen, no odor
SED-0807-6.2-A	MH04	✔	49 54 34.65707	-97 7 26.60970	6.2	Grey-brown SILT and CLAY, black staining, heavy sheen, strong hydrocarbon-like odor
SED-0807-7.2-A	MH05		49 54 38.49220	-97 7 31.47530	6.8	Grey-brown SILT and clay, black staining, no sheen, no odor
SED-0807-NSC1-A	MH06		49 54 34.02907	-97 7 23.82607	6.1	Grey-brown SILT, trace gravel, no sheen, no odor
SED-0807-NSC2-A	MH07		49 54 36.13608	-97 7 27.95633	6.6	Brown-grey SILT, clay, some black staining, no sheen, no odor, sheens on water surface at location in river
SED-0807-UP1.1-A	MH08		49 54 19.35889	-97 6 53.86106	6.4	Brown fine grained SAND with silt, no sheen, no odor
SED-0807-NSC3-A	MH09		49 54 44.34741	-97 7 35.10948	7.7	Grey CLAY with silt, trace gravel, no sheen, no odor
SED-0807-6.2B-A	MH10	✔	49 54 35.28562	-97 7 25.43202	5.3	Brown fine grained SAND with silt, gravel, cobbles, trace sheen and hydrocarbon-like odor, green chironomids present
SED-0807-6.2C-A	MH11	✔	49 54 33.99765	-97 7 25.88315	5.9	Grey SILT and CLAY, trace fine grain sand, trace gravel, black staining, heavy sheen, strong hydrocarbon-like odor
SED-0807-6.2D-A	MH12		49 54 32.96520	-97 7 24.11808	5.0	Grey, brown, black SILT and CLAY, trace gravel, some organic matter, no sheen, no odor
SED-0807-6.2E-A	MH13		49 54 34.73953	-97 7 25.70393	5.3	Brown SILT, trace gravel, trace black staining, no sheen, no odor
SED-0807-2.2B-A	MH14	✔	49 54 30.56350	-97 7 17.79315	5.5	Grey SILT, clay, trace gravel, suspected coal tar, heavy sheen, strong hydrocarbon-like odor
SED-0807-2.3B-A	MH15		49 54 31.27366	-97 7 15.65960	6.6	Grey-black SILT and CLAY, moderate gravel, trace sheen, no odor
SED-0807-2.2C-A	MH16	✔	49 54 29.76161	-97 7 16.26992	5.9	Grey SILT, trace gravel, suspected coal tar, heavy sheen, strong hydrocarbon-like odor
SED-0807-1.4-A	MH17		49 54 27.47335	-97 7 12.94925	5.7	Grey SILT and CLAY, coarse gravel, no sheen, no odor
SED-0807-2.2E-A	MH18	✔	49 54 29.63948	-97 7 16.72593	4.9	SILT, trace fine to coarse grained gravel, suspected coal tar, heavy sheen, strong hydrocarbon-like odor
SED-0807-2.2F-A	MH19	✔	49 54 30.47292	-97 7 18.19780	5	SILT, trace clay, suspected coal tar, heavy sheen, strong hydrocarbon-like odor
SED-0807-2.2G-A	MH20	✔	49 54 31.11218	-97 7 19.67723	4.3	Grey SILT, trace clay, trace gravel, suspected coal tar, some black staining, heavy sheen, strong hydrocarbon-like odor

(1)GPS latitude and longitude are in NAD 1983 degrees, minutes, seconds

Table 2
Field Water Quality Measurements
Manitoba Hydro
Sutherland Avenue MGP Site

Sample Station Designation	Water Column Position	Temperature (ºC)	Dissolved Oxygen (mg/L)	Conductivity (uS/cm)	pH
MH01	near surface	18.9	11.4	752	8.4
	near bottom	18.8	10.3	752	8.4
MH02	near surface	18.8	11.0	752	8.4
	near bottom	18.8	10.5	751	8.5
MH03	near surface	18.9	11.3	752	8.5
	near bottom	18.8	10.4	752	8.5
MH04	near surface	19.0	11.3	753	8.5
	near bottom	18.8	10.2	751	8.4
MH05	near surface	18.9	10.8	752	8.4
	near bottom	18.8	10.1	751	8.4
MH06	near surface	19.0	10.9	762	8.3
	near bottom	19.8	10.1	751	8.2
MH07	near surface	19.2	11.6	754	8.4
	near bottom	18.8	10.2	752	8.2
MH08	near surface	18.7	9.9	746	8.1
	near bottom	18.7	9.8	746	8.2
MH09	near surface	18.8	10.3	747	8.4
	near bottom	18.8	10.1	747	8.4
MH10	near surface	18.8	10.2	747	8.6
	near bottom	18.7	9.9	747	8.6
MH11	near surface	18.9	10.5	747	8.5
	near bottom	18.7	9.9	747	8.5
MH12	near surface	18.9	10.5	748	8.5
	near bottom	18.7	10.3	747	8.4
MH13	near surface	19.2	12.2	750	8.0
	near bottom	18.8	10.9	745	7.7
MH14	near surface	19.3	11.7	754	8.5
	near bottom	19.0	11.6	750	8.4
MH15	near surface	18.9	10.4	750	8.6
	near bottom	18.8	10.8	748	8.5
MH16	near surface	19.2	10.7	754	8.7
	near bottom	18.9	11.6	751	8.6
MH17	near surface	19.1	11.3	752	8.7
	near bottom	18.8	10.8	749	8.6
MH18	near surface	19.0	11.5	753	8.7
	near bottom	18.8	10.9	749	8.6
MH19	near surface	19.1	11.7	752	8.7
	near bottom	19.0	11.3	751	8.7
MH20	near surface	19.1	11.9	752	8.7
	near bottom	19.0	11.6	752	8.7

Table 3
PAH Screening Data
Manitoba Hydro
Sutherland Avenue MGP Site

Sample ID	Database ID	Selected For Detailed Chemical Analysis	Total PAH_{16}(1) (EPA 16)	Total PAH_{34}(2) (NOAA 34)	Ratio $\text{PAH}_{16}/\text{PAH}_{34}$
			mg/kg Wet Weight	mg/kg Wet Weight	
SED-0807-T2.2-A	MH01		0.69	1.7	0.40
SED-0807-3.4-A	MH02	✓	1.6	1.9	0.82
SED-0807-5.2-A	MH03	✓	6.5	8.6	0.76
SED-0807-6.2-A	MH04	✓	110	190	0.58
SED-0807-7.2-A	MH05		0.72	1.0	0.70
SED-0807-NSC1-A	MH06		1.1	1.3	0.80
SED-0807-NSC2-A	MH07		0.62	0.86	0.72
SED-0807-UP1.1-A	MH08		0.15	0.30	0.51
SED-0807-NSC3-A	MH09		0.26	0.44	0.59
SED-0807-6.2B-A	MH10	✓	1.5	2.0	0.74
SED-0807-6.2C-A	MH11	✓	13	17	0.74
SED-0807-6.2D-A	MH12		0.35	0.57	0.62
SED-0807-6.2E-A	MH13		0.80	1.0	0.77
SED-0807-2.2B-A	MH14	✓	490	700	0.70
SED-0807-2.3B-A	MH15		0.46	0.62	0.73
SED-0807-2.2C-A	MH16	✓	2700	4400	0.61
SED-0807-1.4-A	MH17		0.75	1.0	0.75
SED-0807-2.2E-A	MH18	✓	1300	2000	0.65
SED-0807-2.2F-A	MH19	✓	247	343	0.72
SED-0807-2.2G-A	MH20	✓	1600	2400	0.67

(1) Sum of 16 EPA priority pollutant PAHs noted below with an asterisk.

(2) Sum of 34 PAHs includes 18 parent and 16 groups of alkylated PAHs: naphthalene*, C1 naphthalenes, C2 naphthalenes, C3 naphthalenes, C4 naphthalenes, acenaphthylene*, acenaphthene*, fluorene*, C1 fluorenes,C2 fluorenes, C3 fluorenes, phenanthrene*, anthracene*, C1 phenanthrenes/anthracenes, C2 phenanthrenes/anthracenes, C3 phenanthrenes/anthracenes, C4 phenanthrenes/anthracenes, fluoranthene*, pyrene*, C1 fluoranthenes/pyrenes, benz[a]anthracene*, chrysene*, C1 chrysenes, C2 chrysenes, C3 chrysenes, C4 chrysenes, benzo[b]fluoranthene*, benzo[k]fluoranthene*, benzo[e]pyrene, benzo[a]pyrene*, perylene, indeno[1,2,3-cd]pyrene*, dibenz[ah]anthracene*, benzo[ghi]perylene*.

*Note that these screening-level measurements were made using sonication to provide a rapid evaluation of PAH concentrations used to sub-select samples for detailed characterization. The results are not considered final concentrations values and should not be used to provide site characterization or interpretations of PAH bioavailability.

