WORKPLAN FOR PHASE IIB BIOLOGICAL IMPACT ASSESSMENT AND SOIL VAPOUR SURVEY

Prepared for:

CENTRA GAS MANITOBA INC.

Prepared by:

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Waterloo, Ontario

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Contents

Section		Page
1	**Introduction**	1-1
	Background	1-1
	Objectives	1-1
2	**Technical Approach and Methodology**	2-1
	Part 1 - Biological Impact Assessment	2-1
	Task 1: Reconnaissance Survey	2-1
	Task 2: Benthic Invertebrate Study	2-2
	Task 3: Fish Habitat Evaluation	2-4
	Task 4: Contaminant Levels in Biota	2-4
	Task 5: River Habitat Health Assessment	2-6
	Task 6: Impact Assessment Document	2-7
	Part 2 - Shallow Soil Vapour Survey and Offsite Risk Assessment	2-7
	Task 8: Shallow Soil Gas Survey	2-7
3	**Project Team**	3-1
4	**Schedule**	4-1

APPENDIX

A	Project Team Resumes	

Figures

Number		Page
1	Proposed Locations for Soil Vapour Survey	2-9

Section 1

Introduction

Background

Centra Gas Manitoba Limited (Centra Gas) commenced an Environmental, Health and Safety Assessment (EHSA) of its Sutherland Avenue Operations Facility in 1993. The primary objective of the EHSA was to identify whether by-products associated with the former coal gasification facility were located at the site and to assess the potential effect of any by-products found. A four-phased approach was adopted for the EHSA as follows:

- Phase I: Preliminary Site Assessment
- Phase II: Detailed Site Assessment
- Phase III: Feasibility Study and Risk Management
- Phase IV: Remediation

CH2M HILL ENGINEERING LIMITED (CH2M HILL) was retained in to conduct Phase I starting in September 1993 and finishing in April 1994. Phase II was undertaken between March 1994 and was completed in January 1995, also by CH2M HILL. Centra Gas, through consultation with Manitoba Environment and others has decided to undertake further detailed site assessment to that undertaken to date. This additional assessment, referred to as Phase IIB, will involve undertaking a biological impact assessment in the Red River in addition to a soil vapour survey of the site perimeter. CH2M HILL was requested by Centra Gas to develop a workplan for Phase IIB which is contained in this document.

Objectives

The objectives of Phase IIB are as follows:

<u>Biological Impact Assessment</u>

- to undertake a biological impact assessment of the Red River adjacent to the former coal gasification site
- to determine whether the impacts on aquatic life are significant and whether mitigative action is warranted
- to define the nature and extent of sediments requiring remediation, if any

Shallow Soil Vapour Survey

- determine whether soil gases characteristic of manufactured gas plant residues are present at and beyond the south, north and west property boundaries

- to assess the significance of offsite soil gas migration by comparison with established guidelines and background levels.

Section 2

Technical Approach and Methodology

Phase IIB of the EHSA has two main components, a biological impact assessment and a soil gas assessment which are described separately in this section of our proposal.

Part 1 - Biological Impact Assessment

The conventional approach to this problem is the conduct of a retrospective biophysical impact assessment. This kind of study determines contaminant levels in biota, the composition and structure of the resident community, and measures organism abundance in the area of contamination and in a representative control area. The study results, along with other existing resource information, are used to establish the social and ecological importance of the contaminated area, to determine the mobility of the contaminant and any associated bioaccumulation, and to quantify any ecological changes which may be related to the contamination. This information is used to assess the significance of the impacts, leading to an evaluation of the need for any remediation. An evaluation of the need for remediation should consider the level of remediation necessary, the available methods, and a cost/benefit analysis.

Task 1: Reconnaissance Survey

The first step in the study will be a reconnaissance survey of the contaminated area and of the river habitat immediately upstream and downstream. The purpose of this survey being to:

- confirm the lateral extent and visual characterization of contamination defined in the Phase II report;
- select a suitable upstream reference site (bottom type and slope; exposure to flows) between the contaminated area and any potential upstream impact sources (e.g. sewer outfalls or industrial discharges);
- determine the distribution of river bottom substrate to aid in the design of the benthic monitoring study, with respect to controlling for variation in substrate type and selection of a cutoff for depth stratification of sampling; and,
- to gather the physical and biological information necessary to evaluate the suitability of habitat for fish and other aquatic life (e.g. waterfowl nesting) within and adjacent to the contaminated area.

The reconnaissance survey will involve the establishment of a series of transects located at about 50 m intervals along the length of the approximately 300 m of contaminated river bed and extending for an additional 300 m upstream and 300 m downstream. Each transect will initially be 50 m in length, which should be sufficient to include the documented extent of contamination based on the field classification. Transect length will be extended in the event that any more extensive contamination is detected. Water depth will be measured, and a sediment sample will be taken for determination of substrate type and a field assessment of contamination (following the NC/TC/VC protocol used in the Phase II study), at 5 m intervals along each transect. Locations and characteristics of aquatic vegetation, waterfowl nesting, and instream or overhanging cover will be documented as encountered. A shoreline survey also will be extended approximately 1 km upstream to identify locations of any other upstream impact sources such as sewer outfalls or industrial discharges.

Task 2: Benthic Invertebrate Study

Background

The chronic toxicity testwork to date indicates that some of the contaminated sediments are chronically toxic to fish and benthic invertebrates and that the invertebrates may be more sensitive than fish. A reduction of zoobenthos standing crop and/or diversity is therefore a potential adverse impact of the sediment contamination. However, the significance of any such impact is dependent upon the characteristics of the zoobenthic community which would be expected to occur in the area in the absence of the contamination. A statistically significant decrease in standing crop or diversity in a rich zoobenthic community may be considered a more important impact than a change of similar magnitude in a depauperate community. The results of the preliminary study in June 1994 indicate the latter situation may be the case.

Determination of the current state of the benthic community in the affected area also is important for estimation of the risk to other food chain components. The lack of a benthic food base in the zone of contamination might discourage fish or waterfowl from frequenting the area, thereby limiting their exposure to the PAHs.

A number of variables should to be considered in the design of the benthic sampling program. Substrate is a major consideration as it affects both the community characteristics and the sampling methods which must be used. Fine-grained sediments can be effectively sampled using a variety of jaw-type dredges or corers. Dredges are generally the preferred equipment because of their larger sampling area. Corers can be useful in situations where surface debris tends to prevent a dredge from closing, although as many as 20 cores are necessary to cover the same surface area as a single dredge sample. We are equipped with both an Ekman dredge and a Wildco hand corer. The Ekman dredge jaws are spring loaded, allowing the jaws to cut through small woody debris.

Granular sediments are a major sampling problem. In shallow areas (i.e. <1 m deep), a "kick and sweep" method can be used in which the substrate is disturbed and the dislodged animals are captured in a sweep net. Another approach is suction dredging by a SCUBA diver. The diver uses a suction source (e.g. a hand operated guzzler pump or a gas powered portable water pump) to remove the surface layer of substrate within a quadrat and the discharge is passed through a series of progressively finer screens to separate the organisms from the substrate. This approach would be used only as a last resort in the present situation due to the difficult conditions for diving, the potential for clogging of the screens by any tars associated with the contaminated substrate, and the possible requirement for collection and proper disposal of quantities of PAH contaminated water and substrate.

An alternative to sampling granular substrates is the use of artificial substrates. These can consist of granular material placed in a wire basket or mesh bag; an artificial tree branch fabricated from uniform diameter sections of natural tree branches; or fabricated structures such as the Hester-Dendy multiple plate sampler. The substrates are placed on the river bottom for a period (e.g. 6-8 weeks) then recovered and the invertebrates which have colonized the substrate are removed and identified.

Although useful in some situations, artificial substrates would not be a good choice for this particular study. The substrate may isolate the organisms from direct contact with the contaminated sediments such that the colonization results may not be indicative of the effects of the contaminants.

Benthic Study Plan

The following study plan is offered on the basis of the available information on substrate distribution and zoobenthos standing crops. At this time it is proposed that sampling be restricted to the fine-grained (i.e. sand and smaller) sediments and that sampling be stratified by depth. The initial drilling program indicated fine-grained sediments predominated in the contaminated area. Depth stratification is recommended on the basis of the results of the preliminary study which suggested community composition and standing crop may vary with depth. At this time it is proposed that two depth strata be used, with the cutoff depth (likely around 2 m) being finalized during the reconnaissance survey. This single substrate depth stratified approach will be reviewed on completion and any necessary changes to the plan and their associated costs will be discussed with the project manager for CH2M HILL and the client at that time.

Another variable which should be considered in the benthic survey is variation in PAH concentration within the contaminated zone. The zone of contamination has not been delineated in a manner which facilitates separation into areas of moderate or severe contamination, so a simple stratification by degree of contamination is not possible. Instead, it is proposed that samples be randomly distributed within each depth stratum, with a surface sediment (5 cm depth) core sample taken adjacent to each benthic sample and submitted for PAH analysis. This will facilitate examination of benthic community variation in relation to PAH concentration.

