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WASCANA LAKE WATER QUALITY MONITORING PROGRAM

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ABSTRACT

The 2003-04 winter rehabilitation of Regina's Wascana Lake (the "Big Dig") was intended to improve water quality in the lake. It presented a unique opportunity to monitor the quality of lake water from "day one" by tracking changes in various physical, chemical and biological parameters over the course of the lake's maturity. An existing assessment tool, the CCME Water Quality Index (WQI) was used to evaluate data from water samples taken at several sites within the lake during the first two years. The WQI includes measures of how many parameters exceed national water quality guidelines, how often, and by how much. Data for the first two years show that the lake remains a poor site for recreational activities involving extensive contact with the water (WQI = 32) due to high levels of bacteria (Total coliforms, *E. coli*, fecal Streptococci) and pH. A significant waterfowl population resides in and around the lake, contributing to the high counts of fecal bacteria. Bacterial counts increased as the lake warmed throughout summer. Wascana Lake provides a marginal environment for wildlife based on the parameters examined (WQI = 57). Phosphorus and nitrogen levels are elevated to levels that may contribute to overgrowth of vegetation and algae.

Summary Table: Wascana Lake WQI Calculations: 2004 & 2005

Overal l	Drinking	Aquatic	Recreation	Irrigation	Livestock
71	37	57	32	90	52
Fair	Poor	Marginal	Poor	Good	Marginal

The WQI provides a "Health Report Card" for Wascana Lake as it progresses from a new body of water to a mature urban lake. The WQI was applied primarily with respect to two main usage criteria: suitability for recreational purposes, and suitability for the support of aquatic life. By monitoring the lake for several years, it may be possible to identify and act upon factors that adversely affect water quality in this lake.

Keywords: Water quality monitoring, water quality index (WQI), urban lake, recreation

use

INTRODUCTION

Wascana Lake

Wascana Lake is a man-made reservoir located within the City of Regina, SK. It was initially created in 1883 by damming Wascana Creek to provide drinking water for livestock. Due to the low flow of water through the Creek, the Lake is susceptible to silt deposition. The shallow water is then prone to overgrowth of weeds and algae during the hot summer weather typical of southern Saskatchewan. In 1931, and again in 2003-04, Wascana Lake was completely drained and deepened to prevent reversion to a marsh. The most recent excavation, commonly referred to as "The Big Dig", involved the removal of 1.3 million cubic metres of sediment, to create a lake with an average depth of 5.0 metres, compared to an average of only 1.5 meters prior to the operations.

The Water Quality Index

A stated objective of the revitalization project was the improvement of water quality. We used an existing assessment tool, the Water Quality Index (WQI) (CCME 2001) in an attempt to determine whether the water quality in Wascana Lake is now of acceptable quality for recreational purposes. The WQI was used to evaluate data from water samples taken at several sites (Fig.1) within the lake during the first two years after the excavation project. Each site was sampled four times throughout the summer, as prescribed by the WQI calculator, so that WQI scores could be calculated for each site over time if required, or the four sites could be considered together on each sampling date to provide a whole-lake score.

The WQI measures how many test variables exceed national water quality guidelines, how often, and by how much (i.e. *scope*, *frequency*, and *amplitude,* respectively). The WQI calculation yields a score between 0 (worst) and 100 (best) as determined by formula [1]:

[1] $$WQI = 100 - \sqrt{(F12 + F22 + F32)/1.732}$$ where

F1 (scope) is the percentage of test variables that do not meet their objectives,

F2 (frequency) is the percentage of individual tests that fail, and

F3 (amplitude) is the amount by which failed tests do not meet their objectives.

Further details on the calculations may be found in the User's Manual (CCME, 2001).

Figure 1: Wascana Lake Sampling locations. Water flows in at S2 (Broad St.) and exits at S1 (Albert St.).

Parameters

Physical / Chemical

Alkalinity, Conductivity, Dissolved Organic Carbon, pH Sodium Adsorption Ratio, Temperature, Turbidity

Metals

Aluminum, Arsenic, Boron, Barium, Copper, Iron, Lead, Manganese, Mercury, Nickel, Nitrogen (TKN), Phosphorus (Total), Selenium, Zinc

Major Ions

Chloride, Fluoride, Nitrate, o-Phosphate, Sulfate, Calcium, Magnesium, Potassium, Sodium

Bacteriological

E. coli, Fecal Streptococci, Pseudomonas, Total Coliforms

Selection of the appropriate parameters for WQI calculations is a site-dependent exercise. It is important to avoid inclusion of a large number of relatively unimportant parameters that rarely exceed guidelines, as this will artificially improve the score calculated for the site. Conversely, it is also important to avoid choosing parameters that do not affect the

intended use of the body of water under investigation, even if they exceed guidelines established for other intended uses of that water.