Table 4
Bulk Sediment Total PAH Concentrations
Manitoba Hydro
Sutherland Avenue MGP Site

	MH02			MH03			MH04			MH10			MH11		
Sediment PAH's (mg/kg)	**Rep 1**	**Rep 2**	**Mean**	**Rep 1**	**Rep 2**	**Mean**	**Rep 1**	**Rep 2**	**Mean**	**Rep 1**	**Rep 2**	**Mean**	**Rep 1**	**Rep 2**	**Mean**
naphthalene	2.16	2.06	2.11	5.50	5.98	5.74	41.3	43.5	42.4	143	3.58	73.2	35.7	35.1	35.4
2-methylnaphthalene	0.524	0.489	0.506	0.431	0.517	0.474	18.2	19.4	18.8	114	2.36	58.1	7.59	9.46	8.52
1-methylnaphthalene	0.304	0.280	0.292	0.549	0.653	0.601	16.4	16.9	16.6	62.6	1.26	32.0	6.47	7.31	6.89
C2 naphthalenes	1.99	1.52	1.75	2.66	2.91	2.79	40.2	40.6	40.4	195	4.87	100	15.2	19.6	17.4
C3 naphthalenes	1.03	0.910	0.968	2.64	2.70	2.67	16.0	15.7	15.8	84.5	3.83	44.2	7.57	9.49	8.53
C4 naphthalenes	ND	ND	ND	ND	ND	ND	11.4	10.8	11.1	52.0	4.26	28.1	7.52	8.43	7.98
acenaphthylene	0.963	0.911	0.937	0.688	0.875	0.781	4.28	3.91	4.10	127	3.35	65.1	2.24	3.52	2.88
acenaphthene	0.289	0.258	0.273	0.983	1.38	1.18	36.0	35.7	35.8	52.2	1.22	26.7	17.4	21.5	19.5
fluorene	0.445	0.420	0.433	0.561	0.841	0.701	10.7	10.9	10.8	121	2.81	62.0	8.49	11.4	10.0
C1 fluorenes	1.39	1.39	1.39	1.38	1.56	1.47	12.8	13.0	12.9	95.1	2.58	48.8	6.77	9.35	8.06
C2 fluorenes	1.66	1.68	1.67	1.70	1.89	1.79	12.3	11.3	11.8	121	3.37	62.3	8.51	11.6	10.0
C3 fluorenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
phenanthrene	1.61	1.91	1.76	2.01	3.74	2.88	50.5	48.5	49.5	407	12.7	12.7	33.3	48.9	41.1
anthracene	0.485	0.569	0.527	0.979	1.84	1.41	23.6	22.8	23.2	361	9.12	185	18.1	26.3	22.2
C1 phenanthrenes/anthracenes	1.46	1.52	1.49	1.48	2.36	1.92	32.6	31.0	31.8	251	5.61	128	14.9	22.8	18.9
C2 phenanthrenes/anthracenes	2.81	2.94	2.87	2.96	4.51	3.74	50.1	48.7	49.4	439	9.68	224	26.4	39.6	33.0
C3 phenanthrenes/anthracenes	1.15	1.17	1.16	ND	ND	ND	16.6	15.4	16.0	133	2.78	67.8	8.09	11.8	9.9
C4 phenanthrenes/anthracenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	26.1	ND	26.1	ND	ND	ND
fluoranthene	0.786	0.879	0.833	1.15	2.63	1.89	24.4	22.8	23.6	232	7.77	120	22.5	33.5	28.0
pyrene	0.602	0.667	0.635	0.933	2.16	1.54	32.3	30.1	31.2	252	6.38	129	19.5	29.0	24.2
C1 fluoranthenes/pyrenes	0.555	0.557	0.556	0.762	1.90	1.33	26.6	25.7	26.1	318	5.69	162	17.0	26.2	21.6
benz[a]anthracene	0.308	0.296	0.302	0.412	1.12	0.767	11.6	10.5	11.1	140	3.19	71.8	9.03	13.9	11.5
chrysene	0.266	0.255	0.260	0.446	0.944	0.695	10.8	10.2	10.5	205	4.34	105	7.59	11.7	9.7
C1 chrysenes	0.491	0.447	0.469	0.659	1.55	1.10	18.1	16.4	17.2	210	4.19	107	14.0	19.8	16.9
C2 chrysenes	ND	ND	ND	ND	ND	ND	10.5	9.48	9.97	108	2.34	55.0	6.68	9.80	8.24
C3 chrysenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	49.6	ND	49.6	ND	ND	ND
C4 chrysenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
benzo[b+k]fluoranthene	0.339	0.312	0.326	0.476	1.22	0.846	11.3	10.1	10.7	167	3.35	85.3	9.27	15.1	12.2
benzo[e]pyrene	0.113	0.107	0.110	0.163	0.402	0.283	5.50	4.79	5.15	57.4	1.09	29.2	3.08	5.19	4.13
benzo[a]pyrene	0.292	0.280	0.286	0.409	1.07	0.739	13.3	12.2	12.8	149	3.02	76.0	8.68	14.1	11.4
perylene	0.173	0.172	0.172	0.195	0.389	0.292	2.69	2.51	2.60	38.5	0.83	19.7	2.35	3.65	3.00
indeno[1,2,3-cd]pyrene	0.306	0.291	0.299	0.422	1.08	0.749	11.4	10.8	11.1	181	2.93	92.1	9.02	14.1	11.5
dibenz[ah]anthracene	0.055	0.059	0.057	0.071	0.184	0.128	1.57	1.47	1.52	43.5	0.53	22.0	1.62	2.23	1.92
benzo[ghi]perylene	0.145	0.136	0.141	0.203	0.512	0.357	6.97	6.20	6.59	79.0	1.34	40.2	4.16	6.56	5.36
Total PAH_{16} (mg/kg)	9.05	9.30	9.18	15.3	25.6	20.4	290	280	285	2660	66	1360	206	287	247
Total PAH_{34} (mg/kg)	22.7	22.5	22.6	30.8	46.9	38.9	580	561	570	5020	120	2570	359	501	430
Ratio PAH_{16}/PAH_{34}	0.40	0.41	0.41	0.49	0.55	0.53	0.50	0.50	0.50	0.53	0.55	0.53	0.58	0.57	0.57
%Total Organic Carbon (TOC)	1.46	NA	NA	1.29	NA	NA	1.59	NA	NA	1.16	NA	NA	1.51	NA	NA
%Soot Carbon (SOC)	0.17	NA	NA	0.18	NA	NA	0.24	NA	NA	0.12	NA	NA	0.15	NA	NA
Ratio SOC/TOC	0.11	NA	NA	0.14	NA	NA	0.15	NA	NA	0.10	NA	NA	0.10	NA	NA

ND - Non detected
NA - Not Applicable

Table 4
Bulk Sediment Total PAH Concentrations
Manitoba Hydro
Sutherland Avenue MGP Site

	MH14			MH16			MH18			MH19			MH20		
Sediment PAH's (mg/kg)	**Mean**	**Std Dev.**	**N**	**Rep 1**	**Rep 2**	**Mean**	**Rep 1**	**Rep 2**	**Mean**	**Rep 1**	**Rep 2**	**Mean**	**Rep 1**	**Rep 2**	**Mean**
naphthalene	1260	1040	4	4890	4500	4690	2420	1050	1730	574	606	590	1880	1930	1900
2-methylnaphthalene	378	334	4	1320	1220	1270	686	246	466	150	147	149	488	519	504
1-methylnaphthalene	207	183	4	707	644	676	360	128	244	77.4	75.6	76.5	251	267	259
C2 naphthalenes	409	364	4	1420	1300	1360	721	247	484	150	145	147	489	533	511
C3 naphthalenes	152	136	4	535	499	517	267	92.4	179	56.7	54.4	55.6	178	196	187
C4 naphthalenes	87.9	78.6	4	312	296	304	154	54.5	104	32.9	31.4	32.1	99.5	113	106
acenaphthylene	377	341	4	1460	1280	1370	754	272	513	154	148	151	439	429	434
acenaphthene	105	77.9	4	291	273	282	226	76.5	151	41.2	38.1	39.7	270	296	283
fluorene	272	243	4	836	734	785	495	181	338	115	107	111	345	371	358
C1 fluorenes	157	145	4	488	441	464	274	95.6	185	58.2	54.1	56.1	177	198	188
C2 fluorenes	216	203	4	653	580	616	376	130	253	81.0	74.4	77.7	237	279	258
C3 fluorenes	ND	ND	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
phenanthrene	859	698	4	3230	2760	2990	1880	745	1310	422	394	408	1373	1457	1415
anthracene	441	384	4	1880	1620	1750	920	366	643	185	177	181	737	956	847
C1 phenanthrenes/anthracenes	451	407	4	1500	1310	1410	810	274	542	175	161	168	537	610	574
C2 phenanthrenes/anthracenes	730	687	4	2430	2150	2290	1310	396	852	241	227	234	836	950	893
C3 phenanthrenes/anthracenes	216	202	4	776	701	739	422	140	281	72.3	67.5	69.9	264	301	283
C4 phenanthrenes/anthracenes	82.7	16.2	2	157	153	155	90	38.7	64	ND	ND	ND	64.2	71.8	68.0
fluoranthene	450	347	4	1060	888	975	981	403	692	257	245	251	600	580	590
pyrene	481	403	4	907	874	891	981	380	681	221	212	216	690	593	642
C1 fluoranthenes/pyrenes	523	489	4	961	951	956	955	316	636	183	174	179	616	560	588
benz[a]anthracene	236	201	4	620	608	614	416	169	293	106	103	104	310	332	321
chrysene	209	188	4	688	645	667	375	139	257	82.4	77.1	79.7	270	317	294
C1 chrysenes	348	309	4	916	920	918	598	224	411	135	133	134	422	465	443
C2 chrysenes	159	141	4	435	441	438	285	110	198	59.2	57.3	58.3	198	219	209
C3 chrysenes	148	42.3	4	267	436	351	180	56.4	118	ND	ND	ND	128	201	164
C4 chrysenes	ND	ND	4	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
benzo[b+k]fluoranthene	291	267	4	777	658	718	537	191	364	111	116	113	412	398	405
benzo[e]pyrene	96.4	88.0	4	259	220	240	179	63.8	121	37.2	39.0	38.1	138	137	137
benzo[a]pyrene	261	238	4	740	627	684	518	184	351	98.1	103	101	397	385	391
perylene	57.1	49.3	4	212	202	207	102	39.4	70.7	25.8	27.6	26.7	84.2	87.7	86.0
indeno[1,2,3-cd]pyrene	294	262	4	926	802	864	492	175	333	130	122	126	322	379	351
dibenz[ah]anthracene	51.5	46.1	4	202	176	189	116	39.5	77.8	21.0	16.4	18.7	74.0	87.4	80.7
benzo[ghi]perylene	129	120	4	432	371	401	228	82.2	155	51.6	48.6	50.1	151	176	164
Total PAH_{16} (mg/kg)	11400	4340	4	18900	16800	17900	11300	4450	7890	2570	2510	2540	8270	8680	8480
Total PAH_{34} (mg/kg)	20000	8000	4	32300	29300	30800	19100	7100	13100	4100	3980	4040	13500	14400	13900
Ratio PAH_{16}/PAH_{34}	0.57	0.01	4	0.59	0.57	0.58	0.59	0.63	0.60	0.63	0.63	0.63	0.61	0.60	0.61
%Total Organic Carbon (TOC)	6.44	NA	NA	16.58	NA	NA	4.12	NA	NA	3.23	NA	NA	6.31	NA	NA
%Soot Carbon (SOC)	1.24	NA	NA	3.39	NA	NA	0.76	NA	NA	0.65	NA	NA	1.15	NA	NA
Ratio SOC/TOC	0.19	NA	NA	0.20	NA	NA	0.18	NA	NA	0.20	NA	NA	0.18	NA	NA

