The Lake Winnipeg Research Consortium Inc.

Report on Science, Education and Outreach Activities

April 1, 2008 - March 31, 2009

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Introduction

The Lake Winnipeg Research Consortium Inc. (LWRC) was organized by a group of federal and university researchers in August 1998 to address the need for scientific studies on Lake Winnipeg following the 1997 Red River Flood. Since then, through cost sharing arrangements with Manitoba Hydro (MH), Environment Canada (EC), Manitoba Water Stewardship (MWS), and the City of Winnipeg (See http://www.lakewinnipegresearch.org), the LWRC has offered the MV *Namao* as a sampling platform for government scientists with a responsibility to investigate and protect national and provincial freshwater resources. In 2008, funds from private and community foundations (See http://www.thomassillfoundation.com/lake.html) and other donors supported LWRC management, and science and education coordination. Science and education - related activities included three sampling surveys at 60 lake-wide sites (Appendix A), deployment of instrumentation (Appendix B), a science workshop, classroom and field training for Manitoba and North Dakota students, an Open House, presentations to public service organizations and LWRC representation at various government and NGO meetings.

Several government scientists from the National Water Research Institute (NWRI) in Burlington, the National Hydrology Research Institute (NHRI) in Saskatoon, MWS, and the Freshwater Institute (FWI) in Winnipeg, and researchers from the University of Manitoba (UM) participated in 2008 field studies to determine factors responsible for declining Lake Winnipeg water quality. The compliment of Lake Winnipeg researchers and their respective disciplines are listed in Appendix C.

RESEARCH ACTIVITIES

Field Activities

Lake Winnipeg was sampled three times during the 2008 open water season, May 26 to June 19 (57 stations + rivers), July 21 to August 14 (66 stations + rivers), and September 16 to October 9 (61 stations) to ensure comparability with survey data from previous years.

EC, with a mandate to preserve water quality in Canadian lakes (See http://www.ec.gc.ca/sd-dd_consult/SDS2007/c1_e.htm#s1_1), continued to measure a suite of physical, chemical and biological parameters with instruments either moored in Lake Winnipeg or deployed from the *Namao* (See Appendix D for chemical and biological parameters sampled and protocols). Preliminary results of some aspects of EC investigations during 2008 were presented at the Science Workshop in March 2009 and summarized in Presentation Abstracts (Appendix E). In particular, dissolved oxygen measurements will help EC scientists determine the level of risk posed to food web organisms, including commercially important fish species, by decomposing algae in Lake Winnipeg. Water temperature, currents, and solar radiation measurements will provide insight into the mixing of chemicals and biota in the lake. To better manage the lake, the sources and in-lake processing of phosphorus are being determined using isotopic analyses.

Manitoba Water Stewardship is the only LWRC member with a mandate to manage Manitoba's water and fish resources and to ensure that people are safe from water hazards (See http://www.gov.mb.ca/waterstewardship/index.html). MWS staff continued to monitor 14 long-term stations for general chemistry, nutrients, bacteria, benthos, chlorophyll-a, pesticides, trace metals, phytoplankton diversity, and microcystin-LR when algal blooms were evident. MWS Fisheries Branch staff continued a trawl net sampling program to examine the distribution and abundance of small fishes in the lake.

The UM Centre for Earth Observation Studies (McCullough) and the Freshwater Institute (Stainton) further refined methods to estimate Lake Winnipeg surface algal bloom chlorophyll – *a* concentrations and phytoplankton species assemblages using satellites such as MERIS with continuing funding from the Canadian Space Agency.

Sediment samples for benthic invertebrates were collected at all stations in each survey for the UM (Hann). Phytoplankton and zooplankton samples were also collected at each site, preserved and archived for possible future analyses.

Investigations into the predator-prey relationship between rainbow smelt and zooplankton began in 2008 (UM, Hann and Olynyk).

Science Workshop

LWRC Science organized and facilitated a workshop March 24 and 25, 2009 at the Freshwater Institute to exchange information collected during the 2008 field season. The workshop attracted nearly 100 participants and included scientific presentations, discussions, and planning for the 2009 field season. The workshop agenda, abstracts, and list of attendees are provided in Appendices E, F, and G, respectively. An appeal for research papers for the Journal of Great Lakes Research special Lake Winnipeg issue produced several preliminary titles (Appendix H).

EDUCATION ACTIVITIES

A formal Lake Ecology Field Program was introduced to the LWRC Education Program this year. Phase 1 (2008/09) of the Field Program provided schools with semi-dedicated ship time on board MV *Namao* and the opportunity for field-based, hands-on learning about aquatic ecosystems. Prior to each field trip, participating schools received an in-class presentation to provide context for the trip and a big picture perspective on Lake Winnipeg, lake ecosystems and water quality. On board, students had the opportunity to sample water, plankton and sediment using various types of field equipment and to process and characterize their samples using analytical equipment, taxonomic keys and microscopes. During the spring and fall cruises of the 2008 open water season, 10 schools participated in the new Field Program. Among the schools were three First Nations and a college in North Dakota. Phase 2 (2009/10) of the Field Program will be developed and introduced during the 2009 open water season.

