BATTLE RIVER WATERSHED ALLIANCE

Policies and Practices for Managing Non-point Source Pollution (Nutrient Management Focus)

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List of Acronyms

AESA	Alberta Environmentally Sustainable Agriculture (Program)
AESRD	Alberta Environment and Sustainable Resource Development
AOPA	Agricultural Operation Practices Act
BMPs	beneficial management practices
BRWA	Battle River Watershed Alliance
CAESA	Canada-Alberta Environmentally Sustainable Agriculture (CAESA) (Program)
NPS	non-point source
NRCB	Natural Resources Conservation Board
SOW	State of the Watershed (Report)
U.S. EPA	United States Environmental Protection Agency
WMP	Watershed Management Planning (Process)

1 Background

Under *Water for Life: Alberta's Strategy for Sustainability* (Government of Alberta, 2003), the Battle River Watershed Alliance (BRWA) is the Watershed Planning and Advisory Council for the Battle River and Sounding Creek watersheds within Alberta. Figure 1 shows a map of the BRWA's planning boundaries.

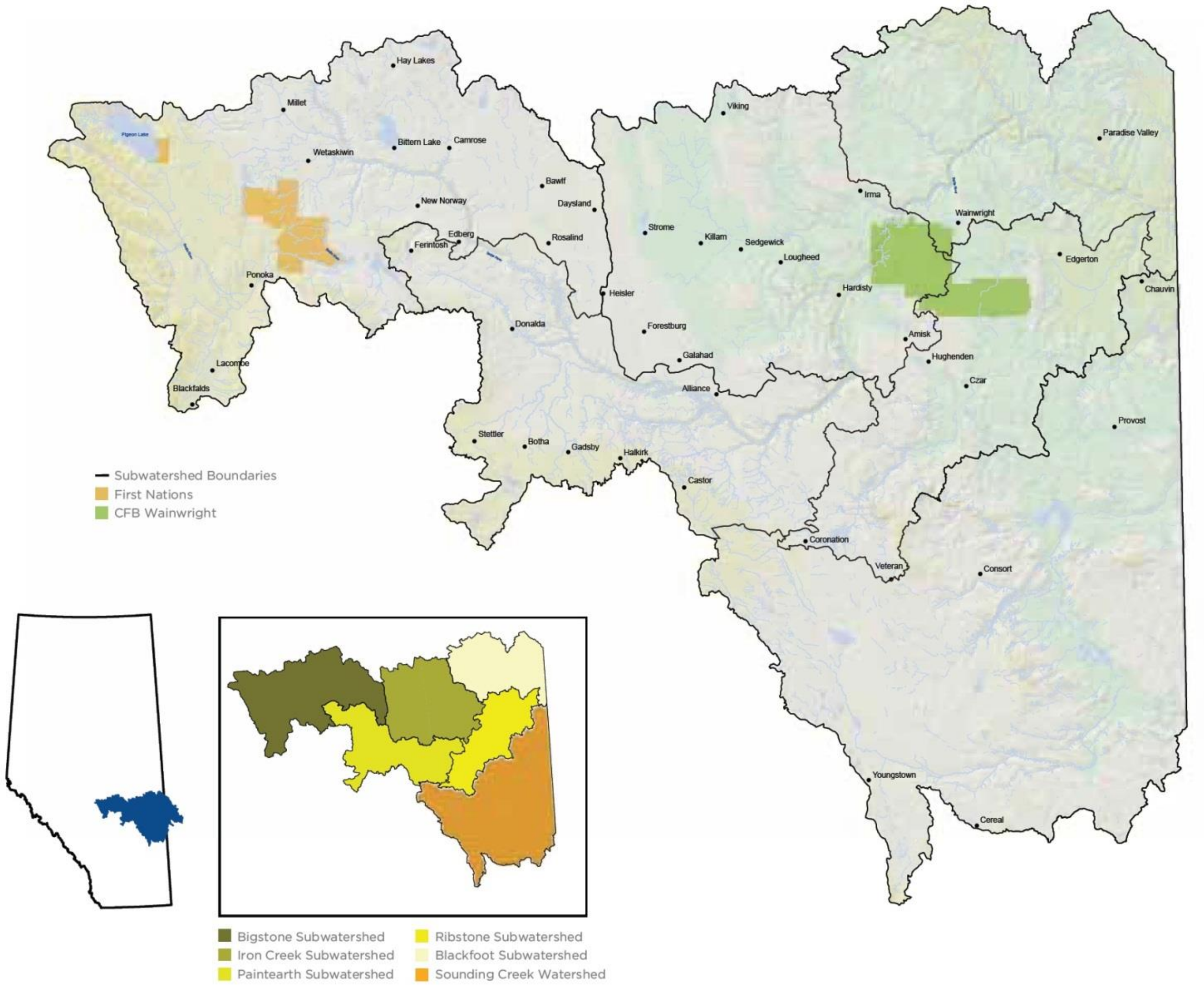


Figure 1: Battle River and Sounding Creek Watersheds within Alberta (BRWA planning boundaries)

In 2011, the Battle River Watershed Alliance (BRWA) completed its first State of the Watershed (SOW) Report (BRWA 2011). With the completion of this report, the BRWA has now shifted into its watershed management planning (WMP) process. This work is guided by the BRWA's WMP Terms of Reference (BRWA 2012).

As outlined in the WMP Terms of Reference, various "watershed management components" have been identified as key issue areas to be addressed through the WMP process. These are outlined in Figure 2, below.

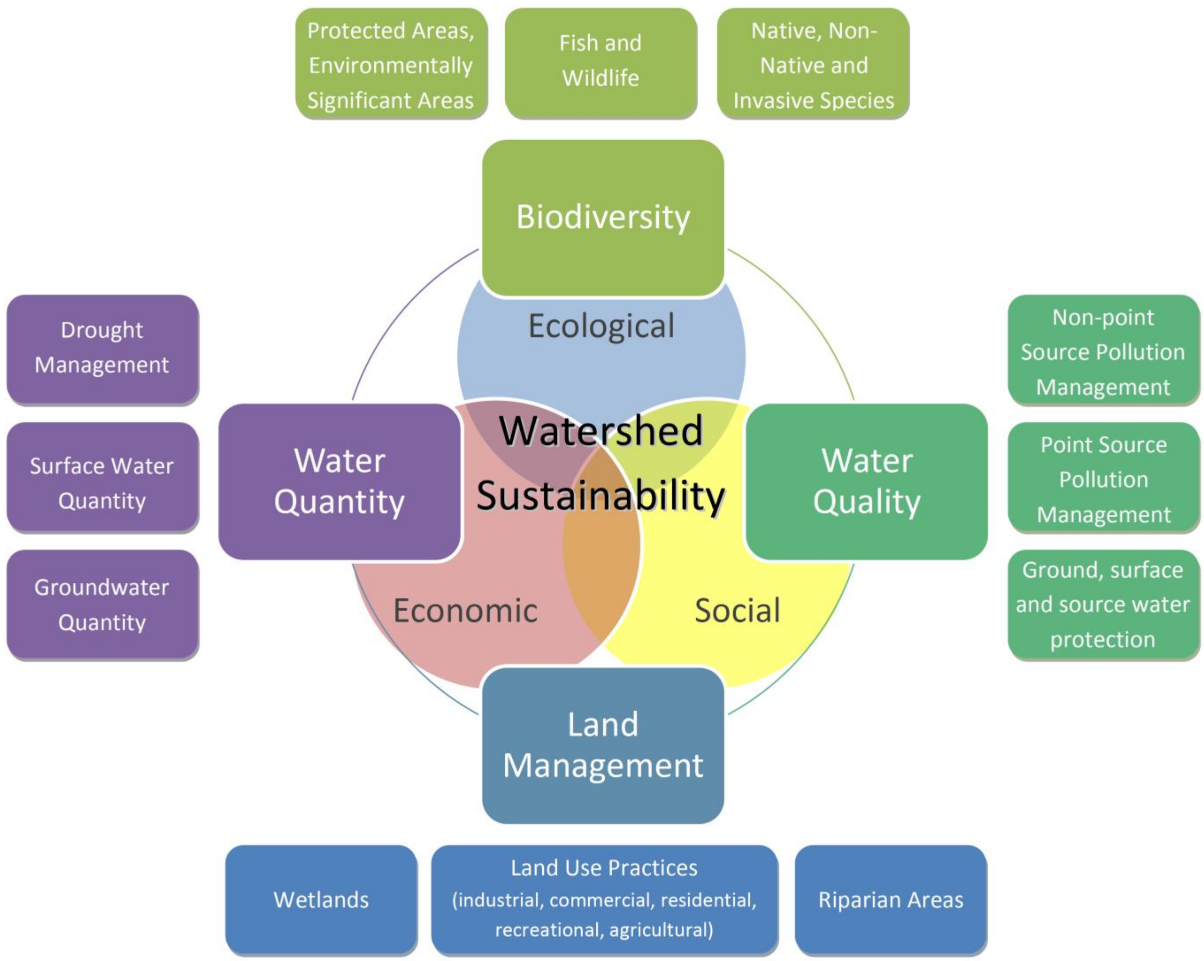


Figure 2: Watershed management components of the BRWA WMP process

Non-point source (NPS) pollution management has been identified as one of the "watershed management components". The WMP process calls for the development of policy recommendations and implementation guidelines for each watershed management component (BRWA 2012). Figure 3 outlines the process the BRWA will use to develop these recommendations and implementation options.

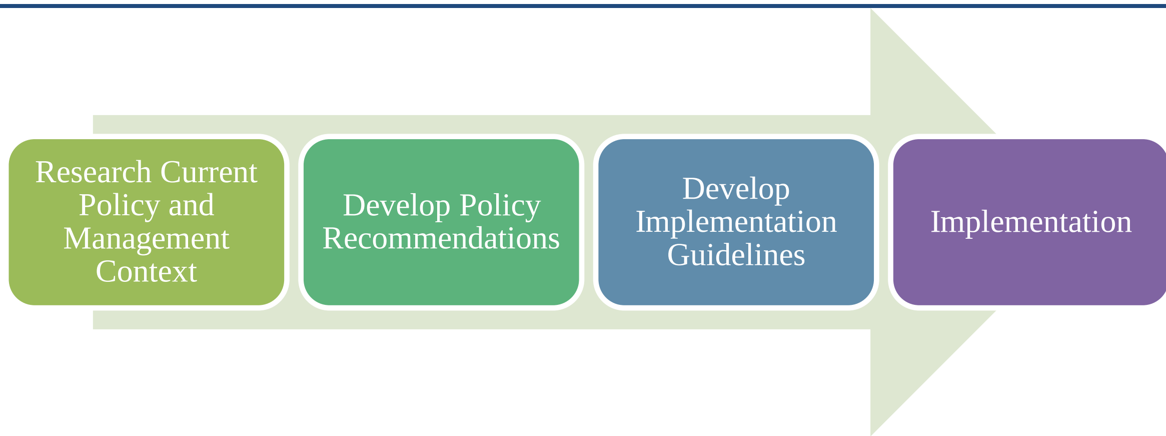


Figure 3: Watershed management planning process for each watershed management component

The purpose of this report is to outline the current knowledge of NPS pollution, the current management context for NPS pollution management, and current and emerging management options for reducing NPS pollution. Due to the fact that nutrient loading to aquatic ecosystems in east-central Alberta is a major water quality concern, nutrient management will be the primary focus of this project.

The ultimate goal of this NPS pollution project is to develop non-point source pollution management policy advice and implementation guidelines that will lead to the improvement of water quality in the Battle River and Sounding Creek watersheds in Alberta. This project compliments the work of Alberta Environment and Sustainable Resource Development (AESRD) to develop water quality objectives for the Battle River (Golder Associates 2011). Part of the BRWA's NPS pollution project will involve gaining feedback on the draft objectives that have been developed. Once water quality objectives are approved, NPS management strategies developed through the BRWA's WMP process will seek to achieve those objectives.

2 Identifying the Issue: Nutrients in our Watersheds

As identified through the SOW report and the BRWA's community workshops in November 2011, water quality in the Battle River watershed is a major issue of concern. In particular, high nutrient levels pose a threat to water quality and the overall health of aquatic ecosystems in this watershed.