In this study, the CCME WQI calculations were performed primarily with respect to recreational use and support of aquatic life in Wascana Lake. Results for other uses (irrigation, livestock, drinking, and an overall score) are also presented for information purposes. Because the most common serious adverse effects from recreational water use are gastrointestinal illness related to ingestion of contaminated water, the criteria used in the calculations of the WQI for Recreational use are based primarily on bacterial counts: Total coliforms and/or *E. coli* < 2000 CFU / L, fecal streptococci < 350 CFU / L, as well as pH between 5.0 and 9.0. The criteria are more extensive for all other uses of water: concentrations of cations, anions, alkalinity and metals are included, but bacterial counts are not considered unless the water is intended for livestock watering.

RESULTS & DISCUSSION

All bacteriological and chemical testing was performed by Environmental Services (Water Laboratory) at the Saskatchewan Disease Control Laboratory in Regina, SK. The WQI calculator automatically provides output for multiple uses of the location under investigation (Figure 2).

Canadian Water Quality Index 1.0

Data Summary	Overall	Drinking	Aquatic	Recreation	Irrigation	Livestock
CWQI	71	37	57	32	90	53
Categorization	Fair	Poor	Marginal	Poor	Good	Marginal
F1 (Scope)	27	33	44	100	13	14
F2 (Frequency)	20	30	35	35	11	12
F3 (Amplitude)	37	100	49	50	1	80
Minimal Dataset Requirement of 4 Variables	Met	Met	Met	Met	Met	Met
Contaminant Analysis of Last Sample	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested	Not Tested

Details of any contaminant failures listed at the bottom of this sheet when applicable.

Turbidity Flagging Option	Not Used	
Site Specific Guideline Generation Option (CCME)	Not Used	Details available in Calculations Summary when applied.

File Used: C:\Documents and Settings\JLIVESEY\My Documents\Wascana Lake project\Wascana_data_2004&2005.xls

In-depth Report Options: Calculations Summary | WQI Chart | Indexed Test Data | Data Outliers | Turbidity

Please Note: In order to provide meaningful results the CWQI should be applied on data sets that contain at least 4 variables and at least 4 tests of each variable. However, users can exercise professional judgement based on knowledge of the data and site specific conditions.

Figure 2: Wascana Lake WQI Calculations for Combined 2004 & 2005 Data.

WQI Results for Recreational Use of Wascana Lake

High bacterial counts, particularly during the warmest months, are the main contributor to a "Poor" WQI rating for Wascana Lake as a recreational site (Figure 2, Table 1).

Table 1: Wascana Lake Water Quality 2004-2005: Parameters Affecting Suitability for Recreational Use*

Date	Water Temp. ºC	pH units	Fecal Streptococci CFU / L	Total Coliforms CFU / L	*E. coli* CFU / L
2004-Apr-27	12.0	**9.3**	260	90	45
2004-Jun-23	17.8	8.4	300	390	90
2004-Aug-25	17.6	**9.2**	**3500**	**5250**	**2250**
2004-Nov-02	3.8	8.8	**1660**	**2200**	925
2005-May-11	10.3	8.2	225	**2725**	253
2005-Jul-07	22.0	**9.0**	275	**3900**	125
2005-Sep-14	16.6	**9.3**	**2450**	**6000**	**2725**
2005-Nov-09	3.0	8.8	**684**	**10016**	72
CCME Guideline	30	5.0 - 9.0	350	2000	2000

Note: results that exceed their guideline values appear in bold type. * Values in table are means from the four sampling sites on each date.

The 'Poor' score in the Recreation category stems from each test in the index having individual results (Table 1) that exceeded their guideline values (F1 Scope = 100), 35% of all test results failed a guideline value (F2 Frequency), and the failures were often well in excess of the guidelines (F3 Amplitude = 50).

Total precipitation for the summer of 2004 was close to the 290 mm average (Environment Canada, 2008b). The hottest months, (July-Aug.) were ~2.4ºC cooler than normal. The summer of 2005 was somewhat cooler (mean temperature 13.0ºC) compared to the average May-Oct temperatures (13.6ºC), with more precipitation (440 mm from

June-Oct) than the May-Oct average (290 mm). When Regina next experiences a warmer than normal summer, bacterial counts may be expected to exceed those reported here.