OUTREACH ACTIVITIES

Namao Open House

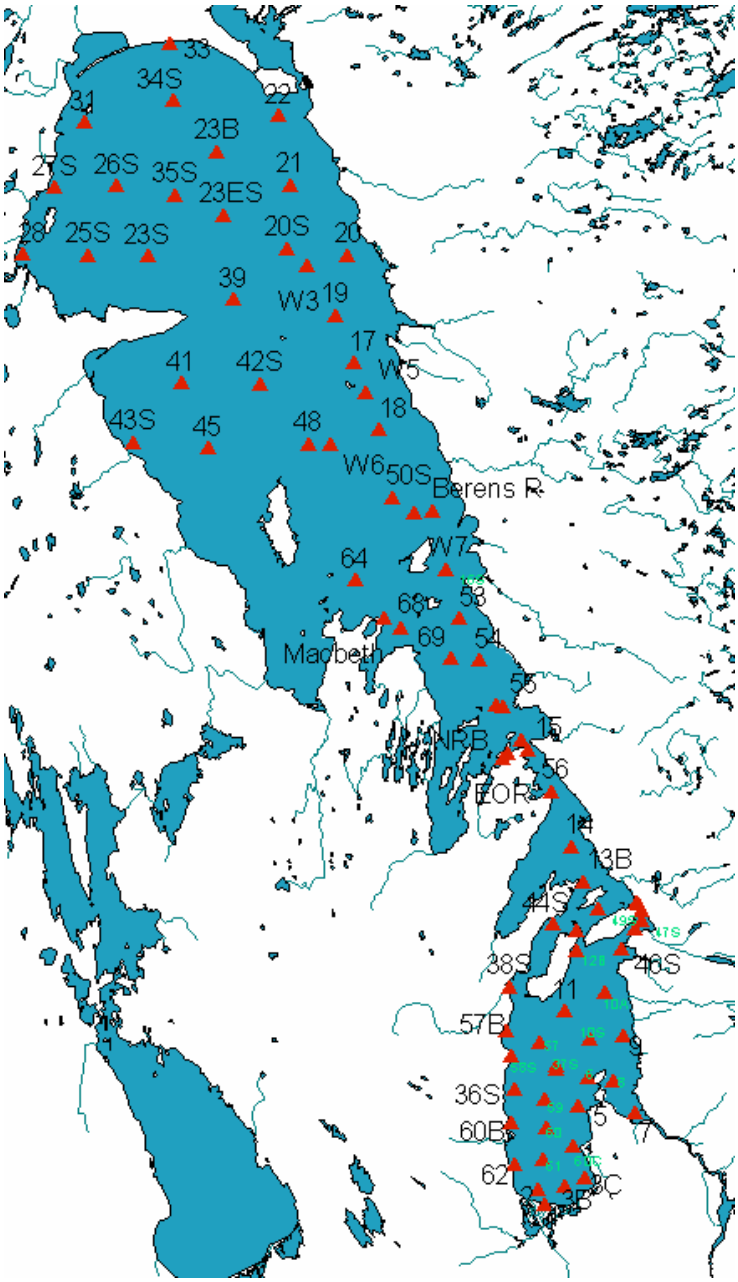
The LWRC Open House was held Monday, August 4, 2008, 11:00am to 3:00 pm on the *Namao* to showcase the research vessel and equipment used by federal, provincial and university investigators monitoring Lake Winnipeg. Environment Canada scientists volunteered to answer questions from the scores of visitors attending the event.

Public Presentations, Community Events, Advisory Committees

During the 2008 -2009 fiscal year, LWRC Science, Education, and Outreach responded to invitations from stakeholder groups and service clubs for presentations on Lake Winnipeg research, assistance at community events, and participation on official advisory committees. A list of engagements is included in Appendix I.

APPENDIX A

Lake Winnipeg Station Map



APPENDIX B

Mooring Locations (2008 – 2009)

STATION NUMBER	MOORING NUMBER	LATITUDE N.	LONGITUDE W.	INST./DEPTH
500	2007-10S-01A	50° 47' 00"	96° 45' 00"	TEMP/ADCP (1, 3, 4, 6, 8, 10, 11, 12m)
501	2007-10M-02A	50° 55' 00"	96° 35' 00"	MET
502	2007-10T-03A	51° 41' 00"	96° 47' 00"	TEMP (1, 2, 4, 6, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18m)
	2007-10C-04A			ADCP (18m)
503	2007-10T-05A	52° 20' 00"	97° 30' 00"	TEMP (1, 2, 4, 6, 8, 10, 11, 12, 13, 14, 15, 16m)
504	2007-10T-06A	52° 37' 00"	98° 09' 00"	TEMP (1, 2, 4, 6, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18m)
505	2007-10S-07A	53° 23' 00"	98° 30' 00"	YSI/ OPTICAL DO/ TEMP (1, 2, 4, 6, 8, 10, 11, 12, 13, 14, 15, 16, 17, 18m)
	2007-10C-08A			ADCP (18m)
506	2007-10S-09A	53° 18' 00"	97° 40' 00"	YSI/ TEMP (1, 3, 4, 6, 8, 10, 11, 12m)
	2007-10C-10A			ADCP (12m)
	2007-10A-11A			SEQ. SED. TRAP(m)
George I	2007-10M-12A	52° 49' 00"	97° 40' 00"	MET

APPENDIX C

Government / University researchers on Lake Winnipeg

Researcher	Title	Affiliation	Research Field
		Environment Canada	
Keith Hobson	Research Scientist	NHRI Saskatoon	Chemical Properties
Len Wassenaar	Research Scientist	NHRI Saskatoon	Chemical Properties
Sue Watson	Research Scientist	CCIW-NWRI Burlington	Algal Nutrients
Ram Yerubandi	Research Scientist	CCIW-NWRI Burlington	Physical properties
Veronique Hiriart-Baer	Research Scientist	CCIW-NWRI Burlington	Chemical Properties
		Fisheries and Oceans Canada	
Mike Stainton	Research Chemist	Freshwater Institute Winnipeg	Chemical Properties
		University of Manitoba	
Brenda Hann	Professor	Biological Sciences	Invertebrates, Food Web
Greg McCullough	Post – doc Fellow	Centre Earth Obs. Studies	Remote Sensing
		Manitoba Water Stewardship	
Chelsey Lumb	Fisheries Biologist	Fisheries Branch	Forage Fish
Derek Kroeker	Fisheries Biologist	Fisheries Branch	Commercial fish
Elaine Shipley	WQ Specialist	Water Quality Branch	Chemical Properties

APPENDIX D

2008 Chemical and Biological Samples and Protocols

CHEMICAL

CANADA

Rosette Profiles using Seabird Software

At each station, the Rosette was lowered from the surface to just above the sediment, creating a profile for a variety of chemical and physical parameters being monitored. Hexfiles and graphs were saved and data clean-up was carried out by Environment Canada (Saskatoon).

Water and Sediment Phosphates and Isotope Ratios

At each station, water was collected from surface and meter off bottom (MOB) for phosphates, phosphate isotopes, and oxygen isotopes (summer cruise only). During the fall cruise, a ponar sample was used to obtain sediment for phosphate isotope analysis (Environment Canada, Saskatoon). At select stations, sediment from the Ponar samples was also collected and sent to Environment Canada (Burlington) for analysis.

Nutrient Status

At each station, samples from surface and MOB were collected and analyzed within 12 hours for silica- phosphorus-, and nitrogen-debt analysis (Environment Canada, Burlington).

Fluorinated Compounds

Samples were collected from surface at stations 23b, 21, 28, and 42 for chemical analysis during the summer cruise (fluorinated compounds c/o Gregg Tomy and Brian Scott (Environment Canada)).