Nutrients, such as phosphorus and nitrogen, are essential building blocks of life. However, excess nutrient levels in water may lead to harmful algae blooms and a general decrease in the health of aquatic ecosystems. Water quality monitoring has shown that excess nutrient levels are found along the entire Alberta length of the Battle River, regularly exceeding Canadian Water Quality Guidelines for aquatic life and impairing water quality well below desirable levels.

Two long-term river network (LTRN) stations were set up on the Battle River in 2003, and are located downstream of highway 53 (upstream of Ponoka) and upstream of Driedmeat Lake at highway 21 (previously located at north end of Driedmeat Lake). See Figure 4 for the locations of these water quality monitoring stations (stations number 2 and 5). Water quality monitoring at these stations is used to calculate the Alberta River Water Quality Index. See Table 1 for Battle River index and sub-index scores from 2003-2010. Based on water quality testing at these locations in 2009/2010, the Battle River received an overall rating of *fair*, meaning that federal and provincial water quality guidelines were sometimes exceeded by moderate amounts, with water quality occasionally departing from desirable levels.

Nutrient levels received a rating of *poor* from 2008 to 2010, meaning that federal and provincial guidelines were almost always exceeded by large amounts, leading to the impairment of water quality well below desirable levels.

Surface water quality monitoring from 2004-2005 for eleven stations along the Battle River confirms these ratings. See Figure 4 for monitoring station locations. A comparison of monitoring results to Canadian Water Quality Guidelines is presented in Table 2. Canadian Water Quality Guidelines for phosphorus were exceeded more than 50% of the time at all stations and 100% of the time at seven of the stations. Guidelines for nitrogen were also exceeded more than 50% of the time at eight of the stations.

From this water quality monitoring data, we see that nutrient levels in the Battle River watershed regularly exceed desirable levels. A central goal of the BRWA is to support the ecological, social and economic sustainability of our watersheds. Current nutrient levels in our watersheds are unsustainable, not only because of the ecological impacts of high nutrient levels, but also because of the implications of poor water quality for our communities and our economies. There is a need to improve water quality in the Battle River watershed.

Though less data is available for water quality in the Sounding Creek watershed, the BRWA will engage residents of this watershed with the topic of water quality and non-point source pollution management to ensure that any issues are addressed.

Table 1: Alberta River Water Quality Index Scores, 2003-2010 (Alberta Environment and Sustainable Resource Development (AESRD, 2012a)

Location	Sub-Index Values				Overall Index
	Metals	*Nutrients*	*Bacteria*	*Pesticides*	
2009-2010					
Highway 53	90	29	100	91	78
Driedmeat Lake	88	33	96	52	66
2008-2009					
Highway 53	90	31	72	93	72
Driedmeat Lake	91	29	100	78	75
2007-2008					
Highway 53	97	60	71	83	78
Driedmeat Lake	92	46	91	64	73
2006-2007					
Highway 53	92	49	85	88	78
Driedmeat Lake	92	33	97	63	71
2005-2006					
Highway 53	100	63	94	89	86
Driedmeat Lake	89	46	100	71	76
2004-2005					
Highway 53	97	61	97	79	83
Driedmeat Lake	91	32	100	81	76
2003-2004					
Highway 53	91	34	90	95	77
Driedmeat Lake	91	21	100	66	69

Blue	Excellent (96-100)	Guidelines almost always met; best quality
Green	Good (81-95)	Guidelines occasionally exceeded, but usually by small amounts; threat to quality is minimal
Orange	Fair (66-80)	Guidelines sometimes exceeded by moderate amounts; quality occasionally departs from desirable levels
Yellow	Marginal (46-65)	Guidelines often exceeded, sometimes by large amounts; quality is threatened, often departing from desirable levels
Red	Poor (0-45)	Guidelines almost always exceeded by large amounts; quality is impaired and well below desirable levels; worst quality

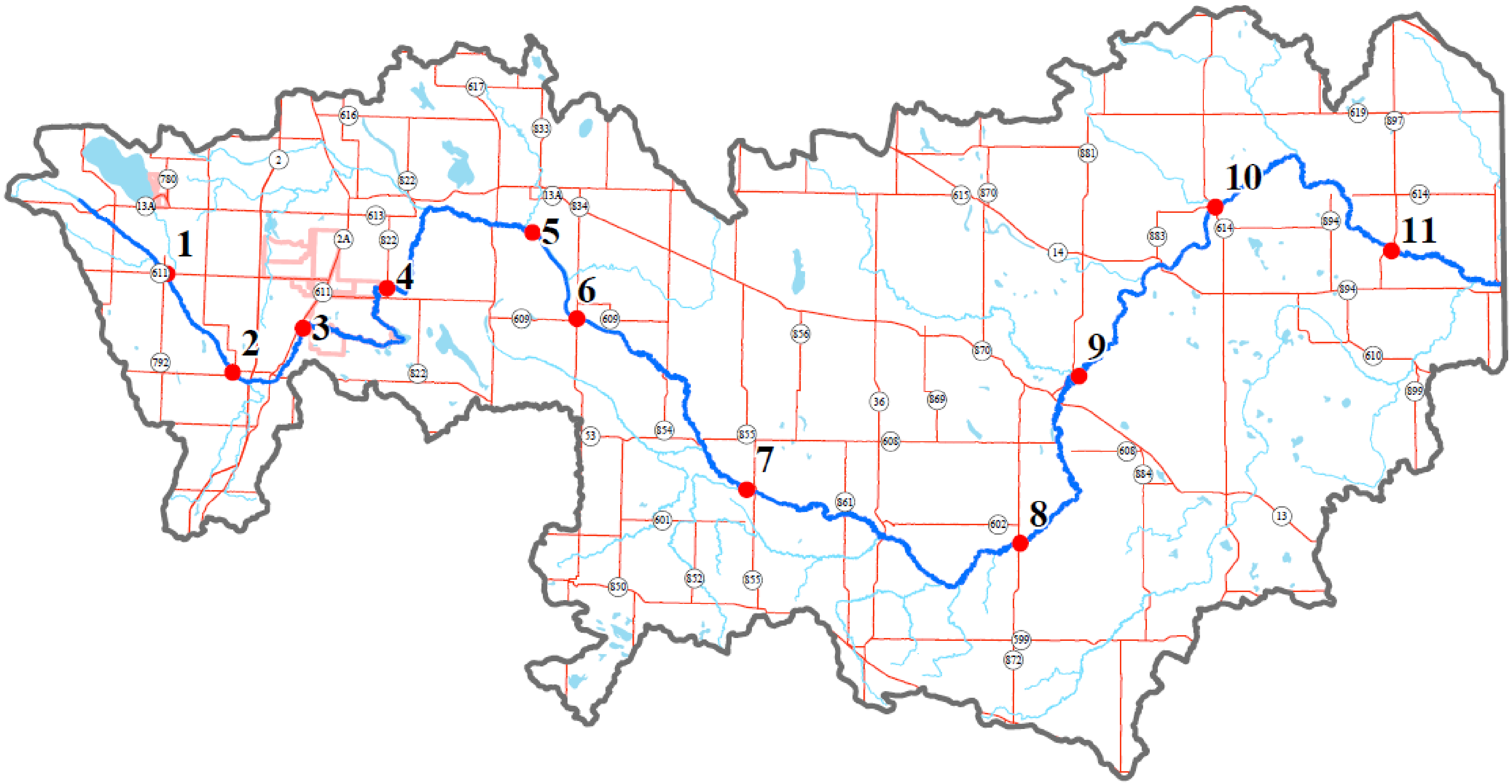


Figure 4: Battle River Water Quality Monitoring Stations (2004-2005). Long-term water quality monitoring stations are located at number 2 and 5.

Table 2: Water Quality Compliance with Surface Water Quality Guidelines, December 2004 – October 2005 (Alberta Environment, 2005)

Parameter	Guideline	Station Number										
		1	2	3	4	5	6	7	8	9	10	11
Total Phosphorus	Aquatic life (0.05 mg/L)	100	100	100	100	100	100	100	75	63	67	89
Total Nitrogen	Aquatic life (1 mg/L)	33	67	78	89	90	100	89	75	75	33	44
Total ammonia	Aquatic life (calc.)	0	0	11	11	10	0	0	0	0	0	0
Nitrite	Aquatic life (0.06 mg/L)	0	0	22	11	0	0	0	0	0	0	0
Fecal Coliforms	Irrigation (100 per 100 mL)	20	27	10	0	0	30	0	30	40	20	10
Fecal Coliforms	Recreation (200 per 100 mL)	10	0	0	0	0	20	10	10	0	10	10
Dissolved Oxygen	Aquatic life (>5.0 mg/L)	0	18	30	10	27	40	30	0	20	30	30
pH	Aquatic life (6.5-8.5)	0	0	40	40	27	50	10	0	0	0	0

(red)	Canadian Water Quality Guidelines exceeded more than 50% of the time
(yellow)	Canadian Water Quality Guidelines exceeded up to 50% of the time
(green)	Canadian Water Quality Guidelines never exceeded

3 The Issue: Through the Eyes of the Media

In order to gain a greater understanding of how water quality issues are portrayed in the media, the BRWA conducted a media scan of newspapers to find articles of relevance to the topic of water quality in the Battle River and Sounding Creek watersheds.

Based on this media scan, some key themes were identified. The three main themes were drinking water quality, stormwater management, and water quality of recreational lakes. Other themes included the use of cosmetic herbicide and fertilizer chemicals, the linkages between water quality issues and livestock production, and regulations surrounding private septic systems.

In the media, the conversation around water is often limited to water quantity, with articles often focusing on the efforts of communities to obtain adequate water supplies for their community. These efforts often involve tying into regional water lines. Another water quantity focus in the media was, not surprisingly, drought.

The conversation around water quality was much more limited. The quality of drinking water for communities was one of the main topics. For example, there were many articles discussing the upgrade to the Camrose water treatment plant, beginning with the approval of the project in 2006. Comments about how the quality of source water impacts water treatment measures were included in a few of these articles. Another topic that received some attention in the media was stormwater management, which is a key component of non-point source pollution management in urban settings. Media articles relating to stormwater management often focused around plans for new stormwater retention ponds in communities such as Lacombe, Wetaskiwin and Camrose.

The water quality topic that received the most media attention, by far, was concern about the quality of water in recreational lakes in the region. More discussion of this is included below.

3.1 Recreational Lakes – The Canary in the Coal Mine

Albertans love their recreational lakes. Many summer activities involve going to the lake to swim, fish, boat, canoe, kayak and do any number of other activities. Because so much enjoyment is derived from these areas, it is not surprising that they would be the first areas to receive attention when things like water quality are being degraded. Two lakes in the Battle River watershed that have received such attention in recent years are Lacombe Lake and Pigeon Lake.

Lacombe Lake is a small lake located near the City of Lacombe. In recent years, residents living around the lake have voiced concerns about decreasing water quality in the lake, which they attribute to poor-quality water entering the lake through a diversion from Whelp Creek. Since the diversion of water from Whelp Creek stopped in 2008, Lacombe County has collected water quality samples from the lake on a monthly basis during the open water season in order to assess water quality conditions in the lake. Whelp Creek, as with most water ways in this region of Alberta, is an “agricultural” stream in that it flows through what is largely agricultural land. It is acknowledged that the addition of water from Whelp Creek will introduce some quantity of nutrients to Lacombe Lake that would otherwise not be present. The degree to which this has occurred in the past, and the impact it has had on the health of lake, is still uncertain.

Pigeon Lake is one of Alberta's most popular recreational lakes, situated about one hour south of Edmonton. Increasing incidents of blue-green algae blooms and fish kills have been observed at the lake, especially since 2007. Both the frequency and intensity of these blooms has increased in recent years. For a place whose social and economic wellbeing depends on lake tourism during the summer months, these occurrences are a major cause for concern. To a certain extent, fish kills may be attributed to hot summer temperatures and lower dissolved oxygen levels in the lake. Likewise, increasing temperatures are an exacerbating factor for algae bloom occurrence, which places additional stress on fish populations. Local lake residents and prominent researchers such as David Schindler take this one step further. They point to ongoing lake water quality issues as a major contributing factor to algae blooms and subsequent fish kills, and discuss the degree to which poor water quality is exacerbated by increasing lakeside development and pollutant inputs (especially nutrient inputs) from surrounding agricultural land uses and the cottages and other developments that surround the lake.