It is proposed that 6 samples each for benthos and PAHs be taken per depth stratum from each of the contaminated and reference areas, for a total of 24 of each sample type. The 6 samples per stratum represent the absolute minimum number necessary to conduct a statistical analysis of differences between the contaminated and the reference areas. The benthic samples will be sieved in the field through a 400 mesh-size net and preserved with 70 percent ethanol.

The zoobenthos samples will be sorted in the laboratory under a stereomicroscope. At this time it is proposed that a two stage identification process be employed in order to minimize study costs. Initially, all organisms would be identified to Family/Order and enumerated to identify any gross differences in community composition or structure. Depending on the nature of any effects, this level of identification may prove to be adequate. A decision to take the identification to the level of genus or species can be made on the basis of the results of the initial analysis. Sample identification to the level of species runs in the range of an additional $50 to $100 per sample, depending on the range of taxa involved and the number of organisms per sample, with an additional 3 to 4 months required to complete the identifications.

Task 3: Fish Habitat Evaluation

The risk of fish exposure to the PAH contaminated sediments is determined in part by the quality of the habitat provided in or near the contaminated area. High quality habitat for spawning, rearing, or feeding would be expected to attract fish, and to induce them to spend longer in the area than they might otherwise, thereby contributing to the ecological risk. Conversely, the avoidance of poor quality fish habitat in favour of other habitat in the general area might aid in minimizing or even eliminating any exposure risk associated with the PAH contaminated sediments.

The habitat suitability evaluation will be based on substrate composition, water depth and bottom slope, the occurrence of submerged and emergent macrophyte vegetation, and the availability of instream and overhanging cover. The habitat assessment will extend over the estimated 300 m length of contaminated sediments, an additional 300 m upstream and 300 m downstream of the contaminated zone. The physical habitat information will be collected during the initial reconnaissance survey. A numerical habitat suitability rating will be determined for those species for which a formal habitat suitability rating system has been developed (e.g. walleye, channel catfish, northern pike, yellow perch, smallmouth bass). Habitat suitability for other species will be expressed qualitatively on the basis of their documented habitat preferences.

Task 4: Contaminant Levels in Biota

Although the Phase II work to date has indicated there is the potential for the PAHs in the river sediments to accumulate in aquatic biota under laboratory test conditions, there is a real need to determine if PAH bioaccumulation is occurring in situ. The high river flows and affinity of the PAHs for organic matter in the sediments may aid in limiting the actual

degree of bioaccumulation. In this respect there are two biotic components which are of concern. First is the group of organisms for which the contaminated area represents all or a significant part of an individual's home range. This group includes larval insect stages, crustaceans (e.g. benthic cladocerans, amphipods, and crayfish), molluscs (e.g. snails, clams, and mussels), forage fish species (e.g. minnows, young-of-the-year yellow perch), and sedentary bottom dwelling fish species (e.g. sculpins). These organisms are the most likely to bioaccumulate PAHs simply because of the continuous exposure. Of these, the best organisms for contaminant monitoring are the larger invertebrates (e.g. mussels, clams, crayfish) because of their sessile (molluscs) or territorial (crayfish) natures and relatively large body sizes which facilitate analysis. The smaller invertebrates are not as good a choice because of the large number of individuals required to make up a single sample and difficulty in distinguishing bioaccumulation in tissues from surface contamination. The small forage fish species [e.g. cyprininds (minnows)], and bottom dwelling/ feeding species (e.g. sculpins) are attractive from the standpoint of size and their role in the food chain, but tend to be wider ranging than the invertebrates.

The second group of concern is that comprised of the more wide-ranging, larger, fish species which includes the major sportfish species. Although any individual fish in this group is unlikely to spend a large portion of its life cycle in or near the contaminated area, it is generally necessary to sample representative species within this group to assess the occurrence of contamination in fish which may be consumed by humans, and the associated human health risk associated with this exposure pathway.

Contaminant Study Plan

It is proposed that representative species from each group be sampled as part of this study. Of the sportfish species occurring in the Red River, the channel catfish is probably the best choice for testing. Its bottom feeding habits make it the most likely to come in contact with PAH contaminated habitat and food sources and it is among the more popular sportfish species. In the invertebrate/forage fish group it is proposed that a representative invertebrate species (either crayfish or mollusc) and forage fish species be sampled.

The benthic invertebrate and forage fish species which are sampled for analysis will ultimately be determined by those which are found in the contaminated area. The occurrence of molluscs will be determined as part of the benthic survey. The occurrence of crayfish and forage fish will be determined as part of an activity trapping survey. Activity traps (wire minnow traps) will be set on the contaminated river sediments and in the reference area and checked daily for a period of about 5 days. In addition to enabling the selection of test species, the activity trapping program will provide information on which (if any) forage fish species occur in the contaminated area and if there are differences in species occurrence between the contaminated and the reference areas.

In the event that no suitable monitoring organisms are found to occur commonly in both the contaminated and the reference areas, an alternative approach would be to install suitable test organisms in both locations. Caged forage fish or clams are options which could be considered. Costs associated with these options will be discussed as required.

The sportfish test species will be captured either by angling or through the use of short term (2-4 hour) gill-net sets. Both methods minimize the number of non-target fish that are killed and the potential for interference with boat traffic. Sampling will be conducted as near the contaminated sediments as is practical. At this time it is proposed that sampling be restricted to the one location with a decision to add one or more upstream or downstream sites based on the results of the initial sampling. A minimum sample size of 6 fish is proposed at this stage; with the fish selected to represent a range of lengths within the range typically captured by sportfishers. Only muscle tissue is proposed for analysis at this time as this is the part of the fish which is typically consumed in this area. In the event that any PAH contamination is detected, additional tissues (e.g. liver) may be added to the analytical program. All fish sampled will be weighed and measured and will be examined for the presence of external and internal abnormalities, tumours, lesions, along with a field assessment of stomach contents. Sampling at the upstream reference used for the benthic and lower food chain contamination studies is not recommended as this location does not represent an appropriate control due to the wide ranging nature of these larger species.

The finding of no detectable PAHs in the tissue would indicate that contamination of sportfish species is not an issue, whereas the finding of measurable PAHs would indicate a requirement for further investigation. The obvious questions in the latter situation being the relationship between the contaminated sediments and the PAH contamination in channel catfish and the potential for contamination of other sportfish species. The first question cannot be simply addressed through comparison with a single adjacent upstream reference station. The PAH contaminated area under study may be the only known site in the Red River but it may not be the only site. Consequently, any followup study should include a number of sampling locations at increasing distance both upstream and downstream of the study area. This approach would determine if the PAH contamination in channel catfish is a general characteristic in the Red River or if it is restricted to the vicinity of the known area of contamination. At the same time, sampling would be extended to other sportfish species, with emphasis on selecting species representing a range of feeding habits.

Task 5: River Habitat Health Assessment

The suggestion in the terms of reference to compare the health of the river habitat in the area of contamination to that of the general health of the Red River makes sense in the context of an ecological risk assessment. However, based on some preliminary investigations, any assessment of the health of river habitat within Winnipeg is likely to be quite incomplete. Although there are numerous potential impact sources along the banks of the river in Winnipeg, the river habitat has not been extensively studied (Art Derksen, Impact Assessment Biologist, Manitoba Department of Natural Resources, Fisheries Branch, pers. comm.; Dr. Terry Galloway, Department of Entomology, University of Manitoba, pers. comm.).

Given this state of knowledge, we propose to review the existing aquatic resources information for the Red River in the immediate vicinity of Winnipeg. The outcome of this

review will be a description of the historical and current states of the aquatic system and of the potential impact sources, to the extent that these are known, and a comparison with the documented conditions in the area of contamination.

Task 6: Impact Assessment Document

The results of the field study, including the reconnaissance survey, benthic survey, fish habitat evaluation, and contaminant survey will be incorporated into an impact assessment report. The report will document the current state of the aquatic habitat in the contaminated area in relation what is expected, as indicated by the conditions of the contaminated and reference areas with respect to benthic community composition and structure, fish habitat quality, and contaminant levels in biota. Any significant (both statistical and ecological) adverse or positive effects will be identified and any requirement for remediation of adverse effects will be evaluated.

Part 2 - Shallow Soil Vapour Survey and Offsite Risk Assessment

Part 2 of the proposal is to complete a shallow soil vapour survey and discrete sampling of soil vapour for chemical analysis at and beyond the perimeter of the Sutherland Avenue Facility. Completion of such a survey would define the concentrations of soil gas within the road allowance across the street adjacent to residential land uses, the most sensitive land use with respect to soil gas migration. These analysis would allow the evaluation of soil gas migration beyond the property line and facilitate reliable definition of exposure concentrations. An offsite risk assessment would be considered to estimate potential impacts if residues are found in the soil gas beyond the property boundary.

Task 7: Shallow Soil Gas Survey

A shallow soil vapour survey is recommended to determine the degree of soil vapour concentrations and the extent of soil vapour migration beyond the property line. The soil vapour survey will proceed in two stages described below:

Screening Survey for Total Organic Vapour

The first stage of the soil vapour survey will involve analyzing soil gas for an indicator parameter called total organic vapour (TOV). This parameter can be analyzed readily in the field, and samples can be analyzed from a large number of locations in a short period of time. TOV readings can be used to guide sampling for specific chemicals.

The survey will be collected largely on the road allowance around the site. It is anticipated that Centra Gas will be able to provide assistance in obtaining permission from the City of this work.

