Central Assiniboine Watershed Integrated Watershed Management Plan - Water Quality Report

October 2010

Water Quality Investigations and Routine Monitoring:

This report provides an overview of the studies and routine monitoring which have been undertaken by Manitoba Water Stewardship's Water Quality Management Section within the Central Assiniboine watershed.

There are six long term water quality monitoring stations (1965 – 2009) within the Central Assiniboine Watershed. These include the Assiniboine, Souris and Cypress Rivers. There are also ten stations not part of the long term water quality monitoring program in which some data are available for alternate locations on the Assiniboine, Souris, and Little Saskatchewan Rivers.

The Central Assiniboine River watershed area is characterized primarily by agricultural crop land, industry, urban and rural centres. All these land uses have the potential to negatively impact water quality, if not managed appropriately. Cropland can present water quality concerns in terms of fertilizer and pesticide runoff entering surface water. There are a number of large industrial operations in the Central Assiniboine Watershed, these present water quality concerns in terms of wastewater effluent and industrial runoff. Large centers and rural municipalities present water quality concerns in terms of wastewater treatment and effluent.

The tributary of most concern in the Central Assiniboine watershed is the Assiniboine River, as it is the largest river in the watershed. The area surrounding the Assiniboine River is primarily agricultural production yielding a high potential for nutrient and bacteria loading. The Assiniboine River serves as the main drinking water source for many residents in this watershed. In addition, the Assiniboine River drains into Lake Winnipeg, and as such has been listed as a vulnerable water body in the *Nutrient Management Regulation* under the *Water Protection Act*. Please refer to the section on 'Water Quality Management Zones' for more detailed information with this regard. The Souris and Cypress Rivers are comparatively smaller tributaries, which also contribute to nutrient loading in the watershed and ultimately Lake Winnipeg.

Currently, four of the six long term water quality monitoring stations are sampled monthly (which includes quarterly sampling), these include the Assiniboine River at 18th Street in Brandon, Assiniboine River at Happy Hollow Farm, Assiniboine River at PR 340 upstream of Treesbank, and the Souris River at PR 530 near Treesbank. The remaining two sites are sampled quarterly, which include the Souris River at Souris, and Cypress River at the Town of Cypress River. Monthly samples are analyzed for general chemistry, nutrients, metals and bacteria, whereas quarterly samples also include pesticide monitoring.

Water Quality Index Calculations:

The Canadian Council of Ministers of the Environment (CCME) Water Quality Index is used to summarize large amounts of water quality data into simple terms (e.g., good) for reporting in a consistent manner (CCME, 2001). Twenty-five variables are included in the Water Quality Index (Table 1) and are compared with water quality objectives and guidelines contained in the Manitoba Water Quality Standards, Objectives, and Guidelines (Williamson 2002 and Table 1).

The Water Quality Index combines three different aspects of water quality: the 'scope,' which is the percentage of water quality variables with observations exceeding guidelines; the 'frequency,' which is the percentage of total observations exceeding guidelines; and the 'amplitude,' which is the amount by which observations exceed the guidelines. The basic premise of the Water Quality Index is that water quality is excellent when all guidelines or objectives set to protect water uses are met virtually all the time. When guidelines or objectives are not met, water quality becomes progressively poorer. Thus, the Index logically and mathematically incorporates information on water quality based on comparisons to guidelines or objectives to protect important water uses. The Water Quality Index ranges from 0 to 100 and is used to rank water quality in categories ranging from poor to excellent.

- Excellent (95-100) - Water quality never or very rarely exceeds guidelines
- Good (80-94) - Water quality rarely exceeds water quality guidelines
- Fair (60-79) - Water quality sometimes exceeds guidelines and possibly by a large margin
- Marginal (45-59) - Water quality often exceeds guidelines and/or by a considerable margin
- Poor (0-44) - Water quality usually exceeds guidelines and/or by a large margin

Table 1: Water quality variables and objectives or guidelines (Williamson 2002) used to calculate Water Quality Index (CCME 2001).

Variables	**Units**	**Objective Value**	**Objective Use**
Fecal Coliform MF	Bacteria/100mL	200	Recreation
pH	pH Units	6.5-9.0	Aquatic Life
Specific Conductivity	uS/cm	1000	Greenhouse Irrigation
Total Suspended Solids	mg/L	25 (mid range)	Aquatic Life
Dissolved Oxygen	mg/L	5 (mid range)	Aquatic Life
Total or Extractable Cadmium*	mg/L	Calculation based on Hardness (7Q10)	Aquatic Life
Total or Extractable Copper*	mg/L	Calculation based on Hardness (7Q10)	Aquatic Life
Total Arsenic	mg/L	0.025	Drinking Water, Health
Total or Extractable Lead*	mg/L	Calculation based on Hardness (7Q10)	Aquatic Life
Dissolved Aluminum	mg/L	0.1 for pH >6.5	Aquatic Life
Total or Extractable Nickel*	mg/L	Calculation based on Hardness (7Q10)	Aquatic Life
Total or Extractable Zinc*	mg/L	Calculation based on Hardness (7Q10)	Aquatic Life
Total or Extractable Manganese	mg/L	0.05	Drinking Water, Aesthetic
Total or Extractable Iron	mg/L	0.3	Drinking Water, Aesthetic
Total Ammonia as N	mg/L	Calculation based pH	Aquatic Life
Soluble or Dissolved Nitrate-Nitrite	mg/L	10	Drinking Water, Health
Total Phosphorus	mg/L	0.05 in Rivers or 0.025 in Lakes	Nuisance Plant Growth
Dicamba	ug/L	0.006 where detectable	Irrigation
Bromoxynil	ug/L	0.33	Irrigation
Simazine	ug/L	0.5	Irrigation
2,4 D	ug/L	4	Aquatic Life
Lindane	ug/L	0.08	Aquatic Life
Atrazine	ug/L	1.8	Aquatic Life
MCPA	ug/L	0.025 where detectable	Irrigation
Trifluralin	ug/L	0.2	Aquatic Life

A Water Quality Index was calculated for the Assiniboine River at 18th Street in Brandon, the Assiniboine River near Treesbank, the Souris River near Treesbank, and the Cypress River at the Town of Cypress River. While water chemistry has been monitored at these sites since 1965, certain pesticides that are required to calculate the WQI were not monitored prior to 1990. Therefore, the Water Quality Index has been calculated from 1990 to present and these indices are represented on Figures 1 through 4.

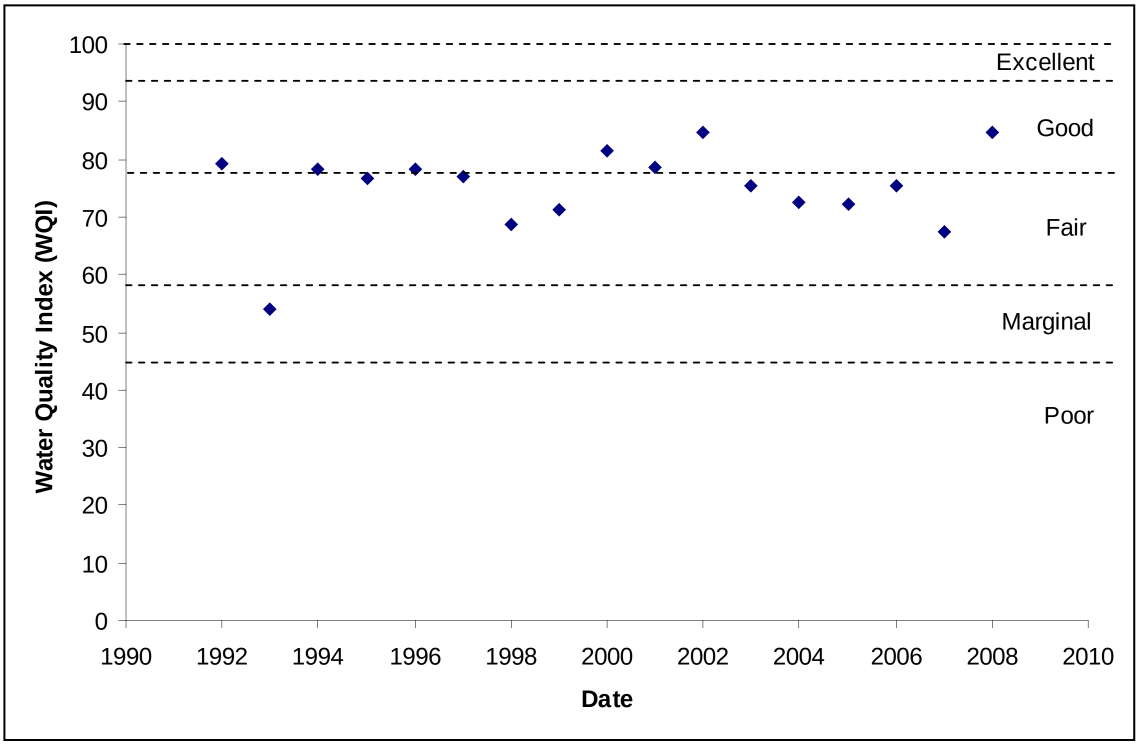

Figure 1: Water Quality Index calculated from 1990 to 2008 for the Assiniboine River at 18th Street in Brandon.

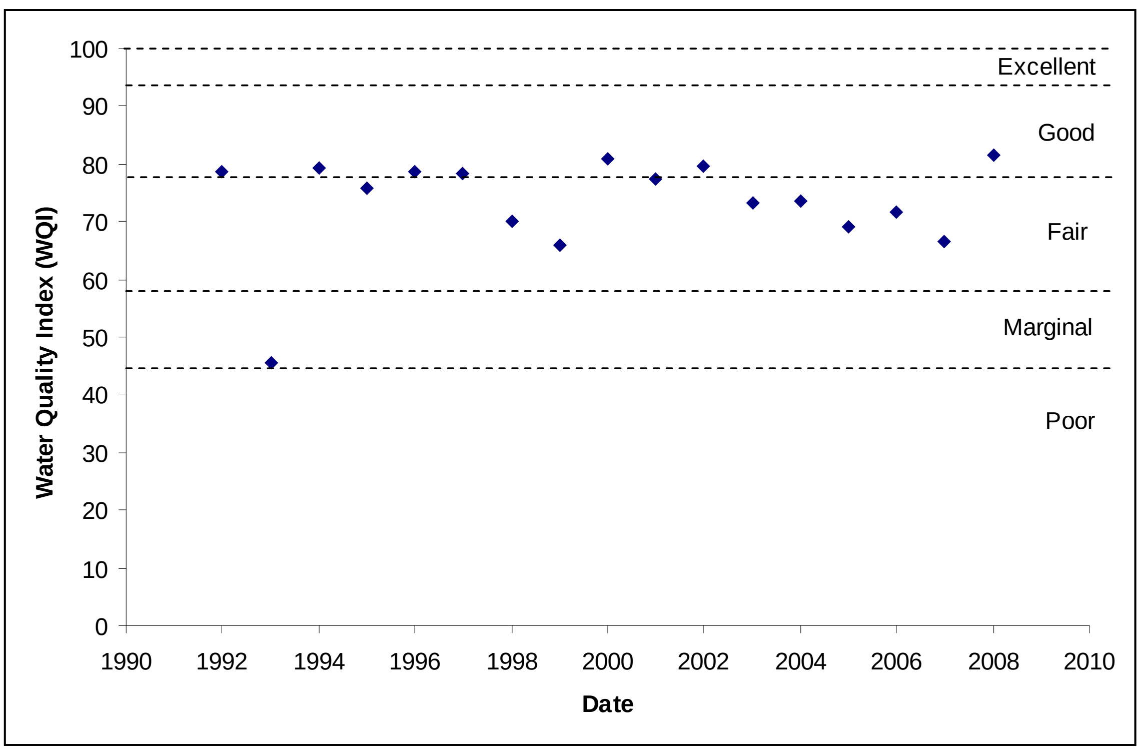

Figure 2: Water Quality Index calculated from 1990 to 2008 for the Assiniboine River near Treesbank.