Water Chemistry

From each station, water collected from the top meter was filtered on-board within 8 hour of collection for the following components:

- *Total Suspended Solids (TSS)* – water filtered onto pre-weighed, pre-combusted GF/C filter paper, desiccated overnight and stored at –20°C.
- *Suspended Carbon and Nitrogen (Susp. C/N)* – water filtered onto pre-combusted GF/C filter paper, desiccated overnight and stored at –20°C.
- *Suspended Phosphorus (Susp. P)* – water filtered onto pre-combusted GF/C filter paper, desiccated overnight and stored at –20°C.
- *Chlorophyll a (Chl)* – water filtered onto GF/C filter paper, desiccated overnight and stored at –20°C.
- *Suspended Silica (Susp. Si)* – water filtered onto 0.2μm (or 0.1μm) membrane filter, desiccated and stored at –20°C.
- *Dissolved Organic Carbon (DOC)* – GF/C filtrate collected for clean 175 ml Nalgene bottle, refrigerated.
- *Dissolved Si* – filtrate from 0.2 μm membrane filter collected to 20 ml plastic scint vial (with red lid), refrigerated.

All of the above listed samples were sent to the Freshwater Institute (Winnipeg) for analysis.

Microcystin Field-kit Evaluation

At 4 stations in the North Basin where substantial cyanobacterial growth was observed, water was collected from an integrated sample through the euphotic zone and tested for the presence of microcystin using 2 types of field kits being evaluated for use by Health Canada. Particulate and

dissolved microcystin samples were also collected and shipped to Health Canada (Ottawa) for laboratory analysis and confirmation of field kit results.

Algae Online Analyzer (AOA)

AOA was run continuously between and at station, drawing water from just below the surface. At overnight anchor sites, the AOA was allowed to run overnight in order to monitor diurnal changes in phytoplankton assemblage (Department of Fisheries and Oceans, Winnipeg).

GPS Tracks

A Garmin GPS, coupled with datalogger, was run continuously while cruising and at anchor. The datalogger was downloaded to a dedicated computer, to be extracted upon return to the Freshwater Institute (DFO, Winnipeg).

Branker Logger

During the summer and fall cruises, the Branker logger was run continuously between stations, at station, and while at anchor. Logged data are to be extracted upon return to the Freshwater Institute (DFO, Winnipeg).

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ACS (Absorption-Attenuation Meter)

The ACS was run continuously between stations, drawing water from just below the surface. At station, clear water (Gimli or Grand Rapids tap water) was run through the instrument to create a "blank" reference. A net haul sample (70μm mesh) was collected through 2-times Secchi depth and "washed" using clear water to remove residual lake water. The sample was then re-suspended in 2 L clear water and run through the ACS. Where algal biomass was low, multiple hauls were done to concentrate algal material. Where algal biomass was high, only a portion of the net haul sample was used, ensuring that the absorption remained below the upper limit of quantification (Greg McCullough, University of Manitoba). Subsamples of the re-suspended net haul sample was run through the Algal Online Analyzer (AOA) and saved for laboratory analysis (algal taxonomy, DOC, TSS and Chl).

MANITOBA

Sediment Metals and Particle Size

During the summer cruise, a Ponar was used to collect 4 sediment samples at each Provincial monitoring station ("W" stations only). Sediment was sub-sampled for particle size analysis (1 sample) and determination of metal concentrations in sediment (in triplicate) (Manitoba Water Stewardship).

Water Quality Monitoring

At each station and where substantial blooms were observed between stations, water samples (integrated through the euphotic zone) were collected for a variety of water quality parameters (Manitoba Water Stewardship). These included both biological (algal taxonomy, chlorophyll, microcystin, and bacteriological sampling) and chemical parameters (dissolved oxygen, nutrients). During the fall cruise, additional samples were collected for a bioassay experiment, to be carried out by ALS.

BIOLOGICAL

CANADA

Phytoplankton and Picoplankton, Bacteria and Heterotrophic Flagellates
At each station, 20 ml phytoplankton samples were collected from the surface (0-0.5 m) and meter off bottom (MOB). A sample, integrated through the euphotic zone, was also collected. These samples were preserved with 0.5 ml Lugol's iodine solution. At each station, 20 ml of water from the integrated sample was preserved using 1.5 ml of formaldehyde for picoplankton, bacteria and heterotrophic flagellates. Where fluorescence peaks were observed, phytoplankton and picoplankton samples were collected at every 1 or 2 meters, capturing the peak. This was done at $\geq$ 8 stations. Surface, MOB, and profile samples were sent to Sue Watson (Environment Canada, Burlington) for analysis, while those from integrated samples were sent to Hedy Kling (Algal Taxonomy and Ecology Inc.).

Zooplankton

At each station, zooplankton samples were collected by hauling 72 μm mesh-size Wisconsin net (mouth diameter 25 cm) through the entire water column. Samples were preserved with 5 ml formaldehyde (37% solution) and archived for future laboratory analysis. A total of 184 samples were obtained.

Algal Toxins and Bloom Taxonomy
Where substantial blooms were observed in the summer and fall surveys (at or between stations), whole water samples were collected for the following and sent to Sue Watson (Environment Canada, Burlington):

- β-cyclocitral (GF/F filter and filtrate)
- Grazer toxins and Cyanotoxins (GF/C filters)
- Phytoplankton (20 ml whole water, preserved with Lugol's solution)
- Picoplankton (preserved with formaldehyde and frozen in liquid nitrogen)
- Live samples
- Whole water sample, frozen in liquid nitrogen

At select stations in the spring and where substantial blooms were observed, net haul and whole water samples were also collected for identification, isolation, and culture (Algal Taxonomy & Ecology Inc.).

UNIVERSITY OF MANITOBA

Benthos

At each station, one Ekman grab was taken for benthos samples. Sediment was sieved through a 200μm mesh. Cleaned samples were preserved with 5 ml formaldehyde (37% solution) and sent to the University of Manitoba for analysis. Where substrate was excessively sandy or rocky, multiple jars were used to contain cleaned benthos samples (labelled X of Y).

Smelt
Stomachs were collected from trawls in the north basin during the summer cruise. These were preserved in ethanol for analysis of stomach content by the University of Manitoba (Andrew Olynyk (student)).

MANITOBA

Benthos
During the spring cruise only, a Ponar dredge was used to collect sediment samples (in triplicate). These samples were washed as above and preserved with ethanol for laboratory analysis (Manitoba Water Stewardship).

