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CITY OF GRANDE PRAIRIE

Grande Prairie Reservoir Feasibility Study

Submitted to:
City of Grande Prairie

REPORT



Report Number: 11-1326-0020





Executive Summary

The Grande Prairie Reservoir was originally necessary to provide the City of Grande Prairie (City) with a drinking water source. Although it is no longer the source of drinking water, it still provides benefits as part of a park setting within the City. Over time, the reservoir has been accumulating sediment. The sediment is now mounded, in places, above the spillway sill of the dam. Based on current reservoir operations, the City will need to implement management measures within the next 5 years to avoid loss of capacity at the spillway. This loss of capacity will have a direct effect on the safety of the dam by increasing the risk of overtopping flows during a large flood similar to 1990.

There are a number of site-specific issues associated with the existing reservoir conditions, and the City has opportunities available to make improvements. The key issues for management of the Grande Prairie Reservoir are sedimentation and nutrient loading. Sedimentation is a maintenance issue for the City, and the high nutrient loading will limit the recreational use of the reservoir (e.g. swimming). Depending on the selected management strategy, the City may be able to provide a relatively stable water level for boating. However, a stable year-round water level will be difficult to achieve with such high flood inflows and periods of zero inflow with summer drawdown due to lake evaporation.

At the reservoir, high sediment loading over the years has resulted in sediment accumulation in the reservoir, including mounds of exposed sediment at low water levels. The estimated total sedimentation is about 600,000 m³. At reservoir levels at or below the spillway sill (650.44 m), the exposed sediment creates a nuisance odour and the City receives complaints from nearby residents. The sediment and remaining shallow water also limit the recreation use of canoes on the reservoir.

Reservoir water quality is characterized by high nutrient and sediment loading from upstream agricultural areas. The reservoir also receives stormwater directly from several outfalls and is therefore providing some pre-treatment of stormwater prior to the downstream Bear River. The high nutrient loading greatly increases the chance of algae blooms. However, the potential for algae blooms seems to be mitigated by high turbidity in the reservoir. Sunlight is required for most aquatic plants to thrive, and the high turbidity restricts sunlight penetration to the reservoir.

To date, the City has responded to the sediment issues by operating the reservoir at higher levels in summer. While this prevents the summer odour issue and creates a relatively stable water level for boating, the City must operate the dam with the gates closed. By operating at a high level with the gates closed, the City increases the risk of dam overtopping during a large flood if the gates are not opened quickly.

Another important observation is that the upstream Bear Lake has a tremendous influence by reducing the flood peak at the reservoir by more than 50%. However, Bear Lake also increases the effect of dry periods due to lake evaporation. The lake is relatively large, and low water levels on Bear Lake will prevent a large portion of the watershed from discharging to the reservoir. The result of this evaporation loss at Bear Lake is about 20% of the time with negligible reservoir inflow.



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The key issue to be addressed is the accumulation of sediment in the reservoir. Other study objectives had to be addressed in the context of managing the sediment. The following opportunities are summarized in terms of the original study objectives:

- 1) A reservoir restoration strategy to enhance water quality may be developed in the form of a watershed management plan. However, it is unlikely that the character of the existing water quality can be changed significantly. This is because the vast majority of the nutrient and sediment loading is due to upstream agricultural land use along Bear River near Grande Prairie, and due to agricultural land use further upstream along Grande Prairie Creek.
- 2) An erosion control and bank stabilization program for the reservoir will be addressed as part of the selected management option.
- 3) Active recreation uses such as boating, swimming, and skating within the reservoir were objectives for developing and comparing options. In particular:
 - a) The potential boating use was a key factor for the development of options.
 - b) The potential for swimming will likely be limited regardless of the selected management option, and this recreation use should not be used to select a preferred option. This is because the reservoir is, in part, a stormwater (pre-treatment) pond as a result of the seven stormwater outfalls. As well, the relatively high nutrient and sediment loading from upstream agricultural areas will likely prevent the reservoir from ever becoming a high value public swimming location.
 - c) Skating on the reservoir will depend on the formation of sufficient ice depth and minimal cracking. This requires a stable winter reservoir level and low water velocity under the ice. We anticipate that the reservoir level in winter will be stable, based on normal levels near the spillway sill. However, the suitability for skating will need to be evaluated each winter based on prevailing ice conditions.
- 4) Maintaining a stable water level was an objective for developing and comparing options. We suggest that one permanent water level should be selected, instead of allowing seasonal levels that are different by more than 2 m. A permanent level is possible both at the FSL (i.e. top of the closed gates) and at the spillway sill. Operating near the spillway sill provides the best combination of dam safety and stable water levels while also increasing the wildlife habitat near the reservoir shoreline.
- 5) Increasing the wildlife habitat around the reservoir is possible with a permanent normal water level, by allowing riparian and littoral vegetation to become established along the shoreline.

Four main options to manage the Grande Prairie Reservoir were identified from the discussion of issues and options. They are:

- 1) Continue to operate seasonally or permanently at a high reservoir level;
- 2) Operate year-round at a low water level and reclaim the existing exposed mounds of sediment;
- 3) Re-grade reservoir sediment to form islands within the original reservoir footprint, and operate year-round at a low reservoir level; and
- 4) Remove reservoir sediment and operate at a low reservoir level.



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The options presented in this report offer some tradeoffs for the City to consider. Primarily, the cost of removing some or all of the sediment provides some benefit in terms of boating, wildlife habitat, and a likely reduction of nuisance odour complaints. There are several options for achieving these benefits, and further tradeoffs among them. The least cost option is to reclaim the existing sediment and operate at a low water level, although this would provide no opportunity for boating. Boating opportunities come at a cost to remove or relocate the reservoir sediment that has accumulated over the past 60 years. The cost will vary between \$2.1 million (Option #3) and \$12 million (Option #4) depending on the selected configuration, and these options will require further maintenance in the next 20 years to 50 years after the reservoir accumulates additional sediment.

The recommended next steps are:

- Select a preferred option, based on tradeoffs among costs and benefits;
- Implement management measures related to the Bear River Control Structure;
- Conduct field studies to address key data gaps;
- Feasibility level design of the preferred option to provide a basis for permitting, depending on the field study results;
- Submit applications for required permits and approvals; and
- Detailed design of the preferred option for the purpose of contract tendering.

Together, these next steps are anticipated to cost about \$200,000.

Reservoir management plan guidelines are also provided for riparian setback and other best management practices.



Study Limitations

This study was completed based on available information provided by the City of Grande Prairie (City), and based on other publicly available information. The results are subject to acceptance of a preferred option by the City. This study is intended as a first step with future next steps toward a reservoir management solution to address the long-term accumulation of sediment in the reservoir and associated impacts.

This report has been issued to the City of Grande Prairie for use by City staff to select a preferred option and to direct future reservoir management activities.



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1.0 INTRODUCTION

1.1 Background

In May 2011, Golder Associates Ltd. (Golder) was retained by the City of Grande Prairie (the City) to provide a reservoir feasibility study of the Grande Prairie Reservoir. This report presents the study results to identify reservoir management options and to suggest next steps.

A dam on the Bear River was originally constructed for water supply purposes for the City of Grande Prairie (City), but the City drinking water source is now the Wapiti River. The reservoir now serves more of a recreational and aesthetic function within Centennial Park and the larger Muskoseepi Park system through the City along the Bear River valley.

The Muskoseepi Park Master Plan (2009) outlines an overall concept for the park areas, including plans to revise trails, additional landscaping and improve parking and the nearby RV park. The goals that are identified in the Plan are listed below:

- Provide diversity in trail types and routes within the park;
- Establish standards for Natural area Preservation and Restoration;
- Improve park cleanliness;
- Provide a balance of sports with nature;
- Improve the sense of security and safety;
- Improve access, parking, and legibility within park;
- Decrease encroachment on park boundaries and extend the park along the creek;
- Improve/Add park facilities as necessary;
- Evaluate appropriate programs and activities within park; and
- Establish park operations and maintenance standards.

Alignment of a reservoir management plan with the Muskoseepi Park goals is essential to the overall Park Master Plan.

1.2 Development Objectives

The development of a Reservoir Management Plan for the Grande Prairie Reservoir and surrounding area has been identified as a priority by the City of Grand Prairie. The City is planning to improve the reservoir as part of the overall Muskoseepi Park Master Plan, and to address issues involving the reservoir that otherwise limit the value of the reservoir.

Specifically, the City is planning to develop the following:

- A reservoir restoration strategy to enhance water quality;
- An erosion control and bank stabilization program;



- Active recreation such as boating, swimming, and skating within the reservoir;
- A permanent stable water level within the reservoir; and
- Increased wildlife habitat around the reservoir.

1.3 Development Plan

The development plan for Grande Prairie Reservoir is anticipated to occur over the course of several steps or stages of development from planning to construction. The City anticipates the following steps:

- Step 1. Evaluate reservoir management options;
- Step 2. Execute required studies for the preferred option;
- Step 3. Detailed design and permitting; and
- Step 4. Construction.