ND - Non detected
NA - Not Applicable

Table 5
Bioavailable PAH Concentrations
Manitoba Hydro
Sutherland Avenue MGP Site

	MH02			MH03			MH04			MH10			MH11		
Sediment SPME Pore Water PAHs (µg/L)	**Rep 1**	**Rep 2**	**Mean**	**Rep 1**	**Rep 2**	**Mean**	**Rep 1**	**Rep 2**	**Mean**	**Mean**	**Std Dev**	**N**	**Rep 1**	**Rep 2**	**Mean**
naphthalene	ND	ND	ND	21.4	20.9	21.1	1350	1200	1280	ND	ND	4	854	838	846
2-methylnaphthalene	ND	ND	ND	0.732	0.732	0.732	162	171	166	ND	ND	4	35.6	34.1	34.9
1-methylnaphthalene	ND	ND	ND	2.27	2.24	2.26	217	231	224	0.098	0.006	4	47.7	46.3	47.0
C2 naphthalenes	ND	ND	ND	1.25	1.29	1.27	168	176	172	0.461	0.028	4	23.8	24.1	24.0
C3 naphthalenes	ND	ND	ND	0.237	0.284	0.260	50.5	54.0	52.2	ND	ND	4	4.92	5.01	4.96
C4 naphthalenes	ND	ND	ND	ND	ND	ND	11.8	12.7	12.3	ND	ND	4	0.646	0.790	0.718
acenaphthylene	ND	ND	ND	0.589	0.619	0.604	0.241	0.304	0.272	0.014	ND	4	10.0	11.7	10.9
acenaphthene	0.014	0.020	0.017	2.84	2.82	2.83	228	241	234	0.152	0.004	4	57.3	55.8	56.6
fluorene	0.025	0.022	0.023	0.571	0.597	0.584	3.27	3.60	3.44	0.038	0.027	4	0.446	0.497	0.471
C1 fluorenes	ND	ND	ND	0.182	0.196	0.189	13.1	13.7	13.4	0.132	0.025	4	1.93	1.84	1.89
C2 fluorenes	ND	ND	ND	ND	ND	ND	3.84	3.89	3.87	ND	ND	4	0.242	0.283	0.263
C3 fluorenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	ND	ND	ND
phenanthrene	0.085	0.084	0.085	0.408	0.463	0.435	45.3	47.8	46.5	0.068	0.020	4	9.19	8.96	9.07
anthracene	0.020	0.013	0.017	0.070	0.073	0.072	8.31	8.66	8.49	ND	ND	4	1.22	1.23	1.23
C1 phenanthrenes/anthracenes	0.152	0.092	0.122	0.106	0.127	0.117	13.2	13.8	13.5	ND	ND	4	1.12	0.980	1.05
C2 phenanthrenes/anthracenes	ND	ND	ND	ND	ND	ND	4.28	4.79	4.53	ND	ND	4	ND	ND	ND
C3 phenanthrenes/anthracenes	ND	ND	ND	ND	ND	ND	1.16	1.09	1.13	ND	ND	4	ND	ND	ND
C4 phenanthrenes/anthracenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	ND	ND	ND
fluoranthene	0.091	ND	0.091	0.060	0.070	0.065	4.94	5.38	5.16	ND	ND	4	0.680	0.629	0.655
pyrene	0.082	0.016	0.049	0.043	0.048	0.046	6.10	6.63	6.37	0.022	0.009	4	0.523	0.492	0.507
C1 fluoranthenes/pyrenes	0.053	0.032	0.042	ND	ND	ND	2.46	2.81	2.64	ND	ND	4	0.138	0.134	0.136
benz[a]anthracene	0.012	0.011	0.012	ND	ND	ND	0.297	0.394	0.345	ND	ND	4	0.024	0.024	0.024
chrysene	0.009	0.008	0.008	ND	ND	ND	0.338	0.426	0.382	ND	ND	4	0.021	0.021	0.021
C1 chrysenes	ND	ND	ND	ND	ND	ND	0.053	0.074	0.064	ND	ND	4	ND	ND	ND
C2 chrysenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	ND	ND	ND
C3 chrysenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	ND	ND	ND
C4 chrysenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	ND	ND	ND
benzo[b+k]fluoranthene	ND	ND	ND	ND	ND	ND	0.073	0.117	0.095	ND	ND	4	ND	ND	ND
benzo[e]pyrene	ND	ND	ND	ND	ND	ND	0.065	0.090	0.078	ND	ND	4	ND	ND	ND
benzo[a]pyrene	ND	ND	ND	ND	ND	ND	0.091	0.135	0.113	ND	ND	4	ND	ND	ND
perylene	ND	ND	ND	ND	ND	ND	0.018	0.027	0.023	ND	ND	4	ND	ND	ND
indeno[1,2,3-cd]pyrene	ND	ND	ND	ND	ND	ND	0.012	0.018	0.015	ND	ND	4	ND	ND	ND
dibenz[ah]anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	4	ND	ND	ND
benzo[ghi]perylene	ND	ND	ND	ND	ND	ND	0.020	0.026	0.023	ND	ND	4	ND	ND	ND
SPME PAH_{34} (ug/L)	0.544	0.299	0.421	30.7	30.5	30.6	2290	2200	2250	0.608	0.462	4	1050	1030	1040
SPME Predicted Biota (umol/g lipid)	0.152	0.079	0.115	0.762	0.789	0.775	88.7	91.9	90.3	0.055	0.029	4	20.0	19.7	19.9
Dissolved Organic Carbon (mg/L)	6.0	NA	NA	6.3	NA	NA	7.9	NA	NA	7.1	NA	NA	6.4	NA	NA

ND - Non detected
NA - Not Applicable

Table 5
Bioavailable PAH Concentrations
Manitoba Hydro
Sutherland Avenue MGP Site