Fish Trawls

Manitoba Fisheries Department conducted trawls at each station, where weather permitted. The trawl net was pulled alongside the ship (10' x 10' opening, pulled at 2 knots for 30 minutes). Fish were sorted according to species, bagged and frozen or preserved in formalin for further taxonomic identification and age determination. During the summer cruise, index netting was also carried out at pre-determined locations throughout the north basin. The species, sex, and fork length of the fish obtained were recorded, and otoliths and scales were collected from all specimens of walleye *(Sander vitreus)* and lake whitefish *(Coregonus clupeaformis).*

APPENDIX E

LAKE WINNIPEG RESEARCH CONSORTIUM SCIENCE WORKSHOP

FRESHWATER INSTITUTE SEMINAR ROOM
MARCH 24 - 25, 2009

AGENDA

TUESDAY MARCH 24
RESULTS OF THE 2008 FIELD PROGRAM

8:40	Welcome Alex Salki LWRC
9:00	Physical Limnology and Water Quality: Measurements and Modeling. Ram Yerubandi, Environment Canada
9:25	Integrated Watershed and Lake Modeling. Bill Booty, Environment Canada Burlington
9:50	An Overview of Lake Winnipeg Water Quality. Elaine Shipley, Manitoba Water Stewardship
10:15	**Coffee**
10:35	Dissolved oxygen in Lake Winnipeg: status, process and spatiotemporal patterns. Len Wassenaar, Environment Canada Saskatoon
11:00	Phosphorus sources tracking in Lake Winnipeg. Veronique Hiriart-Baer, Environnent Canada, Burlington
11:25	Cyanobacterial toxins in Lake Winnipeg: past, present and future issues. Brian Kotak[1], S. Watson[2], H. Kling[3], and C. Herbert[4]. [1]Miette Environmental; [2]AEMRD Environment Canada; [3] ATEI; [4]DFO
11:50	**Lunch**
13:20	Isotopic assessment of food web structure in Lake Winnipeg: a progress report. Keith Hobson, Environment Canada Saskatoon
13:45	Nutrient Sequestration in Lake Winnipeg Basin. Brian Parker, Environment Canada Winnipeg
14:10	A Near Real Time Remote Sensing Application for Mapping Cyanobacteria Blooms Using MERIS imagery. Greg McCullough U of Manitoba, Mike Stainton DFO
14:35	Nutrient fractions, bioavailability, and deficiency in Lake Winnipeg: a synopsis of current and future approaches to understand and manage bloom events. Sue Watson[1], Len Hendzel[2], Hedy Kling[3], Jay Guo[1] and Sven Becker. [1]AEMRD; [2]DFO - FWI, [3]ATEI
15:00	**Coffee**
15:30	Rainbow Smelt in Lake Winnipeg: Summer Diet Electivity. Andrew Olynyk, Gail Davoren and Brenda Hann Department of Biological Sciences, University of Manitoba
15:55	Netley-Libau Marsh Research – what do we know, and where do we go from here? R.E. Grosshans, L.G. Goldsborough, N. Cicek, D.A. Wrubleski, H.D. Venema, Eric Bibeau, and Garth Ball. IISD, U. of Manitoba, DUC, Delta Marsh, Mb Conservation
16:20	Wrap-up

Dinner

18:00	Get-together Dinner at U of Manitoba Faculty Club for registered workshop participants
19:30	After-dinner presentation "Upstream research by Environment Canada under the Lake Winnipeg Basin Initiative" Malcolm Conly Environment Canada

WEDNESDAY MARCH 25
PLANNING FIELD OPERATIONS, DATA MANAGEMENT, PUBLICATIONS

9:00	Science Plans for Lake Winnipeg. Malcolm Conly EC, Nicole Armstrong MWS, Terry Miles Mb Hydro, Nick Szoke Winnipeg, Hugh Arkley Community Foundations.
9:30	Discussion of Science Plans
10:00	**Coffee**
	Field Program 2009 planning
10:30	Statistical assessments of sampling networks. Andre Saint-hilaire. Universite du Quebec
11:00	Discussion and decisions on 2009 field program
12:00	**Lunch**
	Data Management and Publication
13:00	EC Data Portal – Sarah Ross, Environment Canada
13:20	Discussion of data management expectations, role of LWRC
14:00	Lake Winnipeg JGLR Special Issue – Len Wassenaar, Environment Canada
14:20	Open discussion
15:00	Wrap-up

APPENDIX F

LWRC 2009 Science Workshop Submitted Abstracts

Physical limnology and water quality measurements and modeling in Lake Winnipeg

Ram Yerubandi, Jun Zhao and Weitao Zhang
Environment Canada
Water S & T, Canada Centre for Inland Waters

Lake Winnipeg is the tenth largest lake in the world. The lake is shallow (mean depth~12 m) and has two distinct basins. Significant changes in water transparency, biological species composition, algal productivity, and sedimentary chemistry indicate that the lake is on a trajectory of progressive eutrophication and approaching a state of deterioration that may affect ecosystem sustainability. Because of these reasons new research projects were initiated to study the relative roles of physical, chemical, and biological factors on the ecology of Lake Winnipeg at various space and time scales. Currents, water temperature, winds, solar radiation, waves and some water quality parameters were recorded at several fixed moorings in Lake Winnipeg during 2007. In 2008 Water temperature and meteorology is measured again at several moorings. Circulation within and between the basins are dominated by surface winds and seiches in the basins. The thermal structure and exchange processes during summer stratification in the lake have also been examined using a time series data of horizontal velocity profiles from broadband ADCPs and temperature profiles at the moorings. A three dimensional model has been used to model the water circulation and temperature in the lake. Several simulations have been carried out to study the impact of river plumes in the coastal zones of Lake Winnipeg. Mass balance models are being used to study the nutrient dynamics in the lake.