1.4 Current Scope of Work

The scope of work for this study is to support the City during Step 1 by identifying and evaluating the reservoir management options. This included the following tasks:

- Compilation and review of existing information;
- Evaluation of reservoir water quality (loadings);
- Characterization of reservoir levels and outflows;
- Development of management options and preliminary evaluation of the options, including a rough estimate of cost; plus
- Recommended next steps.

Details of the scope of work were outlined in the Request for Proposal (RFP) and the Golder technical proposal.

The selected approach for this study was to observe and estimate the existing conditions as needed to identify potential management options, to provide a conceptual plan for each option for comparison purposes, and to provide the City with recommended next steps for the preferred option. We understand that the City will select a preferred option prior to proceeding with detailed investigations and engineering design.

To support the evaluation of management options, it was necessary to estimate the reservoir inflows and to develop an inventory of sources that contribute to reservoir water quality. For this, we conducted a water balance analysis of the reservoir and upstream watershed areas, and we conducted a nutrient budget analysis to help characterize the reservoir water quality. Finally, management options were identified in sufficient detail to provide rough cost estimates. The effort for this study was focused on these tasks.



2.0 EXISTING CONDITIONS

2.1 Centennial Park

Centennial Park (Park) and the Grande Prairie Reservoir is situated within the City of Grande Prairie (City) along the Bear River near the Highway 43 108 Street bridge crossing. The 16 ha reservoir area is surrounded by Centennial Park and the larger Muskoseepi Park system through the City.

Figure 1 shows Grande Prairie Reservoir within Centennial Park and some of the nearby facilities or infrastructure, including:

- Grande Prairie Regional College;
- Rotary Campground and RV Park;
- Boat launch;
- Seven (7) municipal stormwater outfalls; and
- Hiking trails and pathways.

Centennial Park provides the equivalent of an environmental reservoir with limited public access to the shoreline. The Park has a number of pathways, and other public access locations, but the majority of the shoreline has not been landscaped. Near the reservoir, the original valley walls for the Bear River valley are vegetated with trees.

The reservoir shoreline is comprised primarily of the original valley walls with little or no evidence of slope instability. The exception to this, at the time of this report, is a bank failure along the north shore as a result of poor drainage collection at an existing manhole within the Elks Lodge parking lot. This bank failure is scheduled to be repaired.

The reservoir is currently relatively shallow with islands of exposed sediment during low reservoir levels. The shallow conditions are a limiting factor for recreation use such as boating, and the exposed sediment often results in odour complaints from nearby residential areas. Together, these conditions have a negative impact on the overall community value for Centennial Park.



2.2 Bear River Control Structure

The Grande Prairie Reservoir is controlled by the Bear River Control Structure, a dam built in 1948 and reconstructed in 1975-76. The dam results in a drop of about 5.7 m from the reservoir to Bear River. Releases from the reservoir are controlled by a spillway with 2 radial gates each 5 m wide. The gates were recently refurbished to allow reservoir ice conditions against the gates. There are no separate low level outlets. The configuration of the control structure is shown on Figure 2.

Key elevations at the structure include:

- Spillway invert = 650.44 m (2,134 ft);
- Full supply level (top of gate when closed) = 652.58 m (2,141 ft);
- Top of spillway = 654.34 m (2,146.8 ft);
- Top of dam (assumed) = 655 m (2149 ft); and
- Downstream Bear River channel bottom = 644.73 m (2,115.25 ft).

The gates are manually operated to manage spring floods and winter recreation. The reservoir normal operating level was historically 650.4 m during the winter, coinciding with the spillway invert at the dam. In the spring, the gates are typically opened to pass flood flows. Later in the summer, the gates are often closed by mid-June to maintain higher reservoir levels near 652.58 m for summer recreational use (i.e. near the full supply level).

The dam is currently licensed for recreation and erosion control purposes by Alberta Environment: Water Resources Act licence to divert water, File #7218, Priority # 1945-05-21-01, interim licence 08743 issued January 7, 1981. The licence includes provisions for evaporation losses of 50 ac-ft (61,700 m³) and water storage of 210 ac-ft (260,000 m³).

The licence requires that the City provide facilities for the release of water for downstream riparian purposes. The Department of Fisheries and Oceans Canada (DFO) have also requested “adequate releases” for downstream fish habitat. This release rate has not been quantified as part of any licence or approval, and is assumed to be equivalent to the reservoir inflow rate.



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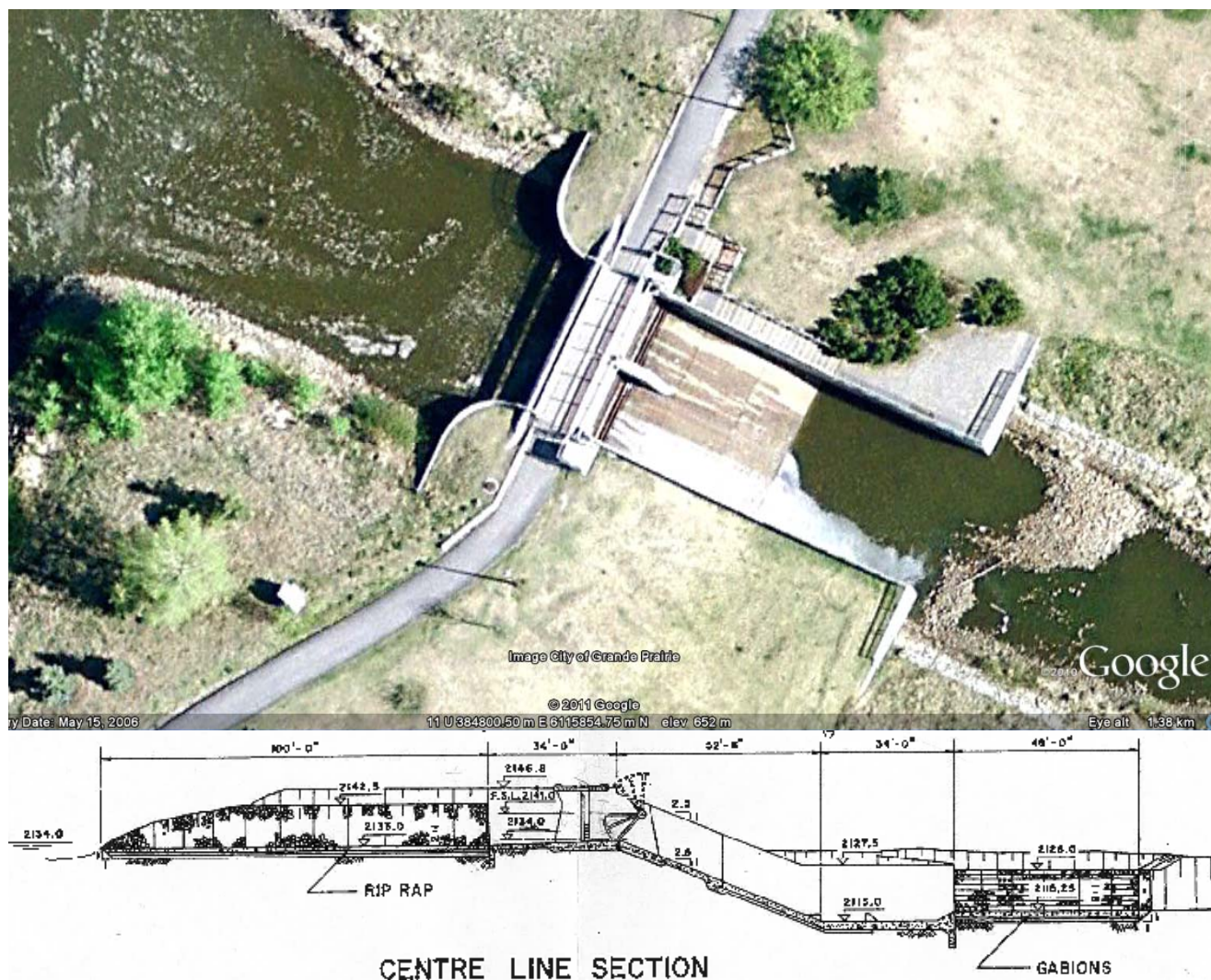


Figure 2: Bear River Control Structure As-built Configuration (1957)

2.3 Watershed Characteristics

The Bear River is a tributary of the Wapiti River downstream of Grande Prairie. The 1,562 km² watershed area upstream of the Grande Prairie Reservoir includes Bear Lake, agricultural lands, forested areas, urban stormwater outfalls, and effluent from several upstream landfills and sewage lagoons. The watershed is shown on Figure 3. A summary of the watershed area is provided in Table 1.