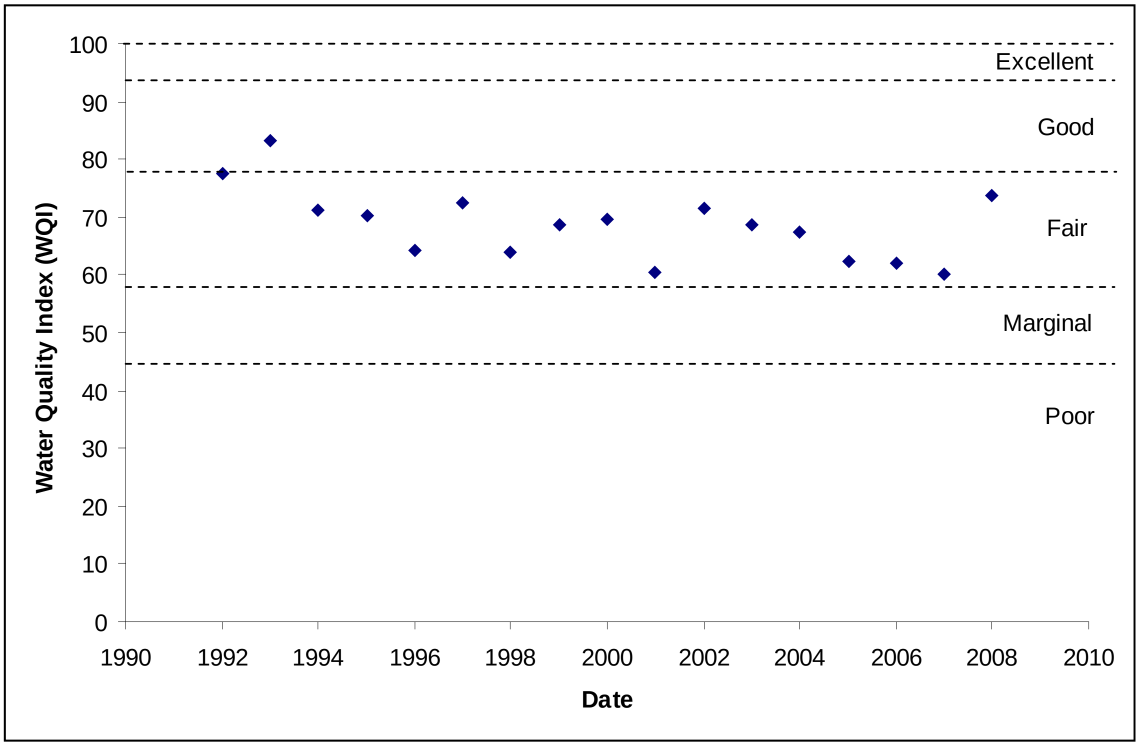

Figure 3: Water Quality Index calculated from 1990 to 2008 for the Souris River near Treesbank.

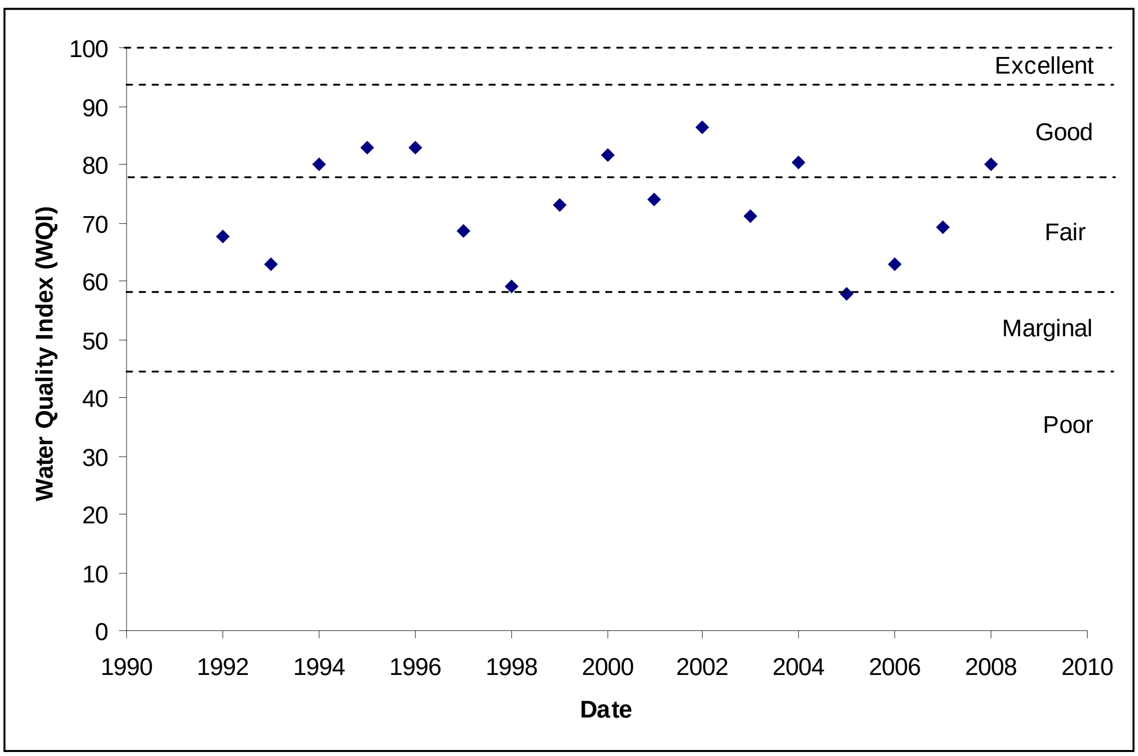

Figure 4: Water Quality Index calculated from 1990 to 2008 for the Cypress River near the Town of Cypress River.

In general, the Water Quality Index for the Assiniboine, Souris and Cypress Rivers fell within the categories of ‘Fair’ and ‘Good’ (Figures 1 to 4) indicating that water quality sometimes exceeded water quality guidelines for some variables. While numerous variables are used to calculate the overall Water Quality Index, the percentage of variables that exceeded their objective in the Assiniboine River at Brandon from 1990 to 2008 ranged from 13 to 39 per cent, and in the Assiniboine River near Treesbank ranged from 13 to 30 per cent. The percentage of variables that exceeded their objective in the Souris River at Treesbank from 1990 to 2008 ranged from 17 to 35 per cent, and in the Cypress River near the town of Cypress River ranged from 13 to 35 per cent. Total phosphorus is typically responsible for driving down the Water Quality Index, as discussed in more detail below. As well, other water quality parameters will be discussed in greater detail below as a means to explain observed Water Quality Index values. Overall, while some water bodies contain naturally elevated concentrations of nutrients due to watershed characteristics, many human alterations impact nutrient loading to the Assiniboine, Souris and Cypress Rivers.

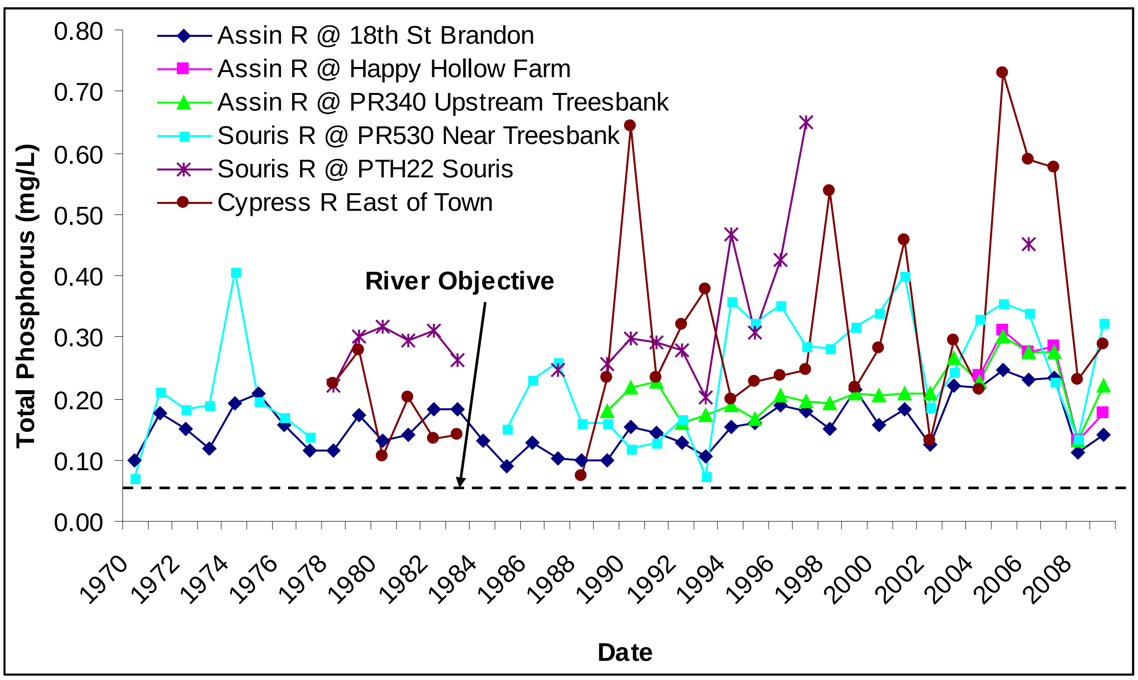

Figure 5: Total phosphorus (mg/L) concentrations from six long term water quality monitoring sites in the Central Assiniboine watershed between 1970 and 2009.