In general, bacterial counts rose with water temperature, and for fecal streptococci and total coliforms, remained elevated compared to the spring sampling session even when the lake was approaching freeze-up.

During the warmest months, the pH of the lake was high enough (> pH 9.0) that prolonged contact could cause skin irritation in some individuals. These exceedances contributed to the WQI = Poor rating, but to a lesser extent than the bacterial results.

Non-recreational Uses of Wascana Lake

Aquatic life

The WQI indicates that water in Wascana Lake is of marginal quality for the support of aquatic life (Fig. 2, Table 2).

The shallow, warm, and relatively salty waters of Wascana Lake provide a good environment for bacterial growth. The sources of the bacteria are probably the large waterfowl populations found in Wascana Lake and in the upstream Migratory Bird Sanctuary, and from stormwater runoff from the surrounding urban areas.

Fish are present in sufficient quantities to support a small colony of pelicans, usually resident east of Broad St., and a colony of cormorants resides on Spruce Island. The presence of these top-level predators is an encouraging indicator that Wascana Lake after the "Big Dig" does provide a reasonably healthy aquatic ecosystem.

There are, however, large malodorous floating mats of vegetation present throughout the summer months. Phosphorus and nitrogen guidelines are now being incorporated into the Canadian Environmental Sustainability Indicators monitoring programs (Environment Canada et al., 2008). In our study, total phosphorus exceeded even the highest provincial guideline in all samples analyzed. When phosphorus is included in the analyses, with a maximum allowable concentration of 0.05 mg/L, it contributes to a downwards reclassification of Wascana Lake waters to "marginal", compared to our initial analyses, which were performed without a guideline value for phosphorus. Nitrogen levels also exceeded the guideline of 1.0 mg/L (Environment Canada et al., 2008) in all samples. The WQI decreased from 85 (i.e. "good") to 57 with both phosphorus and nitrogen included.

Drinking Water

Wascana Lake would be a poor source of drinking water without treatment for bacterial contamination, high pH, and turbidity (results not shown).

Table 2: Wascana Lake Water Quality 2004-2005: Parameters Affecting Sustainability of Aquatic Life*

Date	pH units	Phosphorus mg/L	Nitrogen mg/L	Arsenic mg/L
2004-Apr-27	**9.3**	**0.44**	**3.3**	0.004
2004-Jun-23	8.4	**0.42**	**1.8**	**0.006**
2004-Aug-25	**9.2**	**0.42**	**1.8**	**0.008**
2004-Nov-02	8.8	**0.31**	**1.8**	0.005
2005-May-11	8.5	**0.55**	**1.7**	**0.006**
2005-Jul-07	**9.0**	**0.39**	**1.4**	0.005
2005-Sep-14	**9.3**	**0.37**	**1.6**	**0.006**
2005-Nov-09	8.8	**0.20**	**1.6**	0.004
CCME Guideline	5.0 - 9.0	0.05	1.0	0.005

Note: results that exceed their guideline values appear in bold type. *Only those parameters with failures are listed. Values in table are means from the four sampling sites on each date.

Livestock

The water would be of marginal quality for livestock watering, again, because of high bacteria levels, and high pH.

Irrigation

The WQI produced a "good" rating for irrigation use, and while the water from Wascana Lake is currently used for irrigation of some of the surrounding parks in Wascana Centre, the water did consistently exceed pH, conductivity and total coliforms guidelines for this use.

Overall WQI

The overall rating combines criteria from the other usage categories. In this case, Wascana Lake received a grade of "Fair". As described above though, a detailed evaluation of the Index for its specific application provides the most accurate indicator of the water quality.

Future Monitoring

The deepening of Wascana Lake provided a temporary improvement in aesthetic quality of the water. However, substantive improvements in WQI values are likely only if there is an increase in water flow through the creek and lake (eg. more precipitation), and/or a decrease in nutrient inputs from agricultural and urban sources.

The ratio of total phosphorus to nitrogen seen in Wascana Lake is conducive to the growth of blue-green algae, as observed in the Regina stormwater retention ponds (Wang et al., 2008). Nutrient levels will continue to be monitored, and algal blooms, if present, will be tested for microcystins, to allow for warnings against exposure to these potent toxins.

Sampling in future years will also include more extensive measurements of metals, at greater sensitivity than was available for the initial sampling periods. This should allow better assessment of the WQI for sustainability of aquatic life.

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