	MH14			MH16			MH18			MH19			MH20		
Sediment SPME Pore Water PAHs (µg/L)	**Rep 1**	**Rep 2**	**Mean**	**Rep 1**	**Rep 2**	**Mean**	**Rep 1**	**Rep 2**	**Mean**	**Rep 1**	**Rep 2**	**Mean**	**Rep 1**	**Rep 2**	**Mean**
naphthalene	3000	3050	3020	1240	1350	1290	1880	1430	1650	3360	2080	2720	1850	2030	1940
2-methylnaphthalene	512	509	511	452	452	452	430	391	411	504	469	486	505	535	520
1-methylnaphthalene	343	343	343	361	344	352	300	291	296	325	337	331	386	398	392
C2 naphthalenes	120	123	122	79.5	80.3	79.9	115	95.0	105	160	116	138	122	128	125
C3 naphthalenes	33.0	33.6	33.3	23.2	24.5	23.8	34.3	27.7	31.0	45.9	30.7	38.3	35.5	36.9	36.2
C4 naphthalenes	4.95	4.95	4.95	4.11	4.56	4.33	5.88	4.55	5.21	7.05	4.29	5.67	6.15	6.09	6.12
acenaphthylene	407	405	406	390	378	384	322	314	318	360	372	366	314	322	318
acenaphthene	64.3	64.1	64.2	58.5	56.1	57.3	67.5	65.6	66.6	64.2	65.2	64.7	189	197	193
fluorene	4.39	4.48	4.44	5.31	5.25	5.28	4.40	4.52	4.46	4.00	4.42	4.21	5.82	5.99	5.90
C1 fluorenes	16.0	16.0	16.0	19.3	19.0	19.2	16.0	15.7	15.8	15.9	14.9	15.4	21.1	21.6	21.3
C2 fluorenes	1.62	1.74	1.68	3.01	3.00	3.00	2.27	2.11	2.19	1.98	1.55	1.77	3.00	3.06	3.03
C3 fluorenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
phenanthrene	72.5	72.7	72.6	102	99.54	101	81.1	81.4	81.2	71.0	71.3	71.2	122	127	124
anthracene	11.3	11.5	11.4	16.4	16.0	16.2	13.3	13.2	13.2	11.2	10.8	11.0	19.0	19.8	19.4
C1 phenanthrenes/anthracenes	10.4	10.3	10.3	20.0	20.0	20.0	13.6	13.3	13.4	10.3	9.45	9.87	21.5	22.3	21.9
C2 phenanthrenes/anthracenes	1.75	1.80	1.78	4.69	5.40	5.05	2.90	2.90	2.90	1.90	1.52	1.71	5.32	5.51	5.42
C3 phenanthrenes/anthracenes	ND	ND	ND	1.00	1.17	1.09	0.501	0.415	0.458	ND	ND	ND	0.984	1.04	1.01
C4 phenanthrenes/anthracenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
fluoranthene	6.18	6.21	6.19	15.2	15.4	15.3	9.97	9.87	9.92	6.00	5.89	5.94	19.1	19.7	19.4
pyrene	4.34	4.38	4.36	12.1	12.4	12.3	7.71	7.62	7.67	4.29	4.13	4.21	15.0	15.6	15.3
C1 fluoranthenes/pyrenes	1.05	1.05	1.05	3.60	4.01	3.81	1.86	1.88	1.87	0.960	0.842	0.901	4.27	4.57	4.42
benz[a]anthracene	0.138	0.140	0.139	0.644	0.825	0.735	0.309	0.315	0.312	0.119	0.122	0.120	1.10	1.18	1.14
chrysene	0.087	0.094	0.090	0.421	0.554	0.488	0.200	0.210	0.205	0.093	0.086	0.090	0.757	0.793	0.775
C1 chrysenes	ND	ND	ND	0.083	0.117	0.100	0.027	0.028	0.028	ND	ND	ND	0.126	0.137	0.132
C2 chrysenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C3 chrysenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
C4 chrysenes	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
benzo[b+k]fluoranthene	ND	ND	ND	0.137	0.168	0.153	0.050	0.055	0.053	ND	ND	ND	0.301	0.331	0.316
benzo[e]pyrene	ND	ND	ND	0.067	0.109	0.088	0.038	0.043	0.040	ND	ND	ND	0.180	0.176	0.178
benzo[a]pyrene	ND	ND	ND	0.131	0.167	0.149	0.054	0.072	0.063	ND	ND	ND	0.285	0.345	0.315
perylene	ND	ND	ND	0.026	0.036	0.031	0.018	0.018	0.018	ND	ND	ND	0.059	0.077	0.068
indeno[1,2,3-cd]pyrene	ND	ND	ND	0.012	0.015	0.014	ND	ND	ND	ND	ND	ND	0.061	0.074	0.067
dibenz[ah]anthracene	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
benzo[ghi]perylene	ND	ND	ND	0.018	0.027	0.022	ND	ND	ND	ND	ND	ND	0.063	0.077	0.070
SPME PAH_{34} (ug/L)	4610	4660	4630	2810	2890	2850	3310	2770	3040	4960	3600	4280	3650	3900	3780
SPME Predicted Biota (umol/g lipid)	103	104	103	95.3	98.0	96.7	93.6	83.0	88.3	112	88.4	100	125	131	128
Dissolved Organic Carbon (mg/L)	22.5	NA	NA	6.9	NA	NA	24.3	NA	NA	19.7	NA	NA	19.0	NA	NA

ND - Non detected
NA - Not Applicable

APPENDIX F:
Human Health Risks Associated with Sediment Contact

Appendix F. Human Health Risks Associated with Sediment Contact

1. RISK ASSESSMENT

Risks to human health associated with presence of coal tar beneath the building and parking lot at the Sutherland site have been evaluated previously, and the results are reported elsewhere. Herein, we address possible risks to human health associated with PAH contamination of the sediments in the Red River adjacent to the Site. In particular, a quantitative evaluation was completed for scenarios involving dermal (skin) contact with the contaminated sediments.

It cannot be absolutely precluded that humans could come in contact with contaminated sediment. In particular, there is some remote possibility that a person could come in contact with the sediment when walking or playing along the waters edge beneath the Site during low water periods. Contact might also occur as a result of the handling of anchors, fishing lures, or other objects that have come into contact with the contaminated sediment, and to which sediment adheres.

Such human exposure events are considered highly improbable, but not impossible. Given the low probability of occurrence, frequency or duration of such exposures would be very low; i.e., once to nor more than ten times in a person's lifetime. If a person were to get PAH contaminated sediment on their skin, the potential for dermal uptake would remain until such time as the sediment were washed off, or until the PAH concentration in the adhering sediment is depleted in the microzone adjacent to the skin.

1.1. Quantifying PAH Exposure Potential

In general, there is a possibility for humans to be potentially exposed to contaminants via the one or more of six major pathways:

- **Uptake in drinking water:** This pathway is precluded as a potentially viable exposure route, since (i) the population is served through a treated, distributed potable water source; (ii) the river water at or immediately downstream from the Site is not a recognized drinking water source, and (iii) PAHs are strongly hydrophobic, suggesting very limited partitioning from sediment into river water (the available river water data confirms this).

- **Uptake from food substances:** This pathway is also precluded as a potentially viable exposure route, since (i) humans do not rely on or otherwise ingest aquatic biota at or near the site to any appreciable degree, and (ii) PAHs generally do not bioconcentrate or biomagnify in higher trophic level animals, since they are metabolized to readily excreted compounds.

- **Inhalation of volatile (gaseous-phase) substances:** Pulmonary (deeper respiratory) uptake of PAHs from sediments is highly unlikely since coal-tar contaminated sediment resides beneath the water column, and water-air partitioning is strongly limited by the prior necessary sediment-water partitioning. In addition, the small amount of sediments disturbed and brought to the surface (on hands or other objects) would not be expected to result in airborne concentrations of volatile coal tar constituents of sufficient magnitude to appreciably contribute to the overall potential exposure.

- **Inhalation of suspended fine particulates ($PM_{2.5}$, PM_{10}, $>PM_{10}$):** Airborne sediment particulates would not be expected, since the wet nature of the sediment would preclude transfer to air as dust particles. This calculation does not address potential for exposures to dusts from coal-tar contaminated sediment that is transferred to the land and then allowed to dry. No such situation is known to occur; nor is it expected in the future. The sediments along the river bank, that might be exposed during low flow conditions, contain much lower concentrations of PAHs than farther out in the river bed.

- **Incidental ingestion of sediment, and**
- **dermal contact with sediments.**

Human exposures were estimated for only the last two of these six exposure routes, for reasons provided above.

The concentration of PAHs in the sediment provides a basis for estimation of dermal exposure. Two different estimates of the concentration of PAHs in sediment were considered:

1) The maximum observed concentration of unsubstituted PAHs in the most recent analysis (2007) of surface sediments collected by petite ponar grab;

2) An upper estimate (90th %ile) concentration of PAHs in any sediment sample with coal tar contamination. The data assessed was from core samples collected in 2002. The highest concentrations of PAHs occur near the surface of the riverbed, but underlie a cover of minimally contaminated recent sediments. The highest observed concentrations were found in sediments with visual and olfactory evidence of free-phase coal tar.

The 90th %ile of sediment concentration for PAH16 and individual unsubstituted PAHs was generally approximately two orders of magnitude lower than the maximum observed concentration (Figure F-1).