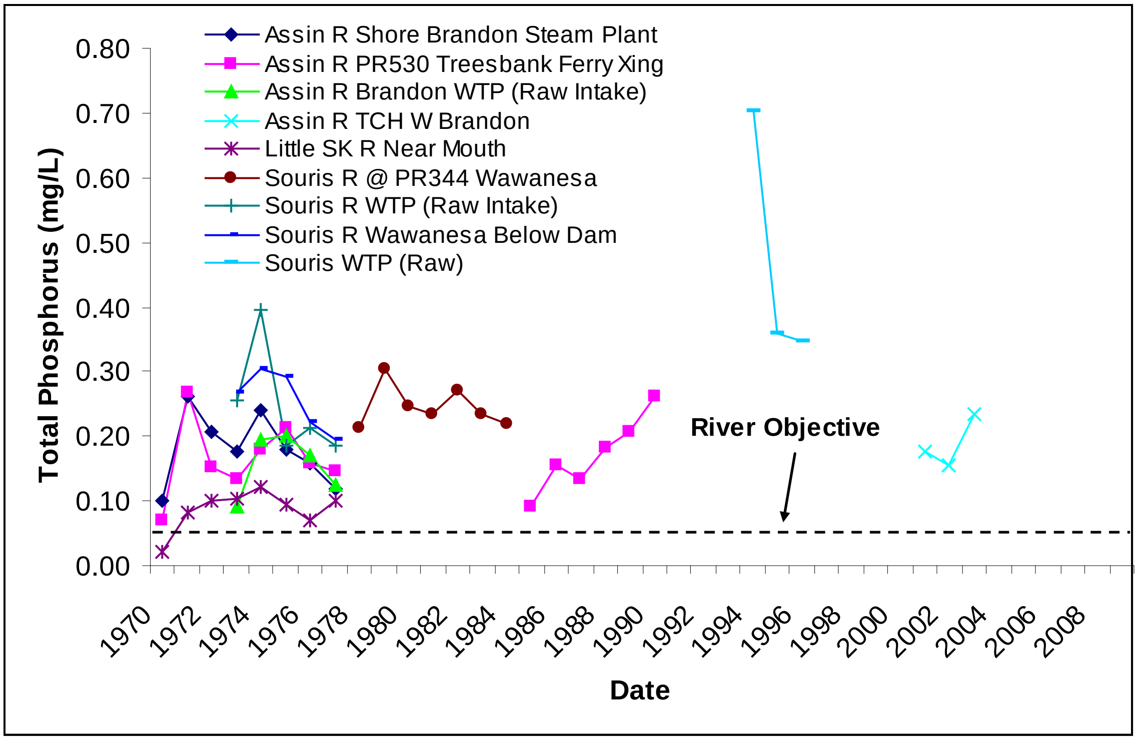

Figure 6: Total phosphorus (mg/L) concentrations for 9 other monitoring sites, not part of the long term water quality monitoring program, in the Central Assiniboine watershed between 1970 and 2009.

Figures 5 and 6 illustrate total phosphorus concentrations in the Central Assiniboine watershed. Typically, total phosphorus concentrations were well above the Manitoba Water Quality Guideline for rivers of 0.05 mg/L (Williamson 2002). In addition, total phosphorus concentrations tended to increase at most sampling sites between 1970 and 2009. As part of the Lake Winnipeg Action Plan, Manitoba is implementing several strategies to better manage plant nutrients. Part of this Action Plan includes the development of more appropriate site-specific or regional-specific water quality objectives or guidelines for nutrients. In the meantime, the narrative guidelines will be retained for nutrients such as nitrogen and phosphorus until more site specific objectives are developed. It is generally recognized, however, that narrative guidelines for phosphorus likely do not apply to many streams in the Canadian prairie region since other factors such as turbidity, stream velocity, nitrogen, and other conditions most often limit algal growth. As well, relatively high levels of phosphorus in excess of the narrative guidelines may arise naturally from the rich prairie soils. It should be noted that most streams and rivers in southern Manitoba exceed this guideline, in some cases due to the natural soil characteristics in the watershed and/ or due to inputs from human activities and land-use practices.

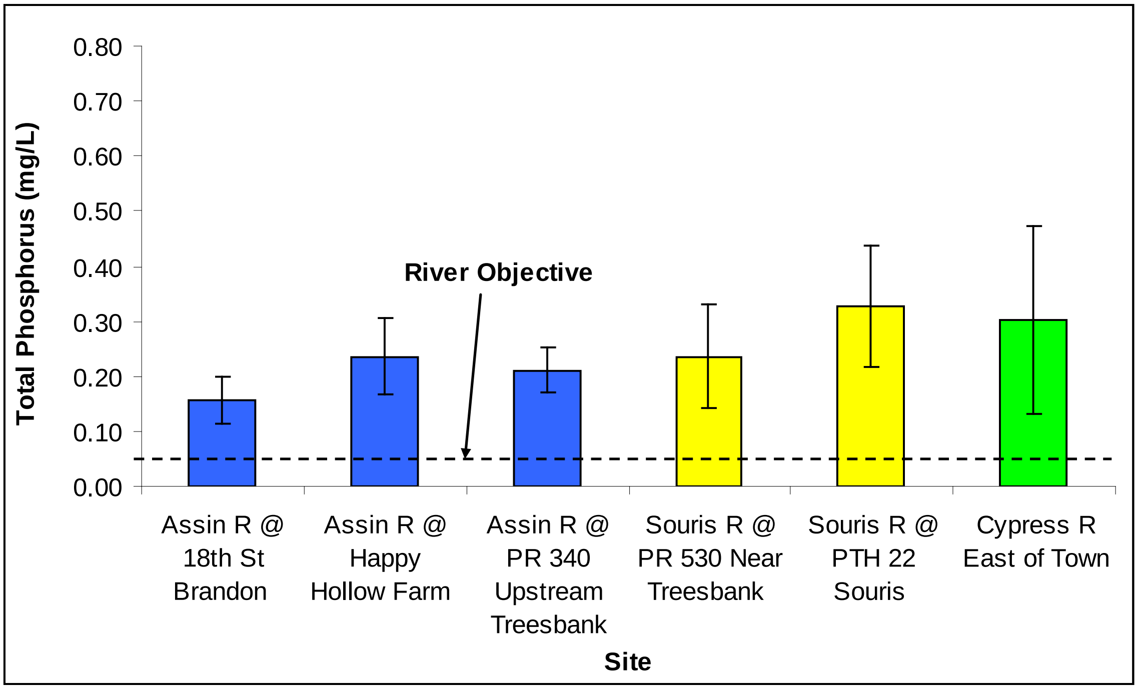

Figure 7: Mean total phosphorus concentrations (mg/L) between 1970 and 2009 for six long term water quality monitoring sites.

Figure 7 compares the mean total phosphorus concentrations (1970-2009) between the Assiniboine, Souris and Cypress Rivers. The Souris River at PTH 22 in the town of Souris has significantly greater total phosphorus concentrations than the Assiniboine River at 18th street in Brandon ($p<0.05$). On average, the Assiniboine River has lower total phosphorus concentrations than does the Souris and Cypress Rivers.

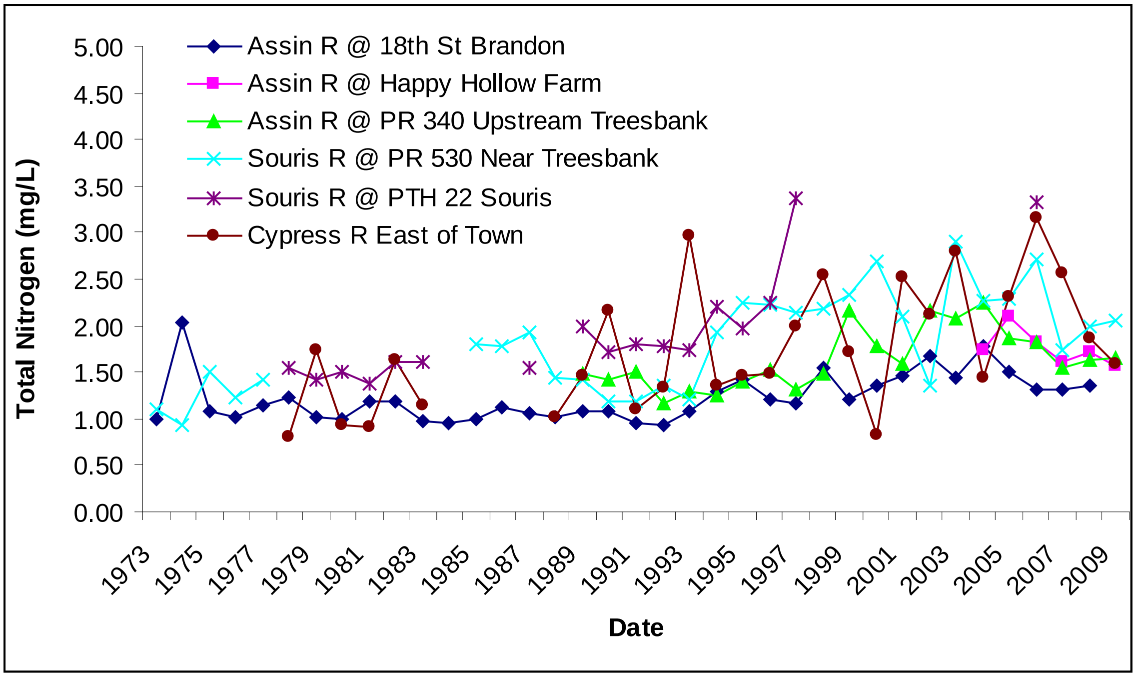

Figure 8: Total nitrogen (mg/L) concentrations from six long term water quality monitoring sites in the Central Assiniboine watershed between 1970 and 2009.

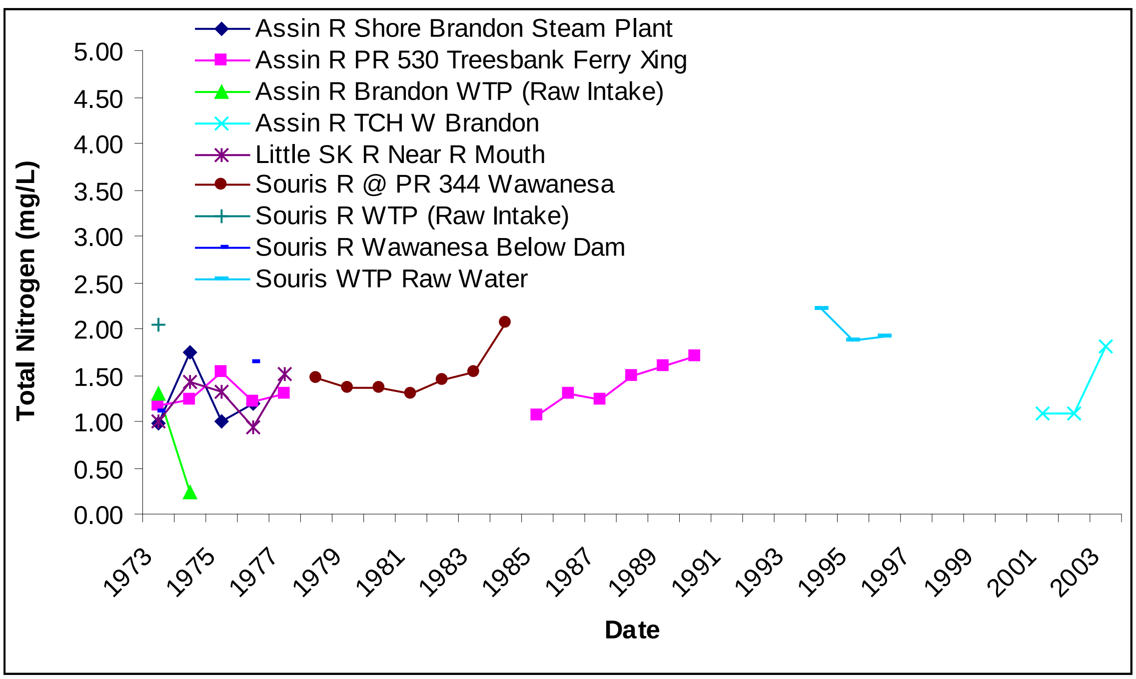

Figure 9: Total nitrogen (mg/L) concentrations for 9 other monitoring sites, not part of the long term water quality monitoring program, in the Central Assiniboine watershed between 1970 and 2009.