While media attention has focused predominantly around these recreational lakes, similar conditions to those experienced at Pigeon Lake may be observed along the Battle River and in other lakes and streams in the watershed. Our recreational lakes may serve as an indication of worsening water quality in our watershed as a whole.

4 Defining Non-point Source and Point Source Pollution

Pollutants enter our water systems through a variety of point and non-point sources. For the purposes of this project, the BRWA defines non-point source pollution as contaminants that enter water bodies from diffuse sources. This pollution is often carried by surface water runoff but may also enter water bodies through atmospheric deposition and seepage from groundwater systems. In an urban environment, NPS pollution enters water bodies through stormwater runoff and stormwater drainage systems. The BRWA also considers leakage from septic systems to be a non-point source of pollution. In a rural environment, NPS pollution may enter water bodies through runoff from a variety of land uses, including agriculture, mining, logging, construction and development.

In contrast, point source pollution enters our water systems through discrete, identifiable "point" locations, such as a pipe that releases treated water from a wastewater treatment plant into a lake, stream or river. Point sources of pollution are not considered in this report.

5 Identifying the Sources

While non-point source pollution may include any number of contaminants, such as oil, bacteria, pesticides, herbicides and other harmful chemicals, the discussion below focuses primarily on non-point sources of nutrients in east-central Alberta.

Many of Alberta's landscapes and soils are naturally nutrient-rich. Even in the absence of human and development-related inputs, nutrient levels in many streams may still exceed water quality guidelines (Paterson, Olson and Bennett, 2006). However, naturally high nutrient levels in many Alberta streams make these waterways sensitive to additional nutrient inputs, even in relatively small amounts. As such, human-related inputs exacerbate pre-existing conditions.

In the Battle River watershed, studies have shown that the majority of pollutants entering the Battle River and its tributaries come from municipal and agricultural sources (Teichreb, 2012).

Water quality studies under the Canada-Alberta Environmentally Sustainable Agriculture (CAESA) initiative and the Alberta Environmentally Sustainable Agriculture (AESA) program also point to agricultural practices as a major contributor to the degradation of water quality in agricultural areas of Alberta (Palliser Environmental Services and Alberta Agricultural and Rural Development (ARD), 2008; Lorenz, Depoe, and Phelan, 2008).

Water quality studies in the Battle River watershed estimate that about half of the nutrient loading to the river comes from non-point sources, with the other half being attributed to point sources (primarily municipal, i.e. waste water effluent) (Anderson, 1999; Teichreb, 2012). The proportion of non-point source pollution coming from rural vs. urban landscapes is not known at this time. However, based on the above information, agricultural and municipal sources of non-point source pollution are the principal focus of this report.

5.1 A Closer Look at Nutrients – Phosphorus and Nitrogen

Phosphorus and nitrogen are both key nutrients essential to life, and are both found in abundance, and often excess, in the lakes, rivers and streams of the Battle River watershed. While both nutrients contribute to the total nutrient loading to water systems, phosphorus has often received more attention due its role as a major contributing factor to algae blooms and eutrophication impacts in surface water systems (Correll, 1998). Eutrophication, in turn, may result in an increased occurrence of fish kills, not unlike those that have been experienced at Pigeon Lake in recent years (Carpenter et al., 1998).

Water quality monitoring of the Battle River has found that most of the nitrogen loading in the river is organic nitrogen, which is not thought to contribute significantly to eutrophication impacts (Golder, 2012; Teichreb, 2012). However, high nitrogen levels are still a concern, as nitrogen may cause or accelerate eutrophication if sufficient phosphorus is present (Casson, Olson, Little and Nolan, 2008). In addition, high nitrogen levels in drinking water have been linked to adverse health impacts in humans. In addition, both nitrogen and phosphorus can be costly to remove from water for drinking water purposes (Kay et al., 2012).

6 Rural Non-point Source Pollution

Various land uses, such as agriculture, mining, logging, and construction, may contribute to non-point source pollution in rural landscapes. The Battle River and Sounding Creek watersheds are predominantly agricultural landscapes, with approximately three quarters of the land base being utilized as annual and perennial crop and pasture land (Agriculture and Agri-food Canada (AAFC, 2001). It is thus not surprising that agricultural land uses have been identified as major rural contributors to non-point source pollution in these watersheds (Anderson, 1999; Teichreb, 2012). Nutrient losses from agricultural lands, and from livestock production in particular, are recognized as a significant contributor to surface water quality degradation in Alberta (Paterson et al., 2006). Long-term water quality monitoring from 1999 to 2006 under the AESA program (Lorenz, Depoe and Phelan, 2008) demonstrated that streams in watersheds with high agricultural intensity had elevated nitrogen and phosphorus concentrations, and that these watersheds had the lowest compliance with Alberta's total phosphorus and total nitrogen guidelines (Olson and Kalischuk, 2008). This section outlines various research findings related to non-point source pollution and nutrient management strategies for agricultural landscapes.

6.1 Agricultural Land Use and NPS Pollution Management

Much research has been carried out provincially, nationally and internationally on the topic of NPS pollution management in agricultural landscapes. This section outlines findings from this research as they pertain to NPS pollution and nutrient management in the specific context of the Battle River and Sounding Creek watersheds in Alberta.

6.1.1 Rural NPS Pollution Management Considerations

A key consideration when examining the link between agricultural land uses and their impact on water quality is the extent to which pollutants on the land are transported to surface water bodies. Alberta Agriculture and Rural Development has carried out numerous studies related to agricultural nutrient inputs and the potential impact on Alberta's surface water systems. Of particular note are the 2006 *Soil Phosphorus Limits Project* and the 2008 *Assessment of Environmental Sustainability in Alberta's Agricultural Watersheds*. Key findings from these projects are outlined below.

In Alberta, research has shown that "there is a direct, linear relationship between soil-test phosphorus levels and the phosphorus concentration in runoff water" (Paterson et al., 2006, p. vii-viii). In other words, as phosphorus levels in soil increase, so too do phosphorus levels in runoff water. Figure 5 demonstrates this relationship. "Soil-test phosphorus" refers to phosphorus in soil that is available to plants. Linear relationships have also been found between nitrate in soil and nitrate in runoff water, as well as between nitrate in soil and total nitrogen in runoff water (Casson et al., 2008). That is, as nitrate levels in soil increase, nitrate and total nitrogen levels in runoff water also increase. This is an important consideration because it points to the potential efficacy of implementing phosphorus and nitrogen limits for soil in agricultural lands in order to limit nutrient levels in surface water systems.

Various factors may influence the transport of nutrients and other pollutants, such as soil structure, soil water holding capacity, the slope of the land, and the extent and type of vegetation or ground cover (Alberta Agriculture and Food, 2007).

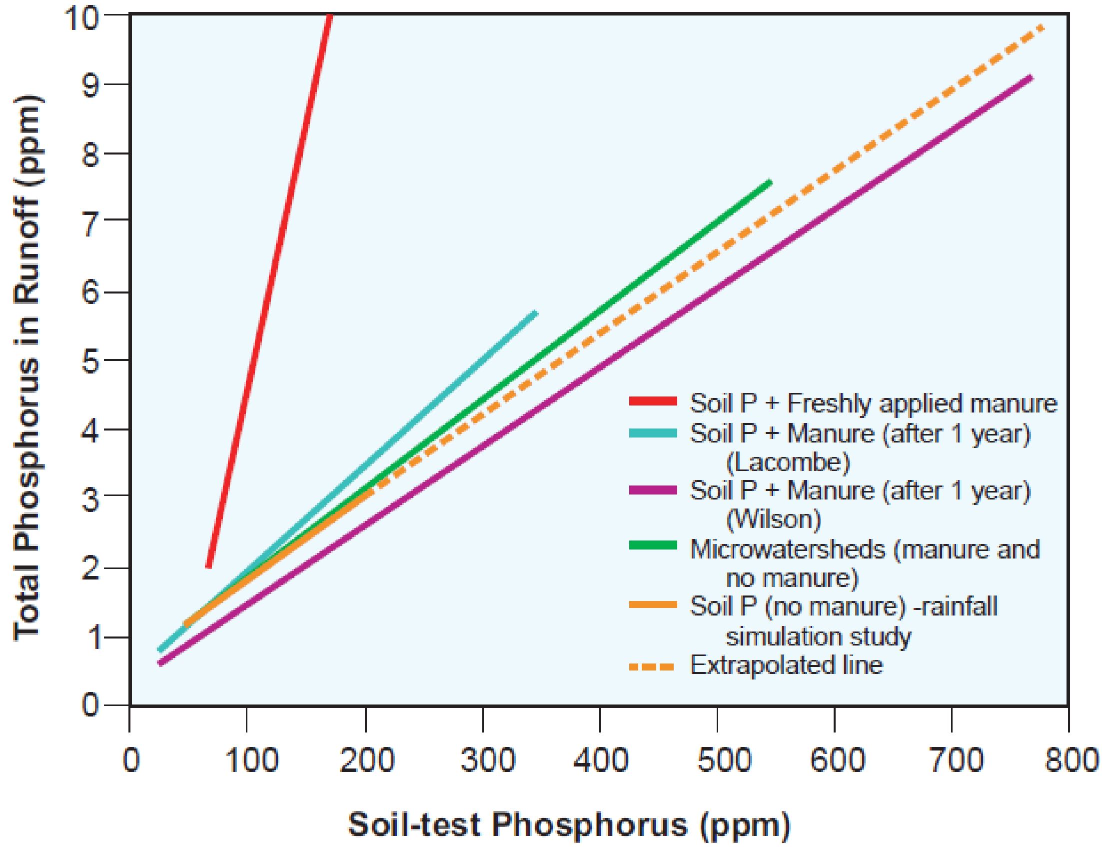


Figure 5: Relationships between soil-test phosphorus and total phosphorus in runoff water (*from* Paterson et al., 2006)

The 2006 *Soil Phosphorus Limits Project* sought to determine if soil phosphorus limits were a viable option in Alberta. Based on research conducted as part of this project, it was determined that legislated soil-test phosphorus limits for agricultural land could not be supported at that time, due primarily to the financial burdens such limits would cause to Alberta's livestock producers. These financial burdens would be associated with increased manure transportation and spreading costs, particularly in areas of the province with large livestock concentrations. Much of the land base in these areas already has high soil phosphorus levels, and un-manured land is not accessible within a reasonable distance.

Despite the recommendation that soil-test phosphorus limits could not be supported at the time, there was a recognition that Alberta's agricultural industry must move towards a phosphorus management strategy (including reviewing the possibility of regulating soil-test phosphorus limits) to limit the amount of nutrients entering the environment.

A key consideration in the *Soil Phosphorus Limits Project* was the agronomic soil-test phosphorus threshold; that is, the level of phosphorus in soil beyond which crops generally do not respond to, or benefit from, additional phosphorus additions. In Alberta, this threshold was determined to be 60 ppm (about 120 kg/ha). It was concluded that it would be unreasonable to require agricultural producers to maintain soil-test phosphorus levels below this threshold, except in environmental significant areas such as flood plains and riparian areas where the risk of runoff and nutrient movement is high (Paterson et al., 2006).