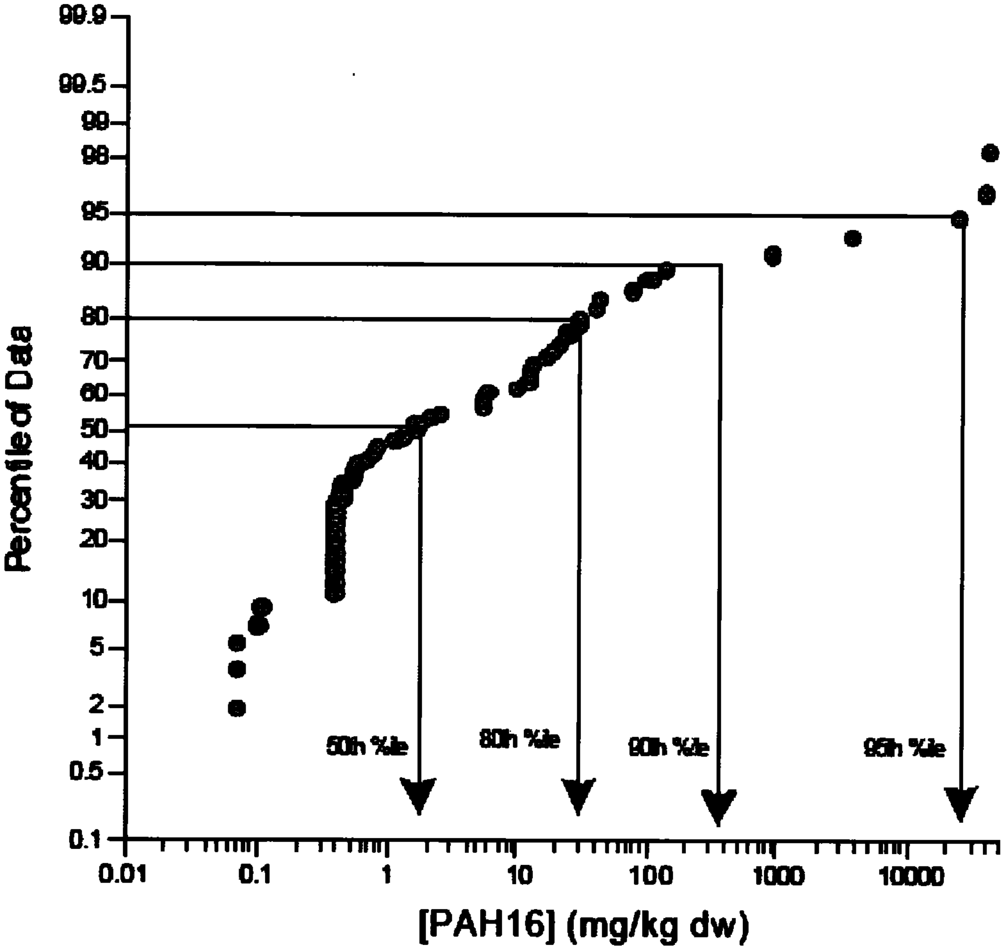


Figure F-1: PAH16 Statistical Distrution in Red River Sediment Samples (All Core Depths) from Adjacent to the Sutherland Site.

The upper-bound estimates from observed concentration of PAHs under these two scenarios is documented in Table F.1

Table F-1: Upper Concentration Estimates for Bulk Sediment PAHs[1]

	Upper bound concentration in sediment (mg/kg dw)		
PAH	**Upper 90th %ile UMA (2002) coring study – all sediment depths**	**Maximum observed UMA (2007) grab samples – top 5 to 10 cm only**	(sample)
Naphthalene	23.4	**2.4**	T3-3
Acenaphthylene	8.4	**0.62**	T3-2
Acenaphthene	6.2	**0.68**	T3-2
Fluorene	5.8	**1.1**	T3-2
Phenanthrene	11	**6.2**	T3-2
Anthracene	6.8	**1.9**	T3-2
Fluoranthene	24	**6.2**	T3-2
Pyrene	8.0	**5.1**	T3-2
Benzo(a)anthracene	13	**2.3**	T3-2
Chrysene	13	**2.2**	T3-2
Benzo(b)fluoranthene	4.5	**2.0**	T3-2
Benzo(k)fluoranthene	4.2	**0.74**	T3-2
Benzo(a)pyrene	4.8	**1.8**	T3-2
Indeno(1,2,3-cd)pyrene	1.8	**1.6**	T3-2
Dibenzo(a,h)anthracene	4.4	**0.24**	T3-2
Benzo(g,h,I)perylene	2.7	**1.0**	T3-2
PAH16	124		

Notes: 1) non-detected PAHs were assumed to occur at one half their detection limit value.

Exposure potential also varies as a function of how humans interact with the contaminated media, and particulars of physiological attributes such as body size, ingestion rates and skin surface area that might be exposed. Assumed characteristics of potentially exposed humans ("receptors") were based on data specific to the Canadian population. Values used in the risk assessment were primarily based on recommendations provided by Health Canada (2004). Other sources such as CCME (2000), CCME (1996), Richardson (1997) and other published scientific literature were also considered. The standardized assumptions used herein are also the same or similar to estimates used by the USEPA for the purpose of risk assessment guidance at Superfund sites.

The various receptor characteristics used in the risk assessment are discussed below and summarized in Table F-2.

TABLE F-2: Assumed Characteristics for Human Receptors

Variable	Toddler (0.5-4 yrs old)	Adult (> 18 yrs old)
Body weight	16.5 kg	70.7 kg
Time spent at intertidal areas	5 days per week; 50 weeks per year; entire life stage	5 days per week; 50 weeks per year; entire life
Sediment adherence factor	10 $g/m^2/day$ (hands) 1 $g/m^2/day$ (rest of body)	10 $g/m^2/day$ (hands) 1 $g/m^2/day$ (rest of body)
Surface area available for exposures to sediments	0.043 m^2 (hands) 0.26 m^2 (rest of exposed body)	0.089 m^2 (hands) 0.82 m^2 (rest of exposed body)
Sediment ingestion rate	80 mg/day	20 mg/day

1.1.1. Body Weight

For body weight, Health Canada (2004), Richardson (1997) and CCME (2000) recommended values were considered for assessment of the child and adult receptors. The following values were selected as receptor characteristics in the current assessment:

Younger Child (ages 0.5-4 yrs):	16.5 kg (Health Canada, 2004)
Adult Receptor:	70.7 kg (Health Canada, 2004)

1.1.2. Sediment Ingestion Rate

With respect to sediment ingestion, it was assumed that a person would have a similar ingestion rate as described for soils. Soil ingestion is most likely to occur through incidental (non-intentional) transfer to the mouth of soil (or sediment) adhering to the hands. Health Canada (2004) and CCME (2000) recommended soil ingestion rates for the various human receptor types. The following values were selected as receptor characteristics in the current assessment:

Younger Child (ages 0.5-4 yrs):	80 mg/day (Health Canada, 2004)
Adult Receptor:	20 mg/day (Health Canada, 2004)

Sediments may adhere to hands more than soil samples; however, the recommended soil ingestion rates are generally recognized to be highly conservative estimates of soil ingestion potential, except perhaps in toddlers that exhibit pica behaviour. It is noted that in the calculation of exposures, all sediment ingestion was assumed to occur from the site (i.e., it was not amortized for the less than continuous time spent at the site).

1.1.3. Skin Surface Area

In the case of skin surface area available for contact with sediment, Health Canada (2004) and CCME (2000) used values recommended by Richardson (1997) for the adult and toddler receptors for soil which subsequently adopted for sediment dermal contact. The following values were selected as receptor characteristics in the current assessment:

Younger Child (ages 0.5-4 yrs):	0.043 m^2 (hands) (Health Canada, 2004)
	0.26 m^2 (rest of exposed body, i.e., arms and legs) (Health Canada, 2004)
Adult Receptor:	0.089 m^2 (hands) (Health Canada, 2004)
	0.82 m^2 (rest of exposed body, i.e., arms and legs) (Health Canada, 2004)

1.1.4. Sediment to Skin Adherence Factor

With respect to soil to skin adherence factor, Health Canada (2004) and CCME (2000) used the following values for both the child and adult receptors:

Hands:	1 $g/m^2/day$ (Health Canada, 2004)
Other body parts:	0.1 $g/m^2/day$ (Health Canada, 2004)

In the case of adherence factors for sediment, the moist nature of such sediments resulted in use of a factors that may be up to 10-times greater than those cited above based on information provided in the US EPA (2002). As a result, the Health Canada recommended soil adherence factors were multiplied by a factor of 10 for use in estimation of dermal exposures from sediment.

The mathematical formulae used to quantify exposures from these pathways are discussed below.

1.1.5. Estimation of Exposure from Ingestion of Sediment

Using 95% UCLM and maximum concentrations of surface subtidal sediments, the following equation was applied to estimate exposure from sediment ingestion:

$$E_{Ing} = \frac{SC \times SR \times BAIG \times NDSY \times LAF}{BW \times NDY}$$

where:

E_{Ing} = exposure from the sediment ingestion pathway (μg/kg body weight/day)

SC = sediment chemical concentration (mg/kg = μg/g)

SR = sediment ingestion rate of person (g/day)

BAIG = bioavailability fraction via the ingestion route (chemical -specific)

NDSY = number of days at site per year (days) – *assumed to be 2 days*

LAF = lifetime amortization factor (assumed to be 1 non-carcinogens and 0.36 for carcinogens [based on an assumed exposure of 25 yrs/70 yrs])

BW = body weight of person (kg)

NDY = number of days in a year (365 days)

1.1.6. *Estimation of Exposure from Dermal Contact with Sediment*

It was also possible that recreational receptors may have direct dermal exposure to intertidal sediments. Using 95% UCLM and maximum concentrations of surface subtidal sediments, dermal exposure was estimated according to the following equation:

$$E_D = \frac{SC \times (SAFH \times ASH + SAFR \times ASR) \times BAID \times NDSY \times LAF}{BW \times NDY}$$

where:

E_D = exposure from the dermal pathway (µg/kg body weight/day)

SC = sediment chemical concentration (µg/g)

SAFH = sediment adherence factor for hands (g/m^2)

ASH = area of skin exposed on hands (m^2)

SAFR = soil adherence factor for rest of body (g/m^2)

ASR = area of skin exposed on rest of body (m^2)

BAID = bioavailability fraction via the dermal route (chemical-specific)

NDSY = number of days at site per week (days) – *assumed to be 2 days*

LAF = lifetime amortization factor (assumed to be 1 for non-carcinogens and 0.36 for carcinogens [i.e., 25 of 70 yrs])

BW = body weight of receptor (kg)

NDY = number of days in a year (365 days)

1.1.7. *Bioavailability Assessment*

As shown in calculations provided above, the assumed percent bioavailability of the PAH via either dermal contact or incidental soil ingestion is an important influence on overall internalized dose (or exposure). Bioavailability adjustments can be controversial, since bioavailability to humans via various exposure routes is very difficult if not impossible to measure on a site-specific basis, and the true bioavailability may vary significantly from documented bioavailability factors from the literature, based on in vivo or in vitro studies. In particular, bioavailability estimates at a Site may depart significantly from published values as a result of important differences in the chemical and physical characteristics of the exposure media, based on differences in how an animal (or human) is exposed, and important inter-specific and inter-individual differences.