Integrated Modelling for Lake Winnipeg Basin Initiative (LWBI)

Bill Booty
Environment Canada, Burlington

In order to be able to carry out an integrated solution to the Lake Winnipeg eutrophication problem, the various models being employed also need to be integrated. This includes the watershed, river and lake models. The “toolbox” approach is being suggested where we will have a number of simple to complex watershed, river and lake models that can be used and their results compared, depending on the management question being asked. In our presentation we have included some examples of the linkage of various non-point source models with in-lake models from other studies. Preliminary results for Lake Winnipeg show the connection of suspended sediments from the watershed non-point source model to the in-lake suspended sediments which may affect the turbidity and also primary production the lake, subject to lake hydrodynamics, wave actions, nutrient and temperature conditions. Under the integrated modelling framework and as a long term goal, we plan to simulate how a given set of watershed management options, including agricultural land-use practices, may affect non-point source nutrient loadings and subsequently in-stream and in-lake water quality condition. We also plan to simulate, conversely, how we may determine the optimal or near-optimal watershed management options for a given set of in-lake water quality objectives. One of the main technical challenges is to link these models properly. Currently we have adapted the OpenMI software standard for linking models (www.OpenMI.org) by adding on an expert system module so that it will handle these models within a “wrapper” coding interface that manages the start-up and running of the models with different time-steps and spatial scales for consistency and interoperability. The rule-based expert system modelling controller helps capture knowledge such as the use of model assumptions for selecting appropriate values for model parameters. The main research challenge of this integrated modelling approach is the treatment of uncertainties in the data as well as in the model results. Several uncertainty analysis methods will be considered including the use of belief network, casual probabilistic network, inverse modelling, Monte Carlo Method, and shuffled complex evolution. The other research challenge is the proper use of optimization techniques for the combined watershed-lake models subject to different management constraints. Various optimization methods that could be employed include stochastic search methods such as Shuffled Complex Evolution, Dynamically

Dimensioned Search and Genetic Algorithms that have worked in similar problems with linked models. Finally, the integrated modeling framework will be matched with the Lake Winnipeg Initiative Information Portal structure to provide the complete sequence of data, information, knowledge and wisdom generated through the LWBI and related projects.

An Overview of Lake Winnipeg Water Quality

Elaine Shipley
Manitoba Water Stewardship

Nutrient loading to Lake Winnipeg has increased over the past 30 years with most apparent changes in lake water quality during the past decade. One of the most visible symptoms of nutrient enrichment has been the development of large cyanobacterial blooms in the north and south basins of Lake Winnipeg, and the appearance of algae attached to fishers' nets. Lake Winnipeg has been monitored sporadically by a number of agencies since the late 1920s with more intensive monitoring initiated following the flood of 1997. Since 1999, the Province of Manitoba has collected and analyzed more than 2500 chemical and biological samples from 14 long-term stations and 60 auxiliary stations to characterize the spatial and temporal long term water quality changes in the lake, and to provide information to support and protect the health of Lake Winnipeg. Much of the monitoring work has been done in cooperation with federal government agencies, the Lake Winnipeg Research Consortium, and others. Here we present a summary of spatial and temporal variation in Lake Winnipeg water quality from 1999 to 2007 and present an update of the results from the 2008 field season. Further data analyses are underway and will culminate in a technical report that will assess the major spatial and temporal water quality patterns, summarize changes in water quality, and assess factors limiting algal growth in Lake Winnipeg.

Dissolved oxygen in Lake Winnipeg: status, process and spatiotemporal patterns

Len Wassenaar
Environment Canada Saskatoon

Dissolved oxygen (DO) is a bell weather assay in eutrophic lakes, and Lake Winnipeg has shown signs of low oxygen conditions in the past, particularly in the North Basin. In 2006 we began a study of dissolved oxygen patterns and processes in Lake Winnipeg, using conventional assays and d18O analyses of DO. Beginning in the summer of 2006, 1 m depth profiles for DO were hand collected during each Namao cruise, with isotopic samples taken at surface and at bottom. In 2008, the addition of a new Seabird sonde system on the Namao facilitated automated high resolution (cm scale) depth profiling. This presentation will outline work to date through the presentation of spatio-temporal trends, oxygen depth profiles, and estimates of productivity from stable isotopic assays. This project is currently ongoing through the TB Lake Winnipeg initiative and is expected to be completed in 2011.

Phosphorus source tracking in Lake Winnipeg

Véronique Hiriart-Baer[1] and Len Wassenaar[2]
[1]Environment Canada, Burlington [2]Environment Canada, Saskatoon

One of the primary factors driving the ongoing eutrophication process in Lake Winnipeg is excess P loading, hence a scientific understanding regarding both the sources and in-lake processing of P is required to better manage and adapt remediation strategies. Given the large watershed of Lake Winnipeg and the numerous different potential sources of P to the lake, this study began by focusing on measuring the oxygen stable isotope ratios of dissolved inorganic phosphates ($\delta^{18}O_{DIP}$) spatially and temporally in the lake. A spatial variability in $\delta^{18}O_{DIP}$ was observed across the entire lake suggesting that the original signature of the phosphorus was retained and source tracking efforts would likely be possible. By comparing the $\delta^{18}O_{DIP}$ to the theoretical equilibrium, there are at least 2 dominant sources of phosphorus with distinct signatures, and the relative contribution of

these sources appears to differ between the North (NB) and South (SB) basins and the time of year. One likely source is agricultural inputs. Nitrate concentrations are significantly ($p<0.001$) lower in the NB compared to the SB and as nitrate concentrations increase, the isotopic signature of $\delta^{18}O_{DIP}$ becomes more enriched. Temporal variations in the $\delta^{18}O_{DIP}$ were also observed in addition to the spatial variability. The NB did not show notable change in the mean and range of $\delta^{18}O_{DIP}$ over the spring, summer and fall seasons, while the SB showed enrichment in the $\delta^{18}O_{DIP}$ in the spring and fall. This pattern was also reflected in the nitrate concentrations, with higher concentrations in the fall. This suggests that delivery of a phosphorus source with an enriched $\delta^{18}O_{DIP}$ is increased in the SB during times of high flow and this source is also delivering higher levels of nitrate. More samples remain to be processed in particular the rivers and STP samples to better characterize the $\delta^{18}O_{DIP}$ signature of these possible sources and allow source apportionment through mixing models. Additionally, surface sediment samples are being processed to determine their $\delta^{18}O_P$ signature to assess whether sediments are a source of dissolved inorganic phosphate to the surface waters of Lake Winnipeg.

Cyanobacterial toxins in Lake Winnipeg: past, present and future issues

Brian G. Kotak[1], Sue Watson[2], H. Kling[3], and C.Herbert[4]
[1]AlgalTox International, Pine Falls; [2]AEMRD, Environment Canada, [3] ATEI, [4]DFO

Cyanobacteria (blue-green algae) can produce both neurotoxins and hepato-(liver)-toxins in freshwaters. Accidental ingestion of such toxins has caused sporadic poisonings and deaths of wildlife, livestock and pets worldwide and has been responsible for gastrointestinal upset in humans after accidental ingestion of the toxin/toxin-containing cyanobacteria during recreational contact (e.g., swimming), and acute poisoning and elevated incidence of certain types of liver cancer in humans as a result of insufficient drinking water treatment. .