CH2M HILL will have three methods available to advance boreholes for soil gas sampling to adapt to the various subsurface conditions and to facilitate sampling at depth. The soil vapour survey is conducted most efficiently by drilling a 2.5 cm diameter borehole using an electric hammer drill, powered by a gasoline generator, and a one metre long auguring drill bit. The borehole is advanced the full length of the auger; the auger is withdrawn and a stainless steel soil vapour sampling probe equipped with an inflatable rubber packer is quickly installed in the borehole. The rubber packer is inflated against the walls of the borehole, isolating the soil gas from the atmospheric air. The soil vapour is collected and analyzed with a Gastechtor Hydrocarbon Surveyor that is connected via a teflon tube to the soil vapour sampling probe. The Gastechtor is a battery powered portable instrument that draws continuous samples of vapour by means of a built-in pump and analyses the vapour for combustible gases on a heated catalytic platinum element. This instrument measures concentrations from 0 to 500 parts per million (ppm) or to 0 to 100 percent Lower Explosive Limit (%LEL).

An alternate method of advancing boreholes for the purposes of measuring soil vapour concentrations is by the use of a subsurface soil sampling probe. The sampling probe is advanced into the ground with a manual drop hammer. The sampling probe is then retracted with a built-in foot jack leaving a 2.5 cm diameter borehole. The advantages to this method are that boreholes can be advanced to depths greater then one meter, if required, and also a soil sample is retrieved and can be logged for geological purposes. This method, however, is less effective in soils containing rocks and debris, compared to the hammer drill and auger method.

A third alternate method of advancing boreholes is with a Pionjar drill. This equipment consists of a gasoline powered hammer drill that drives 2.5 cm diameter solid steel rods into the ground. Similar to the subsurface soil sampling probe, the steel rods are retracted with a foot jack leaving a 2.5 cm diameter borehole, however, a soil sample is not recovered. This method can be effective in soils with rocks and debris and can advance boreholes greater then 1 metre in depth. This method will be needed to define the depth profile of soil gas concentrations throughout the fill zone.

Initially soil vapour measurements will be taken at approximately 20 metre spacings (approximately 12 locations) offsite at opposite sides of the street adjacent to residential areas (see approximate locations in Figure 1). Samples will ideally be collected in the grassed areas within the road allowance. If necessary, samples can also be collected through concrete or asphalt. This will provide an indication of the degree of soil vapour concentration and migration, if any, from the site. At locations where soil vapour concentrations vary significantly between adjacent locations, additional measurements (up to 10 additional locations) will be taken (at approximately 10 m spacings) to more accurately define soil vapour concentrations.

To define the vertical profile of soil gas concentrations throughout the fill zone, it will be required to advance additional deeper boreholes, 3 to 4 metres below the ground surface, to define soil vapour concentrations to the deeper, native geological zones (below fill material). This will be conducted at approximately three locations selected based on the shallow soil gas readings.

SIMMON'S CANADA LTD.
(MATTRESS FACTORY)
COMMERCIAL/INDUSTRIAL
LAND USE

RESIDENTIAL
LAND USE
(5 OLD HOUSES)

LANDS ASSOCIATED WITH
VEHICLE TRANSPORTATION SYSTEM

GLADSTONE STREET

DISRAELI FREEWAY

TRAINING COMPLEX
(SLAB FOUNDATION)

PIPE YARD

COMMERCIAL/INDUSTRIAL
LAND USE

EMPLOYEE
PARKING

SUTHERLAND AVE

PURCHASING DEPT. AND
STORES BUILDING
(SLAB FOUNDATION)

VEHICLE
SERVICE
BUILDING
(SLAB
FOUNDATION)

OPERATIONS
BUILDING
(BASEMENT FOUNDATION)

OPERATIONS
BUILDING
(SLAB FOUNDATION)

LOADING AREA

BH01 BH02 BH03 BH04 BH05 BH06 BH07-1 BH07-2 BH08 BH09 BH10 BH11 BH12 BH13 BH15 BH16 BH17 BH19 BH20

MW01 MW02 MW03 MW05 MW12 MW14 MW18 MW21 MW22 MW23A MW23B MW24A,24B MW24C

CB01 CB02 CB03 CB04 CB05 CB06 CB07 CB08 CB09 CB10 CB11 CB12 CB13 CB14

TP1 TP2 TP3

NAT-GAS

FOTS

CONCRETE BRIDGE
ABUTMENT
DATUM FOR SURFACE
WATER MEASUREMENTS)

ROVER AVE

RED RIVER

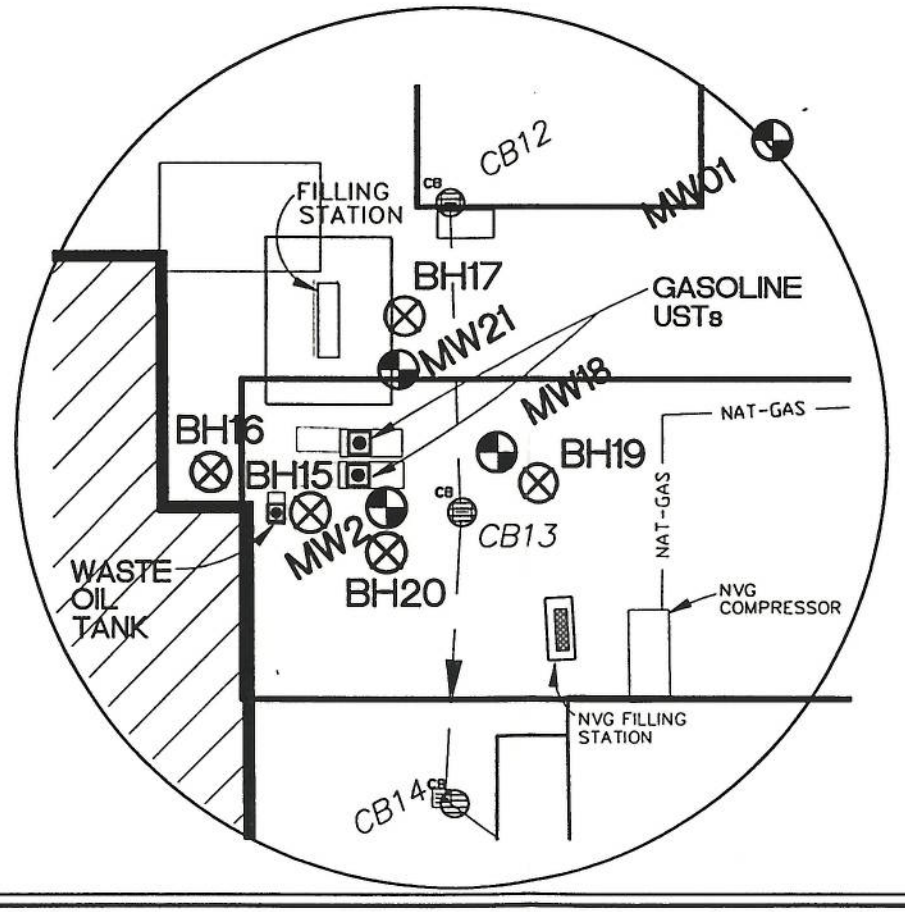
COMBINED SEWER

ANNABELLA STREET

COMMERCIAL/INDUSTRIAL
LAND USE

OLD HOUSING DEVELOPMENT
(RESIDENTIAL LAND USE)

POWER SUBSTATION (COMMERCIAL/INDUSTRIAL LAND USE)



LEGEND

- CATCH BASIN
- MANHOLE
- BH BOREHOLE
- MONITORING WELL
- NAT-GAS NATURAL GAS
- FOTS FIBER OPTICS CABLE
- TP1 TEST PIT
- EXISTING BUILDING
- FORMER PLANT BLDG. FOUNDATION MAY REMAIN
- FORMER PLANT BLDG. FOUNDATIONS REPORTED DEMOLISED
- © COARSE GRID (12 SAMPLES)
- Ⓕ FINE GRID (10 SAMPLES)
- PRIMARY SAMPLE LINE
- SECONDARY SAMPLE LINE

0 50m
SCALE

CH2M HILL ENGINEERING LTD.
WATERLOO ONTARIO
PROJECT No. ONE702.30

FIGURE 1
PROPOSED LOCATIONS
FOR SOIL VAPOUR SURVEY

Soil Gas Analysis for Specific Chemicals

Soil vapour samples will be collected for chemical analysis of four volatile chemicals which are characteristic of manufactured gas plant residues. Samples will be collected from approximately 6 locations. Sample locations with high, medium, and low soil vapour concentrations will be selected from the results of the soil vapour survey. The samples analyzed will include:

- background air samples in the vicinity to assess potential interferences
- a range of soil gas concentrations based on the indicator analysis
- locations with the highest soil gas concentrations across the street from Centra
- samples indicative of soil gas concentrations at depth in the fill

Samples will be collected with special canisters, provided by Environmental Technologies Inc. The soil vapour sampling probe will be installed into the borehole; the Gastechtor is connected to the probe and when soil vapour concentrations peak the sample is collected. To collect the sample the canister is connected to the soil vapour sampling probe via teflon tubing; the canister is under vacuum and when the valve is opened a sample is drawn into the canister. Samples will be submitted to Environmental Technologies Inc. and analyzed for concentrations of naphthalene, benzene, toluene, xylene, and ethylbenzene (BTXE).