In light of the above, a highly conservative assumption made in some site-specific risk assessments is that the entire bulk contaminant concentration in the exposure media is available for uptake and internalization in systemic circulation (i.e., the chemical of concern is 100% bioavailable). For especially dermal contact, and for PAHs – for which bioavailability tends to be strongly influenced by sorption to or occlusion in the exposure medium – an assumption of 100% bioavailability is unreasonably high. Rather, dermal bioavailability estimates for PAHs from the literature have never been documented to approach 100%.

It is common practice when conducting human health risk assessments to extrapolate bioavailability adjustments from the available information, with an accompanying recognition of the high degree of uncertainty associated with doing so. Bioavailability values were selected for the HHRA following a review of the available summary estimates, as provided in Table F-3 and discussed in greater detail below.

Oral Bioavailability of Chemicals – The oral bioavailability of chemicals in food and sediment was assumed to be equal to the bioavailability of these chemicals in food or water. In the case of chemicals in sediments, this is considered to be a conservative assumption since it is quite possible that chemicals found in sediment would have reduced oral bioavailability for a variety of reasons, including (i) occlusion within sediment particles and/or a very high affinity for soot carbon, or (ii) reduced solubility in the gastrointestinal tract. Nevertheless, the scientific literature did not provide specific recommendations for estimating the reduction in bioavailability from sediment and, therefore, the oral bioavailability of chemicals in sediment was assumed to be similar to that in food or water for all chemicals.

Dermal Bioavailability of Chemicals in Sediment – To estimate the dermal bioavailability of chemicals in soil, the scientific literature was reviewed. Estimated bioavailability values were available from a variety of sources including ORNL (2004), US EPA Region 3 (1995) and others. These values were used for people who may be exposed to chemicals via dermal contact with soils. Much of the literature used to estimate dermal bioavailability was from laboratory studies of topical application of chemical solutions (likely to maximize absorption) rather than direct assessment of dermal bioavailability from soils. It is likely that chemicals found in soil would have less dermal bioavailability.

TABLE F-3: Bioavailability values used in the human health risk assessment

Chemical	Dermal		Ingestion	
	Possible Values	Selected Value	Possible Values	Selected Value
Acenaphthene	0.01 (A) 0.1 (B) 0.06 (C)	0.06	0.31 (A)	0.31
Acenaphthylene	0.01 (A) 0.1 (B) 0.06 (C)	0.06	0.31 (A)	0.31
Anthracene	0.01 (A) 0.1 (B) 0.15 (C)	0.15	0.76 (A)	0.76
Benz[a]anthracene	0.01 (A) 0.1 (B) 0.06 (C)	0.06	0.31 (A)	0.31
Benzo[a]pyrene	0.01 (A) 0.1 (B) 0.06 (C)	0.06	0.31 (A)	0.31
Benzo[b]-fluoranthene	0.01 (A) 0.1 (B) 0.06 (C)	0.06	0.31 (A)	0.31
Benzo[g,h,i]perylene	0.01 (A) 0.1 (B) 0.06 (C)	0.06	0.31 (A)	0.31
Benzo[k]fluoranthene	0.01 (A) 0.1 (B) 0.06 (C)	0.06	0.31 (A)	0.31
Chrysene	0.01 (A) 0.1 (B) 0.06 (C)	0.06	0.31 (A)	0.31
Dibenz[a,h]anthracene	0.01 (A) 0.1 (B) 0.06 (C)	0.06	0.31 (A)	0.31
Fluoranthene	0.01 (A) 0.1 (B) 0.06 (C)	0.06	0.31 (A)	0.31
Fluorene	0.01 (A) 0.1 (B) 0.10 (C)	0.10	0.50 (A)	0.50
Indeno[1,2,3-cd]pyrene	0.01 (A) 0.1 (B) 0.06 (C)	0.06	0.31 (A)	0.31
Naphthalene	0.01 (A) 0.1 (B) 0.06 (C)	0.06	0.80 (A)	0.80
Phenanthrene	0.01 (A) 0.1 (B) 0.06 (C)	0.06	0.73 (A)	0.73
Pyrene	0.01 (A) 0.1 (B) 0.06 (C)	0.06	0.31 (A)	0.31

Notes: (A) Value recommended by ORNL (2005); (B) Value recommended by US EPA Region 3 (1995); (C) Value based on relative dermal absorption factor by Health Canada (2004) (i.e., RAF_{Dermal} x oral bioavailability = absolute dermal absorption)

1.2. Effects Assessment - Toxicity Reference Values

Toxicity Reference Values are levels of exposure judged to be acceptable (or “safe”) by regulatory agencies. The selected values used in the current risk assessment were compiled using federal and international regulatory agencies. Data were evaluated using a hierarchical approach where Toxicity Reference Values recommended by Canadian sources were given priority and first consideration. If toxicity estimates were not available from Health Canada, international regulatory agencies were reviewed. Literature reviewed included:

- Health Canada (2002a): Toxicological Reference Doses for Trace Elements and Organic Contaminants;
- Health Canada (2004): Federal Contaminated Site Risk Assessment. Part II: Health Canada Toxicological Reference Values (TRVs);
- WHO (1998a): Polynuclear Aromatic Hydrocarbons in Drinking-water;
- WHO (1998b): Assessment of the Health Risk of Dioxins: Re-evaluation of the Tolerable Daily Intake (TDI);
- US EPA (2005): On-line IRIS database;
- US EPA (2004): Region 9 Preliminary Remediation Goals (PRGs) Table; and
- US FDA as reported in Law et al. (2002).

Toxicological Reference Values used in the HHRA for evaluation of potential chemicals of concern are summarized in Table F-4.

TABLE F-4: Toxicological Reference Values for Chemicals of Potential Concern

Chemical	Tolerable Daily Intake (μg/kg bw/day)	Reference	Slope Factor (μg/kg bw/day)$^{-1}$	Reference
Acenaphthene	60	1	NA	NA
Acenaphthene	60	1	NA	NA
Anthracene	300	1	NA	NA
Benz[a]anthracene	40	2	2.3×10^{-4}	4
Benzo[a]pyrene	40	2	2.3×10^{-3}	3
Benzo[b]fluoranthene	40	2	2.3×10^{-4}	4
Benzo[g,h,i]perylene	40	2	6.9×10^{-5}	5
Benzo[k]fluoranthene	40	2	2.3×10^{-4}	4
Chrysene	40	2	3.0×10^{-5}	5
Dibenz[a,h]anthracene	40	2	2.3×10^{-3}	4
Fluoranthene	40	1	NA	NA
Fluorene	40	1	NA	NA
Indeno[1,2,3-cd]pyrene	40	2	2.3×10^{-4}	4
Naphthalene	16	1	NA	NA
Phenanthrene	40	2	1.5×10^{-6}	2
Pyrene	30	1	NA	NA

Sources:

1) Health Canada (2002a)
2) OME (1997)
3) Health Canada (2004)
4) WHO (1998a)
5) Law et al. (2002)

1.3. Risk Characterization

1.3.1. Methodology

Using the results of the exposure and toxicity assessments, risk characterization involves quantification of human health risks for the various land uses considered in the risk assessment. The following section provides a description of the methods used to estimate human health risks from consumption of aquatic species in the Lower Basin of the Harbour.

1.3.1.1. Estimation of Non-Carcinogenic Risks

For non-carcinogens, the risk assessment involved estimation of risks by comparing the estimated receptor exposure to the exposure rates in the literature considered to be "safe". Non-cancer risks were estimated as HQ values according to the following formula:

$$\text{Risk Quotient (RQ)} = \frac{\text{Estimated Exposure } (\mu\text{g/kg body weight/day})}{\text{Tolerable Daily Intake } (\mu\text{g/kg body weight/day}) \times \text{Study Bioavailability}}$$

In the above equation, both exposure and the TDI were adjusted for bioavailability. In all cases for the risk calculations, the toxicological study used to derive the TDI was based on orally administered chemicals, such that the study bioavailability was for the oral route.

A risk quotient value that is less than 1 is normally considered to be acceptable. A RQ value that is greater than 1 generally indicates a form of risk reduction/management may be required; however, in all cases, interpretation of RQ values requires consideration of the overall risk assessment process, assumptions and uncertainties.

1.3.1.2. Estimation of Cancer Risks

In the case of the carcinogenic metals and PAHs, risks were estimated as incremental lifetime cancer risk (ILCR) estimates according to the following formula:

$$ILCR = \frac{\text{Estimated Lifetime Daily Exposure } (\mu g/kg/day) \times \text{ Cancer Potency Factor } (\mu g/kg/day)^{-1}}{\text{Study Bioavailability}}$$

It is noted that in the above equation, both exposure and the Cancer Potency Factor were adjusted for bioavailability (see Worked Example for more information). In all cases for the risk calculations, the toxicological study used to derive the Cancer Potency Factor was based on orally administered chemicals such that the study bioavailability was for the oral route.