The narrative objective for total nitrogen states nitrogen should be limited to the extent necessary to prevent nuisance growth and reproduction of aquatic rooted, attached and floating plants, fungi, or bacteria, or to otherwise render the water unsuitable for other beneficial uses

(Williamson 2002). Nitrogen and phosphorus are two essential nutrients which stimulate algal growth in Lake Manitoba and its watershed. Figures 8 and 9 illustrate the total nitrogen concentration in the Central Assiniboine watershed. On average since 1973 total nitrogen has increased at all sample locations.

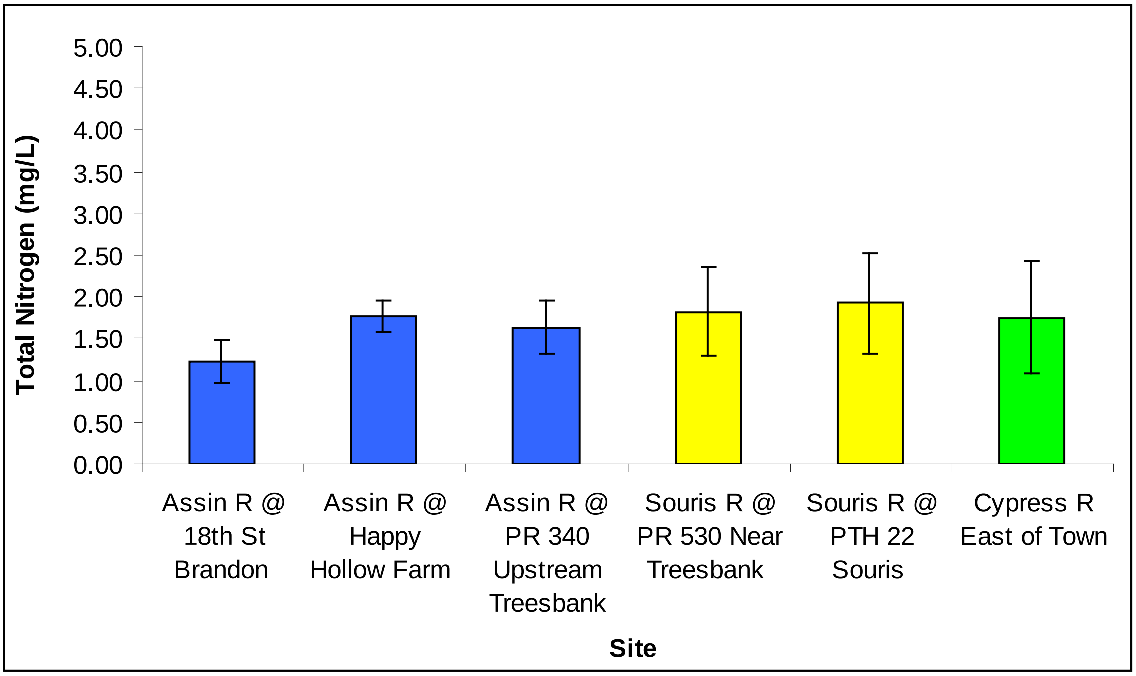

Figure 10: Mean total nitrogen concentrations (mg/L) between 1970 and 2009 for six long term water quality monitoring sites.

Figure 10 compares the mean total nitrogen concentrations between the Assiniboine, Souris and Cypress Rivers. The results show no significant difference between these three rivers. However, the mean total nitrogen concentration in the Assiniboine River at 18th Street in Brandon is significantly lower than the Assiniboine River at Happy Hollow Farm ($p<0.05$). On average, all three rivers have comparable mean total nitrogen concentrations.

Maintenance of adequate dissolved oxygen levels is essential to the health of aquatic life inhabiting rivers and streams. The monitoring conducted in the Central Assiniboine watershed (Figures 11 & 12) demonstrates that dissolved oxygen levels are generally above the 5.0 mg/ L Manitoba objective (Williamson 2002). This is with the exception of 1997 (Figure 11) as samples were collected during winter (January – March) while the river was still frozen, and in June of 1973 (Figure 12), when dissolved oxygen levels were below the detection limit at the Souris Water Treatment Plant raw water intake. Low oxygen levels under ice conditions are not uncommon in small prairie rivers, as the decomposition of plant material consumes oxygen from the water. As well, low oxygen levels are not uncommon after a summer of intense algal blooms consuming oxygen from the water column. Overall, there is typically adequate dissolved oxygen in this watershed to support healthy aquatic life.

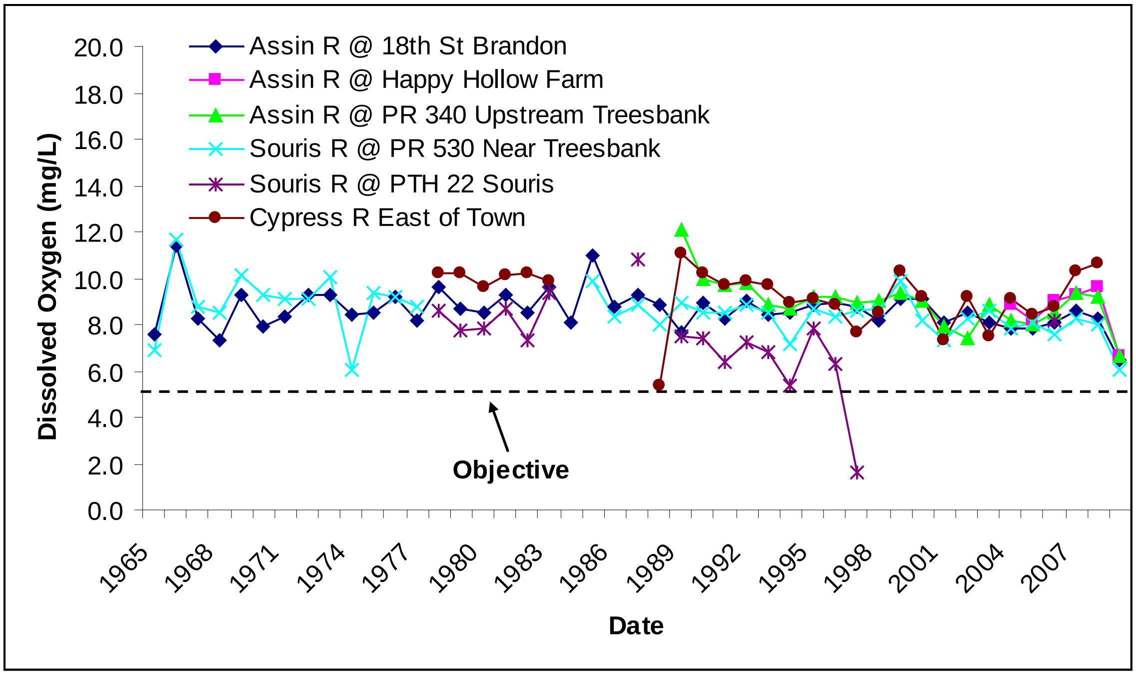

Figure 11: Dissolved oxygen (mg/L) concentrations from six long term water quality monitoring sites in the Central Assiniboine watershed between 1970 and 2009.

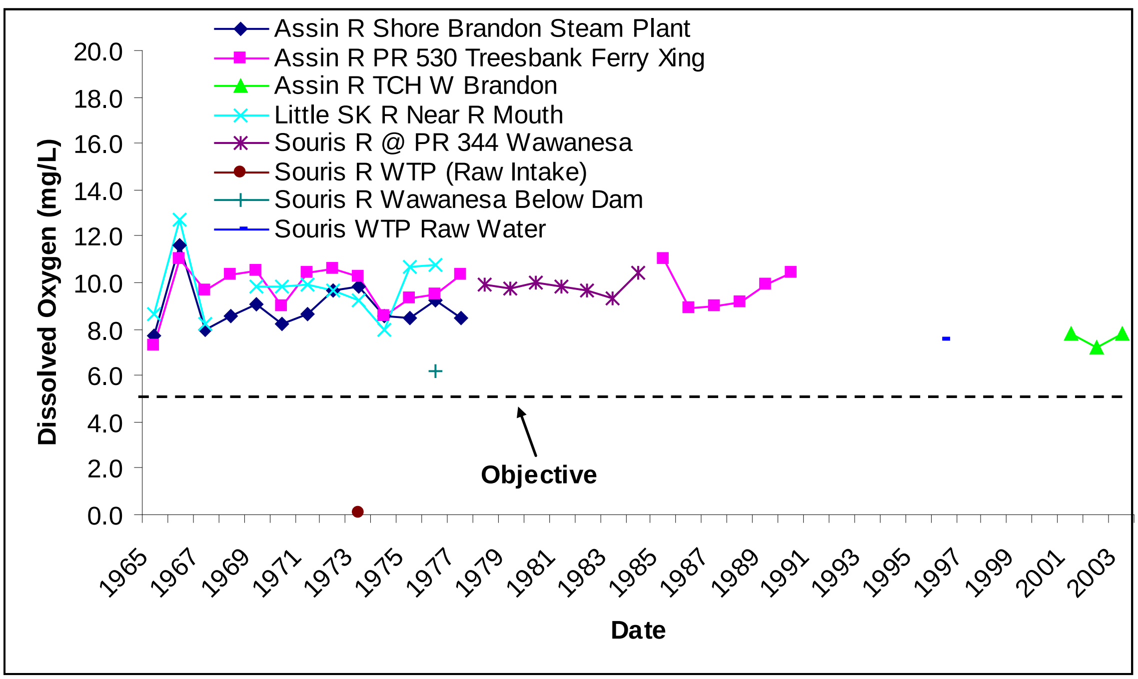

Figure 12: Dissolved oxygen (mg/L) concentrations for 8 other monitoring sites, not part of the long term water quality monitoring program, in the Central Assiniboine watershed between 1970 and 2009.