The data from the soil gas survey will be evaluated to identify and where present, delineate the presence of organic vapours in the subsurface. This data will be plotted on a plan of the study area to illustrate the spatial variability in soil gas concentrations. Vertical variations and trends will also be examined and graphed to illustrate spatial variations. The results of the organic vapour analysis will be compared to and correlated with the detailed chemical analysis performed at up to 6 locations. Chemical analysis will be compared to background locations and to applicable air quality criteria. The results of these analysis will be interpreted to develop conclusions regarding the presence of soil gas beyond the property boundary.

The results will be provided as a section of the Phase IIB report., outlining the work conducted and summarizing the results of the soil vapour survey and chemical analysis. Interpretation of the results and conclusions regarding the impact or lack thereof of offsite soil gas migrations will be provided.

Section 3
Project Team

CH2M HILL has partnered with Agassiz North Associates Limited (Agassiz North) to undertake this project. Agassiz North is a Winnipeg-based environmental consulting firm with expertise in environmental impact assessment monitoring and research. Agassiz North has undertaken environmental projects for Centra Gas in the past (see attached qualifications). Agassiz North will undertake the biological impact assessment with input from CH2M HILL.

CH2M HILL will be the prime consultant and will undertake the soil vapour survey and interpretation. If necessary, CH2M HILL will undertake any human health or ecological risk assessment. CH2M HILL will be responsible for assembling the Phase IIB report with input from Agassiz North. CH2M HILL will liaise directly with Centra Gas as the main project contact.

The personnel who will be assigned to the project are identified below, along with details on their experience in relation to studies such as that proposed here. Detailed resumes for each team member may be found in Appendix A.

Brian Whiffin, M.Eng. (CH2M HILL) - Project Director

The project director for Phase IIB will be Brian Whiffin who acted in a similar capacity for Phases I and II. Brian has over 13 years of experience in the investigation, evaluation, and remediation of contaminated lands, including several coal gasification sites.

Brian will be responsible for leading the project team and completing the project on time and on budget. He will liaise with Agassiz North who will undertake the biological impact assessment. Brian will also lead the soil gas survey and risk assessment components of this project.

Brian will be supported by several engineering and technical staff at CH2M HILL with expertise in the applicable areas.

Doug Ramsey, M.Sc. (Agassiz North) - Study Manager

The study manager and principal investigator for the biological impact assessment will be Doug Ramsey. He will be responsible for study design, management, data interpretation, and reporting.

Doug is an aquatic ecologist with 18 years of field study experience, the past 13 years as an environmental consultant. Over this period, he has designed and conducted numerous retrospective biophysical impact assessments dealing with water and sediment quality, fisheries, and food chain (phytoplankton, zooplankton, and zoobenthos) issues. Represen-

tative projects include studies on the effects of impoundment and diversion on mercury cycling and bioaccumulation, water quality, and fisheries in the Churchill-Nelson river system in northern Manitoba, for the Department of Fisheries and Oceans, Environment Canada, and the provincial Fisheries Branch; biophysical impact assessments, including fisheries and fish habitat assessments, for two gold mines and a municipal sewage treatment plant in northern Manitoba; a fish habitat and biophysical impact assessment related to the remediation of solvent contaminated ground water; the design and implementation of the baseline/construction and operations monitoring program components dealing with aquatic and terrestrial biota for the Manitoba Hazardous Waste Management Corporation's central waste treatment facility; and, assessment of the ecological risk associated with mercury contaminated sediments in Howe Sound, BC.

Gwenn Kruszynski, M.Sc. (Agassiz North) - Ecologist

Gwenn is an aquatic ecologist with 9 years of experience in a wide range of aquatic studies, the past 6 with Agassiz North. She will provide assistance with the field study and data analysis, conduct the review of information on the aquatic ecology of the Red River, and provide expertise for the identification of any aquatic macrophytes occurring in the study area.

Lisette Ross, B.Sc. (Agassiz North) - Entomologist

Lisette is an aquatic entomologist with 14 years of experience in zoobenthos sample sorting and identification. Working as a subconsultant to Agassiz North, she will be responsible for sorting and analysis of the zoobenthos samples.

Section 4
Schedule

It is proposed that he project commence in late June with the reconnaissance survey of the river and the sampling of soil gas. Benthic sampling will be conducted in early July and other biota and sediment sampling conducted in latter July. It is expected that all analytical results from the biological impact assessment and soil vapour survey will be completed by the end of August. The results will be interpreted through September and a report will be submitted. If it is necessary to conduct an Ecological or Human Health Risk Assessment, this will be conducted through October.

Progress reports will be completed on an ad hoc basis as required by Centra or to correspond to major project milestones.

Any requirement for changes in the project scope will be discussed with Centra as soon as identified.

Appendix A

Project Team Resumes

Brian Whiffin

Senior Remediation Engineer/Hazardous Waste Department Manager

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Related Experience

Mr. Whiffin's career has encompassed a variety of environmental management projects focusing on the characterization and reduction of environmental risk/liability. He has considerable experience in the following areas: environmental auditing, designing and conducting field investigations, environmental risk assessment, waste site remediation, liaison and negotiation with regulatory authorities, applied research, waste management, and project management. Since joining CH2M HILL, Mr. Whiffin has been involved in the following studies:

- Project manager for an environmental audit and site assessment at a major automotive assembly plant, a major automotive foundry, and an appliance plant scheduled for closure
- Project manager for the decommissioning of a large phosphate fertilizer plant, phosphogypsum waste storage area, sulphuric acid plant, phosphoric acid plant, and zinc roaster
- Technical advisor for the establishment of a Soil Recycling Centre for light petroleum contaminated soil
- Team leader to identify research, development, and demonstration (R, D, & D) needs in soil and groundwater remediation for the DESRT program
- Remedial assessment team leader for the CFB Borden firefighting training area (FFTA) groundwater contamination project
- Project manager/advisor for the investigation and remediation of numerous service stations, bulk fuel storage sites, and industrial/commercial properties
- Project manager for numerous property transaction environmental site assessments including one project involving five facilities for a major soft drink company and a second involving 23 food sector facilities
- Project manager for the investigation of subsurface environmental impacts at a former lakefill site (i.e. Cherry Beach) under the control of the Toronto Harbour Commission
- Project engineer/hydrogeologist/project advisor for the decommissioning and cleanup of buried wastes and residues at a former coal gasification

plant in Waterloo, Ontario and a coal tar deposit in the Thames River, London, Ontario

- Technical consultant/project manager for the investigation of decommissioned coal gasification plants in St. Thomas, Owen Sound, Stratford, Guelph, and London, Ontario

- Project manager for the subsurface component of a research and demonstration project related to aquifer decontamination at an organic chemical plant

- Project manager for environmental monitoring of a gasoline spill (20,000 gals) involving soil gas sampling, free product measurement, surface and groundwater sampling, and hydrogeologic characterization. Project involvement also included engineering support for design and implementation of a dual hydrocarbon recovery/water table depression system in a product recovery well and an evaluation of treatment alternatives for contaminated groundwater.

- Performed hydrogeological and fill investigations at four industrial waste disposal sites (i.e. fly ash, foundry sand, cement kiln dust, and blast furnace slag) in support of guideline development in Ontario

Prior to joining CH2M HILL in 1986, Mr. Whiffin spent 4 years as a staff consultant with Intera Technologies Ltd. (formerly GTC Geologic Testing Consultants Ltd.) of Ottawa. At Intera, Mr. Whiffin gained expertise in the area of contaminant hydrogeology primarily related to the management and disposal of hazardous wastes.

Education

M.Eng., Civil Engineering, University of Ottawa (jointly with University of Waterloo), 1990)
B.A.Sc., Civil Engineering, University of Waterloo, 1982

Professional Registration

Professional Engineer: Ontario

Membership in Professional Organizations

Association of Ground Water Scientists and Engineers
Association for the Environmental Health of Soils (AEHS)

Brian Whiffin

Additional Training

Field Methods in Contaminant Hydrogeology–University of Waterloo, 1983
Dense, Immiscible Phase Liquid Contaminants (DNAPLS) in Porous and Fractured Media–University of Waterloo, 1990

Martin Adomait
Project Hydrogeologist

Related Experience

Mr. Adomait is a project hydrogeologist/engineer in CH2M HILL's Industrial and Environmental Services Division. Mr. Adomait has been involved in project manage ment and support roles and has diverse experience in a number of areas including:

Contaminant Hydrogeology/Remediation

- Project manager for a remedial investigation of the fire fighting training area at the Lester B. Pearson International Airport, for Transport Canada. The contaminated soil contained a wide variety of hydrocarbons, including unleaded gasoline, jet fuel, diesel, and motor oil.
- Lead engineer for soil gas assessment at CFB Borden fire training area, for Government Services Canada.
- Efficiency assessment of the methane gas control systems at the Kitchener Landfill site
- Development and implementation of a gas control system at the Ottawa Street Landfill Site, Kitchener, Ontario
- State-of-the-art literature review and technology assessment of in situ enhancement techniques of the volatilization of organic contaminants in the unsaturated zones
- Design, implementation, and permitting of a contaminated soil and groundwater treatment system at a retail petroleum facility in London, Ontario
- Geochemical evaluation of groundwater at various landfill and industrial sites including: Summit, Ohio; Guelph, Brantford, Burlington, Listowel, Sarnia, Petrolia, Hamilton, Woodstock, and Elmira, Ontario; and Butler, Pennsylvania
- Mathematical modelling of groundwater flow systems and contaminant transport for sites in: Regions of Halton, West Lincoln, and Waterloo and Minneapolis, Minnesota
- Supervised and managed groundwater and surface water monitoring programs in Petrolia, Sarnia, and Woodstock
- Peer review of hydrogeologic investigations of various landfill sites including: Ontario Waste Management Corporation and Halton Region Landfill
- Assessment of contamination due to fuel oil, hydrocarbons in Hamilton, Ottawa, Windsor, London, and Kitchener, Ontario for both legal and regulatory purposes

Air Quality

- Development of a protocol for the assessment of VOC entry indoors from contaminated soil gases
- State-of-the-art literature review of and the assessment of remedial techniques for Canadian homes that have been affected by soil gases from hazardous lands
- Stack emission testing and evaluation
- Sub-slab venting technology evaluation for the mitigation of methane entry into homes (Research Demonstration Project for the Research Division of Canada Mortgage and Housing Corporation)
- Methane infiltration investigations and evaluations in residential and commercial settings in Kitchener including: Barwood Crescent neighbourhood, Strasburg Road neighbourhood, former incinerator site, and newly-developed Lancaster Park
- Permitting for air emissions and compliance monitoring in Ontario

Groundwater Supply/Treatment Studies

- Groundwater supply investigation for a manufacturing industry in Elmira, Ontario, and a municipal water supply in Earlton, Ontario
- Groundwater interference assessments due to mining activities in Hagersville, quarry excavations in Port Colborne, and groundwater pumping in Earlton, Ontario
- Designed and implemented a variety of control systems for industrial water treatment
- Designed and implemented ion exchange potable water treatment equipment in facilities in Kitchener, Ontario
- Designed and implemented activated carbon treatment for a petroleum facility

Education

Ph.D., Environmental Engineering, University of Guelph (in progress)
M.Sc., Hydrogeology, Earth Sciences, University of Waterloo, 1988
B.Sc. (Eng.), Water Resources Engineering, University of Guelph, 1984

Professional Registration

Association of Professional Engineers of Ontario

Membership in Professional Organizations

International Association of Hydrogeologists
Association of Groundwater Scientists and Engineers (Division of National Water Well ssociation)
Air and Waste Management Association

Publication/Presentations

"Examples of Housing Affected by Gas Monitoring from Hazardous Lands". With Don Fugler and Catherine M. Soroczan. Presented at the 85th Annual Meeting and Exhibition of the Air and Waste Management Association. Kansas City, Missouri, June 21-26, 1992.

"Remediation of Houses Affected by Landfill Gas Entry". With D. Fugler. Presented at the 84th Annual Meeting and Exhibition of the Air and Waste Management Association, Vancouver, British Columbia. June 16-21, 1991.

"In Situ Volatilization Technologies R, D & D Scoping Study." With B. Whiffin. Proceedings of GASReP 1st Annual Groundwater and Soil Remediation R, D & D Symposium. Ottawa, Ontario. January 30-31, 1991.

"Soil Vapour Extraction with Catalytic Oxidation at the Verona Well Field Superfund Site." With Joseph Danko. Proceedings of Prevention and Treatment of Soil and Groundwater Contamination in the Petroleum Refining and Distribution Industry Conference. Montreal, Quebec. October 16-17, 1990.

"Remedial Measures for Housing on Hazardous Lands". With D. Fugler. Presented at the 5th International Conference on Indoor Air Quality and Climate. Toronto, Ontario. 1990.

"Remote Data Collection and Control for Hydrogeologic Monitoring." With R.W. Gillham. Groundwater Monitoring Review, Vol. 10, No. 3. 1990.

"Hydraulic Responses in Fractured Clay". University of Waterloo, 1988.

Rao V. Kolluru
Director, Environmental Health Services

Distinguishing Qualifications

- Exposure and risk assessment
- Environmental and occupational health
- Hazardous waste management
- Strategic planning and management

Related Experience

Dr. Kolluru has more than 20 years of involvement in the environmental and health fields in technical and business management with industrial and consulting firms. He has a strong background in risk assessment and public health.

Representative Projects

- Developed a methodology for characterizing community exposures and health effects of emissions under Title III of the Superfund Amendments and Reauthorization Act.

- Prepared a risk assessment strategy as part of a Resource Conservation and Recovery Act (RCRA) facility investigation for a site in New England comprising several solid waste management units (SWMUs).

- Devised a framework to address chemical risks in addition to radiological hazards at a large nuclear site in New York.

- Manager of manufacturing technology and environmental affairs of the chemicals group at American Cyanamid. The group had more than 20 manufacturing sites producing chemicals, polymers, composites, pharmaceutical intermediates, and agricultural products valued at more than $1 billion.

- At American Cyanamid, developed and implemented an innovative Engineered Standards and Opportunity Value program encompassing four major chemical plants and several smaller plants. The program determined optimal performance on the basis of process design data, yields from raw materials, production bottlenecks, and state-of-the-art technology.

- Evaluated effluent treatment capacity and permitting of an existing plant in California for potential manufacture of a new polymer.

- Directed the preparation and was primary author of a 700-page report on more than 20 coal gasification and liquefaction processes. Analyzed process flow-charts, operating conditions, equipment reliability, through-put, effluents, and commercial prospects.

- Conducted a preliminary exposure assessment of Pelham Bay landfill in the Bronx, New York. Risk assessment manager of a remedial investigation and feasibility study, an $8 million project of the New York Department of Environmental Protection. Developed guidelines for a follow-up epidemiological study.

- Conducted health risk assessments to provide a resource-effective basis for industrial site cleanup levels in New Jersey, New York, and other states. The cleanup levels pertain to requirements of the Resource Conservation and Recovery Act (RCRA) and related state laws.

- Conducted hazop study as part of Risk Management and Prevention Program (RMPP) for a wastewater reclamation plant in California (total project about $200 million).

Education

Doctor of Public Health, Columbia University
M.B.A., New York University
M.S., Chemical Engineering, CCNY

Membership in Professional Organizations

Air and Waste Management Association
American Institute of Chemical Engineers
American Public Health Association
Society for Risk Analysis

Publications and Presentations

Dr. Kolluru has written and presented many reports on technology, capital investment, and environmental and public health. A bibliography is available on request.

DOUGLAS J. RAMSEY
PRESIDENT - AGASSIZ NORTH ASSOCIATES LIMITED

EDUCATION

M.Sc. Zoology, Limnology Major, University of Manitoba, 1985
B.Sc. (Hons.), Zoology, University of Manitoba, 1979

PROFESSIONAL AFFILIATIONS

American Fisheries Society
American Society of Limnology and Oceanography
Canadian Society of Environmental Biologists
North American Lake Management Society
International Association for Impact Assessment

EXPERIENCE

Mr. Ramsey is responsible for the design and management of environmental assessments and research programs undertaken by Agassiz North. In his 13 years as an environmental consultant, Doug has acquired a wide range of experience in the impact assessment field. The majority of this work has been in the measurement of significant environmental change caused by major resource developments, the application of this knowledge in prediction of the impacts of new projects, and the development of appropriate impact prevention and mitigation plans. Projects have included major gold mines in northern Manitoba and British Columbia; hydroelectric developments in Manitoba, northwestern Ontario, and northern Quebec; industrial facilities in Manitoba and British Columbia; and a variety of municipal (sewage treatment plants, linear facilities) and recreational projects. As a principal investigator, Doug has developed new sampling and analytical methods and applied these in a range of environmental conditions. As a project manager, he has been responsible for the management of multi-disciplinary study teams and for the integration of information from a range of disciplines, including: aquatic and terrestrial ecology, microbiology, biogeochemistry, air and water quality, hydrology and hydrogeology, and geography.

Doug's assignments have included:

- Environmental impact assessment of the proposed Flin Flon sewage treatment plant upgrade in support of an application for an environment license (with UMA Engineering Ltd.). Areas of responsibility included water quality modelling, fisheries, wildlife and vegetation, and the development of mitigation measures. Key issues examined included coliform bacteria levels and loading of nutrients, ammonia, BOD, and residual chlorine and the effects of these pollutants on fish and fish habitat. Effluent quality objectives for the upgraded plant were developed in relation to the Manitoba Surface Water Quality Objectives.

- Environmental impact assessment for the Keystone Gold Mine - Farley Lake Project for Granduc Mining Corporation. Working with Goodwin Mining Services Ltd., Doug is currently completing the environmental impact assessment for this next phase of the Keystone Gold project. Responsibilities include design and implementation of the public consultation program, environmental baseline studies, water quality modelling, consideration of impacts on fisheries, wildlife and vegetation, and the development of mitigation measures, a monitoring program, and a mine closure plan.