An ILCR estimate that is less than 1×10^{-5} (less than 1 expected additional case in a population of 100,000) is normally considered to be acceptable. An ILCR estimate greater than this value generally indicates that clean-up or some other form of risk reduction/management may be required; however, in all cases, interpretation of ILCR estimates requires consideration of the overall risk assessment process and assumptions.

1.3.2. Results

The calculated risk quotients and incremental lifetime cancer risks associated with exposure to sediment are tabulated below. Consistent with the recommendations of Health Canada (2004), the toddler receptor was used to evaluate non-cancer risks while the adult was used to evaluate cancer risks. The evaluation of exposure to recreational users also considered that all of the sediment ingestion occurred from the site (i.e., the 80 mg of soil that a typical child ingests on a daily basis was considered to be 100% from the site even though children would spend only a fraction of their time in such settings according to the assumptions used in the HHRA). In addition, it is noted that it was assumed that the sediment had a 10-fold greater soil adherence factor than typical soil (due to the moist nature of sediment as compared to soil). These are considered to be quite conservative factors that may tend to overestimate actual exposures and risks.

1.3.2.1. Non-Cancer Risks

A young child (Toddler: 0.5 to ~ 4 years of age) is a potentially maximally exposed individual, since sediment ingestion rates via hand ot mouth contact are generally higher for this age group relative to other age groups and the expected body weight is lower than for older age groups. Infants less than six months of age are generally less exposed, since they are more closely supervised by their parents and are not as mobile.

Table F-5 provides calculated risk quotients for non-cancer type effects, assuming an average of 2 days exposure per year, and based on the maximum observed surface versus subsurface PAH concentration in sediment, as discussed above.

Table F-5.: Risk Quotients for Non-Cancer type Effects

PAH	TDI (µg/kg d)	Based 90th %ile of Subsurface Conc.			Based on Max. Observed Surface Conc.		
		RQ$_{Ing}$	RQ$_{D}$	RQ$_{Tot}$	RQ$_{Ing}$	RQ$_{D}$	RQ$_{Tot}$
Naphthalene	16	1.4E-05	1.2E-07	**1.4E-05**	4.0E-06	3.4E-08	**4.0E-06**
Acenaphthylene	60	2.7E-06	2.4E-08	**2.8E-06**	2.7E-07	2.4E-09	**2.8E-07**
Acenaphthene	60	2.6E-06	2.2E-08	**2.6E-06**	3.0E-07	2.6E-09	**3.0E-07**
Fluorene	40	7.5E-06	6.5E-08	**7.6E-06**	7.3E-07	6.3E-09	**7.4E-07**
Phenanthrene	40	4.5E-06	3.9E-08	**4.5E-06**	4.1E-06	3.6E-08	**4.2E-06**
Anthracene	300	2.2E-06	1.9E-08	**2.2E-06**	1.7E-07	1.5E-09	**1.7E-07**
Fluoranthene	40	5.3E-06	4.6E-08	**5.3E-06**	4.1E-06	3.6E-08	**4.2E-06**
Pyrene	30	1.2E-05	1.0E-07	**1.2E-05**	4.5E-06	3.9E-08	**4.6E-06**
Benzo(a)anthracene	40	8.8E-06	7.6E-08	**8.9E-06**	1.5E-06	1.3E-08	**1.5E-06**
Chrysene	40	3.0E-06	2.6E-08	**3.0E-06**	1.5E-06	1.3E-08	**1.5E-06**
Benzo(b)fluoranthene	40	2.8E-06	2.4E-08	**2.8E-06**	1.3E-06	1.1E-08	**1.3E-06**
Benzo(k)fluoranthene	40	3.2E-06	2.7E-08	**3.2E-06**	4.9E-07	4.2E-09	**5.0E-07**
Benzo(a)pyrene	40	1.2E-06	1.0E-08	**1.2E-06**	1.2E-06	1.0E-08	**1.2E-06**
Indeno(1,2,3-cd)pyrene	40	2.9E-06	2.5E-08	**2.9E-06**	1.1E-06	9.2E-09	**1.1E-06**
Dibenzo(a,h)anthracene	40	1.8E-06	1.5E-08	**1.8E-06**	1.6E-07	1.4E-09	**1.6E-07**
Benzo(g,h,l)perylene	40	3.3E-07	2.8E-09	**3.3E-07**	6.6E-07	5.7E-09	**6.7E-07**

All risk quotients were substantially lower than 1.0 (i.e., by ~5 orders of magnitude or more); therefore, it is concluded that non-cancer risks of exposures to sediments are acceptably low.

1.3.2.2. Cancer Risks

Table F-6 shows the calculated incremental lifetime cancer risks for an adult exposed to either surface or subsurface coal-tar contaminated sediment. The estimates are based on a 70.7 kg adult who is exposed for up to 2 days per year, over 25 years of a 70 year lifespan.

Table F-6: Calculated Incremental Lifetime Cancer Risks

PAH	Slope Factor (µg/kg d)$^{-1}$	ILCR$_{Ing}$	ILCR$_{D}$	ILCR$_{Tot}$	ILCR$_{Ing}$	ILCR$_{D}$	ILCR$_{Tot}$
Naphthalene	n/a						
Acenaphthylene	n/a						
Acenaphthene	n/a						
Fluorene	n/a						
Phenanthrene	1.5E-06	2.0E-11	1.7E-09	**1.8E-09**	5.1E-12	4.4E-10	**4.5E-10**
Anthracene	n/a						
Fluoranthene	n/a						
Pyrene	n/a						
Benzo(a)anthracene	2.3E-03	5.8E-09	4.9E-07	**5.0E-07**	2.9E-09	2.5E-07	**2.5E-07**
Chrysene	3.0E-05	7.0E-11	6.0E-09	**6.1E-09**	3.7E-11	3.1E-09	**3.2E-09**
Benzo(b)fluoranthene	2.3E-04	6.1E-10	5.2E-08	**5.3E-08**	2.5E-10	2.2E-08	**2.2E-08**
Benzo(k)fluoranthene	2.3E-04	2.3E-10	1.9E-08	**2.0E-08**	9.4E-11	8.1E-09	**8.2E-09**
Benzo(a)pyrene	2.3E-03	5.6E-09	4.7E-07	**4.8E-07**	2.3E-09	2.0E-07	**2.0E-07**
Indeno(1,2,3-cd)pyrene	2.3E-04	3.4E-10	2.9E-08	**3.0E-08**	2.0E-10	1.7E-08	**1.8E-08**
Dibenzo(a,h)anthracene	2.3E-04	6.3E-11	5.4E-09	**5.4E-09**	3.1E-11	2.6E-09	**2.6E-09**
Benzo(g,h,l)perylene	6.9E-05	9.7E-11	8.3E-09	**8.4E-09**	3.8E-11	3.3E-09	**3.3E-09**
ILCR for all potentially carcinogenic unsubst. PAH				**1.1E-06**			**5.1E-07**

An ILCR of less than 1 in 100,000 ($<1.0 \times 10^{-5}$) is considered to be *de minimus*, or acceptable. As shown in Table F-6, cancer-related exposure risks are acceptably low for possible human exposures to surface sediment, based on current riverbed conditions adjacent to the Sutherland site.

1.4. Uncertainty Analysis and Conclusions

While the human health risks have been evaluated using the best available information, it is recognized that there is always some uncertainty about various critical and non-critical elements. Some of the major forms of uncertainty in the risk assessment that might affect conclusions about acceptability about risks include the following:

- Actual concentration of PAHs in sediment to which a person might be exposed;
- Potential for exposures based on human behaviours, including severity or frequency of contact with contaminated sediments;
- Toxicity reference values for PAHs (tolerable daily intake estimates; cancer slope factor estimates).

The expected true concentration of PAHs in bulk sediment to which a person might be exposed is bracketed by the two sets of estimates discussed herein; i.e., the true exposure concentration is likely to be between the 90th percentile of the observed concentrations in subsurface sediments and the average concentration in surface sediments.

The larger dataset provides insights into the likelihood of coming into contact with such highly contaminated sediments within the area of documented coal tar contamination. Laboratory analytical data were available for PAHs of 55 individual sediment samples collected from cores, as part of the UMA (2002) study. While the samples were not selected randomly to provide an unbiased statistical picture of PAHs within a pre-defined area, they nonetheless capture the general range of PAH concentrations in the riverbed area influenced by coal tar deposition and re-distribution. Figure F-1 shows the distribution of samples based on PAH16 concentration.

Another area of uncertainty is the extent to which humans might actually be exposed to coal tar contaminated sediments. As discussed above, any such exposure is deemed to be highly unlikely. The assumption that an adult or toddler are exposed on average 2 days per year is conservation (i.e., biased towards over-protection as opposed to under-protection). Similarly, as assumption that sediment adherence to skin would be 10-fold greater than established soil adherence factors is likely to be conservative.

In light of the risk characterization, and accounting for various types of uncertainty, it is concluded that risks to humans from exposures to coal tar contaminated sediments are unlikely.