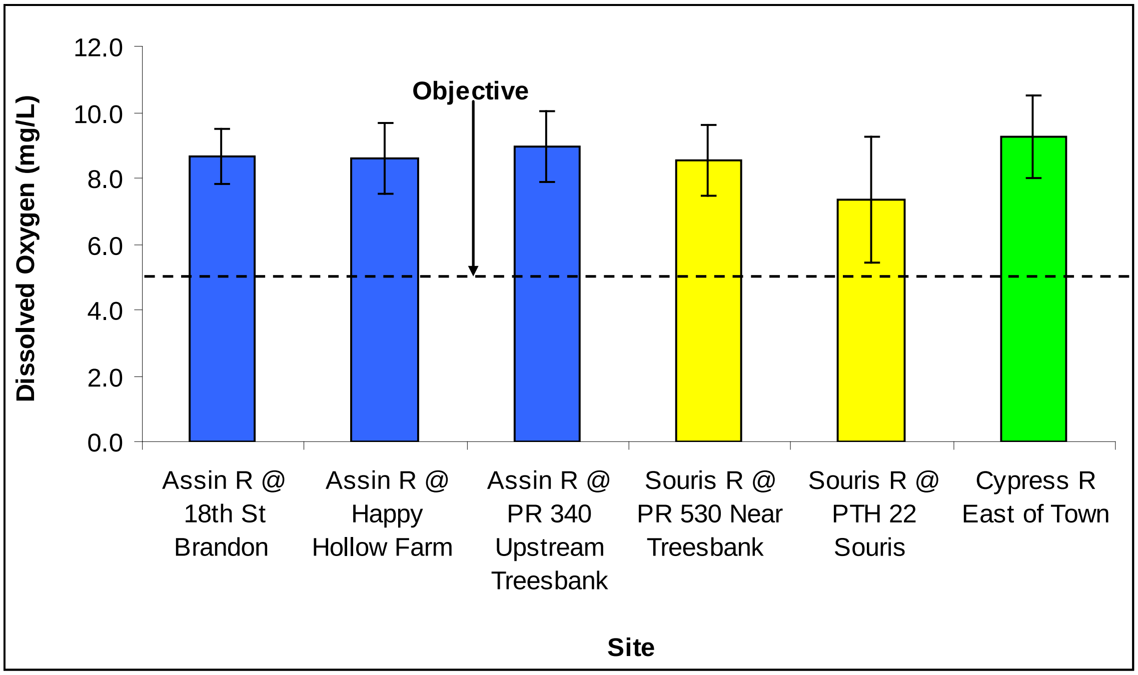

Figure 13: Mean dissolved oxygen (mg/L) concentrations between 1970 and 2009 for six long term water quality monitoring sites.

Figure 13 compares mean dissolved oxygen concentrations between the Assiniboine, Souris and Cypress Rivers. Results indicate no significant difference exists between the three rivers ($p<0.05$).

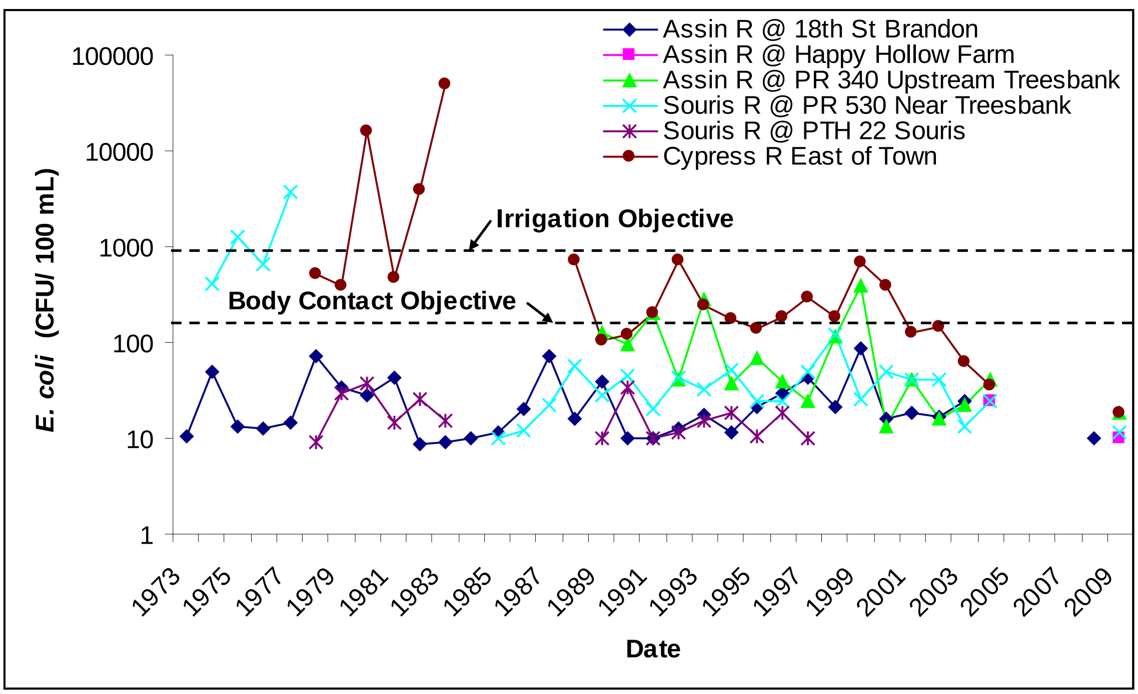

Figure 14: Densities of *Escherichia coli (E. coli*) collected from six long term water quality monitoring sites in the Central Assiniboine watershed between 1970 and 2009. The objective is 200 MPN per 100 mL.

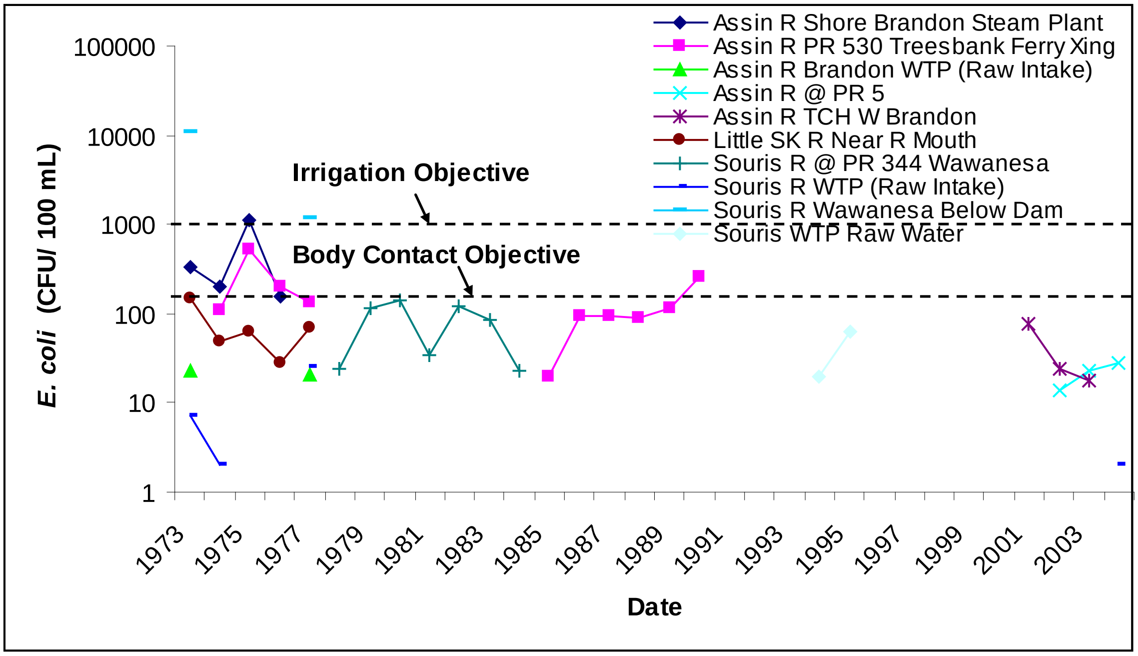

Figure 15: Densities of *Escherichia coli (E. coli*) collected for 10 other monitoring sites, not part of the long term water quality monitoring program, in the Central Assiniboine watershed between 1970 and 2009. The objective is 200 MPN per 100 mL.

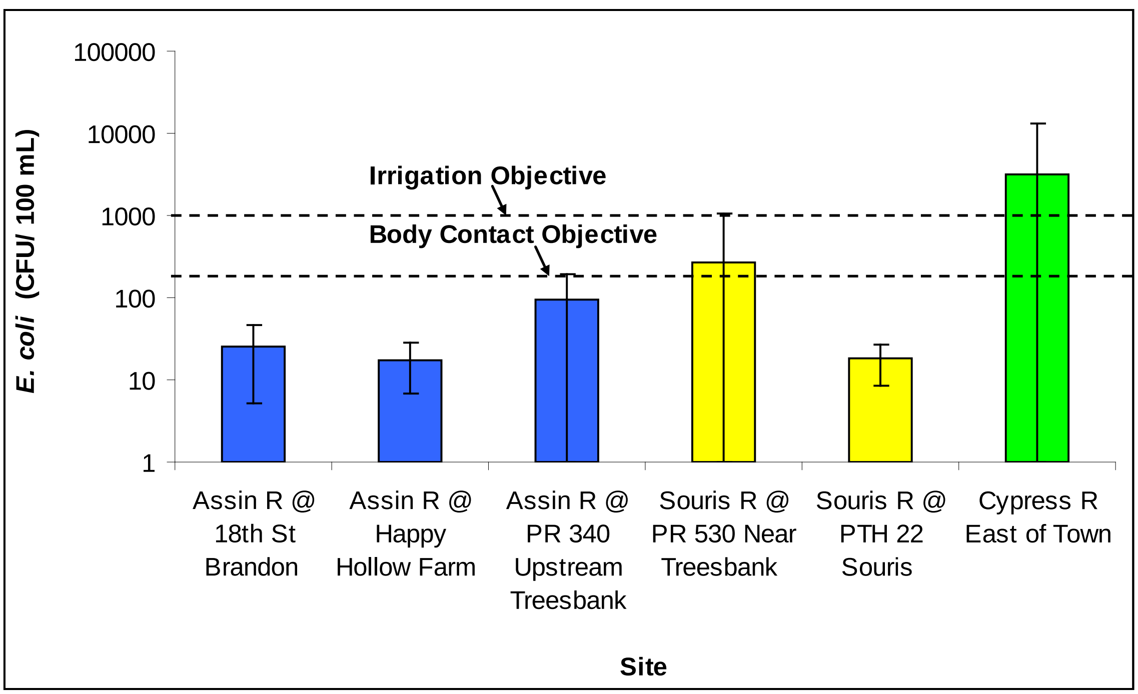

Figure 16: Mean densities of *Escherichia coli (E. coli*) between 1970 and 2009 for six long term water quality monitoring sites.

Escherichia coli (E. coli) is a bacteria commonly found all warm-blooded animals including humans, livestock, wildlife, and birds. *E. coli* itself does not generally cause illness, but when present in large numbers the risk of becoming ill from other organisms is elevated. The most common illnesses contracted by bathers are infections of the eyes, ears, nose, and throat as well as stomach upsets. Typical symptoms include mild fever, vomiting, diarrhea and stomach cramps. Extensive studies were undertaken by Manitoba Water Stewardship in 2003 to determine the source of occasionally high *E. coli* counts and the mechanism of transfer to Lake Winnipeg beaches. Studies have shown large numbers of *E. coli* present in the wet sand of beaches. During periods of high winds, when water levels are rising in the south basin, these bacteria can be washed out of the sand and into the swimming area of the lake. Research shows less than 10% of *E. coli* found at Lake Winnipeg beaches is from human sources, with the remaining percentage from birds and animals.

Figures 14 and 15 illustrate *E. coli* densities in the Central Assiniboine watershed. Typically, *E. coli* densities were below both the irrigation objective of 1000 CFU/ 100 mL, and the body contact recreation objective of 200 CFU/ 100 mL (Williamson 2002). However, the Cypress River east of town was historically well above both objectives, that is until 2001 when a significant reduction in *E. coli* densities was observed. The Souris River at PR 530 near Treesbank historically was well above both objectives, but since 1985 has been below both objectives. Figure 15 illustrates three sites which historically were above the objectives. However, since 2001 all sample locations have been within both the irrigation and body contact recreation objectives.