- Evaluation of Lynn Lake Mill discharges on water quality in the Lynn River for Granduc Mining Corporation. The potential impacts of variations in mill discharge volume on water quality in the Lynn River were examined at average and low flow conditions to evaluate the consequences of changes in milling capacity.

- Lynn Lake Mill tailings study for Granduc Mining Corporation. Working with UMA Engineering Ltd. and Goodwin Mining Services Ltd., the potential environmental impacts of alternative tailings management strategies were identified and compared.

- Environmental impact assessment for the Keystone Gold Project - BT Open Pit Mine for Granduc Mining Corporation. Working with Goodwin Mining Services Ltd., completed the first environmental impact assessment for a new gold mine under the new Manitoba Environment Act. Responsibilities included water quality modelling, fisheries, wildlife and vegetation, and the development of mitigation measures.

- A comprehensive retrospective assessment of significant changes and adverse effects of the Churchill River Diversion and Lake Winnipeg Regulation hydroelectric projects on physical, chemical, and bacteriological water quality and fisheries in the Burntwood and Nelson rivers in northern Manitoba.

- Environmental impact assessment of the Southwestern Manitoba and Swan River components of Centra Gas Manitoba Inc.'s Rural Gas Expansion Plan.

- Expert technical consultant on the Cinola Gold Project. Working for Norecol Environmental Consultants and City Resources (Canada) Ltd., examined the impacts of the project on mercury concentrations in aquatic biota and developed mitigation measures. Issues examined included the effects of acid generation, tailings management and disposal, and organic loading on mercury mobilization and methylation.

- Assessed the potential impact of the Outer Continental Shelf, Norton Sound, Alaska lease sale on mercury mobilization and methylation for the United States Department of the Interior, Minerals Management Service.

- Development and implementation of the baseline/construction environmental monitoring program for the Manitoba Hazardous Waste Management Corporation Central Treatment Facility in the R.M. of Montcalm (with UMA Engineering Ltd. and Atomic Energy of Canada Ltd.). Areas of responsibility included wildlife, vegetation, aquatic resources, and agricultural products.

- Contribution to the detailed site evaluation for the proposed site of the Manitoba Hazardous Waste Management Corporation Central Treatment Facility in the R.M. of Montcalm (for UMA Engineering Ltd.). Areas of responsibility included documentation of wildlife and fisheries resources in the study area and assessment of the potential impacts on these resources.

- Environmental impact assessment in support of an environment license application under the Manitoba Environment Act for the Bristol Aerospace Limited rocket fuel plant (for UMA Engineering Ltd.). Areas of responsibility included wildlife, vegetation, aquatic resources, aerial and surface water contaminants, and soils.

- A retrospective assessment of aquatic environmental impacts in the resource utilization area of The Dalles First Nation, near Kenora Ontario.

- Expert technical consultant on mercury issues for Makivik Corporation in the Federal Environmental Review of the Great Whale Hydroelectric Project in northern Québec.

- Expert technical consultant on mercury issues for the Moose River/James Bay coalition in the environmental review of Ontario Hydro's 25 year demand-supply plan.

- An eight year study of the cause of elevated fish mercury levels in northern hydroelectric reservoirs, estimation of the duration of the elevated mercury levels, and examination of potential mitigation measures. This project required the development and application of new analytical procedures for the study of microbial transformation of mercury species in water and sediments and for the analysis of total mercury concentrations in water at trace levels.

- Assessment of the impacts of a proposed soil remediation land farm in northern Manitoba on wildlife, fisheries, vegetation, and resource use.

- Identification of terrestrial and aquatic environmental impacts and development of a preliminary environmental management plan for a proposed resort development on Mink Bay, near Keewatin, Ontario. This project required the provision of expert testimony at an Ontario Municipal Board hearing in support of an application for rezoning by the developers.

- A siting study and initial environmental assessment for a bridge across the Fraser River at Quesnel, British Columbia. The study considered the impacts of various bridge designs and alternative bridge and approach alignments on wildlife habitat, the potential for road kills, agricultural land use, fish habitat, and the development of velocity barriers to fish passage. A mitigation plan was developed in compensation for lost fish habitat.

- A site capacity study for a proposed industrial park on Howe Sound, British Columbia. The capacity of the site for the development of a variety of forest-related industries, light manufacturing facilities, and a small fuel tank farm was assessed on the basis of environmental constraints. New methods of log handling were suggested to minimize impacts on foreshore habitat while maximizing land use. Terrain hazards were identified and stream buffer zones were established for the protection of salmon streams and wildlife habitat.

D.J. Ramsey - Employment History

1983 to Date AGASSIZ NORTH ASSOCIATES LIMITED, Winnipeg

President, Senior Ecologist

Doug is responsible for the selection and assembly of study teams, and for the design and management of multi-disciplinary environmental studies. Projects have included contributions to environmental assessments of hydroelectric developments, municipal and hazardous waste treatment facilities, offshore dredging proposals, mining projects, and resort developments; background reviews of aquatic resources information; research into the cause, duration, and mitigation of mercury problems in hydroelectric reservoirs; modeling of aquatic systems; and the provision of expert technical reviews for environmental assessments.

1989 NORECOL ENVIRONMENTAL CONSULTANTS LTD., Vancouver

Project Manager

As a project manager, Doug was responsible for the coordination of data collection, analysis, and presentation by the study team and for the integration of this information in impact assessment reports and in support of permit applications. Experience included project scheduling and development of impact assessment reports. Representative projects included studies for the Sunshine Coast Regional District Hillside Industrial Park and the Quesnel - North Fraser Industrial Interconnect.

1982 to 1983 DEPARTMENT OF FISHERIES AND OCEANS, Winnipeg

Research Consultant

Managed enclosure experiments at Southern Indian Lake which simulated reservoir formation to examine the effects on primary and secondary productivity, trophic interactions and, using radioisotopes, on the biogeochemical cycling of mercury.

1981 to 1982 DEPARTMENT OF FISHERIES AND OCEANS, Winnipeg

Zooplankton Ecologist

Using limnocorrals, examined the effects of manipulations of inorganic turbidity and additions of terrestrial organic materials on zooplankton community dynamics and feeding relationships of planktivorous fish.

1979 DEPARTMENT OF FISHERIES AND OCEANS, Winnipeg
to
1981 Research Consultant

Using limnocorrals, examined the effects of manipulations of pH, simulating acidification by acid precipitation, on zooplankton abundance, diversity, community composition, and dynamics. Assisted in crayfish population studies in an experimentally acidified lake. Conducted a sediment core survey of 3 lakes. Cores were collected by hand under ice cover using SCUBA.

PRIMARY PUBLICATIONS AND PUBLISHED REPORTS

Ramsey, D.J. 1995 in press. Impact of Lake Winnipeg Regulation and Churchill River diversion on fish populations in the Rat-Burntwood and Nelson River systems. Manitoba Department of Natural Resources, Fisheries Branch MS Report No. 95-XX, 320 p.

Ramsey, D.J. 1992. Federal Ecological Monitoring Program Final Mercury Report. FEMP Technical Report, Environment Canada, Winnipeg, MB. xxi + 140 p.

Ramsey, D.J. 1992. Federal Ecological Monitoring Program Final Water Quality Report. FEMP Technical Report, Environment Canada, Winnipeg, MB. xxviii + 352p.

Ramsey, D.J. 1991. Analysis of fish mercury data from lakes on the Rat-Burntwood and Nelson river systems, 1983-1989. Manitoba Department of Natural Resources, Fisheries Branch MS Report No. 91-14, 78+x p.

Ramsey, D.J. 1990. Experimental studies of mercury dynamics in the Churchill River diversion, Manitoba. In Delisle, C.E. et Bouchard, M.A. (eds.), Collection Environnement et Géologie, Volume 9. Canadian Society of Environmental Biologists. p. 69-91.

Ramsey, D.J. 1990. Measurements of methylation balance in Southern Indian Lake, Granville Lake, and Stephens Lake, Manitoba, 1989. Ecological Report Series, Northern Flood Agreement Manitoba. 90-3:xii+89p.

Ramsey, D.J. 1989. Measurements of methylation balance in Southern Indian Lake and Granville Lake, Manitoba, and in Sokatisewin Lake, Saskatchewan, 1988. Ecological Report Series, Northern Flood Agreement Manitoba. 89-2:ix+94p.

Ramsey, D.J. 1988. Measurements of methylation balance in Southern Indian Lake, Notigi Reservoir, Sipiwesk and Granville Lakes, Manitoba; 1987. Ecological Report Series, Northern Flood Agreement Manitoba. 88-1:x+109p.

Ramsey, D.J. 1987. Measurements of methylation balance in Southern Indian Lake, Granville Lake, and Laurie Reservoir Manitoba, 1986. Ecological Report Series, Northern Flood Agreement Manitoba. 87-2:ix+92p.

Ramsey, D.J. 1985. The response of planktonic crustacean communities in large enclosures to experimental acidification. M.Sc. Thesis. University of Manitoba, Winnipeg, MB. vii+203p.

Ramsey, D.J., L. Livingston, I. Hagenson, and D.J. Green. 1990. Evolution of limnological conditions in lakes of the Nelson and Rat-Burntwood river systems after Churchill River diversion and Lake Winnipeg regulation: I. An overview. Manitoba Department of Natural Resources, Fisheries Branch MS Report No. 89-15, 89pp.