Monitoring for the hepatotoxin total microcystin the most commonly detected cyanobacterial toxin, , has been undertaken in the open water areas of Lake Winnipeg and at popular beaches periodically for several years by Manitoba Water Stewardship, the Lake Winnipeg Research Consortium, Algal Taxonomy and Ecology, AlgalTox International and Environment Canada. Methods of detection have included HPLC, enzyme-linked (ELISA) and protein phosphatase inhibition assays (PPIA). Data collected from open water sites demonstrate that microcystin levels in raw lake water or in phytoplankton collected using a net, are usually quite low (less than 1 ug/L) and often times, below detection limits. For example, in 2006, microcystin was not detected in a high proportion of more than 90 whole water samples that collected from the euphotic zone at open water sites. Despite low concentrations in open water locations, very high concentrations (>2,000 ug/L) have been occasionally detected in whole water samples during intensive off-shore algal blooms and along shorelines during bloom events.

In 2007, both whole water samples and plankton net samples were collected from open water stations during mid-summer (July-August) and fall (September-October) cruises in the north basin, south basin and narrows of Lake Winnipeg. Microcystin was frequently detected in the net samples, but not in the whole water samples, indicating that the concentration of the toxin in the phytoplankton and/or the phytoplankton biomass was relatively low. Concentrations in both whole water samples and net samples ranged from below detection limits (<0.10 ug/L) to 2.3 ug/L. While there were some differences in the concentration between the 3 sections of the lake (south, north and narrows), the differences are not likely to be ecologically significant. A statistical analysis to examine the relationships between water chemistry, phytoplankton species composition/biomass and microcystin concentration is currently underway. However, the usefulness of exploring such correlations is limited given the very low toxin concentrations. Concentrations of total microcystin in open water samples collected by both Environment Canada and Manitoba Water Stewardship were generally low, consistent with data collected in previous years.

Several important questions remain unaddressed, and should be targeted by future research and monitoring efforts. It is not known which species are responsible for the sporadic MC peaks; most of the cyanobacterial blooms in Lake Winnipeg have recently been dominated by N_2-fixing *Aphanizomenon* spp., which are not known MC producers. To date there are no data for other

cyanobacterial toxins in LW such as the neurotoxic anatoxins and saxitoxins, produced by some strains of *Aphanizomenon* and other species. More effort be placed on sampling near shore areas, particularly during bloom events, since these areas represent the greatest point of contact for lake users and thus, the greatest risk.

A Near Real Time Remote Sensing Application for Mapping Cyanobacteria Blooms Using MERIS Imagery

Greg McCullough[1] and Mike Stainton[2]
[1]University of Manitoba; [2]Department of Fisheries & Oceans, Winnipeg

The Canadian Space Agency provides funding to Canadian government departments under its Government Related Initiatives Program (GRIP). For several years GRIP funding has supported research to develop a remote sensing capability to quantitatively map chlorophyll and, more specifically, cyanobacterial chlorophyll in Lake Winnipeg. The project has now advanced to the point where a near real time application will be available this summer that will use MERIS full resolution (300 M) data to provide digital maps of surface chlorophyll and cyanobacterial chlorophyll. Examples of data products will be presented along with a description of ongoing research to extend estimates of surface concentration to estimates of water column biomass. Other remote sensing issues will be discussed, in particular the opportunity to develop a Lake Winnipeg proposal for the next (2010 – 201X) round of GRIP funded projects that will build on current capabilities.

Nutrient bioavailability, deficiency and cyanobacteria in Lake Winnipeg: a synopsis of current and future approaches to understand and manage bloom events

S.B. Watson[1], L. Hendzel[2], H. Kling[3], J. Guo,[1] R. Yerubandi[1], S. Page[2], M. Stainton, G. McCullough and S. Becker[1]
[1]AEMRD, Environment Canada Burlington; [2]DFO-Freshwater Institute, Winnipeg; [3]ATEI, Winnipeg

Lake Winnipeg (LWPG, Manitoba) is experiencing frequent and severe late summer algal (cyanobacterial) blooms, largely as a result of high nutrient loading, particularly phosphorus (P). An initial gap analysis highlighted several important unresolved questions about the factors controlling these blooms and the nature of the blooms themselves. This talk will present a synopsis of our current and proposed research which targets several of these intrinsically linked issues: the timing, particulate-dissolved fractionation and bioavailability of external and internal nutrient loading, and the taxa and toxicity of the key bloom species. Historical and current data indicate that at times, a considerable proportion of the nutrient loading may be particulate-bound, derived from watershed input and in-lake resuspension, and/or present as a significant dissolved fraction. One component of our work has been evaluating seasonal and spatial patterns in the proportions and bioavailability of nutrient fractions along the major tributaries and within the South and North basins of LWPG – which differ in morphometry, loading and hydrology. To address this we have applied size fractionation and chemical analyses, coupled with biological assays to water and sediment samples, collected from selected sites along the Red River and LWPG. Here we present preliminary data showing important spatial and temporal differences in the nutrient content and bioavailability. This information will add significant value to current estimates of internal deposition and loading and overall nutrient budget estimates of the lake, which are essential to the development of management criteria to control the current water quality issues. A second component of our work attempts to link these nutrient-related data to physical processes (mixing, translocation, light) and evaluate how these influence the success, species and toxicity of the bloom taxa. Samples collected over the past few years show an apparently high morphological variance among the dominant LWPG cyanobacteria (*Aphanizomenon* spp.) - all or only some of which may be different species which may vary in toxicity – and which are difficult to resolve using traditional microscope approaches. We present some new genetic approaches that we propose to develop and link to the ongoing taxonomic and toxicological analyses of LWPG booms as a means to address these questions.