Table 1: Grande Prairie Reservoir Watershed Area Summary

Grande Prairie Reservoir Surface Area	0.16 km ²
Watershed Areas Downstream of Bear Lake	403 km ²
Bear Lake Surface Area	33 km ²
Watershed Areas Upstream of Bear Lake	1,126 km ²
Grande Prairie Reservoir Watershed Total Area	1,562 km²

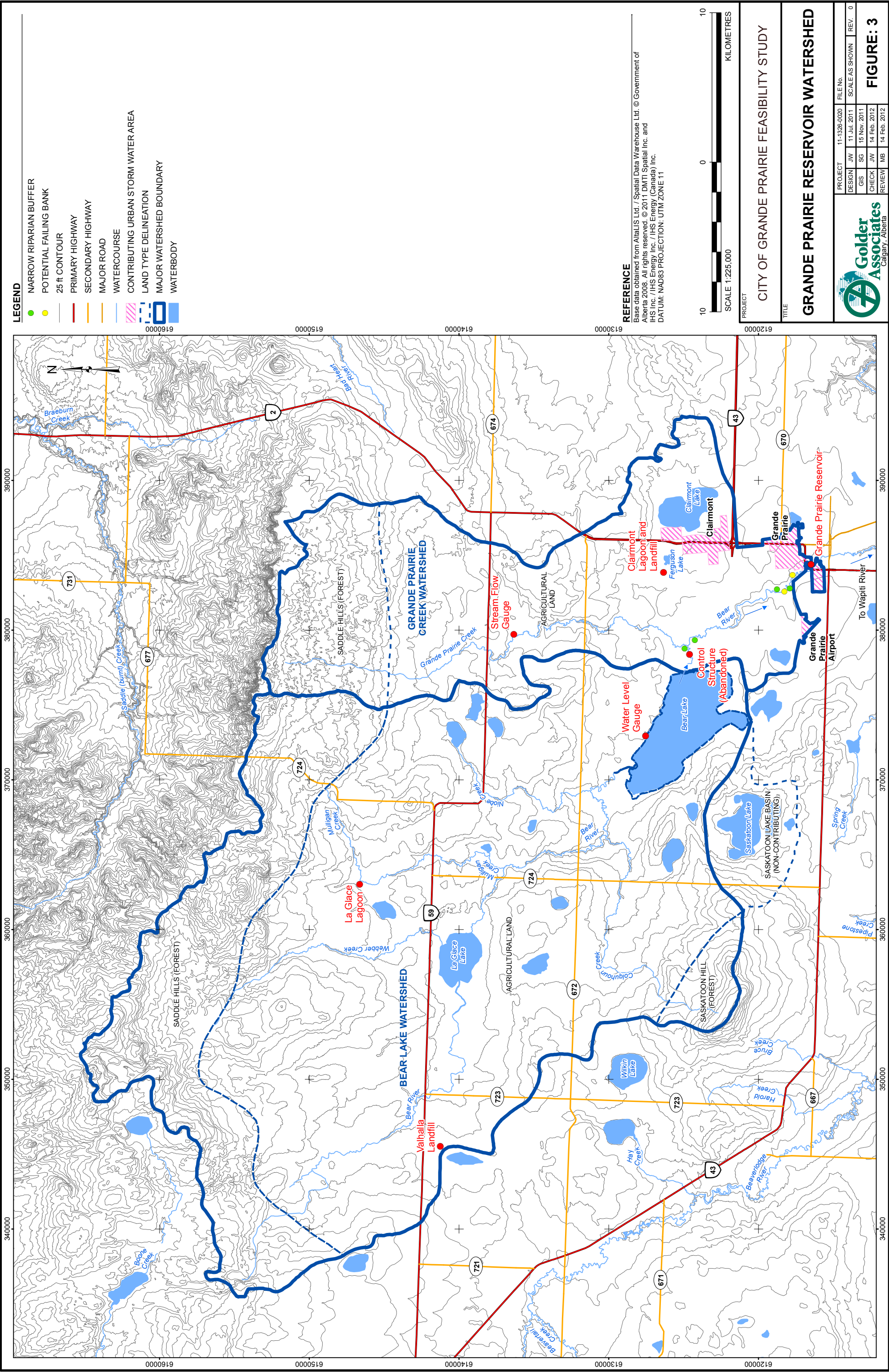



The watershed is dominated by agricultural land use, about 75% of the total area. The upper 22% of the watershed is forested along the Saddle Hills. Of the remaining watershed, stormwater outfalls from about 8 km² of urban Grande Prairie discharge directly to the reservoir or to outfalls immediately upstream of the reservoir. The effects of these land uses on reservoir water quality are discussed later in this report as part of the reservoir nutrient balance.

Other watershed features that may be relevant to reservoir management include the following:

- Five (5) stormwater outfalls discharging directly to the reservoir;
- Two (2) stormwater outfalls discharging directly to Bear River within 1 km upstream of the reservoir;
- Clairmont sewage lagoons;
- Clairmont landfill;
- La Glace sewage lagoons;
- Valhalla Centre landfill;
- River reaches along Bear River downstream of Bear Lake with relatively narrow riparian buffers alongside cultivated fields; and
- Evidence of unstable banks that are actively eroding along Bear River upstream of the reservoir.

The Bear River upstream of the reservoir also has some unique channel hydraulic features. There is an (abandoned) stop-log control structure outlet from Bear Lake near Grande Prairie Creek. Previous studies of the area concluded that there is a temporary flow reversal during flood events at the Bear Lake outlet, allowing Grande Prairie Creek to flow into Bear Lake (MMM 1984). The flow reversal was incorporated into this study's hydrologic modelling of the system for both flood flows and low flows, assuming a bed elevation of 663.0 m at the bifurcation point.



 Golder Associates Calgary, Alberta	PROJECT		FILE No.	
	DESIGN	JW	11 Jul. 2011	SCALE AS SHOWN
	GIS	SG	15 Nov. 2011	REV. 0
	CHECK	JW	14 Feb. 2012	
		REVIEW	MB	14 Feb. 2012

GRANDE PRAIRIE RESERVOIR WATERSHED

TITLE

CITY OF GRANDE PRAIRIE FEASIBILITY STUDY

PROJECT



2.4 Reservoir Characteristics

2.4.1 Climate Summary

The Grande Prairie area near the reservoir receives average annual precipitation of 447 mm per year (Environment Canada Grande Prairie Airport climate station), and the reservoir is subject to average annual evaporation of 659 mm per year (lake evaporation estimates published by Alberta Environment for the Grande Prairie area). Therefore, there is an annual net evaporation loss of about 200 mm with most of the evaporation occurring in the summer months. In summer, the average net evaporation is 300 mm from May to September.

2.4.2 Reservoir Storage and Sediment Accumulation

Reservoir water storage has greatly diminished over the years since the dam was constructed. The original storage capacity of the reservoir was potentially 605,000 m³ up to the spillway sill (estimated based on assumed original valley walls below 650.4 m). However, the presence of exposed sediment at low water suggests that the reservoir currently has virtually no storage capacity at the spillway sill. The estimated loss of storage due to sedimentation is based on the valley shape and the estimated 0.5% gradient of the natural river. The reservoir stage-storage curve above the spillway sill is shown on Figure 4, assuming no effective storage below the spillway sill.

Based on sediment accumulation at the dam, approximately 0.1 m per year of sediment has accumulated since the original impoundment. By comparison, deposition rates for Chestermere Lake near Calgary were estimated to be about 0.01 m per year (Golder 2005). Chestermere Lake is an irrigation reservoir east of Calgary along a canal with water diverted from the Bow River. Chestermere Lake is heavily impacted by urban runoff but is relatively clear. It has problems nuisance aquatic plant growth.

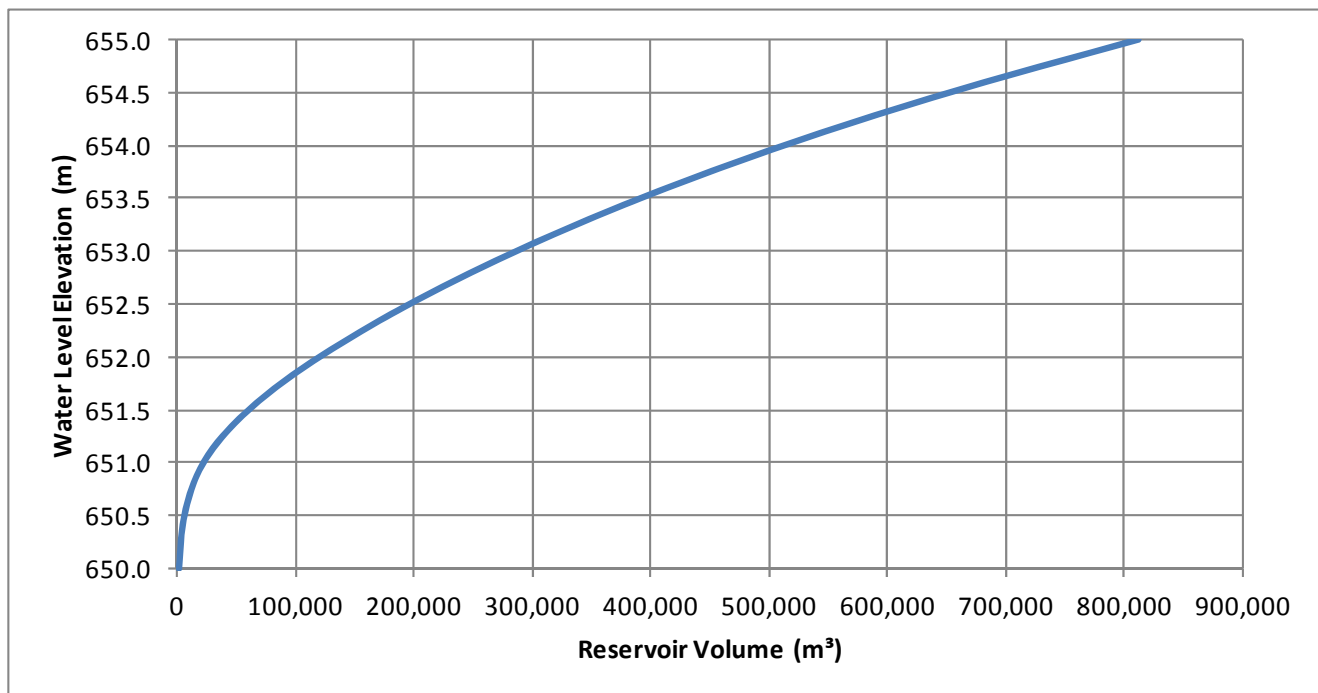


Figure 4: Grande Prairie Reservoir Stage-Storage Curve (above the spillway sill)



2.4.3 Reservoir Inflows and Outflows

Grande Prairie Reservoir is a run-of-river facility with a reservoir that is small in comparison to the contributing watershed, with an average annual retention time of less than one day. Therefore, outflows from the reservoir are roughly equal to the inflows during normal operations.