Figure 16 compares mean *E. coli* densities between the Assiniboine, Souris and Cypress Rivers. Results indicate no significant difference exists between the three rivers ($p<0.01$) as *E. coli* data were highly variable within sites. All sites were below both the irrigation and body contact recreational objectives, with the exception of the Souris River at PR 530 near Treesbank which exceeded the body contact recreational objective and the Cypress River east of town which exceeded both objectives.

The majority of pesticides were below the level of detection, or very close to that limit, and thus did not exceed water quality objectives at most sites. The pesticides Dicamba and MCPA exceeded irrigation objectives (0.006 and 0.025 µg/L, respectively) on a number of occasions, at the Cypress River east of town, Assiniboine River at PR 340 upstream of Treesbank, Assin R @ Happy Hollow Farm, Assiniboine River at 18th Street in Brandon, the Assiniboine River PR 530 at the Treesbank ferry crossing, Souris River at PTH 22 at Souris, and the Souris River at PR 530 near Treesbank. However, the aquatic life objective for Dicamba (10 µg/L) was never exceeded at any of the sites. The aquatic life objective for MCPA (2.6 µg/L) was exceeded in 1991 at Souris

River at PR 530 near Treesbank, and in 1993 at Souris River at PTH 22 at Souris, Assiniboine River at PR 340 upstream of Treesbank, Assiniboine River at 18th Street in Brandon. In July of 1993 the objective for Bromoxinil (0.33 µg/L) was exceeded at the Cypress River east of town (0.43 µg/L). Historic data indicates Simazine significantly exceeded objectives at the Souris River at PR 530 near Treesbank for the entire year of 1973, but has not exceeded objectives since. The objective for Simazine was also significantly exceeded at the Souris River at the Wawanesa Dam from 1973 to 1975.

Discussion

Nutrient enrichment or eutrophication is one of the most important water quality issues in Manitoba. Excessive levels of phosphorus and nitrogen fuel the production of algae and aquatic plants. Extensive algal blooms can cause changes to aquatic life habitat, reduce essential levels of oxygen, clog fisher's commercial nets, interfere with drinking water treatment facilities, and cause taste and odour problems in drinking water. In addition, some forms of blue-green algae can produce highly potent toxins.

Studies have shown that since the early 1970s, phosphorus loading has increased by about 10% to Lake Winnipeg and nitrogen loading has increased by about 13%. A similar phenomenon has also occurred in many other Manitoba streams, rivers, and lakes.

Manitobans, including those in the Central Assiniboine watershed, contribute about 47% of the phosphorus and 44% of the nitrogen to Lake Winnipeg (Bourne *et al.* 2002, updated in 2006). About 15% of the phosphorus and 6% of the nitrogen entering Lake Winnipeg is contributed by agricultural activities within Manitoba. In contrast, about 9% of the phosphorus and 6% of the nitrogen entering Lake Winnipeg from Manitoba is contributed by wastewater treatment facilities such as lagoons and sewage treatments plants.

As part of Lake Winnipeg Action Plan, the Province of Manitoba is committed to reducing nutrient loading to Lake Winnipeg to those levels that existed prior to the 1970s. The Lake Winnipeg Action Plan recognizes that nutrients are contributed by most activities occurring within the drainage basin and that reductions will need to occur across all sectors. Reductions in nutrient loads across the Lake Winnipeg watershed will benefit not only Lake Winnipeg but also improve water quality in the many rivers and streams that are part of the watershed, including the Central Assiniboine watershed. The Lake Winnipeg Stewardship Board's 2006 report "Reducing Nutrient Loading to Lake Winnipeg and its watershed: Our Collective Responsibility and Commitment to Action" (LWSB 2006) provides 135 recommendations on actions needed to reduce nutrient loading to the Lake Winnipeg watershed. However, reducing nutrients loading to the Lake Winnipeg watershed, including the Westlake watershed, is a challenge that will require the participation and co-operation of all levels of government and all watershed residents. Ensuring good water quality in the Central Assiniboine watershed and downstream is a collective responsibility among all living in the watershed.

Water Quality Management Zones

In June 2005 *The Water Protection Act* received royal ascension. This Act is intended to enable regulations to be developed for strengthening adherence to water quality standards, for protecting water, aquatic ecosystems or drinking water sources, and to provide a framework for integrated watershed management planning. The first regulation under *The Water Protection Act* — the *Nutrient Management Regulation (see:* www.gov.mb.ca/waterstewardship/wqmz/index.html) — defines five Water Quality Management Zones for Nutrients to protect water from excess nutrients that may arise from the over-application of fertilizer, manure, and municipal waste sludge on land beyond the amounts reasonably required for crops and other plants during the growing season.

As of January 1, 2009, substances containing nitrogen or phosphorus cannot be applied to areas within the Nutrient Buffer Zone or land within Nutrient Management Zone N4 (Canada Land Inventory Soil Capability Classification for Agriculture Class 6 and 7, and unimproved organic soils). The width of the Nutrient Buffer Zone varies depending upon the nature of the body of water and is generally consistent with those contained in the Livestock Manure and Mortalities Management Regulation (42/98).

The *Nutrient Management Regulation* (MR 62/2008) prohibits the construction, modification, or expansion of manure storage facilities, confined livestock areas, sewage treatment facilities, and wastewater lagoons on land in the Nutrient Management Zone N4 or land in the Nutrient Buffer Zone. Further, the construction, installation, or replacement of an on-site wastewater management system (other than a composting toilet system or holding tank) within Nutrient Management Zone N4 or land in the Nutrient Buffer Zone is prohibited (Part 4: Section 14(1): f).

It is recommended that measures are taken to prevent the watering of livestock in any watercourses to prevent bank erosion, siltation, and to protect water quality by preventing nutrients from entering surface water.

No development should occur within the 99 foot Crown Reserve from the edge of any surface water within the rural municipalities. Permanent vegetation should be encouraged on lands within the 99 foot crown reserve to prevent erosion, siltation, and reduce the amount of nutrients entering surface water.

The Nutrient Management Regulation under *The Water Protection Act*, prohibits the application of a fertilizer containing more than 1% phosphorus by weight, expressed as P_2O_5, to turf within Nutrient Management Zone N5 (built-up area such as towns, subdivisions, cottage developments, etc.) except during the year in which the turf is first established and the following year. In residential and commercial applications, a phosphorus containing fertilizer may be used if soil test phosphorus (using the Olsen-P test method) is less than 18 ppm.

The Nutrient Management Regulation (MR 62/2008) under *The Water Protection Act*, requires Nutrient Buffer Zones (set-back distances from the water's edge) be applied to all rivers, streams, creeks, wetlands, ditches, and groundwater features located across Manitoba including within urban and rural residential areas and within agricultural regions (Table A9 in Appendix 9).

Drainage

Although it is recognized that drainage in Manitoba is necessary to support sustainable agriculture, it is also recognized that drainage works can impact water quality and fish habitat. Types of drainage include the placement of new culverts or larger culverts to move more water, the construction of a new drainage channels to drain low lying areas, the draining of potholes or sloughs to increase land availability for cultivation and the installation of tile drainage. Artificial drainage can sometimes result in increased nutrient (nitrogen and phosphorus), sediment and pesticide load to receiving drains, creeks and rivers. All types of drainage should be constructed so that there is no net increase in nutrients (nitrogen and phosphorus) to waterways. To ensure that drainage maintenance, construction, and re-construction occurs in an environmentally friendly manner, the following best available technologies, and best management practices aimed at reducing impacts to water quality and fish habitat are recommended.

The following recommendations are being made to all drainage works proposals during the approval process under *The Water Rights Act*:

- There must be no net increase in nutrients (nitrogen and phosphorus) to waterways as a result of drainage activities. Placement of culverts, artificial drainage and construction and operation of tile drains can sometimes result in increased nutrient (nitrogen and phosphorus), sediment and pesticide loads to receiving drains, creeks and rivers.

- Synthetic fertilizer, animal manure, and municipal wastewater sludge must not be applied within drains.

<u>Culverts</u>

- Removal of vegetation and soil should be kept to a minimum during the construction and the placement of culverts.
- Erosion control methodologies should be used on both sides of culverts according to the Manitoba Stream Crossing Guidelines for the Protection of Fish and Fish Habitat.
- A strip of vegetation 1 to 3 metres wide should be maintained along drainage channels as a buffer. This will reduce erosion of channels and aid in nutrient removal.
- The proponent should revegetate exposed areas along drainage channels.

<u>Surface Drainage</u>

- Surface drainage should be constructed as shallow depressions and removal of vegetation and soil should be minimized during construction.
- Based on Canada Land Inventory Soil Capability Classification for Agriculture (1965), Class 6 and 7 soils should not be drained.
- There should be no net loss of semi-permanent or permanent sloughs, wetlands, potholes or other similar bodies of water in the sub-watershed within which drainage is occurring.
- Erosion control methodologies outlined in Manitoba Stream Crossing Guidelines for the Protection of Fish and Fish Habitat should be used where the surface drain intersects with another water body.
- A strip of vegetation 1 to 3 metres wide should be maintained along surface drainage channels as buffers. These will reduce erosion of channels and aid in nutrient removal.
- The proponent should revegetate exposed areas along banks of surface drainage channels.

<u>Tile Drainage</u>

- Discharge from tile drainage should enter a holding pond or wetland prior to discharging into a drain, creek or river.

Manitoba Water Stewardship is working towards the development of an environmentally friendly drainage manual that will provide additional guidance regarding best management practices for drainage in Manitoba.

Conclusions and Recommendations:

1. The Water Quality Index for the Assiniboine, Souris and Cypress Rivers are typically ‘Fair’ to ‘Good’. The majority of total phosphorus concentrations exceeded objectives, thus impacting the Water Quality Index.

2. Total phosphorus and nitrogen data indicate a steady increase in concentrations from 1970 to 2009. Therefore, management decisions should focus on nutrient reductions to the Assiniboine, Souris and Cypress Rivers to ensure the reduction of phosphorus and nitrogen loading to the Central Assiniboine watershed, and ultimately to Lake Winnipeg.

3. Although *E. coli* densities typically are below the objectives, the Souris and Cypress Rivers tended to have greater *E. coli* densities than the Assiniboine River. Thus, management decisions should ensure cattle are excluded direct access to water bodies. This will significantly reduce bacterial contamination and nutrient loading to surface waters in the Westlake watershed.

4. Overall, strategies need to be implemented to protect and enhance the water quality and habitat in the Central Assiniboine watershed. Best Management Practices should be adopted to reduce nutrient loading to the watershed, and ultimately Lake Winnipeg. Consistent with the interim water quality targets set out in the Lake Winnipeg Action Plan, the Central Assiniboine watershed could consider setting a nutrient reduction goal of 10%.