Critical Source Areas and Effective Drainage Area

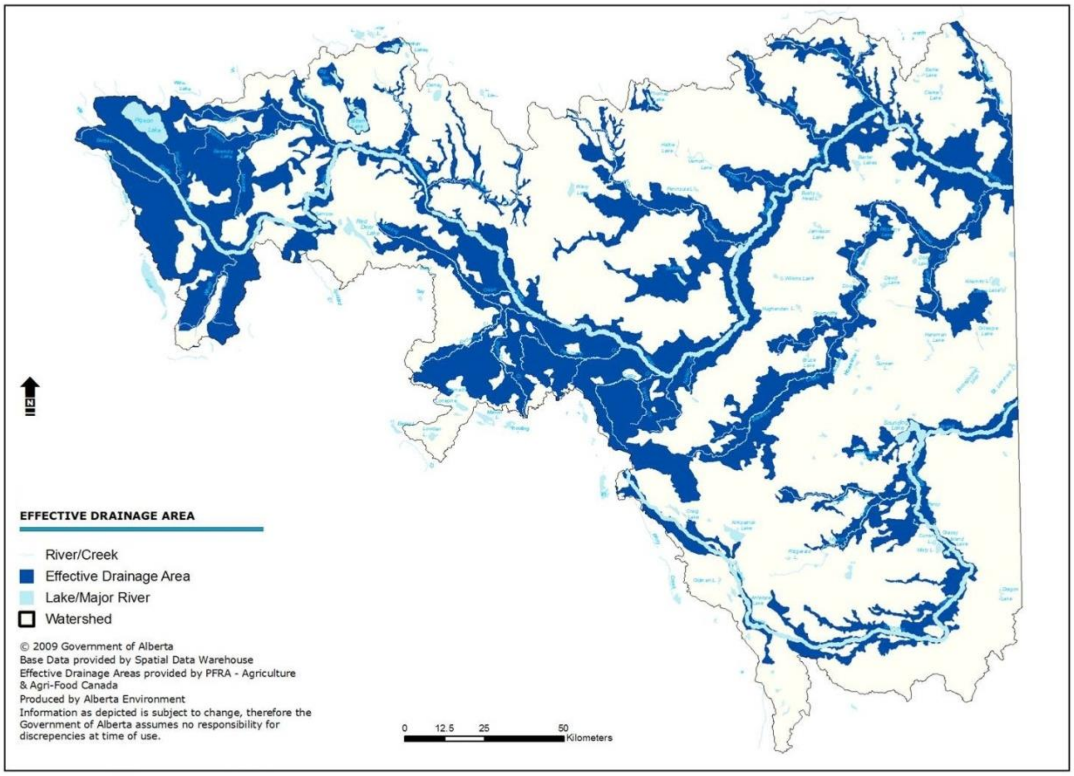
An important finding from the 2008 *Assessment of Environmental Sustainability in Alberta's Agricultural Watersheds* was that "critical source areas, areas where high runoff potential coincides with elevated STP [soil-test phosphorus], are likely responsible for the majority of nutrient losses from agricultural land" (Jedrych, 2008, p. 20; see also Palliser Environmental Services and Alberta ARD, 2008). Jedrych (2008) further concluded that reducing soil phosphorus concentrations and limiting runoff in these high risk areas would be the most effective means of reducing the amount of phosphorus entering surface water systems. Identification of critical source areas is essential to implementing land management practices in those areas where they will have the greatest impact. Paterson et al. (2006) also emphasize the importance of avoiding manure application in these areas. Research from Europe has also concluded that the identification of critical source areas as a means of targeting NPS pollution losses is crucial for the correct allocation of beneficial management practices (Strauss et al., 2007). In addition, where financial incentives are utilized to encourage adoption of beneficial management practices, the cost-effectiveness of these programs may also be improved greatly by targeting areas of the watershed expected to have the greatest impact (Weersink and Livernois, 1996).

It is important to identify critical source areas within the Battle River and Sounding Creek watersheds. Accurate export coefficient numbers (to determine the pollutant export potential from various land use types within the watershed) and soil testing (to determine areas with elevated STP) are required in order to identify these critical source areas.

Another key consideration is the effective drainage area within these watersheds and the land use activities that take place here. The effective drainage area is defined as that portion of a watershed that might be expected to entirely contribute runoff to the main stream (in this case the Battle River and Sounding Creek) during a flood with a return period of two years.

Figure 6 provides a map of the effective drainage area within the Battle River and Sounding Creek watersheds, as well as a key land factor with the potential to contribute to NPS pollution in this area: livestock manure production. Livestock manure production is just one example of the various land use practices occurring on the landscape; all of these land use practices should be examined for their potential contribution to NPS pollution.

While it is important to consider land use practices throughout the watershed, regions known to contribute runoff to the Battle River and Sounding Creek on a regular basis are key areas to consider for NPS pollution management.



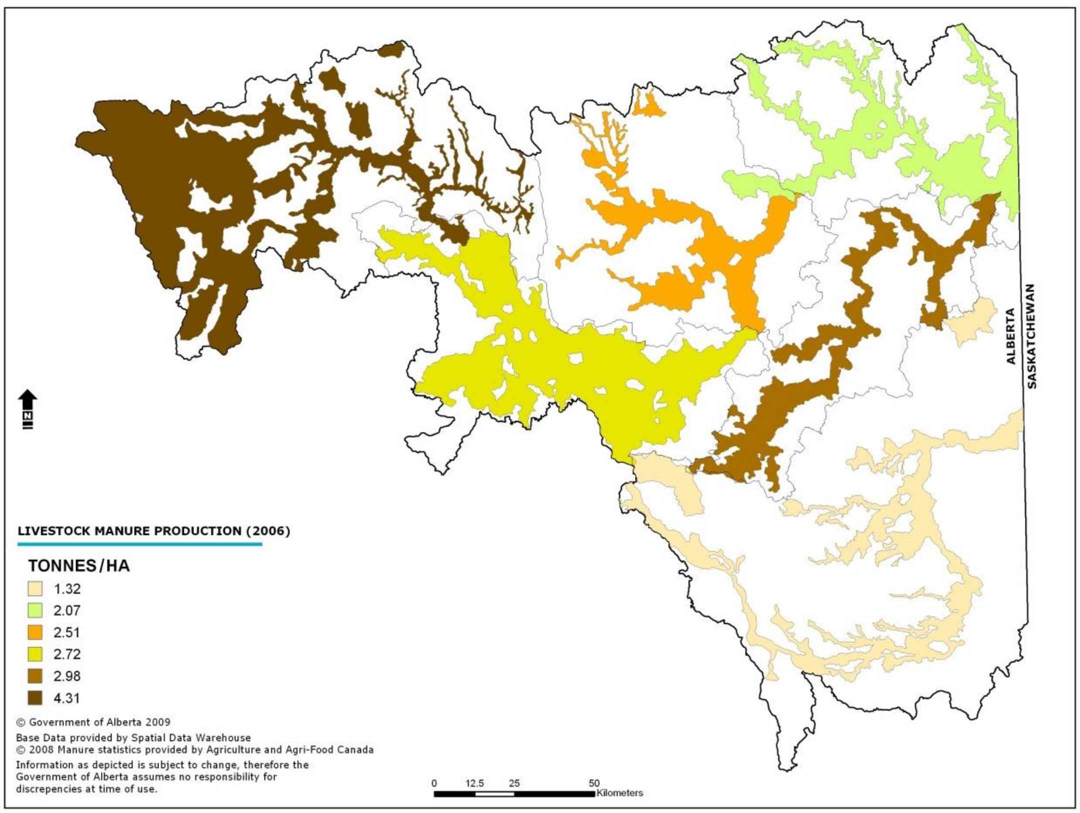


Figure 6: Effective drainage area of the Battle River and Sounding Creek watersheds (top) and livestock manure production within that area (bottom)

Watershed Characteristics Influencing Pollutant Transport

Site- and region-specific factors such as soil type, climate, hydrology, topography, land cover and land use may influence the degree to which nutrients and other pollutants are transported across the landscape. Various beneficial management practices may be more or less effective depending on the characteristics of a particular landscape (Kay et al., 2009). A detailed characterization of the soil, climate, hydrology, topography, land cover and land use in the Battle River and Sounding Creek watersheds is thus an important component of effective decision-making for NPS pollution management.

These unique watershed characteristics may then be entered into watershed management models to predict the effectiveness of various beneficial management practices on these landscapes. The Soil and Water Assessment Tool (SWAT) model is currently being utilized by Alberta Agriculture and Rural Development (ARD) "to predict the impact of management practices on soil and water quality at river basin scales" (Jedrych, 2008). The Agricultural Policy Environmental eXtender (APEX) model serves a similar purpose at the field scale. These models are both part of the broader Comprehensive Economic and Environmental Optimization Tool, which has the capacity to simulate specific agricultural areas of Alberta and identify the impacts of various beneficial management practices on water and soil quality at the field and watershed scales. Recently, this tool was utilized during ARD's *Nutrient Beneficial Management Practices* project (Olson and Kalischuk, 2008; Olson and Kalischuk 2009).

Critical data gaps in assessing watershed characteristics include water quality data for tributary streams and a suite of export coefficients for each land use/land cover type and natural sub-region in Alberta.

6.1.2 Rural NPS Pollution Management Strategies

Kay, Edwards, and Foulger (2009) outline three broad categories for the management of agricultural pollutants:

1) reducing inputs of pollutants,
2) reducing the transport of pollutants, and
3) capturing and degrading pollutants.

Various management strategies exist under each of these categories. Strategies that may be of benefit in the Battle River and Sounding Creek watersheds are detailed below.

6.1.2.1 Reducing Inputs

Research has shown that water pollution from agricultural lands may be reduced through limiting nutrient applications to crop requirements. In other words, where inorganic fertilizer and/or manure are applied to fields, they should be applied only to meet the annual crop nutrient uptake rates, thereby maximizing crop production without releasing excess nutrients into the environment (Alberta Agriculture and Food (AAF), 2007; Kalischuk, Paterson, Bennett, Olson and Ontkean, 2006). It is accepted that where farmers already apply phosphorus and nitrogen at or below crop uptake rates, further reductions may not be reasonable (Paterson et al., 2006).

Research in Alberta has shown that reducing nitrogen and phosphorus levels in soil reduces nutrient levels in runoff water, as described in greater detail in section 6.1.1. In addition, while the recent soil phosphorus limits project determined that legislated soil phosphorus limits for agricultural lands in Alberta could not be supported at the time, a key recommendation of the study was to “design and implement management systems for high risk and sensitive landscapes” (Paterson et al., 2006, p. xii). Riparian and flood plain zones were recognized as sensitive ecosystems and critical phosphorus source areas that required special consideration among other landscape types. A further recommendation was that phosphorus application to these lands should be limited to annual agronomic uptake rates, which would generally exclude manure application.

Manure and inorganic fertilizer application rates have been the focus of much research in Alberta and beyond. Kalischuk et al. (2006) noted that in Alberta, inorganic fertilizers are applied in excess less frequently than manure due to the fact that most producers are aware of the nutrient content of inorganic fertilizers and appreciate the cost of purchasing these fertilizers.

Crop nutrient uptake rates are significantly lower than manure application rates currently allowed in Alberta under the AOPA (see section 6.2.2). In 2006, technology available to producers did not even allow manure application at these relatively low rates. Olson and Paterson (2005) suggest that phosphorus-based manure application will require producers to apply “lower rates with greater precision and uniformity” (p. 3), which will require improved manure application technologies. Technologies that encourage incorporation or injection of manure would also limit manure transport in surface water runoff. Where technology does not exist to apply manure at crop uptake rates, Kaliscuk et al. (2006) recommend applying manure to meet 3 or 4 years of crop phosphorus requirements, which would mean applying manure once every 3 or 4 years to meet the crop phosphorus requirements for those years.

Limiting crop nutrient applications appears to be more effective for nitrogen than phosphorus, due to the nature in which phosphorus accumulates in soils (Kay et al., 2009). On a related note, an important consideration in applying manure to agricultural land is that manure applied on the basis of nitrogen will result in an accumulation of phosphorus in soil (Kalischuk et al., 2006; Olson and Paterson, 2005). This is due to the fact that the nitrogen:phosphorus ratio of most manure is 1:1, whereas most crops require a nitrogen:phosphorus ratio of 8:1 (Zhang et al. 2004). As such, the amount of phosphorus in manure is greater than the amount that crops can utilize. In Alberta, manure application limits under the Agricultural Operation Practices Act (AOPA) are currently based on nitrogen considerations.