Reservoir levels, inflows, and outflows are not currently monitored. Therefore, inflows to the reservoir were estimated based on available historical stream flow information for Grande Prairie Creek near Sexsmith, watershed area and land use characteristics, estimated stormwater runoff from urban areas, and hydraulic characteristics of the flood flow reversal at Bear Lake. The estimates were calibrated to historical Bear Lake water levels. Historical reservoir levels and outflows were estimated from the calculated inflows and assumed gate operations.

The estimated average annual reservoir inflow is $2.9 \text{ m}^3/\text{s}$ with the potential for negligible inflow for several months during the year. The variability of inflows from year to year ranges from near zero to over $8 \text{ m}^3/\text{s}$ on an average annual basis, as shown on Figure 5. On a seasonal basis, inflows tend to peak in May and recede to less than $1 \text{ m}^3/\text{s}$ by the end of August (see Figure 6). Although the average flows indicate the presence of water during most of the year, the flow in late summer and winter is often virtually zero. The inflows are estimated to be negligible for as much as 20% of the time, as shown on Figure 7.

During floods, the flood peak inflows to the reservoir may be $18 \text{ m}^3/\text{s}$ or more, as presented in Table 2. The estimated 100-year return period flood peak is $112 \text{ m}^3/\text{s}$ (daily average basis, with a higher instantaneous peak flow). It is anticipated that the flood benefit due to attenuation in Bear Lake upstream of Grande Prairie is a reduction of the reservoir flood peak inflows to less than half.

Outflows from the reservoir are roughly equal to the inflows, with the only significant differences due to active changes to the spillway gate settings – resulting in a slight offset of outflows by one or two days.

Reservoir outflows are also affected by periods of low inflow and net evaporation during the summer. The resulting evaporation loss is equivalent to about $0.004 \text{ m}^3/\text{s}$, based on average net evaporation in summer. The reservoir may therefore be drawn down periodically below the spillway sill. The effect on reservoir levels is discussed in the following section.



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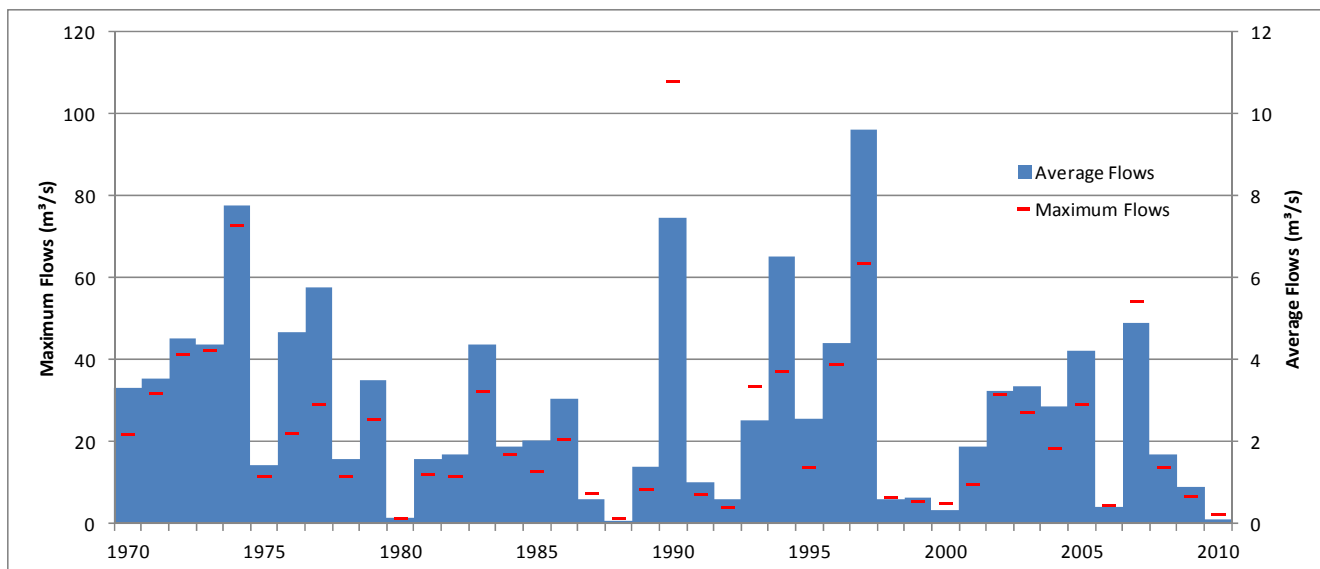