Ramsey, D.J., and P.S. Ramlal. 1987. Measurements of mercury methylation balance in relation to concentrations of total mercury in northern Manitoba reservoirs and their use in predicting the duration of fish mercury problems in new reservoirs. Summary Report of the Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion, Appendix 11. Winnipeg, MB. 53 p.

Ramsey, D.J., and P.S. Ramlal. 1987. Measurements of rates of production and degradation of methyl mercury and concentrations of total mercury in Southern Indian Lake, Cedar Lake, and Granville Lake, Manitoba; Results of a survey conducted in July and August 1985. Summary Report of the Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion, Appendix 12. Winnipeg, MB. 41p.

Kruszynski, G.M., and D.J. Ramsey. 1995 in press. Limnological changes in lakes of the Rat-Burntwood and Nelson river systems following Churchill River diversion and Lake Winnipeg regulation. Manitoba Department of Natural Resources, Fisheries Branch MS Report No. 95-XX.

Stewart, D.B., R.A. Ratynski, L.M.J. Bernier, and D.J. Ramsey. 1993. A fishery development strategy for the Canadian Beaufort Sea - Amundsen Gulf area. Can. tech. rep. Fish. Aquat. Sci. 1910: v + 127 p.

Hecky, R.E., D.J. Ramsey, R.A. Bodaly and N.E. Strange. 1992. Increased methylmercury contamination in fish in newly formed freshwater reservoirs. In T.F. Clarkson, T. Suzuki, and A. Imura (ed.) Advances in mercury toxicology, Plenum Press.

Davies, I.J., and D.J. Ramsey. 1989. A diver operated suction gun and collection bucket for sampling crayfish and other aquatic macroinvertebrates. Can. J. Fish. Aquat. Sci. 46(6): 923-927.

Hecky, R.E., R.A. Bodaly, N.E. Strange, D.J. Ramsey, C. Anema, and R.J.P. Fudge. 1987. Mercury bioaccumulation in yellow perch in limnocorrals simulating the effects of reservoir formation. Can. Data Rep. Fish. Aquat. Sci. 628: v+158p.

Hecky, R.E., R.A. Bodaly, D.J. Ramsey, and N.E. Strange. 1987. Enhancement of mercury bioaccumulation in fish by flooded terrestrial materials in experimental ecosystems. Summary Report of the Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion, Appendix 6. Winnipeg, MB. i+35p.

Hecky, R.E., R.A. Bodaly, D.J. Ramsey, and P.S. Ramlal. 1987. Evolution of limnological conditions, microbial mercury methylation, and mercury concentrations in fish in reservoirs in northern Manitoba. Summary Report of the Canada-Manitoba Agreement on the Study and Monitoring of Mercury in the Churchill River Diversion, Appendix 9. Winnipeg, MB. 53p.

PAPERS PRESENTED

Ramsey, D.J., R.E. Hecky, and R.A. Bodaly. 1990. Microbial methylation of mercury in reservoirs of northern Manitoba, Canada. International Conference on Mercury as an Environmental Pollutant, June 1990, Gävle, Sweden.

Ramsey, D.J., and R.E. Hecky. 1982. Biological effects of experimental manipulations of inorganic turbidity in large enclosures. American Society of Limnology and Oceanography Annual Meeting, June 1982, Raleigh, N.C.

UNPUBLISHED REPORTS

Ramsey, D.J. 1995. Rural Gas Expansion Project - Environmental assessment of the proposed southwestern Manitoba natural gas pipeline system. Prepared for Centra Gas Manitoba Inc.

Ramsey, D.J. 1995. Rural Gas Expansion Project - Environmental assessment of the proposed Swan River area natural gas pipeline system. Prepared for Centra Gas Manitoba Inc.

Ramsey, D.J., K.M. Hallard, and R.E. Hecky. 1995 in prep. Phytoplankton primary productivity and nutrient status in the Southern Indian Lake impoundment, 1974 to 1988.

Ramsey, D.J., and C. Anema. 1995 in prep. Water chemistry in the Southern Indian Lake impoundment, 1974 to 1988.

Ramsey, D.J., and G.M. Kruszynski. 1993. Manitou Abi Model Forest - Baseline Aquatic Resources Information Inventory. Prepared for the Manitou Abi Model Forest Inc., Pine Falls, MB. 221 pp.

Ramsey, D.J. 1992. Predictions of fish mercury concentrations in the Moose River Basin, Northern Ontario, following development of hydroelectric potential as proposed by Ontario Hydro. Prepared for the Moose River/James Bay Coalition Ontario Hydro Demand/Supply Hearing Panel 3E5, Health. 16 p.

Ramsey, D.J. 1992. A review of aquatic environmental impacts in The Dalles First Nation resource utilization area. Prepared for The Dalles First Nation, Kenora, ON. 33 p.

Ramsey, D.J., and G.M. Kruszynski. 1992. Bristol Aerospace Limited Rockwood Plant Environmental Impact Statement - Aquatic Resources, Wildlife, and Vegetation. Prepared for UMA Engineering Ltd., Winnipeg, MB.

Ramsey, D.J., and G.M. Kruszynski. 1991. Pukatawagan Land Farm Environmental Impact Statement - Vegetation, Wildlife, and Aquatic Resources. Prepared for UMA Engineering Ltd., Winnipeg, MB.

Ramsey, D.J. 1991. Overview of fisheries and wildlife resources in the vicinity of the proposed Manitoba Hazardous Waste Management Corporation central treatment facility in the R.M. of Montcalm, Manitoba. Prepared for UMA Engineering Ltd, Winnipeg, MB.

Ramsey, D.J. 1990. Impact of the Outer Continental Shelf, Norton Sound, Alaska, lease sale on mercury mobilization and methylation. Prepared for the United States Department of the Interior, Minerals Management Service.

Ramsey, D.J. 1989. Microbial mercury methylation and demethylation in water and sediments of the Huntsville lakes, 1989. Prepared for Department of Fisheries and Oceans, Winnipeg, MB.

Ramsey, D.J. 1989. Measurements of methylation balance in the Complexe La Grande Quebec, 1986. Prepared for the Cree Regional Authority, Montreal, Quebec.

Ramsey, D.J. 1988. Cinola Gold Project - Studies of Mercury and Mercury Methylation. Prepared for City Resources (Canada) Limited, Vancouver, BC.

Ramsey, D.J. 1987. Measurements of methylation balance in the Little Jackfish River System. Prepared for Ontario Hydro, Environmental Studies and Assessments Department, Toronto, Ontario.

Ramsey, D.J. 1987. Zooplankton community composition, abundance, and biomass in lakes of the Mackenzie Delta - Tuktoyaktuk Peninsula: 1985-1986. Prepared for Department of Fisheries and Oceans, Freshwater Institute, Winnipeg, MB.

Ramsey, D.J., and P.S. Ramlal. 1985. A review of the limnology of the Mackenzie Delta and Tuktoyaktuk Peninsula. Prepared for Department of Fisheries and Oceans, Freshwater Institute, Winnipeg, MB.

Ramsey, D.J., and P.S. Ramlal. 1984. Summary report of the 1983 enclosure experiments at Southern Indian Lake, Manitoba. Prepared for the Department of Fisheries and Oceans, Freshwater Institute, Winnipeg, MB.

Ramsey, D.J. 1983. Summary report of the 1982 enclosure experiments at Southern Indian Lake, Manitoba. Prepared for the Department of Fisheries and Oceans, Freshwater Institute, Winnipeg, MB.

Stewart, D.B., R.A. Ratynski, L.M.J. Bernier, and D.J. Ramsey. 1989. Beaufort sea fishery development strategy. Prepared for the Fisheries Joint Management Com., Inuvik, NWT.

GWENN M. KRUSZYNSKI
ECOLOGIST

EDUCATION

M.Sc. Botany, University of Manitoba, 1989
B.Sc. (Hons.), Botany, University of Manitoba, 1984

EXPERIENCE

Gwenn Kruszynski is a botanist with a strong background in environmental chemistry and ecological field studies. Gwenn's area of expertise in botany lies in diatom systematics. She has worked as an environmental scientist for the past 12 years, the past 6 with Agassiz North. Over this period she has been involved in studies on the impact of herbicides on aquatic productivity and algal community structure; in studies of microbial transformations of mercury in northern reservoirs; performed fisheries, fish habitat, water quality, and vegetation surveys for environmental impact assessments; conducted literature searches; and, compiled bibliographic information on limnological and fisheries issues. Her analytical experience includes siliceous (diatom) and non-siliceous periphyton, phytoplankton, macrophyte identification and enumeration; primary productivity measurements; gas chromatographic determinations of CO_2 and methane in water and air; spectrophotometric determinations of herbicides and inorganic compounds in water; and, radiochemical measurements of algal productivity and of microbial methylation and demethylation rates.