Olson, McKenzie, and Larney (2006) recommend that manure application rates based on phosphorus requirements (with additional nitrogen fertilizer applications, if required) may be just as effective at producing optimum crop yields while producing less environmental concerns. However, a related concern is that manure applied on the basis of phosphorus has to be applied over a substantial land base (perhaps double the land base required for nitrogen-based application rates), and producers do not always have access to adequate areas of land at reasonable transportation costs (Olson and Paterson, 2005). Section 6.1.4 includes a further discussion around manure management strategies that may aid in resolving this concern.

To a limited extent, livestock feeding strategies may also be utilized to reduce both the amount of manure produced and the nutrient content of that manure. Finally, the amount of manure being applied to land may be reduced through finding alternative uses for manure, such as composting and biogas/bioenergy production (Olson and Paterson, 2005; Paterson et al., 2006).

6.1.2.2 Reducing Pollutant Transport

Several techniques exist for reducing nutrient transport from agricultural lands, These are discussed in greater detail below.

Crop management techniques for limiting nutrient transport include farming along the contour lines of fields, ensuring soil is bare for a minimum amount of time, conservation tillage, and changing the way in which nutrients are applied.

Planting crops along the contour of the land (across the slope of the land rather than up and down the slope) may reduce runoff (AAF, 2007; AAFC, 2010; Kay et al., 2009). The presence of ground cover may improve the effectiveness of contouring, and in general soil erosion and nutrient transport may be reduced through keeping soil bare for a minimum amount of time (AAF, 2007; Kay et al., 2009). This may be accomplished through reducing the number of acres in summer fallow (uncultivated land) by planting cover crops or retaining crop residues or stubble on the land. Ground cover protects soil from the erosive power of wind, rain and snowmelt and encourages increased water infiltration (AAF, 2007; Alberta Agriculture, Food and Rural Development (AFRD), 2000; Kay et al., 2009). Cover crops are also beneficial in that they can utilize surplus nutrients and thus reduce the risk of nutrient build-up in soil. Including perennial forages in long-term crop rotations has been noted as one of the most effective means of limiting nutrient transport in runoff, as perennial forages provide dense ground cover, hold soil in place, improve soil structure and water infiltration capacity, and more (AAF, 2007).

The practice of conservation or minimum tillage may also reduce soil erosion and nutrient loss from fields. Conservation tillage systems utilize reduced tillage and direct seeding. Withers, Hodgkinson, Bates, and Withers (2007) attributed the benefits of these systems to better ground cover and a firmer surface for tractor wheels. It is important to note, however, that some research has shown increased nutrient transport as a result of minimum tillage (Kay et al., 2009). Where conservation tillage is used, practices such as the direct injection of fertilizer and/or manure are important to ensuring that nutrients do not build up on the soil surface.

In contrast to reduced tillage, rough soil surfaces created through discing or ploughing have also been shown to have a positive, although variable, impact on nutrient transport (Kay et al., 2009). However, tillage has also been associated with poorer soil structure due to the breakdown of organic matter in the soil caused by increased soil aeration and mixing. In general, extensive tillage also increases the risk of soil erosion.

In terms of fertilizer application, Paterson et al. (2006) recommend that fertilizer be applied through banding (placing fertilizer in bands to one or both sides of planted rows) or applied with the seed, as opposed to being broadcast or sprayed over the entire field.

For livestock producers, nutrient transport to water systems may be reduced through a variety of management practices. Based on research done in Alberta, Kalischuk et al. (2006) recommended two key practices. The first involves excluding livestock from natural water bodies and water ways and utilizing off-stream watering systems. This has the potential to improve water quality as well as promote greater weight gain in livestock (Fitch, Adams and O'Shaughnessy, 2003; Kalischuk et al., 2006; Scrimgeour and Kendall, 2002). Research has shown that even in the absence of fencing, cattle will often choose to drink water from off-stream watering systems rather than the surface water supply (Fitch et al., 2003). The second management practice recommended by Kalischuk et al. (2006) deals with livestock over-wintering sites. As outlined in the Alberta AOPA, it is recommended that these sites be set back from surface water sources or that other measures be taken to limit runoff from these sites. More discussion around AOPA regulations is included in section 6.2.2.

Limiting overgrazing, especially in areas where soil is saturated and therefore vulnerable to trampling, may also significantly improve the quality of runoff water (Fitch et al., 2003; Kay et al., 2009). Limiting overgrazing also allows vegetation to rest and rebuild roots and mass, which in turn helps to hold soil in place.

Careful management of manure stockpiles and manure spreading may also reduce nutrient losses to surface water. Management and spreading of manure generated by confined feeding operations in Alberta is of particular concern (Kalischuk et al., 2006; Paterson et al., 2006). For all livestock operations, nutrient loss in runoff can be minimized through incorporating surface-applied manure into soil immediately after application and avoiding the application of manure on snow-covered or frozen ground. This is consistent with the AOPA (see section 6.2.2). Applying manure after snowmelt in the spring is especially beneficial, as the land is most vulnerable to the loss of nutrients in runoff during spring snowmelt (Olson and Kalischuk, 2011). Producers may need to increase their manure storage capacity in order to eliminate the need to spread manure in the winter.

Nutrient transport may also be reduced through the use of manure injection technologies and by applying manure as close as possible to the time of active crop growth in order to maximize crop uptake. Injection of manure is also beneficial in that it eliminates the need to incorporate manure through high-disturbance tillage that may lead to increased soil disturbance and nutrient transport (AAF, 2007). Additional recommendations by Paterson et al. (2006) include avoiding spreading manure in critical source areas (see section 6.1.1) and immediately before rainfall.

6.1.2.3 Capturing and Degrading Pollutants

Kay et al. (2009) discuss buffer zones and wetlands as two means of capturing and degrading pollutants before they reach surface water systems. Buffer zones are often synonymous with riparian areas, which are areas of land adjacent to water bodies and water ways where vegetation and soils are strongly influenced by the presence of water (BRWA, 2011). Other terms used to describe buffer zones include conservation buffers, riparian buffers, and buffer strips. Wetlands are those areas of land that contain water long enough to promote wetland or aquatic vegetation and/or processes.

Wetlands and riparian areas serve many valuable functions, including acting as natural buffers or filters that remove pollutants from surface water runoff (Gabor et al., 2004). As described by the United States Environmental Protection Agency (U.S. EPA, 2005a), “wetlands and riparian areas play a significant role in protecting water quality and reducing adverse water quality impacts associated with non-point source pollution” (1). Often acting as the final barrier between water systems and land use activities, loss or degradation of wetlands and riparian areas provides a more direct route for non-point source pollution to enter water systems.

The following sections discuss the efficacy of wetlands and riparian areas as a tool for non-point source pollution management.

Wetlands

As described briefly above, wetlands serve a variety of functions, including flood mitigation and water storage, groundwater recharge, and habitat for a diversity of species (U.S. EPA, 2005a). Related to water quality, their ability to trap and store nutrients in sediments, convert inorganic nutrients to organic biomass, and otherwise process nutrients through microbial activity make wetlands effective nutrient sinks on many landscapes. Through various processes, both phosphorus and nitrogen may be retained, absorbed or otherwise utilized by wetlands (Gabor et al., 2004). Gabor et al. (2004) found wetland phosphorus retention rates of up to 94%, nitrate retention rates of up to 87% and ammonium retention rates of up to 76%.

The size and position of wetlands influences their effectiveness in mitigating non-point source pollution. The ratio of wetland area to catchment area is often used to estimate wetland pollution retention capacity, with the ideal wetland size being between 1-5% of the total catchment area (Kay et al., 2009). Research has also shown that wetlands located adjacent to first-order streams (streams with no additional streams feeding into them) were more effective at removing nutrients and sediments compared to wetlands located further downstream. Not surprisingly, it has also been suggested that wetlands located immediately below the pollution source may be the most efficient at removing pollutants (U.S. EPA, 2005a). The amount of water present may also affect wetland efficiency; generally, wetlands are less efficient at removing pollutants during times of high flow when retention times are shorter (Kay et al., 2009).

Wetland loss is a major issue in Alberta. A wetland inventory was completed for the Iron Creek subwatershed of the Battle River watershed in 2005. Comparing aerial photographs from 1963 and 2005, it was found that only 33% of the 1963 wetland area remained intact in 2005 (BRWA 2011). Provincially, it is estimated that about 64% of the wetlands in the “white” (settled) area of Alberta have been lost. In addition, annual wetland loss in the white area is estimated at between 0.3% and 0.5% of remaining wetland area (Alberta Water Council, 2008). Wetland loss may serve to increase the effective drainage area of a watershed, resulting in the transport of nutrients and other pollutants from areas of land that did not previously contribute runoff to the stream or river system. Also, whereas intact wetlands may serve as nutrient sinks on a landscape, drained wetlands may become net exporters of nutrients (Gabor et al., 2004). A recent study by Ducks Unlimited looked extensively at the impacts of wetland loss in Manitoba’s Broughton’s Creek watershed (Yang et al., 2008).

Preventing further wetland loss is therefore a key component of non-point source pollution management. In addition, where extensive wetland loss has already occurred, emphasis should be placed on restoring wetlands.

Riparian Areas

Riparian areas serve a similar function to wetlands in their ability to capture runoff and sediment and filter out nutrients and other pollutants. They also serve a variety of other important functions, such as storing water, recharging groundwater systems, stabilizing banks and shorelines, reducing erosion, providing wildlife habitat and supporting biodiversity (Fitch and Ambrose, 2003; Kay et al., 2009; Lovell and Sullivan, 2006). Intact riparian areas may also serve as effective buffers against chemical drift from fields (AAFC, 2010).

Where livestock grazing occurs, healthy riparian areas may be maintained through fencing off these areas and utilizing off-stream watering systems (Fitch et al., 2003; Kalischuk et al., 2006). While in some cases it may be necessary to completely exclude livestock from riparian areas in order to protect fragile landscapes, in other cases riparian pastures may be grazed to a limited degree, provided that these areas are avoided during sensitive times of the year and are given adequate time to rest and regenerate. Various grazing management systems may be utilized to control the timing, intensity and pattern of grazing, including rotational grazing (deferred rotation, rest rotation) and time controlled grazing systems (Fitch et al., 2003)

Maintaining grassed waterways through cropland may help to reduce soil erosion and nutrient transport (AAF, 2007; AAFC, 2010; AFRD, 2000). Maintaining more natural riparian areas that support a diversity of plant life (grasses, sedges, cattails, willows, trees, etc.) may reduce erosion and nutrient transport to an even greater extent, in addition to serving various other important functions that maintain the health of the waterway (Fitch et al., 2003).

While riparian areas have many benefits, their efficiency as a nutrient management tool appears to be highly variable. According to a literature review by Kay et al. (2009), buffer zone nutrient removal efficiencies for total nitrogen vary from a 94% reduction to a 217% increase. Buffer zone nutrient removal efficiencies for total phosphorus ranged from a 97% reduction to a 41% increase. A similar literature review by Ducks Unlimited Canada found total nitrogen reduction rates of between 40 and 94% and total phosphorus reduction rates of between 31 and 91% (Gabor et al., 2004).

One factor that limits the ability of riparian areas to filter out pollutants is that "the maximum delivery period of nutrients (i.e. winter)…overlaps with the least efficient period for many buffer zones due to a combination of high local water tables, reduced infiltration capacities and poor plant growth/cover" (Kay et al., 2009). Not surprisingly, research from Alberta also shows that the large majority of surface water runoff in Alberta's agricultural regions occurs during spring snowmelt, when the capacity of riparian areas to capture and treat this runoff is lowest (Anderson, 1999; Casson et al., 2008; Paterson et al., 2006; Olson and Kalischuk, 2011). Heavy summer rain storms may also contribute significant runoff from agricultural land. In the Whelp Creek watershed, located within the Battle River watershed, peak concentrations of total phosphorus and total nitrogen were often observed after summer rainfall events (Olson and Kalischuk, 2011). Utilizing other nutrient management strategies, such as those discussed above, in conjunction with buffer strips may compensate for these inefficiencies. In particular, the effectiveness of buffer zones may be increased by retaining crop residues and stubble on fallow land and utilizing conservation tillage techniques such as direct seeding and reduced tillage (AAF, 2007).