Figure 5: Estimated Historical Annual Reservoir Inflows

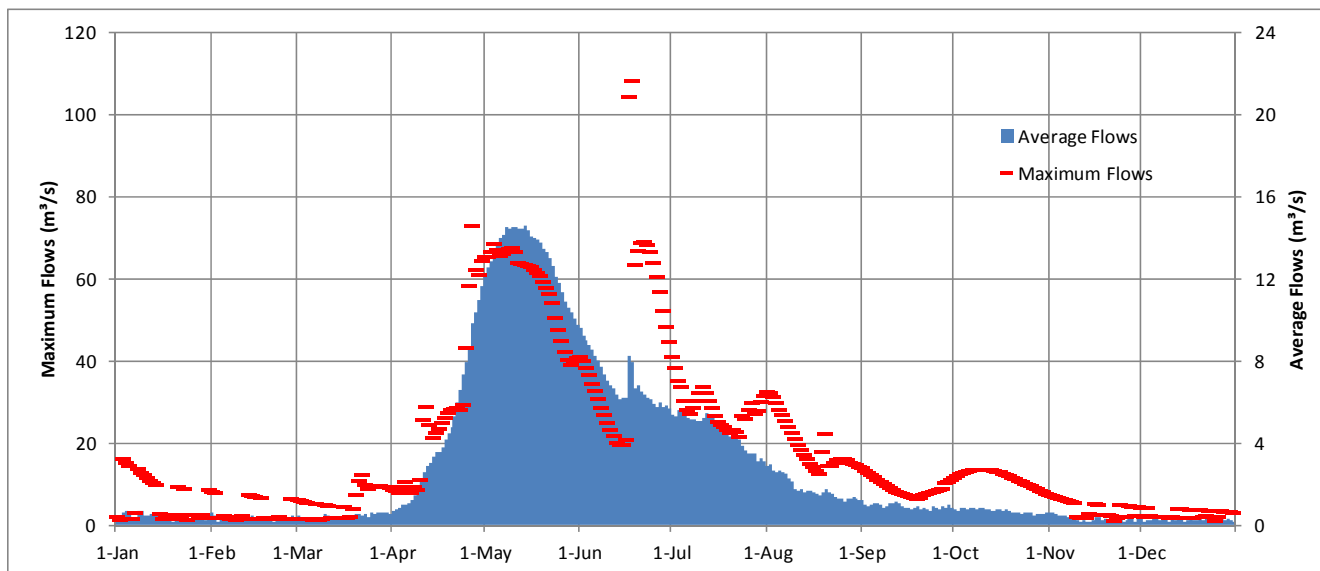


Figure 6: Historical Summary of Estimated Reservoir Inflows



RESERVOIR FEASIBILITY STUDY

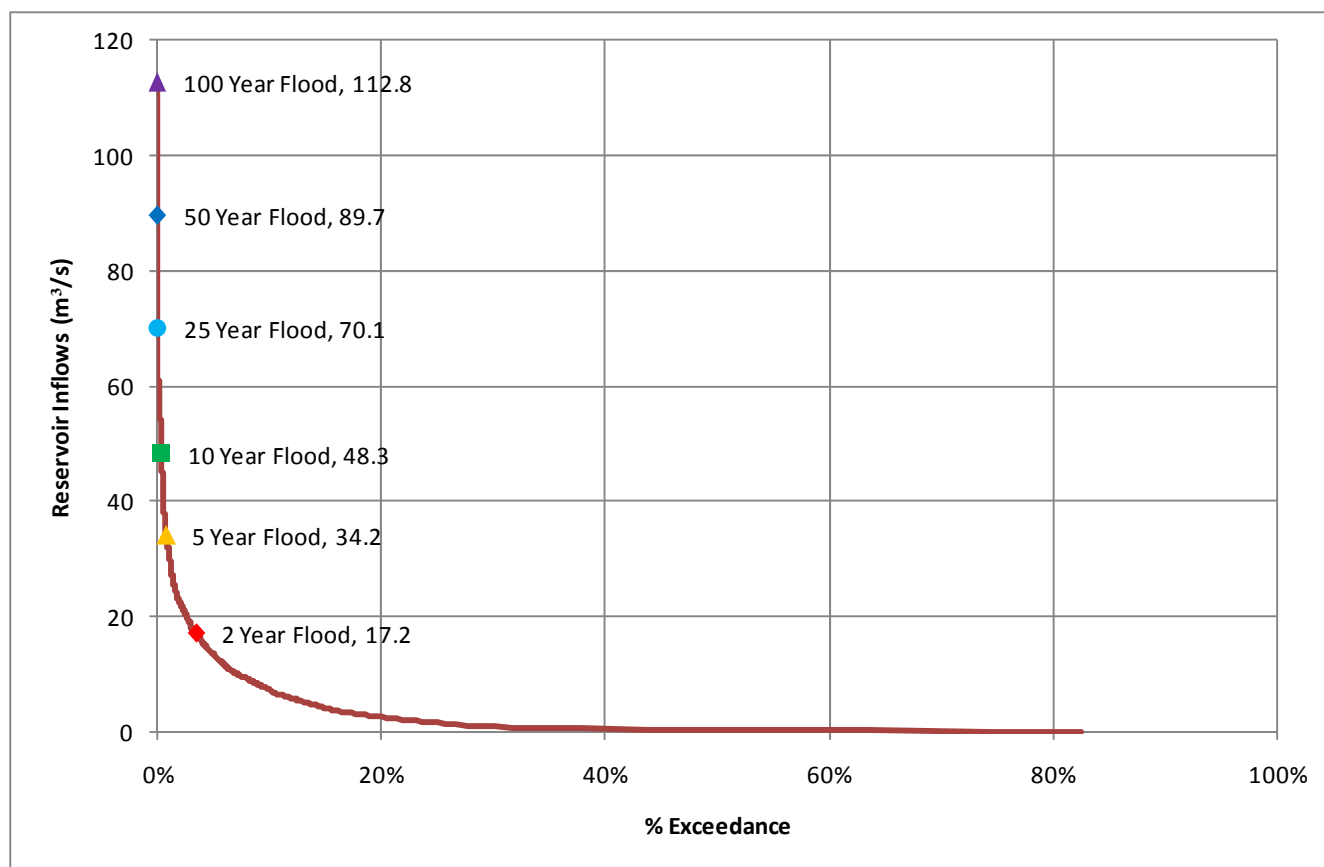


Figure 7: Distribution of Estimated Daily Reservoir Inflows

Table 2: Estimated Reservoir Peak Inflows

Return period flood	Peak Flow (m³/s)
2 year	17.2
5 year	34.2
10 year	48.3
25 year	70.1
50 year	89.7
100 year	112.8

Note: Reservoir peak inflows are daily average rates based on estimated historical daily flows. Peak instantaneous rates may be greater.



2.4.4 Reservoir Levels

Reservoir levels are expected to vary significantly during the year. During low inflows, the reservoir can be drawn down by evaporation in summer. During flood events, the reservoir level can increase quickly by several metres.

Low reservoir levels in summer can result in a drawdown below the normal level as a result of negligible inflow and high lake evaporation. It is possible for the reservoir to be drawn down in summer by up to 0.11 m between rainfall events, assuming the reservoir is operated at the spillway sill elevation of 650.44 m. Drawdown periods with negligible inflow are expected to occur more than one week per year as listed in Table 3. For example, reservoir drawdown for a duration of two months in the summer would be equivalent to a 25-year return period dry condition.

Reservoir peak levels during flood events depend on the operation of the gates and the starting reservoir level at the beginning of the flood event. They also depend on the timing of gate changes. Normal water levels at the spillway spill with the gates open will result in relatively safe reservoir levels for all floods up to and including the 100-year flood peak of 112 m³/s, as shown on Figure 8. The current practice of operating the dam in summer with the gates closed will require active management of the gates by opening them quickly to avoid overtopping the dam during a 25-year flood peak of 70 m³/s.

Table 3: Duration of Reservoir Low Levels below the Spillway Sill (days/year)

Frequency	Annual	Summer (May-Oct)
2 yr	13	9
5 yr	41	30
10 yr	62	44
25 yr	89	63
50 yr	111	78
100 yr	133	93

Note: Minimum water level below the spillway sill = 0.11 m below 650.44 m.



RESERVOIR FEASIBILITY STUDY

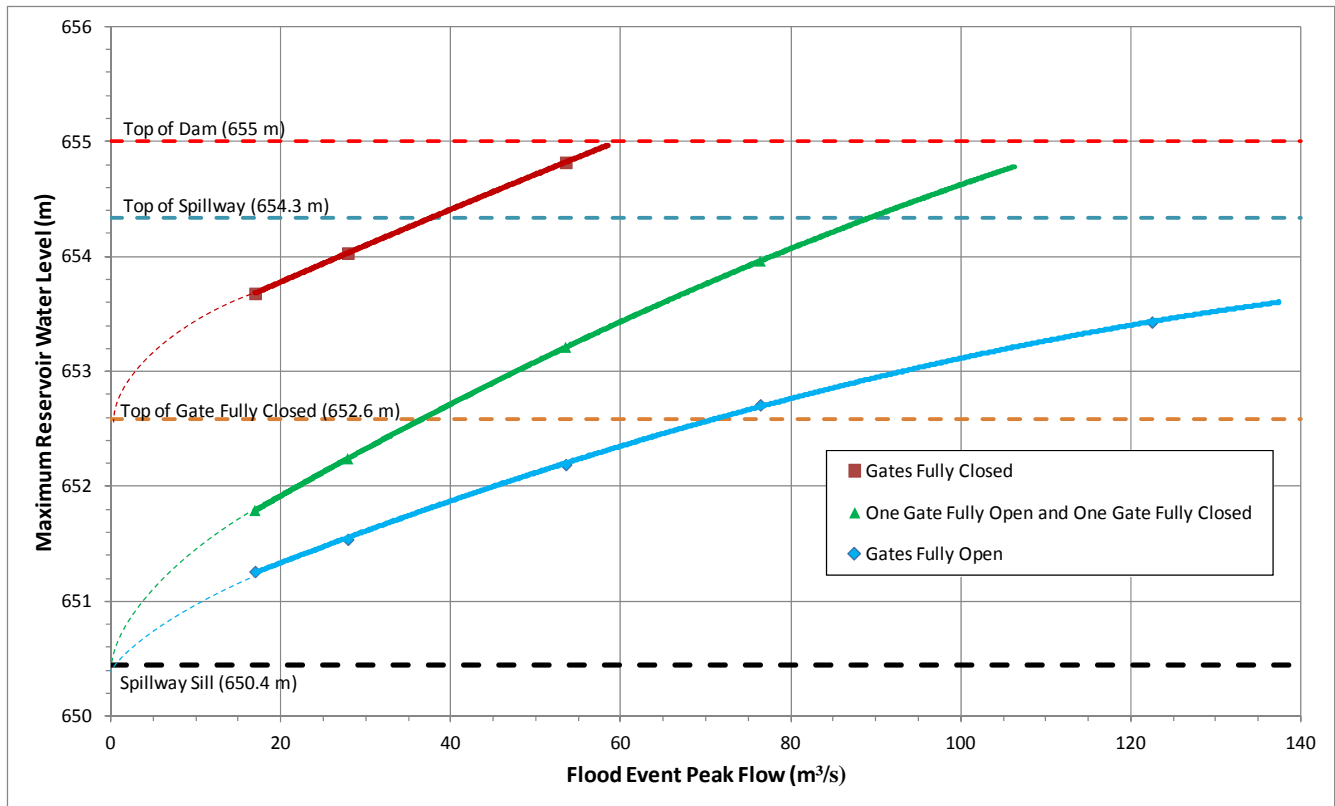


Figure 8: Estimated Reservoir Peak Levels

2.4.5 Reservoir Water Quality

There has been no water quality sampling of Grande Prairie Reservoir or Bear River upstream from the reservoir. In the absence of such data, a nutrient budget was developed with typical export coefficients to estimate mass loadings to the reservoir as a preliminary surrogate for reservoir water quality, and to identify the sources. Export coefficients are commonly used to estimate material export (kg/ha/yr) from various types of land use in the absence of detailed sampling results (Ryding and Rast, 1989).

Mass Loadings

Mass loadings were estimated for Total Phosphorus (TP), Total Nitrogen (TN), and Total Suspended Solids (TSS). The estimated mass loading to Bear Lake and Grand Prairie Reservoir are presented in Table 4, based on the selected export coefficients listed in Table 5.

Export coefficients were selected from information compiled by Alberta Environment for planning studies on land use changes (Jeje 2006). These coefficients were generally from studies on the Canadian prairies, but in a few cases they relied on published sources from the USEPA. Local rainfall patterns, farming practices, and other local observations were considered in selecting appropriate export coefficients for this basin.