5. Many steps can be taken to protect the Central Assiniboine watershed and its downstream environment. These include:
   - Maintain a natural, riparian buffer along waterways. Natural vegetation slows erosion and helps reduce the amount of nitrogen and phosphorus entering lakes, rivers and streams.
   - Where feasible, “naturalize” drainage systems to reduce streambed and stream bank erosion, and allowing opportunities for nutrients to be assimilated and settled out of the stream.
   - Value and maintain wetlands. Similar to riparian buffers along waterways, wetlands slow erosion and help reduce nutrient inputs to lakes, rivers, and streams. Wetlands also provide flood protection by trapping and slowly releasing excess water while providing valuable habitat for animals and plants.

- Reduce or eliminate the use of phosphorus-based fertilizers on lawns, gardens, and at the cottage.
- Choose low phosphorus or phosphorus-free cleaning products.
- Prevent soil from eroding off urban and rural properties and reaching storm drains or municipal ditches.
- Ensure that septic systems are operating properly and are serviced on a regular basis. It's important that septic systems are pumped out regularly and that disposal fields are checked on a regular basis to ensure that they are not leaking or showing signs of saturation.
- Evaluate options for potential reduction of nutrients from municipal wastewater treatment systems. Consider options such as effluent irrigation, trickle discharge, constructed wetland treatment, or chemical treatment to reduce nutrient load to the watershed.
- Review the recommendations in the Lake Winnipeg Stewardship Board 2006 report "Reducing Nutrient Loading to Lake Winnipeg and its Watershed: Our Collective Responsibility and Commitment to Action" with the intent of implementing those that are relevant to the Central Assiniboine watershed.

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Appendix 1:

Table A1: Total phosphorus (mg/L) concentrations collected from the Central Assiniboine watershed long term water quality monitoring stations between 1970 and 2009.

Date	Assin R @ 18th St Brandon	Assin R @ Happy Hollow Farm	Assin R @ PR 340 Upstream Treesbank	Souris R @ PR 530 Near Treesbank	Souris R @ PTH 22 Souris	Cypress R East of Town
1970	0.100	-	-	0.070	-	-
1971	0.177	-	-	0.212	-	-
1972	0.149	-	-	0.182	-	-
1973	0.119	-	-	0.188	-	-
1974	0.192	-	-	0.405	-	-
1975	0.207	-	-	0.195	-	-
1976	0.157	-	-	0.170	-	-
1977	0.115	-	-	0.138	-	-
1978	0.115	-	-	-	0.220	0.223
1979	0.173	-	-	-	0.300	0.278
1980	0.130	-	-	-	0.316	0.104
1981	0.142	-	-	-	0.295	0.203
1982	0.181	-	-	-	0.311	0.134
1983	0.181	-	-	-	0.262	0.141
1984	0.130	-	-	-	-	-
1985	0.090	-	-	0.150	-	-
1986	0.127	-	-	0.232	-	-
1987	0.102	-	-	0.258	0.245	-
1988	0.098	-	-	0.160	-	0.075
1989	0.098	-	0.180	0.160	0.256	0.235
1990	0.154	-	0.218	0.118	0.298	0.643
1991	0.143	-	0.226	0.129	0.292	0.235
1992	0.129	-	0.159	0.166	0.278	0.321
1993	0.105	-	0.172	0.072	0.202	0.379
1994	0.152	-	0.188	0.358	0.468	0.199
1995	0.159	-	0.166	0.324	0.306	0.226
1996	0.188	-	0.204	0.352	0.426	0.238
1997	0.178	-	0.194	0.285	0.648	0.246
1998	0.151	-	0.191	0.281	-	0.536
1999	0.216	-	0.208	0.316	-	0.219
2000	0.158	-	0.205	0.340	-	0.283
2001	0.181	-	0.208	0.398	-	0.458
2002	0.124	-	0.208	0.184	-	0.131
2003	0.222	-	0.267	0.242	-	0.293

2004	0.216	0.236	0.228	0.329	-	0.214
2005	0.246	0.309	0.301	0.356	-	0.728
2006	0.229	0.275	0.275	0.338	0.450	0.589
2007	0.233	0.284	0.275	0.227	-	0.576
2008	0.111	0.132	0.133	0.135	-	0.232
2009	0.142	0.175	0.221	0.322	-	0.287

Appendix 2:

Table A2: Total phosphorus (mg/L) concentrations collected from the Central Assiniboine watershed, other stations not included in the long term water quality monitoring program between 1970 and 2009.

Date	Assin R Shore Brandon Steam Plant	Assin R PR 530 Treesbank Ferry Xing	Assin R Brandon WTP (Raw Intake)	Assin R TCH W Brandon	Little SK R Near R Mouth	Souris R @ PR 344 Wawanesa	Souris R WTP (Raw Intake)	Souris R Wawanesa Below Dam	Souris WTP Raw Water
1970	0.100	0.070	-	-	0.020	-	-	-	-
1971	0.262	0.267	-	-	0.081	-	-	-	-
1972	0.205	0.151	-	-	0.102	-	-	-	-
1973	0.177	0.134	0.092	-	0.102	-	0.257	0.268	-
1974	0.240	0.180	0.194	-	0.121	-	0.394	0.304	-
1975	0.181	0.213	0.200	-	0.095	-	0.184	0.292	-
1976	0.158	0.159	0.171	-	0.070	-	0.214	0.221	-
1977	0.118	0.145	0.124	-	0.100	-	0.187	0.193	-
1978	-	-	-	-	-	0.213	-	-	-
1979	-	-	-	-	-	0.305	-	-	-
1980	-	-	-	-	-	0.246	-	-	-
1981	-	-	-	-	-	0.233	-	-	-
1982	-	-	-	-	-	0.272	-	-	-
1983	-	-	-	-	-	0.234	-	-	-
1984	-	-	-	-	-	0.220	-	-	-
1985	-	0.090	-	-	-	-	-	-	-
1986	-	0.155	-	-	-	-	-	-	-
1987	-	0.133	-	-	-	-	-	-	-
1988	-	0.182	-	-	-	-	-	-	-
1989	-	0.206	-	-	-	-	-	-	-
1990	-	0.262	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-			0.704
1995	-	-	-	-	-	-			0.358

1996	-	-	-	-	-	-	-	-	0.346
1997	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-
2001	-	-	-	0.176	-	-	-	-	-
2002	-	-	-	0.155	-	-	-	-	-
2003	-	-	-	0.235	-	-	-	-	-
2004	-	-	-	-	-	-	-	-	-
2005	-	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-	-	-
2008	-	-	-	-	-	-	-	-	-
2009	-	-	-	-	-	-	-	-	-

Appendix 3:

Table A3: Total nitrogen (mg/L) concentrations collected from the Central Assiniboine watershed long term water quality monitoring stations between 1970 and 2009.

Date	Assin R @ 18th St Brandon	Assin R @ Happy Hollow Farm	Assin R @ PR 340 Upstream Treesbank	Souris R @ PR 530 Near Treesbank	Souris R @ PTH 22 Souris	Cypress R East of Town
1973	-	-	-	1.100	-	-
1974	0.996	-	-	0.933	-	-
1975	2.028	-	-	1.498	-	-
1976	1.088	-	-	1.238	-	-
1977	1.009	-	-	1.423	-	-
1978	1.135	-	-	-	1.539	0.801
1979	1.239	-	-	-	1.413	1.746
1980	1.025	-	-	-	1.498	0.936
1981	0.988	-	-	-	1.370	0.903
1982	1.185	-	-	-	1.613	1.637
1983	1.182	-	-	-	1.618	1.145
1984	0.970	-	-	-	-	-
1985	0.945	-	-	1.800	-	-
1986	1.003	-	-	1.788	-	-
1987	1.127	-	-	1.928	1.540	-
1988	1.049	-	-	1.431	-	1.010
1989	1.014	-	1.477	1.409	1.983	1.470
1990	1.081	-	1.415	1.182	1.717	2.155
1991	1.090	-	1.507	1.195	1.799	1.110

1992	0.961	-	1.163	1.356	1.770	1.340
1993	0.927	-	1.288	1.215	1.732	2.960
1994	1.078	-	1.259	1.924	2.198	1.347
1995	1.295	-	1.393	2.240	1.971	1.464
1996	1.429	-	1.526	2.222	2.239	1.480
1997	1.211	-	1.313	2.150	3.373	1.993
1998	1.169	-	1.473	2.180	-	2.550
1999	1.543	-	2.170	2.332	-	1.727
2000	1.208	-	1.772	2.700	-	0.820
2001	1.362	-	1.595	2.098	-	2.517
2002	1.467	-	2.153	1.358	-	2.110
2003	1.672	-	2.070	2.900	-	2.807
2004	1.448	1.732	2.247	2.278	-	1.440
2005	1.771	2.108	1.856	2.288	-	2.303
2006	1.503	1.816	1.816	2.713	3.330	3.157
2007	1.322	1.620	1.551	1.746	-	2.557
2008	1.313	1.727	1.638	1.986	-	1.863
2009	1.361	1.570	1.652	2.046	-	1.584

Appendix 4:

Table A4: Total nitrogen (mg/L) concentrations collected from the Central Assiniboine watershed, other stations not included in the long term water quality monitoring program between 1970 and 2009.

Date	Assin R Shore Brandon Steam Plant	Assin R PR 530 Treesbank Ferry Xing	Assin R Brandon WTP (Raw Intake)	Assin R TCH W Brandon	Little SK R Near R Mouth	Souris R @ PR 344 Wawanesa	Souris R WTP (Raw Intake)	Souris R Wawanesa Below Dam	Souris WTP Raw Water
1973	-	1.180	1.300	-	1.010	-	2.050	1.100	-
1974	0.980	1.227	0.230	-	1.417	-	-	-	-
1975	1.754	1.536	-	-	1.309	-	-	-	-
1976	1.009	1.222	-	-	0.947	-	-	1.640	-
1977	1.186	1.296	-	-	1.508	-	-	-	-
1978	-	-	-	-	-	1.468	-	-	-
1979	-	-	-	-	-	1.356	-	-	-
1980	-	-	-	-	-	1.368	-	-	-
1981	-	-	-	-	-	1.303	-	-	-
1982	-	-	-	-	-	1.445	-	-	-
1983	-	-	-	-	-	1.542	-	-	-
1984	-	-	-	-	-	2.070	-	-	-
1985	-	1.060	-	-	-	-	-	-	-
1986	-	1.297	-	-	-	-	-	-	-

1987	-	1.243	-	-	-	-	-	-	-
1988	-	1.483	-	-	-	-	-	-	-
1989	-	1.589	-	-	-	-	-	-	-
1990	-	1.708	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	2.220
1995	-	-	-	-	-	-	-	-	1.880
1996	-	-	-	-	-	-	-	-	1.920
1997	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-
2001	-	-	-	1.084	-	-	-	-	-
2002	-	-	-	1.077	-	-	-	-	-
2003	-	-	-	1.812	-	-	-	-	-
2004	-	-	-	-	-	-	-	-	-
2005	-	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-	-	-
2008	-	-	-	-	-	-	-	-	-
2009	-	-	-	-	-	-	-	-	-

Appendix 5:

Table A5: Dissolved oxygen (mg/L) concentrations collected from the Central Assiniboine watershed long term water quality monitoring stations between 1970 and 2009.