As described by Paterson et al. (2006), reducing nutrient loading to surface water systems on a watershed scale will likely be most successful when a variety of best management practices are utilized across the landscape.

6.1.3 Whelp Creek Case Study

The above discussion has provided an overview of beneficial management practices that have emerged as a means of managing non-point source pollution. However, the effectiveness of these best management practices under Alberta conditions is not well known.

In 2007, Alberta Agriculture and Rural Development undertook a 6-year research study in two Alberta watersheds to evaluate the effectiveness of beneficial management practices in reducing agricultural nutrient impacts on water quality at both the field and watershed scales. The Whelp Creek watershed, located within the Battle River watershed near the town of Lacombe, is one of these study areas.

This study used a "before and after" approach to evaluating beneficial management practices (BMPs). That is, the study sites were monitored both before and after BMPs were implemented. Pre-implementation monitoring data provided a baseline from which to evaluate any changes resulting from the implementation of BMPs. Six study sites were established in the Whelp Creek watershed in 2008 and were monitored for two years under pre-existing management conditions. In the spring and fall of 2010, BMPs were implemented at all of these sites. Of the six study sites, four were utilized as annual cropland and two were utilized as pasture land. In addition, two reference sites were established to monitor annually cropped fields with no manure application.

BMPs implemented included: developing nutrient management plans; changing the location, timing and method of manure application; creating a setback area around drainage channels where no manure was applied; the relocation of manure storage; erosion control measures; the reduction of cattle stocking density; excluding cattle from degraded riparian areas; the application of rotational grazing; and the installation of two new livestock watering systems.

This case study serves to highlight some of the challenges and opportunities involved in implementing BMPs for water quality improvement and nutrient management. Monitoring results from the final years of the project have not yet been released, but initial results demonstrate that the effectiveness of these beneficial management practices varied from site to site, with some showing significant improvements to water quality and others showing none. As the final results become available, the effectiveness of these BMPs will become more apparent.

From Field to Basin: Translating Results

Most studies that examine the impact of beneficial management practices on water quality take place at the field and small-watershed scale (Kay et al., 2009). This lack of research means that there is a limited understanding of the degree to which beneficial management practices at the field scale will improve water quality at the larger watershed scale. However, a more recent study by Kay et al. (2012) states that "there is a good deal of science undertaken at the plot scale to suggest that agricultural stewardship should improve water quality at the catchment scale" (16). Kay et al. goes further to say that the success of such stewardship measures will depend largely on the degree to which they are able to be broadly implemented in any given watershed.

6.1.4 Providing Financial Incentives for Stewardship

NPS pollution management in rural, agricultural settings is highly dependent on the individual and collective actions of private landowners. The question arises: *how can stewardship actions promoting improved water quality be encouraged on the land?*

Various management practices with the potential to improve water quality at the watershed scale have already been identified (Deasy et al., 2010; Kalischuk et al., 2006; Kay et al., 2009; Lovell and Sullivan, 2006; and more). However, Kay et al. (2012) suggest that "voluntary schemes with insufficient financial reward or regulatory pressure are unlikely to be successful". Regulatory instruments may be effective at driving changes in management practices, but they may also foster animosity and mistrust between governments and agricultural producers. Various groups have begun looking into the economic valuation of ecological goods and services and opportunities to provide financial incentives to landowners for maintaining these services on their land (Anielski and Watrecon, 2011; Fisher, 2010; Roman, Rehbein, Olson and Bush, 2009; Stirrett, Rolfe and Shewchuk, 2012; Government of Alberta, 2011; Weersink and Livernois, 1996). Providing financial support for the implementation of beneficial management practices may be a more effective and positive approach than forcing compliance through regulations. As such, additional research, evaluation, and implementation of voluntary financial incentive programs to support the adoption of beneficial management practices on agricultural lands in Alberta could benefit non-point source management goals significantly.

On a related note, and specifically related to manure management, one recommendation from the 2006 *Soil Phosphorus Limits Project* called for the development of a manure management incentive program for Alberta livestock producers that would "reduce manure applications on existing land by promoting the transportation of excess manure greater distances" (Paterson et al., 2006, p. xii). The rationale for such a program is that there are often excess amounts of manure in specific regions of the province, based on the locations of major livestock operations. Manure from these operations presents a significant risk to local water systems. In contrast, there are many agricultural regions of the province that could benefit from additional nutrient applications. If it were more economically viable to transport excess manure to areas of the province that could benefit from the additional nutrients and organic matter contained in manure, it may be possible for nutrient losses to Alberta's rivers and streams to be reduced.

6.1.5 Education and Awareness

A recent study from the United States found that one of the most commonly cited reasons for non-adoption of beneficial management practices by agricultural producers was unfamiliarity with the practices (Gillespie, Kim and Paudel, 2007). These results point to the importance of educational efforts to increase knowledge of beneficial management practices. One recommendation of Paterson et al. (2006) was the implementation of an education and awareness program around phosphorus management. This idea could be expanded to include nutrient management as a whole. Increasing awareness and understanding among Alberta's agricultural producers of the issues surrounding excess nutrients in surface water systems and beneficial management practices that could alleviate these issues is essential to encouraging implementation of those practices.

6.2 Current Management Context

While point sources of pollution are generally monitored and regulated, this is not the case with non-point sources of pollution. NPS pollution presents unique management challenges due to the fact that this pollution comes from a number of diffuse sources. However, beneficial management practices to reduce NPS pollution do exist. The following discussion looks at examples of rural NPS pollution management currently taking place in Canada and the United States.

6.2.1 Regional

Rural NPS pollution management at the regional scale has been focused around non-regulatory approaches such as raising awareness about agricultural beneficial management practices. Counties and municipal districts work extensively with agricultural producers in their local areas to promote beneficial management practices and are also key partners in carrying out provincial and federal agricultural programs such as *Growing Forward*. Additionally, rural municipalities may utilize tools such as Municipal Development Plans, Land Use Bylaws, environmental reserves, and Watershed Protection Areas to encourage beneficial land management practices aimed at NPS pollution management.

Other organizations, such as the Alberta Riparian Habitat Management Society (Cows and Fish) and Ducks Unlimited Canada, also work extensively with landowners in east-central Alberta and across Alberta to promote beneficial management practices. As described above, wetlands serve an important function in non-point source pollution management. Ducks Unlimited Canada is a major regional player in the conservation and restoration of wetlands in the Battle River and Sounding Creek watersheds. To date, they have completed more than 700 projects in these watersheds, spanning over 85,000 acres of wetlands and nearly 112,000 acres of upland areas. Cows and Fish also works extensively in the Battle River watershed and across Alberta. To date, they have completed riparian health assessments spanning approximately 170 km of riparian areas along the Battle River and its tributaries. The educational efforts of both of these organizations also contribute greatly to knowledge and understanding of the significance of wetlands and riparian areas and ways in which these areas may be protected.

Various other organizations, such as the Nature Conservancy of Canada, Alberta Conservation Association and regional Land Trust groups also contribute to non-point source pollution management through their various land management projects and programs.

6.2.2 Provincial

Several pieces of provincial legislation and policy have implications for NPS pollution management in the Battle River and Sounding Creek watersheds. This legislative and policy context is outlined in the *Battle River Watershed Management Planning Process Phase Two Terms of Reference* (BRWA 2011).

The Alberta Environmental Farm Plan initiative has been in existence since 2002. It began as a non-profit organization and is now administered by Alberta Agriculture and Rural Development, with on-the-ground support from various agricultural organizations and municipalities. The purpose of the program is to encourage Alberta landowners to develop Environmental Farm Plans that help them identify and address environmental risks and opportunities in their farming or ranching operations.

The *Growing Forward* program is a federally initiated program through which agricultural producers may apply for funding to implement beneficial management practices on their land. In Alberta, the program is delivered by Alberta Agriculture and Rural Development. As described in section 6.2.3 below, the *Growing Forward* program will expire on March 31, 2013. As such, several of the associated programs and funding opportunities are closed to new applications. Plans are currently underway to develop a successor program, but it remains to be seen how this may affect programs and funding available to producers.

Several programs in the first installation of the *Growing Forward* program had linkages with water quality and nonpoint source pollution management; in particular, stewardship programs existed for "Grazing and Winter Feeding Management", "Integrated Crop Management" and "Manure Management". A stipulation of the above programs was that producers complete an Environmental Farm Plan before applying for funding. *Growing Forward* also included a Water Management Program, where funding is available for new water source development. For this program, producers must create a Long Term Water Management Plan and have it reviewed and approved prior to eligible projects being constructed.

Several other provincial programs are contributing to increased discussion around NPS pollution management in Alberta. In 2010, the Alberta Water Council formed a non-point source pollution project team to assess the current state of NPS pollution management in Alberta and offer recommendations on how it might best be managed in the future. This project is ongoing. In addition, Alberta Environment and Sustainable Resource Development recently initiated the Bow River Phosphorus Management Plan project, aimed at developing management strategies and actions for phosphorus management in the Bow River. This Plan may serve as a prototype for similar initiatives across the province. Lastly, Alberta Agriculture and Rural Development and the Intensive Livestock Working Group have initiated a 20-year Phosphorus Strategy aimed at developing a tool to help confined feeding operations identify risks and opportunities associated with their current nutrient management systems. The tool will also present management options aimed at reducing phosphorus loss in surface water runoff.

In addition, several publications of the Government of Alberta address NPS pollution management on a provincial scale. For example, Alberta Agriculture and Rural Development has released numerous publications over the years which are focused on the promotion of a diversity of agricultural beneficial management practices, including nutrient management. In 2012, Alberta Environment and Sustainable Resource Development released their *Stepping Back from the Water* report, which is a guide to beneficial management practices for developments near water bodies (AESRD, 2012b). Several projects of the Alberta Water Council, such as the *Wetland Policy* project (completed in 2008) and *Riparian Land Conservation and Management* project (currently underway) also contribute to provincial knowledge of beneficial management practices relevant to NPS pollution management.

Agricultural Operation Practices Act

The Agricultural Operation Practices Act (AOPA) governs many agricultural actions in Alberta, including livestock and crop management practices. Of particular relevance to non-point source pollution and nutrient management are the requirements related to livestock wintering sites and manure application.

Wintering Sites

According to AOPA, wintering sites should be located a minimum of 30 metres from surface water sources in order to limit nutrient runoff from these areas. If the 30 metre distance cannot be met, either the site must be designed so that runoff is diverted away from the water source or manure must be moved to an appropriate distance before runoff occurs (Government of Alberta, 2008).

Manure Application

AOPA includes required manure application setback distances. Manure must be applied a minimum of 30 metres from water wells, 10 metres from surface water if manure injection is used, and 30 metres from surface water if it is applied on the surface and later incorporated. If the land where manure is being applied slopes towards a surface water source, additional setback distances apply:

4% slope or less	30 metre setback
4-6% slope	60 metre setback
6-12% slopes	90 metre setback
Greater than 12%	Do not apply manure

In addition, surface-applied manure must be incorporated into soil within 48 hours of application, except when applied to forages, direct-seeded crops, or frozen or snow-covered land. Unless authorized by the Natural Resources Conservation Board (NRCB), the spreading of manure on frozen or snow-covered land is prohibited under AOPA (Government of Alberta, 2008).

As mentioned previously, manure application rates in Alberta are currently based on soil nitrate-nitrogen and salinity limits, as outlined in AOPA (see Table 3 for nitrate-nitrogen limits). All operations (including confined feeding operations, custom manure applicators and other livestock producers) must apply manure according to AOPA requirements. However, only operations that handle more than 500 tonnes of manure per year are required to soil test and keep records. Anyone who cannot meet the AOPA manure application requirements must have a Nutrient Management Plan approved by the NRCB which describes alternative practices that will be used to provide equal or better protection to the environment. The extent to which these requirements are adhered to and enforced must also be considered.