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Table 4 - Mass Loading to Grande Prairie Reservoir

Areas Contributing to Grande Prairie Reservoir (not including the lake surface area of 0.16 km ²)	Area	TP	TN	TSS
	km ²	Mg/yr		
Agricultural	299	34.1	188.7	146,296
Saddle Hills (Forest)	90	1.3	22.5	2,250
Clairmont Urban	6	0.1	6.5	1,260
Grande Prairie Urban	8	0.9	2.9	701
Clairmont Sewage Lagoons	-	0.9	4.3	7.0
Clairmont Landfill (no discharge) ^a	-	-	-	-
Subtotal	403	37.3	224.9	150,514

Areas Contributing to Bear Lake (not including the lake surface area of 33 km ²)	Area	TP	TN	TSS
	km ²	Mg/yr		
Agricultural	855	85.5	540.6	419,115
Saddle Hills (Forest)	247	24.7	61.7	6,171
Saskatoon Hill (Partially Forested)	24	2.3	5.9	587
La Glace Sewage Lagoons ^a	-	-	-	-
Valhalla Centre Landfill ^a	-	-	-	-
Subtotal	1126	112.5	608.2	425,873
Total Contribution to Reservoir	1529	149.8	833.1	576,387

^a irregular, and small discharge from one landfill and other lagoon, no discharge from landfill, S. Madden (2011)

Table 5: Selected Export Coefficients

Category	Land Use	TP	TN	TSS
		(kg/ha/yr)		
Agricultural	Oil Seed Crops	1.4	6.8	-
	Cereal Crops	0.97	6	-
	Intensive Agriculture	-	-	4900
Forested	Aspen/Spruce	0.14	2.5	250
Urban	Residential Stormwater	0.22	10.3	2000
	Commercial Buildings	1.6	2.25	869
	Highways and Runways	3.5	5	2000
	Industrial	7.95	2.25	869
	Lawns and Golf Courses	0.19	1.52	208.6
	Forested Urban Park	0.14	2.5	250
	Parking Lots	1.6	2.25	2000

Note: Additional loading rates were estimated for the Clairmont sewage lagoon based on communications with D. Renwick at Aquatera Utilities. Bear Lake is expected to be a nutrient sink. Therefore, decay coefficients were estimated based on Walker (1996). Estimates do not account for possible release of nutrients from Bear Lake sediments.



Nutrients

The estimated total phosphorus and nitrogen loadings to Grande Prairie Reservoir are dominated by agricultural areas in the Grande Prairie Creek basin and areas East of Bear Lake. Agricultural runoff is estimated to contribute over 90% of the phosphorus and over 80% of the nitrogen loading to the reservoir, as shown on Figure 9 and Figure 10 respectively. The phosphorous loading, in particular, is a contributor to problems such as algae blooms.

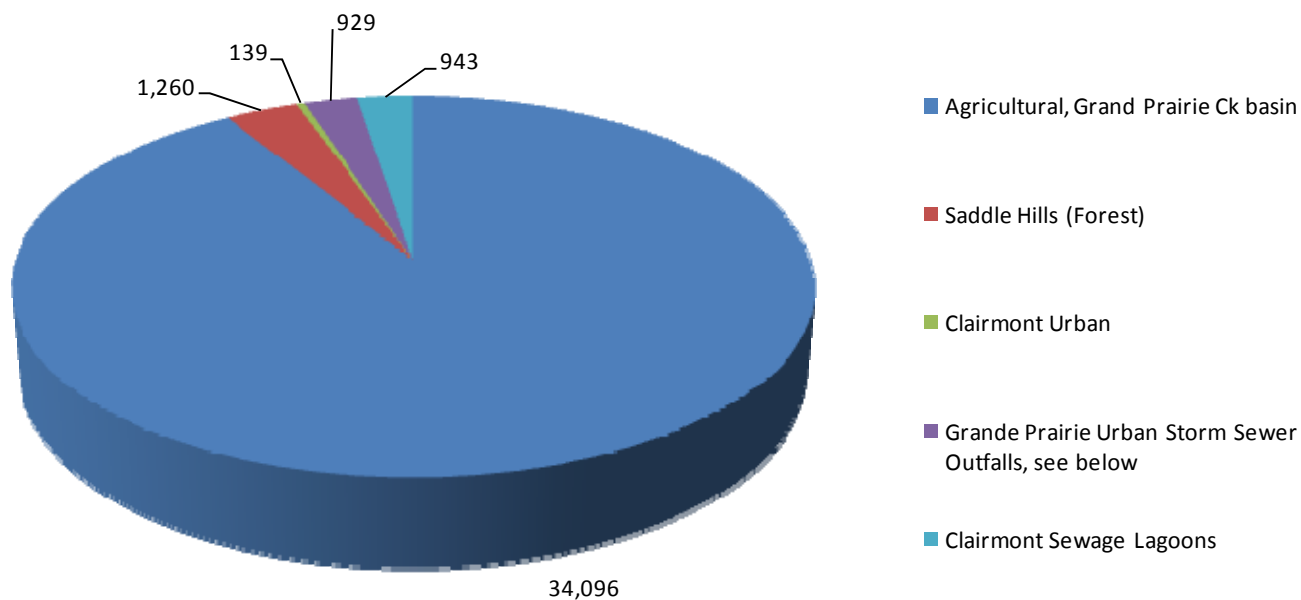


Figure 9: Total Phosphorus Loading to Grande Prairie Reservoir (kg/yr)

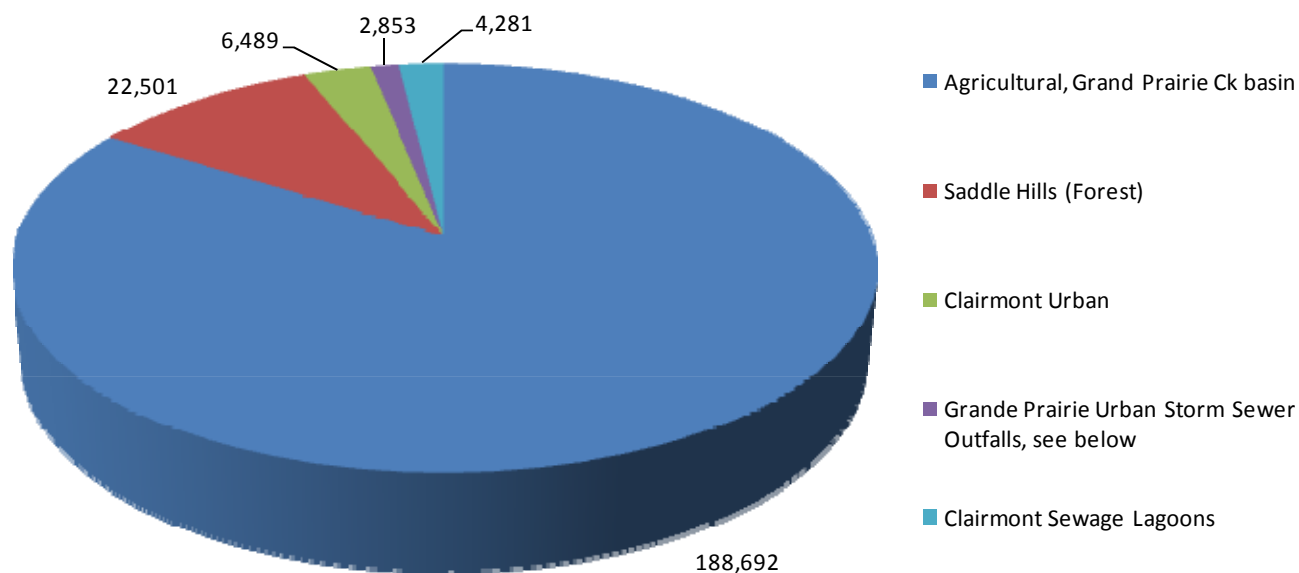


Figure 10: Total Nitrogen Loading to Grande Prairie Reservoir (kg/yr)



Suspended Sediment

The estimated mass loading of suspended sediment to Grande Prairie Reservoir, similar to nutrient loadings, is dominated by agricultural areas along Grande Prairie Creek and Bear River downstream of Bear Lake. Agricultural runoff and erosion of unstable stream banks are estimated to contribute 97% of the suspended sediment in the reservoir, as shown on Figure 11. The particle distribution of this sediment could not be estimated. However, the turbidity of water in Grande Prairie Reservoir is typically high with observed improvements in clarity near the dam.

Although suspended sediment can often diminish the quality and appearance of the water, it also provides a benefit by limiting the penetration of sunlight required for algae blooms. In other words, the high turbidity likely helps to prevent algae blooms in the reservoir.