Date	Assin R @ 18th St Brandon	Assin R @ Happy Hollow Farm	Assin R @ PR 340 Upstream Treesbank	Souris R @ PR 530 Near Treesbank	Souris R @ PTH 22 Souris	Cypress R East of Town
1965	7.600	-	-	6.880	-	-
1966	11.367	-	-	11.700	-	-
1967	8.267	-	-	8.800	-	-
1968	7.340	-	-	8.540	-	-
1969	9.300	-	-	10.150	-	-
1970	7.930	-	-	9.300	-	-
1971	8.380	-	-	9.130	-	-
1972	9.310	-	-	9.133	-	-
1973	9.308	-	-	10.075	-	-

1974	8.442	-	-	6.029	-	-
1975	8.485	-	-	9.400	-	-
1976	9.173	-	-	9.167	-	-
1977	8.175	-	-	8.725	-	-
1978	9.600	-	-	-	8.590	10.186
1979	8.723	-	-	-	7.733	10.200
1980	8.533	-	-	-	7.822	9.614
1981	9.242	-	-	-	8.663	10.150
1982	8.510	-	-	-	7.313	10.229
1983	9.636	-	-	-	9.333	9.900
1984	8.100	-	-	-	-	-
1985	10.950	-	-	9.900	-	-
1986	8.767	-	-	8.367	-	-
1987	9.275	-	-	8.831	10.800	-
1988	8.867	-	-	8.040	-	5.400
1989	7.650	-	12.067	8.970	7.460	11.100
1990	8.942	-	9.967	8.550	7.375	10.200
1991	8.283	-	9.733	8.475	6.383	9.667
1992	9.058	-	9.792	8.833	7.233	9.833
1993	8.458	-	8.892	8.475	6.800	9.700
1994	8.514	-	8.671	7.107	5.383	8.967
1995	8.882	-	9.190	8.640	7.792	9.075
1996	8.958	-	9.233	8.375	6.258	8.867
1997	8.750	-	8.925	8.558	1.633	7.633
1998	8.133	-	9.025	8.650	-	8.500
1999	9.083	-	9.338	9.831	-	10.300
2000	9.083	-	8.992	8.208	-	9.200
2001	8.117	-	7.936	7.291	-	7.300
2002	8.517	-	7.406	8.264	-	9.167
2003	8.065	-	8.850	8.625	-	7.467
2004	7.808	8.856	8.192	7.858	-	9.100
2005	7.850	8.133	8.042	8.058	-	8.433
2006	8.092	9.000	8.475	7.591	8.133	8.800
2007	8.573	9.260	9.333	8.218	-	10.300
2008	8.275	9.608	9.167	7.991	-	10.633
2009	6.467	6.650	6.640	6.067	-	-

Appendix 6:

Table A6: Dissolved oxygen (mg/L) concentrations collected from the Central Assiniboine watershed, other stations not included in the long term water quality monitoring program between 1970 and 2009.

Date	Assin R Shore Brandon Steam Plant	Assin R PR 530 Treesbank Ferry Xing	Assin R TCH W Brandon	Little SK R Near R Mouth	Souris R @ PR 344 Wawanesa	Souris R WTP (Raw Intake)	Souris R Wawanesa Below Dam	Souris WTP Raw Water
1965	7.740	7.320	-	8.660	-	-	-	-
1966	11.633	11.000	-	12.700	-	-	-	-
1967	7.967	9.633	-	8.200	-	-	-	-
1968	8.550	10.340	-		-	-	-	-
1969	9.100	10.533	-	9.871	-	-	-	-
1970	8.180	9.020	-	9.871	-	-	-	-
1971	8.680	10.456	-	9.880	-	-	-	-
1972	9.690	10.611	-	9.662	-	-	-	-
1973	9.850	10.258	-	9.233	-	0.100	-	-
1974	8.590	8.567	-	7.929	-	-	-	-
1975	8.517	9.355	-	10.700	-	-	-	-
1976	9.222	9.473	-	10.733	-	-	6.150	
1977	8.467	10.320	-	-	-	-	-	-
1978	-	-	-	-	9.883	-	-	-
1979	-	-	-	-	9.740	-	-	-
1980	-	-	-	-	9.991	-	-	-
1981	-	-	-	-	9.833	-	-	-
1982	-	-	-	-	9.680	-	-	-
1983	-	-	-	-	9.358	-	-	-
1984	-	-	-	-	10.400	-	-	-
1985	-	11.050	-	-	-	-	-	-
1986	-	8.892	-	-	-	-	-	-
1987	-	8.950	-	-	-	-	-	-
1988	-	9.180	-	-	-	-	-	-
1989	-	9.900	-	-	-	-	-	-
1990	-	10.460	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-
1995	-	-	-	-	-	-	-	-
1996	-	-	-	-	-	-	-	7.552
1997	-	-	-	-	-	-	-	-

1998	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-
2001	-	-	7.769	-	-	-	-	-
2002	-	-	7.189	-	-	-	-	-
2003	-	-	7.770	-	-	-	-	-
2004	-	-	-	-	-	-	-	-
2005	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-	-
2008	-	-	-	-	-	-	-	-
2009	-	-	-	-	-	-	-	-

Appendix 7:

Table A7: *E. coli* densities collected from the Central Assiniboine watershed long term water quality monitoring stations between 1970 and 2009.

Date	Assin R @ 18th St Brandon	Assin R @ Happy Hollow Farm	Assin R @ PR 340 Upstream Treesbank	Souris R @ PR 530 Near Treesbank	Souris R @ PTH 22 Souris	Cypress R East of Town
1973	-	-	-	-	-	-
1974	10.5	-	-	414.8	-	-
1975	49.8	-	-	1237.0	-	-
1976	13.5	-	-	648.8	-	-
1977	12.6	-	-	3768.8	-	-
1978	14.8	-	-	-	9.1	512.6
1979	71.8	-	-	-	29.6	387.6
1980	33.3	-	-	-	37.0	16069.1
1981	27.9	-	-	-	14.3	475.9
1982	43.9	-	-	-	25.3	3986.0
1983	8.8	-	-	-	15.2	49011.0
1984	9.0	-	-	-	-	-
1985	10.0	-	-	10.0	-	-
1986	11.3	-	-	12.0	-	-
1987	20.0	-	-	22.7	-	-
1988	71.0	-	-	56.0	-	720.0
1989	15.8	-	126.7	28.2	10.0	106.7
1990	39.1	-	97.5	45.8	33.3	120.0
1991	10.0	-	200.8	20.0	10.0	200.0
1992	10.0	-	41.7	43.3	11.7	730.0
1993	12.5	-	280.0	32.5	15.0	240.0

1994	17.7	-	37.7	52.3	18.0	173.3
1995	11.7	-	67.5	25.0	10.7	140.0
1996	21.7	-	38.3	25.0	18.3	183.3
1997	29.2	-	25.0	49.2	10.0	290.0
1998	43.3	-	113.3	121.7	-	186.7
1999	20.8	-	387.7	25.4	-	676.7
2000	86.7	-	13.3	48.3	-	390.0
2001	16.2	-	41.7	40.0	-	126.7
2002	18.3	-	15.7	40.0	-	142.5
2003	16.9	-	22.1	13.3	-	63.3
2004	25.0	25.0	40.0	25.0	-	35.0
2005	-	-	-	-	-	-
2006	-	-	-	-	-	-
2007	-	-	-	-	-	-
2008	-	-	-	-	-	-
2009	10.0	10.0	18.3	11.4	-	18.3

Appendix 8:

Table A8: *E. coli* densities collected from the Central Assiniboine watershed, other stations not included in the long term water quality monitoring program between 1970 and 2009.

Date	Assin R Shore Brandon Steam Plant	Assin R PR 530 Treesbank Ferry Xing	Assin R Brandon WTP (Raw Intake)	Assin R @ PR 5	Assin R TCH W Brandon	Little SK R Near R Mouth	Souris R @ PR 344 Wawanesa	Souris R WTP (Raw Intake)	Souris R Wawanesa Below Dam	Souris WTP Raw Water
1973	-	-	23.0	-	-	150.0	-	7.0	11000.0	-
1974	328.2	109.5	-	-	-	49.0	-	2.0	-	-
1975	202.2	534.2	-	-	-	61.8	-	-	-	-
1976	1121.0	197.6	-	-	-	27.8	-	-	-	-
1977	159.9	136.6	20.5	-	-	70.8	-	25.8	1190.5	-
1978	-	-	-	-	-	-	23.8	-	-	-
1979	-	-	-	-	-	-	113.5	-	-	-
1980	-	-	-	-	-	-	143.8	-	-	-
1981	-	-	-	-	-	-	34.5	-	-	-
1982	-	-	-	-	-	-	120.1	-	-	-
1983	-	-	-	-	-	-	85.7	-	-	-
1984	-	-	-	-	-	-	23.0	-	-	-
1985	-	20.0	-	-	-	-	-	-	-	-
1986	-	92.3	-	-	-	-	-	-	-	-
1987	-	94.6	-	-	-	-	-	-	-	-
1988	-	91.0	-	-	-	-	-	-	-	-
1989	-	113.3	-	-	-	-	-	-	-	-

1990	-	256.0	-	-	-	-	-	-	-	-
1991	-	-	-	-	-	-	-	-	-	-
1992	-	-	-	-	-	-	-	-	-	-
1993	-	-	-	-	-	-	-	-	-	-
1994	-	-	-	-	-	-	-	-	-	20.0
1995	-	-	-	-	-	-	-	-	-	63.1
1996	-	-	-	-	-	-	-	-	-	-
1997	-	-	-	-	-	-	-	-	-	-
1998	-	-	-	-	-	-	-	-	-	-
1999	-	-	-	-	-	-	-	-	-	-
2000	-	-	-	-	-	-	-	-	-	-
2001	-	-	-	-	76.9	-	-	-	-	-
2002	-	-	-	13.9	23.9	-	-	-	-	-
2003	-	-	-	23.3	18.0	-	-	-	-	-
2004	-	-	-	27.8	-	-	-	2.0	-	-
2005	-	-	-	-	-	-	-	-	-	-
2006	-	-	-	-	-	-	-	-	-	-
2007	-	-	-	-	-	-	-	-	-	-
2008	-	-	-	-	-	-	-	-	-	-
2009	-	-	-	-	-	-	-	-	-	-

Appendix 9:

Table A9: The Nutrient Buffer Zone widths as outlined in the Nutrient Management Regulation (MR 62/2008) under *The Water Protection Act*.

Water Body	A (1)	B (1)
o a lake or reservoir designated as vulnerable	30 m	35 m
o a lake or reservoir (not including a constructed stormwater retention pond) not designated as vulnerable o a river, creek or stream designated as vulnerable	15 m	20 m
o a river, creek or stream not designated as vulnerable o an order 3, 4, 5, or 6 drain or higher o a major wetland, bog, swamp or marsh o a constructed stormwater retention pond	3 m	8 m

(1) Use column A if the applicable area is covered in permanent vegetation. Otherwise, use column B.

A healthy riparian zone is critical to river ecosystem health providing shade, organic inputs, filtering of nutrients and habitat creation (falling trees). Preserving space along rivers gives the river freedom to naturally meander across the landscape and buffers the community from flooding impacts. Reference to the Nutrient Buffer Zone and its significance can be coupled with **Section 3.1.8 – Environmental Policies** which identifies the goals of enhancing surface water and riverbank stability, and the importance of respecting setbacks.