Table 3: Nitrate-nitrogen limits in soil (Standards and Administration Regulation, Schedule 3, Table 3) [taken from Government of Alberta, 2008]

Farming Method	Soil Group	Sandy (>45% sand and water table <4 m)	Sandy (>45% sand and water table >4 m)	Medium and fine textured soils
Dryland	Brown	80 kg/ha (75 lb/ac)	110 kg/ha (100 lb/ac)	140 kg/ha (125 lb/ac)
	Dark Brown	110 kg/ha (100 lb/ac)	140 kg/ha (125 lb/ac)	170 kg/ha (150 lb/ac)
	Black	140 kg/ha (125 lb/ac)	170 kg/ha (150 lb/ac)	225 kg/ha (200 lb/ac)
	Grey Wooded	110 kg/ha (100 lb/ac)	140 kg/ha (125 lb/ac)	170 kg/ha (150 lb/ac)
Irrigated	All groups	180 kg/ha (160 lb/ac)	225 kg/ha (200 lb/ac)	270 kg/ha (240 lb/ac)

AESRD Draft Water Quality Objectives

In 2011, AESRD developed draft water quality objectives for the Battle River for a variety of water quality indicators (Golder Associates, 2011). These objectives are "reach-specific", meaning that objectives were developed for each of the 4 reaches, or sections, of the river. These reaches were defined by the advisory committee that was formed as part of this project.

Of particular interest for nutrient management in the Battle River watershed are the draft water quality objectives for phosphorus and nitrogen. Based on current nutrient levels observed in the river, the draft water quality objectives for total phosphorus for reaches 1, 2 and 4 state that total phosphorus levels should remain below 0.05 mg/L and that there should be a decreasing trend in total phosphorus concentrations over multiple years. This objective is the same as the total phosphorus guideline for the protection of aquatic life determined by Alberta Environment in the 1999 *Surface Water Quality Guidelines for Use in Alberta* (Alberta Environment, 1999). The draft water quality objectives for total nitrogen for reaches 1, 2 and 4 state that total nitrogen levels should remain below 1 mg/L and that there should be a decreasing trend in total nitrogen concentrations over multiple years. This objective is also consistent with the 1999 Alberta Environment guidelines.

An important study to take into consideration in the discussion around these draft water quality objectives is the 2008 *Assessment of Environmental Sustainability in Alberta's Agricultural Watersheds*, which recommended the establishment of nitrogen and phosphorus water quality targets for agricultural streams based on:

- ambient nutrient concentrations in watersheds with minimal human disturbance;
- protection of water quality for aquatic ecosystem health; and,
- livestock development with the best environmentally sustainable management practices (Palliser Environmental Services and Alberta ARD, 2008, p. vii)

Water Quality Management Frameworks are being developed as part of regional planning efforts under the *Land Use Framework*. It is anticipated that the draft water quality objectives described above will be finalized and implemented through inclusion in a Water Quality Management Framework for the Battle River watershed.

6.2.3 National

In Canada, the agricultural policy framework, under Agriculture and Agri-Food Canada, is coordinated through a 5-year federal/provincial/territorial initiative called *Growing Forward*. This initiative will expire on March 31, 2013. As such, plans are currently underway to develop a successor program to take its place. In Alberta, *Growing Forward* serves as one of the primary means through which agricultural producers may apply for funding to implement agricultural beneficial management practices. The specifics of the program as they pertain to Alberta are described in greater detail in section 6.2.2.

6.2.4 Other Resources

In the United States, the following major national reports have been developed to aid in rural non-point source pollution management:

- *National Management Measures to Protect and Restore Wetlands and Riparian Areas for the Abatement of Nonpoint Source Pollution* (U.S. EPA, 2005a)
- *National Management Measures to Control Nonpoint Source Pollution from Agriculture* (U.S. EPA, 2003a)
- *Techniques for Tracking, Evaluating, and Reporting the Implementation of Nonpoint Source Control Measures: Agriculture* (U.S. EPA, 1997)

Several states have also undertaken a variety of strategies to aid in nonpoint source pollution management. Related to soil-test phosphorus levels, many states, including Arkansas, Delaware, Ohio, Oklahoma, Michigan, Texas and Wisconsin have legislated soil-test phosphorus limits of between 150 and 200 parts per million (Paterson et al., 2006).

Incentive Programs

In addition to the *Growing Forward* program (described above), other programs aimed at providing financial incentives for implementation of beneficial management practices have been developed and are currently being used in Alberta.

Ducks Unlimited Canada

Ducks Unlimited Canada has contributed significantly to the implementation of beneficial management practices in watersheds across Alberta through the diversity of programs they offer to landowners and other partners. Many of these programs provide direct financial incentives, cost-share funding and other forms of financial assistance. For example, Ducks Unlimited Canada has invested nearly 34 million dollars in the Battle River and Sounding Creek watersheds in Alberta through their restoration and conservation programs.

Through carefully designed projects, Ducks Unlimited Canada supports landowners in maintaining viable farming or ranching operations at the same time as they emphasize the importance of maintaining or improving the ecological integrity of the land and water upon which those operations depend. For example, programs aimed at the conservation and/or restoration of wetlands support the ecological health of those areas at the same time as they provide financial gains and other benefits to landowners in the form of enhanced flood and drought mitigation, improved water storage capacity and water quality, additional sources of forage and water supply for cattle, and more.

Alternative Land Use Services (ALUS)

ALUS is a voluntary incentive program that provides payments to agricultural producers for the establishment of new environmental initiatives on their land. The overarching goal of these initiatives is to enhance upland, wetland and riparian areas and support the provisioning of ecosystem services in agricultural landscapes.

ALUS began in the 1990s as a vision of Keystone Agricultural Producers (a Manitoba farm organization) and Delta Waterfowl Foundation, and ALUS projects have now been established in four provinces. In 2010, the County of Vermilion River (which is partially located in the Battle River watershed) initiated Alberta’s first ALUS project, undertaking a pilot project to evaluate how ALUS might work in their county. Parkland County has recently undertaken its own ALUS pilot project.

Agri-Trend Carbon Credit Program

Administered by Agri-Trend Aggregation Inc., this program works with landowners to determine their eligibility to receive carbon offset credits for reduced- or no-tillage practices under the Government of Alberta’s Tillage System Management Protocol (Alberta Environment 2009). These credits may then be sold anywhere that there is a market where they are recognized (for example, the Chicago Climate Exchange or to an Alberta large final emitter).

7 Urban Non-point Source Pollution

As described in section 5, municipal (community) sources of nutrients account for about half of the nutrient loading to the Battle River. However, the proportion of these nutrients coming from point vs. non-point sources is not known. Stormwater runoff is the principal means by which urban NPS pollution enters surface water systems. For the purposes of this report, “urban” refers to any city, town, village, summer village, or other community.

7.1 Urban NPS Pollution Management

7.1.1 Urban NPS Pollution Management Considerations

Pollutants Carried By Water Runoff

Any number of pollutants may be carried by water runoff in urban areas. Some pollutants of concern, as identified by the U.S. EPA (2005b), are discussed below:

1) **Road Salts:** Road salts have been identified as a problem for surface and ground water quality. In addition to being an issue in urban settings, the use of road salts on rural roads and highways should also be considered.
2) **Hydrocarbons:** Oil and grease are two examples of hydrocarbons present in urban centres. These substances may be present on driveways and roadways and are easily transported to local waterbodies through stormwater drainage systems. Coal-tar-based road sealcoat products are another potential source of hydrocarbons (Mahler et al., 2012).
3) **Heavy Metals:** Vehicles are thought to be a leading source of heavy metals in urban runoff. Heavy metals have toxic effects on aquatic life and may also contaminate groundwater.
4) **Nutrients:** Sources of nutrients (primarily phosphorus and nitrogen) in urban streams may include fertilizers from lawns, pet wastes, and atmospheric deposition from industry and automobile emissions.
5) **Sediment:** Erosion from various urban developments, and the corresponding transportation and deposition of sediment in water systems, may have a significant impact on the health of aquatic ecosystems. In addition, sediment particles are a primary carrier of various other pollutants, such as those described above.

Impacts of Urban Development

The U.S. EPA (2005b) has identified a number of factors influencing water in an urban setting. In urban environments, evaporation decreases because water moves more quickly off impervious surfaces. Transpiration also decreases because of reduced amounts of vegetation. Perhaps most significant to water quality is that as urban development increases, pervious (permeable) surfaces are reduced, leading to decreased soil percolation and increased surface water runoff. This increased volume of runoff may result in destabilization and widening of stream channels, increased erosion and in-stream sedimentation, higher water temperatures, and reduced water quality and biodiversity (Schueler, 1995, as cited in U.S. EPA, 2005b). In addition, as water moves more quickly over impervious surfaces, stream flow rates may be altered. Streams in developed areas have higher peak flows that occur more quickly than in undeveloped areas.

Urban Fertilizer Use

Just as nutrient management in rural settings requires us to reconsider the way in which manure and fertilizer are applied on the landscape, so too must we examine fertilizer use and application rates in urban settings. To give an example of how over-fertilization could occur, a 10 kilogram (22 pound) bag of fertilizer will treat approximately 10 000 square feet of land (about a quarter of an acre). Urban residents may have about 3000 square feet of lawn and will perhaps use one to two bags of fertilizer on that lawn (about 315-630 pounds/acre). To compare this to rural application rates, fertilizer might be applied to a pasture at 80-100 pounds/acre. In using one to two bags of fertilizer (22-44 pounds), urban residents are applying between 3 to 7 times as much fertilizer as is required (S. Steffen, personal communication, June 6, 2012). Excess fertilizer that cannot be utilized by the lawn makes its way into community stormwater systems.

On-site Private Sewage Systems

On-site private sewage systems, also referred to as septic systems, are small-scale sewage treatment systems utilized in areas with no connection to regional sewage pipes. Most septic systems are comprised of two components: a septic tank to catch solids and a septic or leach field to dispose of liquids. Poorly planned, constructed or maintained systems may contribute to NPS pollution of both ground and surface water systems, especially as a source of fecal coliforms and nutrients.

7.1.2 Urban NPS Pollution Management Strategies

Several management strategies have been developed to minimize non-point source pollution from urban settings, which often comes down to effective stormwater management. Management strategies discussed below focus around the central themes of minimizing impervious land cover, promoting infiltration, removing pollutants from runoff, and limiting the amount of pollutants entering stormwater runoff in the first place.

Low Impact Development

In most communities, stormwater runoff is not treated and flows directly into local waterbodies or waterways. Stormwater management has typically been limited to transporting water away from developments as quickly as possible. In contrast, low impact development is “an approach to land development (or re-development) that works with nature to manage stormwater as close to its source as possible” (U.S. EPA, as cited in City of Edmonton, 2011). This includes managing both the volume and quality of stormwater. Several low impact development best management practices are outlined below.

Additional design considerations and operation and maintenance details for these practices may be found in the City of Edmonton’s low impact development report (City of Edmonton, 2011). A similar report by the U.S. EPA (2007) provides a further discussion of cost considerations related to these practices. In addition, the Toronto and Region Conservation Authority (TRCA) has conducted, and is currently conducting, various studies to evaluate the performance of low impact development technologies in Canada (TRCA, 2009a; TRCA, 2009b; TRCA, 2011; TRCA, 2012).

Rain Gardens

Rain gardens (also referred to as bioretention areas or systems) are a means of slowing the rate of runoff, reducing the overall volume of runoff through encouraging water infiltration, and filtering out pollutants from stormwater. In a recent literature review, the U.S. EPA (2000) confirmed the effectiveness of bioretention areas in fulfilling these functions. Rain gardens should be located close to where runoff is generated (eg. rainwater spouts on buildings) and typically consist of a water pooling area, vegetation, a mulch cover, and a filter medium such as sand or gravel (City of Edmonton, 2011; Canada Mortage and Housing Corporation, 2011). Together, these materials help to slow the flow of water, encourage infiltration, and filter out pollutants. Thus, rain gardens act as a buffer between urban landscapes and stormwater drainage systems.

Where stormwater is transported directly from road surfaces to storm sewers, rain gardens may be located directly adjacent to storm sewers in order to capture and filter stormwater runoff before it enters the sewers. Other effective locations for rain gardens include parking lots and traffic islands.