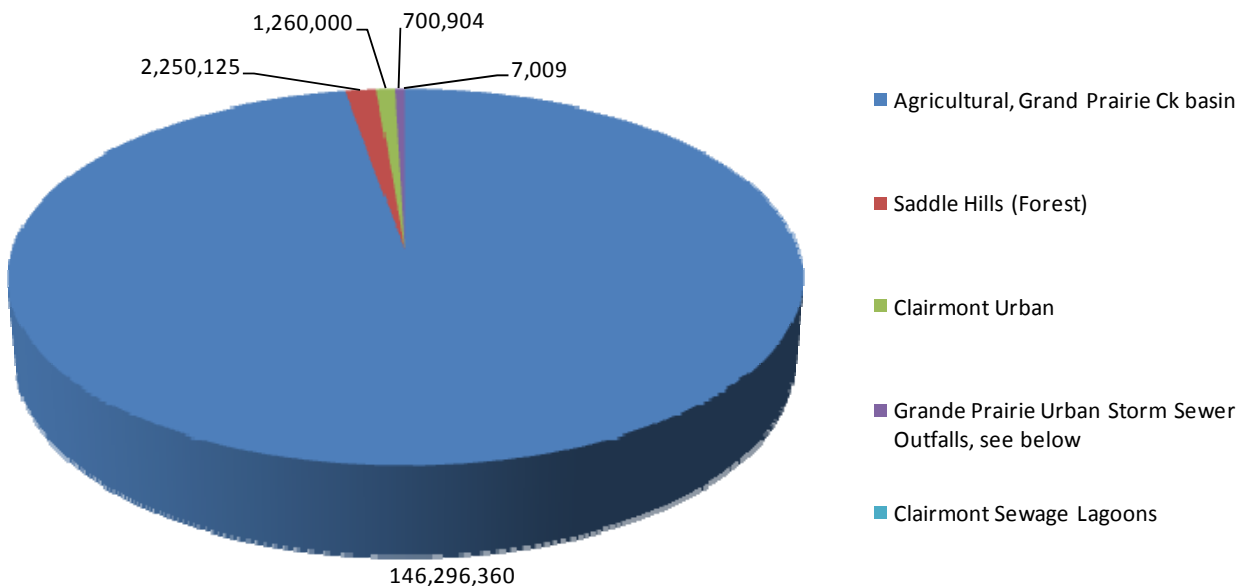


Figure 11: Total Sediment Loading to Grande Prairie Reservoir (kg/yr)

Algae

There is currently no information available to characterize the presence of algae blooms such as toxic blue-green algae. Anecdotal reports suggest that Grande Prairie Reservoir is relatively turbid for most of the open water season. If this is the case, then low clarity could be limiting the growth of aquatic macrophytes and algae in this reservoir. Large reductions in external sediment loading could improve clarity and allow more light penetration. This would promote the growth of aquatic plants and algae unless there are concurrent controls on nutrient loading to the reservoir.

2.5 Reservoir Benefits

The Grande Prairie Reservoir formerly served as a water supply reservoir for the City. Although the reservoir is no longer required for water supply, it provides a number of benefits. In some ways, the benefits may be limited by the existing conditions. For other aspects, it may be important to clarify the relative value of the reservoir. These benefits are described in the following sections, including:

- Downstream flood control benefits due to the operation of the dam;



- Downstream erosion control benefits due to the presence of the dam;
- Recreation uses, such as boating;
- Aesthetic value of a water body within a park setting;
- Nuisance odours arising from exposed sediment during low reservoir levels;
- Wildlife habitat provided by forested areas with access to water;
- Fish and fish habitat in the reservoir;
- Downstream Bear River fish habitat; and
- Upstream fish passage at the Bear River Control Structure.

2.5.1 Flood Control Benefits

The reservoir contributes negligible flood control benefits during a large flood. During a flood, the reservoir detention time is limited to a few hours. The outflows are therefore roughly similar to the inflows. However, the reservoir has the potential to exaggerate the flood peaks depending on the operation of the gates. If the gates are initially closed at the beginning of a flood, the City may be forced to open the gates rapidly to avoid overtopping the dam. A rapid opening of the gates may be similar to a dam breach flow downstream of the reservoir.

2.5.2 Erosion Control Benefits

The Bear River Control Structure is currently licensed as an erosion control dam. However, the structure does not provide a downstream erosion control benefit. It more likely results in additional downstream erosion by reducing the sediment supply to downstream areas. Rivers have a natural sediment regime with downstream transfers of sediment due to erosion and deposition. The dam likely disrupts these transfers to some extent, resulting in a gradual loss of downstream sediment. The loss of downstream sediment can accelerate down-cutting of the river bed. The effect of reservoir sedimentation on downstream erosion control was not quantified as part of this study.

The estimated loss of downstream sediment may be relatively small. About 10% of the sediment loading along Bear River seems to be captured by the reservoir (based on estimated sediment accumulation and TSS loading), although the sediment loss may be focused on sand and large silt particle sizes that are more likely to settle in the reservoir. This would skew the downstream sediment transfer towards fine particle sizes.

2.5.3 Recreation Uses

The primary recreational use of the reservoir is boating in summer. There is an existing boat launch for canoes and other small non-motorized craft, located across from the Rotary Campground. Other uses potentially include skating in the winter. The existing conditions, however, only facilitate boating at high water levels. The dam is currently operated near the top of the closed gates (FSL) in summer at 652.58 m to allow sufficient depth for boating. The reservoir has accumulated too much sediment to facilitate boating at normal water levels near the spillway sill at 650.44 m.

2.5.4 Aesthetic Value

Centennial Park derives a significant aesthetic value from the presence of the reservoir, due to the views from the pathways, and nearby properties. This value has not been quantified, but it is understood that the reservoir is an integral part of the Park.



2.5.5 Nuisance Odours

It is understood that several nearby communities periodically complain of unpleasant odours originating from the reservoir. The odours are assumed to originate from exposed mounds of sediment in the reservoir. Sediment is exposed during low water conditions in the spring, early summer, and fall.

2.5.6 Wildlife Habitat

From a terrestrial resources perspective (i.e., soils, vegetation, wildlife, biodiversity), the current state of the reservoir is relatively undesirable. Bare soils that are exposed when the reservoir is low are subject to drying and wind erosion. Fluctuating water levels also do not allow emergent and riparian vegetation to grow. The bare soils zone between the low and high water levels provides little benefit to wildlife and overall has very low biodiversity. A detailed baseline assessment of wildlife and migratory bird species was not conducted as part of this study.

2.5.7 Reservoir Fish and Fish Habitat

Historical fish inventory data in the Grande Prairie Reservoir is very limited. A study in 1983 reported the following species in the reservoir: brook stickleback, slimy sculpin, yellow perch and white sucker. The only sport fish identified is yellow perch although the current status of this species is unknown. No northern pike have been documented in the Reservoir or in Bear Lake.

2.5.8 Downstream Bear River Fish Habitat

Species that have been documented downstream of the reservoir in the Bear River include white sucker and brook stickleback. The most recent fish and fish habitat survey on record was conducted in 2001, and covered about 9 km of river downstream of the reservoir. It is very likely that the fish species documented downstream of the reservoir (white sucker and brook stickleback) can fulfill their life history requirements (i.e., spawning, egg incubation, rearing, feeding and overwintering) within the Bear River. For the operation of the reservoir, maintaining outlet flows based on run-of-river operation to approximate the inlet flows (+/- 15% of the inflow) should be sufficient to support the downstream fish community.

Regulators have previously asked the City to deliver 'adequate' flow to the Downstream Bear River. The quantity 'adequate' has not been defined. A common interpretation of 'adequate' is to maintain the normal distribution and timing of flows to downstream river reaches. The City normally releases flow to the downstream river roughly equal to the reservoir inflow, subject to a small reservoir evaporation loss which is unavoidable. The only exceptions occur when the reservoir level increases from the spillway sill to the top of the (closed) gates during the summer surcharge period, and subsequently lowered to the spillway sill in the fall.

2.5.9 Upstream Fish Passage at the Bear River Control Structure

A barrier at downstream culverts is likely the limiting factor restricting migratory fish movements in the Bear River system. Providing upstream passage at the reservoir would not likely be critical to sustaining these populations. The downstream fish species are likely limited in part by two culverts on the Bear River near its confluence with the Wapiti River. These culverts are very likely a barrier to upstream migration because the culverts are 192 m in length and there is a vertical drop of approximately 1 m at the downstream end of the culverts. As a result of these perched culverts, the potential upstream movement of northern pike from the Wapiti River is very unlikely.

Our understanding is that the City would not likely be asked to provide upstream fish passage at the Bear River Control Structure as a condition of approval for maintenance of reservoir sediment.



3.0 DISCUSSION OF ISSUES AND OPPORTUNITIES

3.1 Summary of Issues

There are a number of site-specific issues associated with the existing reservoir conditions, and the City has opportunities available to make improvements. Overall, operation of the reservoir is influenced by the upstream watershed in terms of the water quality and distribution of flows as illustrated on Figure 12.

Reservoir water quality is characterized by high nutrient and sediment loading from upstream agricultural areas. The reservoir also receives stormwater directly from several outfalls and is therefore providing some pre-treatment of stormwater prior to the downstream Bear River. The high nutrient loading greatly increases the chance of algae blooms. However, the potential for algae blooms seems to be mitigated by high turbidity in the reservoir. Sunlight is required for most aquatic plants to thrive, and the high turbidity restricts sunlight penetration to the reservoir.