Rainbow Smelt in Lake Winnipeg: Summer Diet Electivity

Andrew Olynyk, Gail Davoren and Brenda Hann,
Department of Biological Sciences, University of Manitoba

The dietary selectivity of zooplanktivorous rainbow smelt (*Osmerus mordax*), which invaded Lake Winnipeg in late 1990, was studied along a transect of 10 stations in the North Basin during the July 2008 cruise of the M.V. *Namao*. Rainbow smelt in two size classes (<120 mm and >120 mm total length) were analyzed to determine proportions of zooplankton prey in gut contents. Environmental densities, proportionsand body lengths of zooplankton were quantified for four main groups: copepods, *Bosmina* spp., *Eubosmina* spp. and *Daphnia* spp. Smaller smelt (<120 mm TL) displayed electivity values that varied among stations; however, electivity for *Daphnia* spp. and against copepods and *Bosmina* spp. was stronger at the northerly stations. Larger smelt (>120 mm) showed consistently high electivity for *Daphnia* spp. Prey quality was assessed on the basis of mean body size, escape ability and caloric content. Dietary preference was correlated with prey quality and was ranked as: *Daphnia* spp.> *Eubosmina* spp.> copepods and *Bosmina* spp. The results of this study suggest two smelt foraging strategies may be present in the North Basin of Lake Winnipeg: a selective approach in the clearer, more productive northern portion and a generalist strategy in the turbid, less productive south.

Netley-Libau Marsh Research – what do we know, and where do we go from here?

R.E. Grosshans[1, 2], L.G. Goldsborough[2, 4], N. Cicek[2], D.A. Wrubleski[3], H.D. Venema[1], Eric Bibeau[2], and Garth Ball[5]
[1]International Institute for Sustainable Development, [2]University of Manitoba, [3]Ducks Unlimited Canada, [4]Delta Marsh Field Station, and [5]Manitoba Conservation

Netley-Libau Marsh is a large freshwater coastal wetland at the south end of Lake Winnipeg and is considered one of the largest freshwater wetlands in Canada. The Red River, which flows through the marsh on its way to the lake, has had significant impacts to this freshwater ecosystem, being the largest contributor of N and P. Netley-Libau Marsh is not functioning as a healthy coastal wetland, and any benefits that it could provide in removing and storing nutrients that would otherwise enrich the lake, have been degraded or lost. The purpose of the on-going research program is to increase our understanding of Netley-Libau Marsh in the context of Lake Winnipeg nutrient enrichment, and to examine how management and revitalization of this large coastal wetland could help improve the quality of water flowing into the lake. Wetlands store and cycle significant amounts of nutrients, and improve the quality of water that flows through them by retaining, removing, and assimilating nutrients that are often the focus of enrichment issues in water bodies. Wetland plants play a significant role in removing nutrients from a wetland by slowing water flow, and increasing retention time of nutrients that are either absorbed from the water or settle into the litter and sediment layer to be later taken up by plants. A plants ability to absorb nutrients from sediment and water makes them potential tools to remove stored nutrients from these aquatic systems. If emergent plants were cut and removed when they still retained enough nutrients, this would prevent their re-release from decomposing plant material. Over time this could reduce loadings in the marsh and inputs to downstream water bodies. Current plant, sediment, and water nutrient conditions of the marsh are being examined. Harvesting experiments were carried out to evaluate nutrient removal potential of harvesting, and regrowth of plant communities following harvests. Preliminary data from winter and late summer cattail harvests shows harvested plant biomass contains significant levels of stored P and N taken up from the litter and sediment. Regrowth the following year in harvested areas also occurs nearly 2 weeks earlier than unharvested areas, with greater plant density and biomass per sq. meter. The question is whether removal of plant material and their stored nutrients will over the long term reduce stored nutrients in the litter and sediment. Additionally, harvested plant material provides a valuable fuel source for bioenergy production, adding a further benefit. Cattail biomass was burned in a gasifier in 2006 and 2007 to produce bioenergy, and compared to agricultural residue feedstocks. Finally, current research is looking at biomass densification into cubes and pellets for transport, storage, and use in other bioenergy technologies. This study demonstrates harvesting

marsh biomass for the combined purposes of habitat improvement, nutrient removal, and bioenergy holds promise.

Lake Winnipeg Basin Initiative (LWBI) Single Window Information Portal.
Sarah Ross
Environment Canada National Water Quality Monitoring and Surveillance Office Burlington

To enhance access to relevant scientific data and information for use in decision making within the Lake Winnipeg basin, a web portal is being developed in order to promote data sharing with key partners and ensure consistent, inter-operable and reliable delivery of relevant information. Environment Canada's National Water Quality Monitoring and Surveillance Office has taken on the role of coordinating partnership based activities, working in partnership with the Water Quality Information Management and Modeling Project who are developing the information and decision support portal. Data and information leveraged through partnerships will, over the course of the next three years, be integrated into a Lake Winnipeg Basin Initiative (LWBI) Single Window Information Portal. This mechanism will compile and review existing LWBI information on point and non-point sources of pollution, and integrate multi-media (e.g., land and water) and multi-disciplinary (e.g., agriculture, fisheries and water quality) data and information using statistical analysis and integrated modeling techniques. This spatially focused information portal will be based on the use of Canadian Geospatial Data Infrastructure standards and will provide varying degrees of access for a number of user groups. Access to both public and secure data, information, models and other tools will be made available through the portal. Its development will take into account the needs and various capacities of its users.

Abstracts Not Available

Isotopic assessment of foodweb structure in Lake Winnipeg: a progress report
Keith Hobson
Environment Canada Saskatoon

Nutrient Sequestration in Lake Winnipeg Basin
Brian Parker
Environment Canada Winnipeg

Statistical Approaches to Sampling Networks
André St-Hilaire, Ph.D.
INRS-ETE
Chaire en hydrologie statistique & Canadian Rivers Institute

APPENDIX G

LWRC 2009 Science Workshop Attendees.