Bioswales

Bioswales (also referred to as grassed swales) are similar to rain gardens in that they are designed to treat, store and infiltrate stormwater runoff through the use of natural vegetation. They are distinguished from rain gardens by their long, linear design; as such, bioswales are well suited to manage roadway runoff and may be used as a replacement for, or in conjunction with, curbs and gutters. Whereas roadside ditches, curbs and gutters are traditionally designed only to move stormwater away from roads, bioswales help to increase stormwater infiltration and pollutant removal.

Vegetated Roof Covers

Ideal for buildings with flat roofs, vegetated roof covers, or "green roofs", use vegetation planted on rooftops to retain and utilize rain and snow fall before it even reaches the ground. Additional benefits of green roofs include providing urban green spaces, creating habitat for birds and insects, and shading underlying surfaces, which may contribute to reduced building cooling costs.

Natural Drainage Ways

Stormwater drainage systems eventually make their way to natural water systems. Maintaining natural vegetation and healthy riparian areas along both man-made and natural stormwater drainage ways will help to reduce erosion from high volumes of stormwater runoff as well as help treat stormwater. See related discussions on riparian area management (section 6.1.2) and drainage ditch management (below).

Permeable Pavement

As described above, urban development is associated with a reduction in pervious (permeable) surfaces. Increasing the area of land covered by permeable surfaces and slowing the rate at which stormwater runs off the landscape may help to reduce NPS pollution in urban areas.

Various types of permeable pavement have been developed as a means of increasing the amount of permeable surfaces in urban areas, including pervious concrete and asphalt, permeable pavers, and grass pavers. Permeable pavement reduces the volume of stormwater runoff by allowing rain water and snowmelt to filter into the ground. Ideal locations for permeable pavement include parking lots, driveways, sidewalks and other walkways, and low-traffic roads.

Impermeable surfaces may also be reduced through limiting street and sidewalk widths and driveway lengths.

Rainwater Harvesting

Rain events often occur very quickly and result in high volumes of runoff in urban areas. Increasing water storage capacity within communities through the use of rain barrels has many benefits. This water may then be used to water gardens, lawns and other plants and trees. Depending on the jurisdiction, rainwater may also be used for toilet flushing and washing clothes. Rainwater storage and use for watering purposes reduces reliance on community drinking water for this purpose and allows rainwater to percolate into the soil. The amount of stormwater entering the stormwater drainage system is thus reduced, which puts less of a strain on the natural watercourses receiving urban stormwater flow. Incentive programs that provide rain barrels or other water storage structures at subsidized rates may help to encourage this practice.

Drainage Ditch Management Strategies

Many small communities manage stormwater runoff through the use of drainage ditches. Municipalities may think they have to keep these ditches mowed close to the ground to alleviate the risk of water backing up or excess vegetation becoming a fire hazard. However, allowing natural plants such as grasses, sedges and rushes to grow in these ditches slows down the flow rate of stormwater and creates a natural filtering system to remove nutrients and other pollutants from the water before it reaches other surface water systems. This can often be done without causing excessive water back-up or creating a fire hazard. Vegetative ditches also serve to control erosion and maintain the integrity of the ditch. Where bulrushes impede flow to an excessive degree, they may be controlled through mowing or cutting before the seed head develops (S. Steffen, personal communication, August 10, 2011).

Where weeds are an issue, management options include handpicking or applying herbicides. Where herbicides are used, the best time to spray is when the ditch is dry. In addition, non-selective herbicides should be avoided, as these remove all vegetation, including beneficial species. Removal of all vegetation may increase erosion and invite the growth of addition weed species. See section 7.2.2 for more information on the Pesticide Code of Practice, which governs herbicide applications in Alberta.

Other Beneficial Management Practices

Managing Cleaning Products

Individuals can take many simple steps to reduce NPS pollution from urban centres, such as ensuring that no household pollutants are poured down stormwater sewers. Where cleaning products are used for purposes such as washing vehicles, people can pour soapy water down household drains (sending this water to the local water treatment plant) or ensure that biodegradable cleaning products are used.

Storm Sewer Filters

Though natural solutions to filter and reduce the volume of stormwater may be preferential for their low impact, engineered solutions to manage the quality of stormwater runoff also exist, such as filters inserted directly into storm sewers. There may be additional costs associated with maintaining and replacing these filters.

Limiting Development Impact

The impact of new developments may be minimized through outlining the smallest site disturbance area in development plans and using conservation designs that preserve important features on construction sites such as wetlands and riparian areas, treed and other natural areas, and areas with valuable topsoil or very porous soils. Such techniques can significantly reduce issues related to the quality and volume of surface water runoff (U.S. EPA, 2000). See *Erosion & Sediment Control Guidelines for Urban Construction*, developed by the Greater Golden Horseshoe Area Conservation Authorities of Ontario (GGHA CA), for other practices that may be put in place to limit NPS pollution from urban construction areas (GGHA CA, 2006).

Managing Fertilizer Use

Managing fertilizer use may be as simple as reading packaging instructions carefully before applying. Community awareness-building efforts could help people to understand the impact of lawn fertilizer use and what they can do to minimize their impact.

7.1.3 Education and Awareness

As with rural NPS pollution management, education and awareness is an essential component of urban NPS pollution management. Some of the management strategies and technologies discussed above, such as low impact development, are relatively new to Alberta and education of both government leaders and the general public is required in order to begin building local knowledge, experience, and expertise in the use of these technologies.

7.2 Current Management Context

While point sources of pollution are generally monitored and regulated, this is not the case with non-point sources of pollution. NPS pollution presents unique management challenges due to the fact that this pollution comes from a number of diffuse sources. However, beneficial management practices to reduce NPS pollution do exist. The following discussion looks at examples of urban NPS pollution management currently taking place in Canada at the regional, provincial, and national level.

7.2.1 Regional

Stormwater Management

The development and implementation of stormwater management measures falls under the jurisdiction of municipal governments. Several communities have implemented beneficial practices such as maintaining natural, vegetated waterways to receive stormwater flows and developing stormwater retention ponds. In addition, various levels of government have implemented stormwater management incentive programs such as providing rain barrels at subsidized rates.

Lake Management

Pigeon Lake is located in the Bigstone subwatershed of the Battle River watershed and is one of Alberta's major recreational lakes. In recent years, it has been beset with algae blooms and fish kills that are attributed to various factors, including high water temperatures and high lake nutrient levels. Summer Villages around the lake are responsible for stormwater and septic system management within their jurisdictional boundaries. Several Summer Villages are attempting to limit septic system leachate through legislating or encouraging holding tank usage by cottages and homes around the lake.

The Association of Summer Villages of Alberta (ASVA) has developed a *Lake Stewardship Reference Guide*, which covers a variety of topics relevant to NPS pollution management, including fertilizer use, road maintenance, and stormwater management (ASVA, 2006).

The *LakeWatch* program of the Alberta Lake Management Society (ALMS) is a community water quality testing program that works with local residents to collect detailed information about their local lake or reservoir. Data is collected by ALMS technicians, with the assistance of local volunteers, and the results and management recommendations are summarized in a water quality report for the lake.

Nature Alberta's Homesite Consultation program, which exists under the broader *Living by Water* initiative, assists lakeshore residents in assessing the health of shorelines adjacent to their homes. Residents then receive customized recommendations for actions which will help to maintain or improve shoreline health.

Low Impact Development Initiatives

The City of Edmonton recently developed a *Low Impact Development Best Management Practices Design Guide* which contains many recommendations for best management practices that promote improved stormwater management within urban environments (City of Edmonton, 2011). A similar guidance document has been developed for Toronto, Ontario (TRCA, 2010).

7.2.2 Provincial

Stormwater management in Alberta requires approval by the provincial government under the Environmental Protection and Enhancement Act and the Water Act. In addition, *Stormwater Management Guidelines for the Province of Alberta* were first developed in 1987, and were later updated in 1999 (Government of Alberta, 1999). These guidelines provide a framework for stormwater management in Alberta, outlining objectives for stormwater management and techniques for the development of stormwater drainage systems.

In addition, *Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems* were developed in 2006 (Government of Alberta, 2006). This document provides stormwater and wastewater management guidelines and best management practices.

In Alberta, standards for the design, installation and material requirements of on-site private sewage systems are provided by the Private Sewage Disposal Systems Regulation and Alberta Private Sewage Systems Standards of Practice under the Safety Codes Act.

Related to weed control in stormwater drainage ditches, herbicide applications in Alberta that are within 30 metres of a waterbody are governed by the Pesticide Code of Practice.

The Alberta Low Impact Development Partnership (ALIDP) is a not-for-profit organization created to support the development and implementation of low impact development initiatives in Alberta. In partnership with Olds College, the ALIDP is currently conducting research on the performance of bioretention areas.

7.2.3 National

In 2005, *Stormwater Management Planning: A Best Practice by the National Guide to Sustainable Municipal Infrastructure* was developed collaboratively with the Government of Canada, the National Research Council (NRC) and the Federation of Canadian Municipalities (FCM) (FCM and NRC, 2005).

An initiative of the Transportation Association of Canada resulted in the *Syntheses of Best Practices - Road Salt Management* (Transportation Association of Canada, 2003). In 2004, Environment Canada developed a *Code of Practice for the Environmental Management of Road Salts* (Environment Canada, 2004) under the Canadian Environmental Protection Act.

A national program by Trout Unlimited Canada, *Yellow Fish Road*, focuses on raising awareness about pollution entering our water systems through stormwater drains.

7.2.4 Other Resources

The U.S. EPA developed *National Management Measures to Control Nonpoint Source Pollution from Urban Areas* in 2005 (U.S. EPA, 2005b). The U.S. EPA also has many valuable resources related to low impact development and stormwater management, including *Low Impact Development (LID): A Literature Review* (U.S. EPA, 2000) and *Reducing Stormwater Costs through Low Impact Development (LID) Strategies and Practices* (U.S. EPA, 2007).

Various levels of government in Canada, the United States, and beyond have begun implementing various Low Impact Development practices as a means of finding new and innovative means of managing stormwater volume and quality. As just one example, the City of Kirkland (Washington, U.S.) now requires the use of LID techniques in new developments in the city (where feasible).

Related to decentralized wastewater treatment systems, the U.S. EPA has developed *Voluntary National Guidelines for Management of Onsite and Clustered (Decentralized) Wastewater Treatment Systems* (U.S. EPA, 2003b). As the title suggests, these guidelines are not mandatory and are designed to provide a flexible framework for septic system management in the United States.

8 The Economics of Water Quality

The adverse impacts of poor water quality on the health of aquatic ecosystems have been well examined, but the financial impacts of poor water quality on individuals, businesses and communities is also important to consider. One need only look at the costs of upgrading water treatment facilities to see that this is true. Research from the United Kingdom (Pretty et al., 2000, as cited in Kay et al., 2009) has estimated the costs of treating pesticides, sediment, carbon, nitrogen and phosphorus for drinking water purposes. Another study from North America has examined the annual damage costs associated with erosion and sediment pollution (Osterkamp et al., 1998, as cited in U.S. EPA, 2005b). In agriculture, clean drinking water is linked to greater weight gains in cattle, which in turn has economic implications for farm operations. Healthy lakes, rivers and streams may promote increased recreational use of natural landscapes within watersheds, reaping economic benefits from increased tourism revenue. These are just a few examples of the numerous ways in which the quality of our water impacts our economic wellbeing. It is important to consider these impacts in management decisions that affect water quality in the Battle River and Sounding Creek watersheds.

9 Social Impacts of Water Quality

Quite simply, water is essential to life. Poor water quality may result in numerous adverse impacts to human health. In addition, water can be a focal point for community, a place to gather together for fun and recreation. Good water quality is supported by land use practices that promote a balance between land development and the preservation of natural landscapes. Natural landscapes and the valuable habitats they provide promote biodiversity, which in turn supports activities such as hunting, fishing, bird and wildlife watching, hiking, camping and any number of other activities that are closely connected to our sense of wellbeing and quality of life.

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At the Battle River Watershed Alliance we desire to live, work and play in a watershed that sustains all life by using sound knowledge, wisdom and wise actions to preserve our watershed for future generations.

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