EMPLOYMENT HISTORY

1989 to Date — AGASSIZ NORTH ASSOCIATES LIMITED, Winnipeg

Ecologist

Responsibilities include the management of the Agassiz North analytical laboratory, the performance of specialized laboratory analyses, and the contribution to project design and execution, data analysis, report production, and technical review. Since joining Agassiz North, Gwenn has contributed to an investigation of the effect of a new fungicide on phytoplankton, an investigation of the cause of naturally high fish mercury levels in the Muskoka district of Ontario, to a study of microbial mercury transformations in northern Manitoba reservoirs, and to several studies of water quality changes related to Churchill-Nelson hydroelectric development. She also has prepared an assessment of the impact of a proposed soil remediation land farm on vegetation and contributed to an environmental impact assessment of an operating rocket fuel plant and a detailed site investigation for a proposed hazardous waste treatment and transfer facility.

1988 MANITOBA DEPARTMENT OF ENVIRONMENT AND WORKPLACE SAFETY AND HEALTH, Winnipeg

Laboratory Technician III

Identified and enumerated algal communities, including siliceous and non-siliceous periphyton and phytoplankton from ponds that were experimentally treated with aerial additions of glyphosate. Maintained cultures of algae and aquatic plant material and assisted in the conduct of toxicity bioassays. Provided assistance in bulk asbestos analysis.

1986 to 1988 MANITOBA DEPARTMENT OF ENVIRONMENT AND WORKPLACE SAFETY AND HEALTH, Winnipeg

Aquatic Ecologist

Conducted laboratory studies and field experiments examining the effects of herbicides used in silvicultural practice on periphytic diatom community composition and productivity and on macrophyte distribution in receiving waters. Responsibilities included management of the field laboratory, supervision of field staff, identification and enumeration of siliceous and non-siliceous periphyton and phytoplankton, measurements of algal primary productivity using uptake of radiolabelled carbon during *in situ* incubations, estimations of algal biomass using chlorophyll *a* concentrations, identification and distribution of macrophytes, meteorological data collection, data collation, and presentation for reports.

1983 to 1986 UNIVERSITY OF MANITOBA, DEPARTMENT OF BOTANY, Winnipeg

Research Assistant

Conducted studies of the initial colonization of periphytic diatoms and the delineation of periphytic diatom associations in aquatic habitats. Participated in studies describing the primary productivity of benthic algal communities in a prairie marsh and the effects of triazine herbicides on algal production and community development. Responsibilities included diatom taxonomy (identification and enumeration), study design, use of artificial substrata for sample collection, measurements of community productivity and CO_2 assimilation, nutrient determinations, herbicide extractions, data analysis and report production.

PRIMARY PUBLICATIONS AND PUBLISHED REPORTS

Kruszynski, G.M., and D.J. Ramsey. 1995 in press. Limnological changes in lakes of the Rat-Burntwood and Nelson river systems following Churchill River diversion and Lake Winnipeg regulation. Manitoba Department of Natural Resources, Fisheries Branch MS Report No. 95-XX.

Kruszynski, G.M. 1989. Investigations into the existence of associations within benthic diatom communities. M.Sc. Thesis. University of Manitoba, Winnipeg, MB. 97p.

Kruszynski, G.M. 1984. A description of short term colonization of artificial substrata by periphytic diatoms in the Delta Marsh, Manitoba. B.Sc. (Hons.) Thesis. University of Manitoba, Winnipeg, MB. 87p.

UNPUBLISHED REPORTS

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LISETTE ROSS
INVERTEBRATE ECOLOGIST

EDUCATION

B.Sc. Major, Zoology; Minor, Microbiology; University of Manitoba, 1985.
National Certificate in Non-profit Organization Management, University of Manitoba, 1993
Human Resource Management Certificate, University of Winnipeg, 1989.

EXPERIENCE

Lisette is an invertebrate ecologist with 14 years experience in the identification of insects and other stream and lake benthos. She has extensive experience in scientific research and resource management and an in-depth knowledge of computers, statistical analysis, data presentation, and scientific writing.

EMPLOYMENT HISTORY

1995 PART-TIME CONSULTANT, Winnipeg

Invertebrate Ecologist

Sorted and identified benthic and nektonic invertebrates collected in kick and ekman samples collected from Lake 226 in the Experimental Lakes Area, northwestern Ontario. Client: Department of Fisheries and Oceans, Freshwater Institute.

1990 to Date INSTITUTE FOR WETLAND AND WATERFOWL RESEARCH, DUCKS UNLIMITED CANADA, OAK HAMMOCK MARSH, Winnipeg

Wetlands Entomologist

Working as a member of the Marsh Ecology Research Project (MERP) study team, Lisette is a primary investigator of factors affecting the distribution and abundance of wetland invertebrates. Responsibilities include data analysis, preparation and publication of manuscripts, presentation of results, and field consulting.

1985 to 1990 **DELTA WATERFOWL AND WETLANDS RESEARCH STATION, Portage la Prairie**

Wetlands Entomologist

Supervised 30 to 40 summer and fall assistants engaged in an extensive invertebrate monitoring program. This included orientation of students in invertebrate, marsh, and waterfowl ecology; training assistants in sampling techniques and insect identification; developing and refining field and laboratory methods; and supervising data compilation. Other responsibilities included identification of wetland invertebrates collected in LeSage and Harrison emergence traps and of nektonic and benthic invertebrates; data entry and analysis; preparation of manuscripts for publication; scientific presentations; and, the provision of technical advise to graduate students and other researchers.

1985 **CANADA BITING FLY CENTRE, Winnipeg**

Summer Lab/Field Technician

Responsible for calculating the concentration of *Bacillus thuringinensis* spores present in water samples taken from two Saskatchewan rivers as part of a study looking at blackfly control. Determined the resistance of *Bacillus* to the natural environment by calculating the concentration of spores in outdoor enclosures.

1981 to 1984 **DEPARTMENT OF FISHERIES AND OCEANS, FRESHWATER INSTITUTE, Winnipeg**

Summer Lab/Field Technician

Participated in a study on the effects of herbicide on stream fish and insects in the Duck Mountain region and a walleye (*Stizostedion vitreum*) enhancement project on Dauphin Lake. Responsibilities included sampling and identifying insects in emergence traps, monitoring stream hydrology and chemistry, and collecting fish using hoop and drift nets.

PUBLICATIONS

Ross, L.C.M., and H.R. Murkin. 1995 in prep. Invertebrates. *In* Prairie wetland ecology: the state of our understanding and the contribution of the Marsh Ecology Research Program. Iowa State University Press.

Ross, L.C.M., and H.R. Murkin. 1995 in review. The effect of above-normal flooding of a northern prairie marsh on Chironomid emergence. Ecological Applications.

Ross, L.C.M., and H.R. Murkin. 1995 in review. Distribution and abundance of nektonic invertebrates following manipulation of water levels in a northern prairie marsh. Freshwater Biology.

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Ross, L.C.M., and H.R. Murkin. 1993. The effect of above-normal flooding of a northern prairie marsh on *Agaylea multipunctata* Curtis (Tricoptera: Hydroptilidae). J. Freshw. Ecology 8:27-35.

Wrubleski, D.A., and L.C.M. Ross. 1989. Diel periodicities of adult emergence of Chironomidae and Tricoptera from the Delta Marsh, Manitoba, Canada. J. Freshw. Ecology 5(2):163-169.

Ross, L.C.M., and H.R. Murkin. 1989. Invertebrates. Marsh Ecology Research Program: Long-term monitoring procedures manual. Delta Waterfowl and wetlands Research Station. technical Bulletin 2. pp.35-38.

CONTRIBUTED PAPERS PRESENTED

Ross, L.C.M., and H.R. Murkin. 1993. The effect of above-normal flooding of a northern prairie marsh on *Agraylia multipunctata* Curtis (Tricoptera: Hydroptilidae). Annual Meeting of the North American Benthological Society, May 25-28, Calgary, AB.

Ross, L.C.M., and H.R. Murkin. 1993. The effect of above-normal flooding of a northern prairie marsh on insect emergence. Annual Meeting of the American Society of Limnology and Oceanography and Society of wetland Scientists, May 30-June 3, Edmonton, AB.

Ross, L.C.M., and H.R. Murkin. 1993. Factors affecting the distribution and abundance of aquatic invertebrates in northern prairie marshes. Prairie ecosystems: wetland ecology, management, and restoration, August 9-13, Jamestown, ND.

Ross, L.C.M., and D.A. Wrubleski. 1992. Wetland ecology and wetland management. Wetland/Waterfowl Biology Workshop, July 7-11, Regina, SK.

Ross, L.C.M., and H.R. Murkin. 1991. The effect of above-normal flooding of a northern prairie marsh on chironomid emergence. Plains Aquatic Research Conference, November 3-5, Regina, SK.

Ross, L.C.M., and D.A. Wrubleski. 1989. Diel periodicities of adult emergence of Chironomidae and Tricoptera from the Delta Marsh, Manitoba, Canada. Annual Meeting of the North American Benthological Society, May 16-19, Guelph, ON.

Ross, L.C.M. 1988. Factors affecting the distribution and abundance of invertebrates in wetlands. Marsh Ecology Research Program Lecture Series - Delta Waterfowl and Wetlands Research Station, May 25, Portage la Prairie, MB.

Murkin, H.R., L.C.M. Ross, and E.J. Murkin. 1987. An update on the Delta Waterfowl and Wetlands Research Station - Ducks Unlimited Canada Marsh Ecology Research Program. Symposium on Ecology and Management of Breeding Waterfowl, August 18-22, MB (poster presentation).