Attendees	Affiliation	Day 1	Day 2
Angus, Colin	A/Manager Mb District Water Survey of Canada Winnipeg	x	
Arkley, Hugh	Exec Director Community Foundations of Manitoba		x
Armstrong, Nicole	Manager Water Quality Manitoba Water Stewardship	x	x
Becker, Sven	Research Scientist Environment Canada Burlington	x	x
Booty, Bill	Research Scientist Environment Canada Burlington	x	x
Burns, Vicki	Community Foundations of Manitoba	x	
Cade-Menun, Barbara	Agriculture and Agri-Food Canada Swift Current	x	
Conly, Malcolm	Manager WQ Monitoring and Surveillance Western Canada EC	x	x
Cosens, Sue	Manager, Environmental Science Division, DFO	x	
Davoren, Gail	Grad Student Biological Science University of Manitoba	x	x
Gilbertson, Mike	Manager Environmental Section Manitoba Conservation	x	
Groening, Laura	Field Technician Manitoba Water Stewardship	x	x
Grosshans, Richard	International Institute of Sustainable Development Winnipeg	x	x
Hann, Brenda	Professor Biological Science University of Manitoba	x	x
Hanson, Mark	Associate Professor University of Manitoba	x	
Hiriart-Baer, Veronique	Research Scientist Environment Canada Burlington	x	x
Hobson, Keith	Research Scientist Environment Canada Saskatoon	x	x
Klein, Geoff	Fisheries Manager Central R Manitoba Water Stewardship	x	x
Kling, Hedy	Algal Taxonomy and Ecology Winnipeg	x	x
Kotak, Brian	Research Scientist Miette Environmental	x	
Kristofferson, Al	Managing Director Lake Winnipeg Research Consortium	x	x
Kroeker, Derek	Fisheries Biologist Manitoba Water Stewardship Gimli	x	x
Lawler, Herb	Head lake Winnipeg Research Consortium	x	x
Lawrence, John	Manager Lake Winnipeg Basin Initiative Environment Canada	x	
Leon, Luis	Research Scientist Environment Canada Burlington	x	x
Levesque, Luci	Aquatic Scientist Environment Canada Saskatoon	x	x
Loadman, Nancy	Instructor University of Winnipeg	x	
Lumb, Chelsey	Fisheries Biologist Manitoba Water Stewardship Winnipeg	x	x
Maclean, Bruce	Centre for Indigenous Environmental Research Winnipeg	x	
McCullough, Greg	Post Doc University of Manitoba Geography	x	x
Neufeld, David	Director, Community Planning Services, M. Intergov. Affairs	x	
Neumann, Gary	Chemist Health Canada	x	
Olynyk, Andrew	Graduate Student Biological Science Dept UM	x	
Page, Steve	Chemist ESD Fisheries and Oceans Canada	x	x
Parker, Brian	Research Scientist Environment Canada Winnipeg	x	x
Roscoe, Veronica	Chemist Health Canada	x	
Ryland, Sharon	Secretary Lake Winnipeg Research Consortium	x	x
Saint-hilaire, Andre	INRS Universite du Quebec		x
Salki, Alex	Science Program Coordinator LWRC	x	x
Ross, Sarah	NWQMS Environment Canada Gatineau QC	x	x
Schreyer, Ed	Member Lake Winnipeg Stewardship Board	x	
Scott, Karen	Education Coordinator LWRC	x	x
Shipley, Elaine	Manitoba Water Stewardship Winnipeg	x	x
Slasor, Rick	Manager Lake Winnipeg Sustainability Fund Initiative E C	x	
Smith, Derek	North Basin Manager, Red River Basin Commission	x	

Stagg, Norm	Member Lake Winnipeg Stewardship Board	x	
Stainton, Mike	Research Chemist Fisheries and Oceans Canada	x	x
Szoke, Nick	Senior Wastewater Engineer City of Winnipeg	x	
Timmerman, Mitch	Manitoba Agriculture Food & Rural Initiatives	x	
Ward, Katherine	Field Technician Manitoba Water Stewardship	x	x
Wassenaar, Len	Research Scientist Environment Canada Saskatoon	x	x
Watson, Sue	Research Scientist Environment Canada Burlington	x	x
Yerubandi, Ram	Research Scientist Environment Canada Burlington	x	x

APPENDIX H

Titles of Manuscripts for Journal of Great Lakes Research

	Author(s)	Proposed Title
1.	W.G. Booty	Watershed Non-Point Source Model Calibration and Uncertainty Analysis in Targeted Watersheds of the Red-Assiniboine Basin
2.	W.G. Booty	Winnipeg Integrated Watershed-Lake Modelling
3.	S. Gewurtz, M. Diamond, G.Stern, W. Franzin, J. Delaronde, J. Sawyer	Dynamics of Mercury in the Biota of Lake Winnipeg.
4.	W. Franzin, D. Watkinson, C. Lumb	Distribution and abundance of small fishes in the offshore waters of Lake Winnipeg as determined from non-random mid-water trawl catches.
5.	R. Yerubandi	Characteristics of Meteorology and Physical limnology of Lake Winnipeg
6.	B.J. Hann, S.L. Kowalchuk	Zoobenthos in Lake Winnipeg: Spatial and seasonal variation in 2002.
7.	B. J. Hann, S.L. Kowalchuk	Long-term trends in benthic invertebrate populations in Lake Winnipeg
8.	L. Wassenaar	Dissolved Oxygen in Lake Winnipeg??
9.	K. Hobson	Isotopic characterization of the Lake Winnipeg food web??

APPENDIX I

LWRC Science Participation in Community Events

Community Group or Agency	LWRC Science Role	Date 2008 -09
Joint Fed-Prov L Wpg Basin Science Com.	Advisory	April 22
Manitoba Schools Science Symposium	Judge	Apr 25-26
Joint Fed – Prov L Winnipeg Basin Com.	Advisory	May 7
Poplar River First Nation, Poplar River MB	Presentation	April 29, 2008
Matheson Island Fishers Meeting, M.I. MB	Presentation	May 1, 2008
River Heights Community Club	Presentation	May 8
River Heights Community Club	Presentation	May 12
IAGLR Trent University, Peterborough	Plenary Address	May 21
L Winnipeg Leaders Forum T Duguid	Display	May 28
JFPLWB Science Sub Committee	Advisory	May 29
Ecole R.H. Smith	Display	June 5
Ducks Unlimited Wetland Proj Review	Advisory	July 11
Grindstone Cottage Owner Association	Display	August 2
L Winnipeg Implementation Committee	Advisory	August 29
Manitoba Wildlife Society, Gimli MB	Presentation	August 16
PDK Masters Thesis Peak Phosphorus	Advisory	September 5
University of Manitoba Water Institute	Advisory	September 16-17
Manitoba Association of Cottage Owners	Presentation	October 25
Lake Winnipeg Foundation	Advisory	October 26
Ashern High School, Ashern MB	Presentation	November 5
Canada Foundation for Innovation	LWRC representative	November 17
Education Sustainable Dev. Conference	Presentation	November 28
Manitoba Conservation Districts Assoc.	Presentation	December 3,
MB Govt. Employees Union, Gull Hbr.	Presentation	January 16, 2009
Red River Basin Commission, Winnipeg	Presentation	January 21
Red River Basin Commission, North Chap.	Presentation	February 26
Manitoba Waste Water Assoc., Brandon	Presentation	March 23
Ducks Unlimited Wetland Review	Advisory	March 26
Climate Change Connections	Advisory	March 27