APPENDIX G:
Remediation Examples - Photographs

Photo 1
Dredging equipment includes a debris grapple and an environmental bucket. Reproduced from EPA website:http://yosemite.epa.gov/r10/cleanup.nsf/9f3c21896330b4898825687b007a0f33/f916a0e7e0aa8d67882569c3005c3798?OpenDocument

Photo 2
Close-up of environmental dredge bucket. Reproduced from EPA website:http://yosemite.epa.gov/r10/cleanup.nsf/9f3c21896330b4898825687b007a0f33/f916a0e7e0aa8d67882569c3005c3798?OpenDocument

Photo 3
Environmental dredge bucket being lowered into the water. Reproduced from EPA website:http://yosemite.epa.gov/r10/cleanup.nsf/9f3c21896330b4898825687b007a0f33/f916a0e7e0aa8d67882569c3005c3798?OpenDocument

Photo 4
Environmental dredge bucket containing sediments is being removed from water. Reproduced from EPA website:http://yosemite.epa.gov/r10/cleanup.nsf/9f3c21896330b4898825687b007a0f33/f916a0e7e0aa8d67882569c3005c3798?OpenDocument

Photo 5

Close-up of environmental dredge bucket after removal. Debris will cause bucket to leak. Reproduced from EPA website:
http://yosemite.epa.gov/r10/cleanup.nsf/9f3c21896330b4898825687b007a0f33/f916a0e7e0aa8d67882569c3005c3798?OpenDocument

Photo 6

A water-tight barge is used to transport the sediment. Reproduced from EPA website:
http://yosemite.epa.gov/r10/cleanup.nsf/9f3c21896330b4898825687b007a0f33/f916a0e7e0aa8d67882569c3005c3798?OpenDocument

Photo 7
A swinging ladder cutterhead hydraulic dredge was used on the Fox River in Wisconsin. This dredge digs into sediment and has a suction pump that pumps the sediment and water to an on-shore facility where the water is treated and the solid material is collected for off-site disposal. Photo reproduced from Little Lake Cleanup Team website: http://www.littlelakecleanup.com/

Photo 8
This is one of two dredges operating around the clock six days a week on the Fox River in Wisconsin. Photo reproduced from Little Lake Cleanup Team website: http://www.littlelakecleanup.com/

Photo 9
A conceptual drawing of the on-shore sediment treatment area used for Fox River, Wisconsin dredging. Photo reproduced from Little Lake Cleanup Team website: http://www.littlelakecleanup.com/

Photo 10
Geotubes are used to separate the sediment from the water. Photo reproduced from Little Lake Cleanup Team website: http://www.littlelakecleanup.com/

Photo 11
Sediment is dewatering in geometric tubes located in the staging area on the Fox River, Wisconsin Photo reproduced from Little Lake Cleanup Team website: http://www.littlelakecleanup.com/

Photo 12
After the sediment is dewatered in geotubes, it is trucked to a landfill. Photo reproduced from Little Lake Cleanup Team website: http://www.littlelakecleanup.com/

Photo 13
Dewatered sediment is loaded into lined trucks for transport to a licensed landfill. Photo reproduced from Little Lake Cleanup Team website: http://www.littlelakecleanup.com/

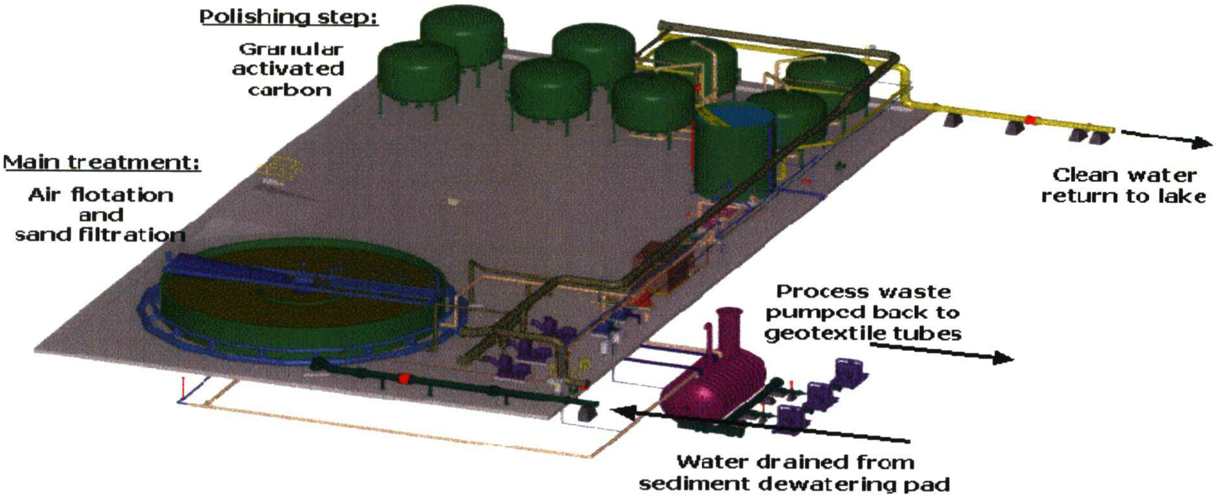


Photo 14
The water treatment plant removes contaminants before returning clean water to the Fox River. Photo reproduced from Little Lake Cleanup Team website: http://www.littlelakecleanup.com/

Photo 15
A filtration tank is delivered to the water treatment plant- Fox River, Wisconsin. Photo reproduced from Little Lake Cleanup Team website: http://www.littlelakecleanup.com/

Photo 16
Crews install filter tanks for a water treatment plant- Fox River, Wisconsin. Photo reproduced from Little Lake Cleanup Team website: http://www.littlelakecleanup.com/

Photo 17

Inside the water treatment facility- Fox River, Wisconsin. Photo reproduced from Little Lake Cleanup Team website: http://www.littlelakecleanup.com/

Photo 18

A bucket is used to grab capping sand from a barge. KPC Site in Ward Cove, Alaska
http://yosemite.epa.gov/r10/cleanup.nsf/1a16218b78d8c4d58825674500015b42/f916a0e7e0aa8d67882569c3005c3798!OpenDocument

Photo 19

The bucket released sand at or near the surface of the water in deep areas, and near the bottom in shallower areas.
http://yosemite.epa.gov/r10/cleanup.nsf/1a16218b78d8c4d58825674500015b42/f916a0e7e0aa8d67882569c3005c3798!OpenD

Photo 20

View of sediment capping operation.
http://yosemite.epa.gov/r10/cleanup.nsf/1a16218b78d8c4d58825674500015b42/f916a0e7e0aa8d678

Photo 21
Diffuser barge used to hydraulically cap fine-grained sediment at the St. Paul Waterway, Tacoma, Washington. Photo from the US Army Corps of Engineers, reproduced from White Paper 6B – In-Situ Capping as a Remedy Component for the Lower Fox River.

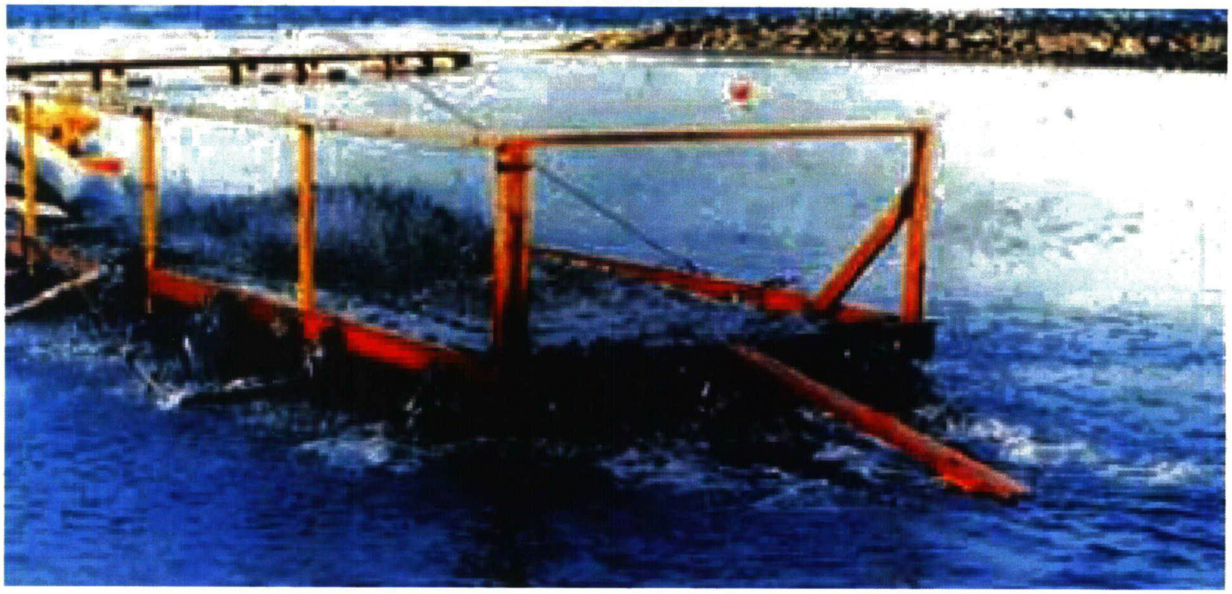


Photo 22
Close-up of diffuser barge at the St. Paul Waterway, Tacoma, Washington. Photo from the US Army Corps of Engineers, reproduced from White Paper 6B – In-Situ Capping as a Remedy Component for the Lower Fox River.

Photo 23
Hydraulic cap placement in the Netherlands. Photo courtesy of Bean Environmental LLC. Reproduced from White Paper 6B – In-Situ Capping as a Remedy Component for the Lower Fox River.