At the reservoir, high sediment loading over the years has resulted in sediment accumulation in the reservoir, including mounds of exposed sediment at low water levels. The estimated total sedimentation is about 600,000 m³. At reservoir levels at or below the spillway sill (650.44 m), the exposed sediment creates a nuisance odour and the City receives complaints from nearby residents. The sediment and remaining shallow water also limit the recreation use of canoes on the reservoir.

To date, the City has responded to the sediment issues by operating the reservoir at higher levels in summer. While this prevents the summer odour issue and creates a relatively stable water level for boating, the City must operate the dam with the gates closed. By operating at a high level with the gates closed, the City increases the risk of dam overtopping during a large flood if the gates are not opened quickly.

The upstream Bear Lake also has a tremendous influence on the reservoir by reducing the flood peak by more than 50%. However, Bear Lake also increases the effect of dry periods due to lake evaporation. The lake is relatively large, and low water levels on Bear Lake will prevent a large portion of the watershed from discharging to the reservoir. The result of this evaporation loss at Bear Lake is about 20% of the year with negligible reservoir inflow.

Regulators have requested that the City release 'adequate' flow to the downstream Bear River. However, the quantity has not been defined. Releases to the downstream Bear River from the dam are normally equivalent to the reservoir inflows. The reservoir is simply too small to affect the distribution and timing of downstream flow. This is characteristic of run-of-river dams. However, because of upstream watershed characteristics such as the presence of Bear Lake, this also results in negligible flow to downstream areas for several months of the year because the reservoir inflows are essentially zero for up to 20% of the time.

The key issues for management of the Grande Prairie Reservoir are sedimentation and nutrient loading. Sedimentation is a maintenance issue for the City, and the high nutrient loading will limit the recreational use of the reservoir (e.g. swimming). Depending on the selected management strategy, the City may be able to provide a relatively stable water level for boating. These issues are illustrated on Figure 13.

3.2 Management Objectives

The reservoir management opportunities vary considerably, depending on the preferred capital investment and ability to conduct regular maintenance. It is possible to provide a deep reservoir for boating. It is possible to provide a relatively stable water level. It is also possible to reduce the nutrient loading.



Overall, the opportunities to achieve the City's development objectives are:

- A reservoir restoration strategy to enhance water quality may reduce the nutrient loading but is not likely to alter the overall character of the reservoir water quality;
- An erosion control and bank stabilization program may reduce the sediment loading but is unlikely to make a significant change in the rate of reservoir sediment accumulation;
- Active recreation such as boating, swimming, and skating within the reservoir – can be achieved for boating, and for skating (if skating conditions with 0.3 m minimum ice thickness were possible in the past), but not likely for swimming due to the seven stormwater outfalls that discharge to the reservoir;
- Maintaining a permanent water level within the reservoir is possible at high water levels with active gate management, but is more easily achieved if flood levels are allowed to vary by operating at low water levels near the spillway sill elevation (650.44 m); and
- Increasing the wildlife habitat around the reservoir can be achieved by selecting a permanent normal water level – the existing seasonal change between 650.44 m and 652.58 m is very limiting on wildlife habitat due to the resulting lack of littoral and riparian vegetation.

3.3 Potential Management Strategies

Strategies that the City could pursue are illustrated on Figure 14 and further discussed in the list below:

- Operate seasonally at a high level, as per existing operations. This option may mitigate summer odour complaints by operating seasonally at a high level, and the high level will provide a relatively stable environment for recreation use. However, sediment will continue to accumulate while the reservoir level is high. The sediment will be subsequently exposed each fall when the reservoir level is lowered for winter.
- Operate permanently at a high reservoir level, taking advantage of recent gate improvements to withstand winter ice. This will allow the sediment to further accumulate and reduce the effectiveness of gate releases during large floods. Eventually, sediment will need to be removed from the gate area. We anticipate that sediment will accumulate to the top of the gates in about 5 years if the dam is operated permanently at a high level.
- Operate permanently at a low reservoir level to avoid risks of overtopping the dam and further sediment accumulation, by allowing the sediment loading to flush through the reservoir. This strategy will not provide an opportunity for boating, but the current nuisance odour problems could be mitigated if the exposed sediment is reclaimed.
- Re-grade a limited amount of sediment within the reservoir and reclaim the exposed sediment mounds. Early indications are that it will be feasible to relocate sediment within the reservoir, operate the reservoir at a low level year-round, and reclaim the exposed sediment to create islands. This would allow the City to operate at a lower reservoir level for dam safety purposes while providing recreation opportunities for boating. It would also resolve the nuisance odour issues, create new wildlife habitat, and provide fish habitat diversity. The aesthetic value of Centennial Park may also be augmented. Regular maintenance may still be required every 20 years on average, to remove sediment from the remaining open water areas.



RESERVOIR FEASIBILITY STUDY

- Remove the sediment and haul to a deposition area. This could be considered as the default strategy to provide regular maintenance by removing the sediment. It's the selected approach for similar lakes such as Chestermere Lake near Calgary. Regular maintenance of the reservoir sediment is required, although the time interval between major maintenance actions depends on the sedimentation rate. In the case of Grande Prairie Reservoir, sediment would need to be removed every 50 years. We anticipate that up to 600,000 m³ of sediment may need to be removed. This is an estimate, as we do not have access to information regarding the pre-disturbance topography. There is no convenient short haul site to deposit the sediment. Together, the quantity and haul distance may result in a relatively high cost for this strategy.
- Remove the dam and restore the river valley. This option has become common-place in the US, but not yet in Canada. It would involve removing the dam, and then removing or stabilizing the accumulated reservoir sediment. We understand that, as a park setting, the reservoir has become an integral part of the park experience. We have therefore not investigated this option.
- Improve the release of adequate flow in summer by adjusting the spillway configuration near the gate. During summer low flows, the downstream release may be zero for a duration of one or more weeks in the summer if the reservoir is operated near the spillway sill elevation. The impact of this on downstream reaches of Bear River was not defined. However, it is assumed that zero summer flow to the downstream Bear River is undesirable to the City and to regulators. The City may consider an adjustment to the spillway configuration as a mitigation to avoid zero releases. The adjustment would consist of an additional 'lip' to the spillway sill at one gate complete with a low flow notch. Therefore, the normal water level would be raised slightly and the reservoir would continue to flow out at a defined rate. This would provide a downstream base flow and reduce the overall duration of zero release.
- Implement a watershed management plan to reduce the nutrient and sediment loading to the reservoir. In addition to the direct intervention measures listed above, watershed management programs such as bank stabilization and riparian setbacks may reduce the loading of nutrients and sediment to the reservoir. Other measures could include pre-treatment stormwater ponds for the two outfalls upstream of the reservoir. This would be done to improve the overall water quality in the reservoir and to potentially slow the rate of sedimentation. However, we do not anticipate that these efforts would result in a measurable change of water quality.



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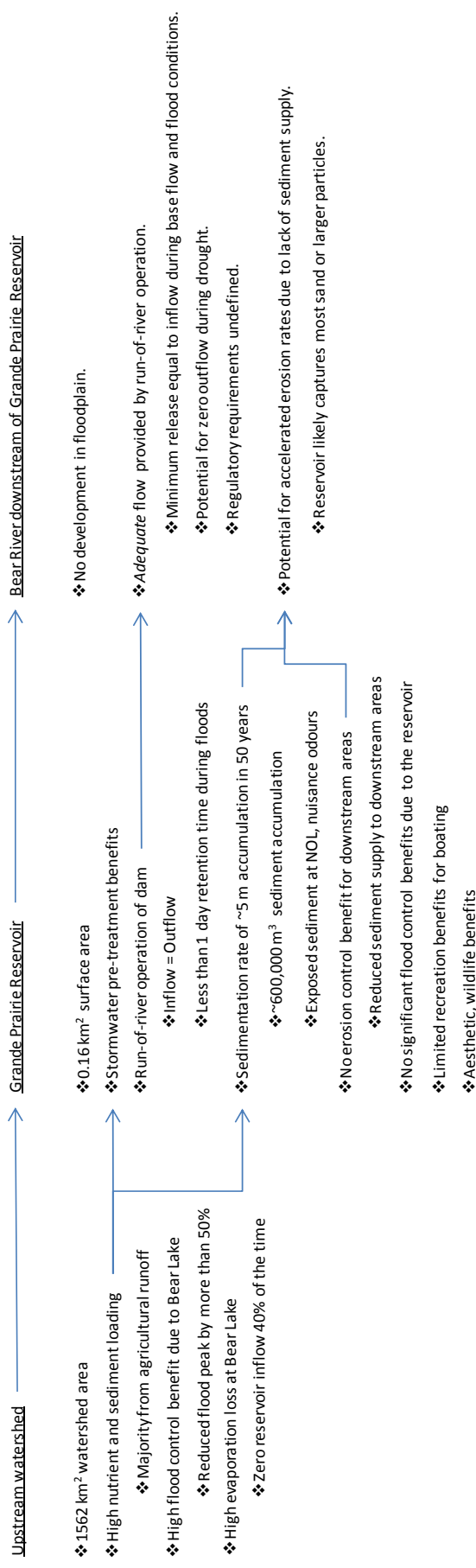


Figure 12: Summary of Existing Conditions



RESERVOIR FEASIBILITY STUDY

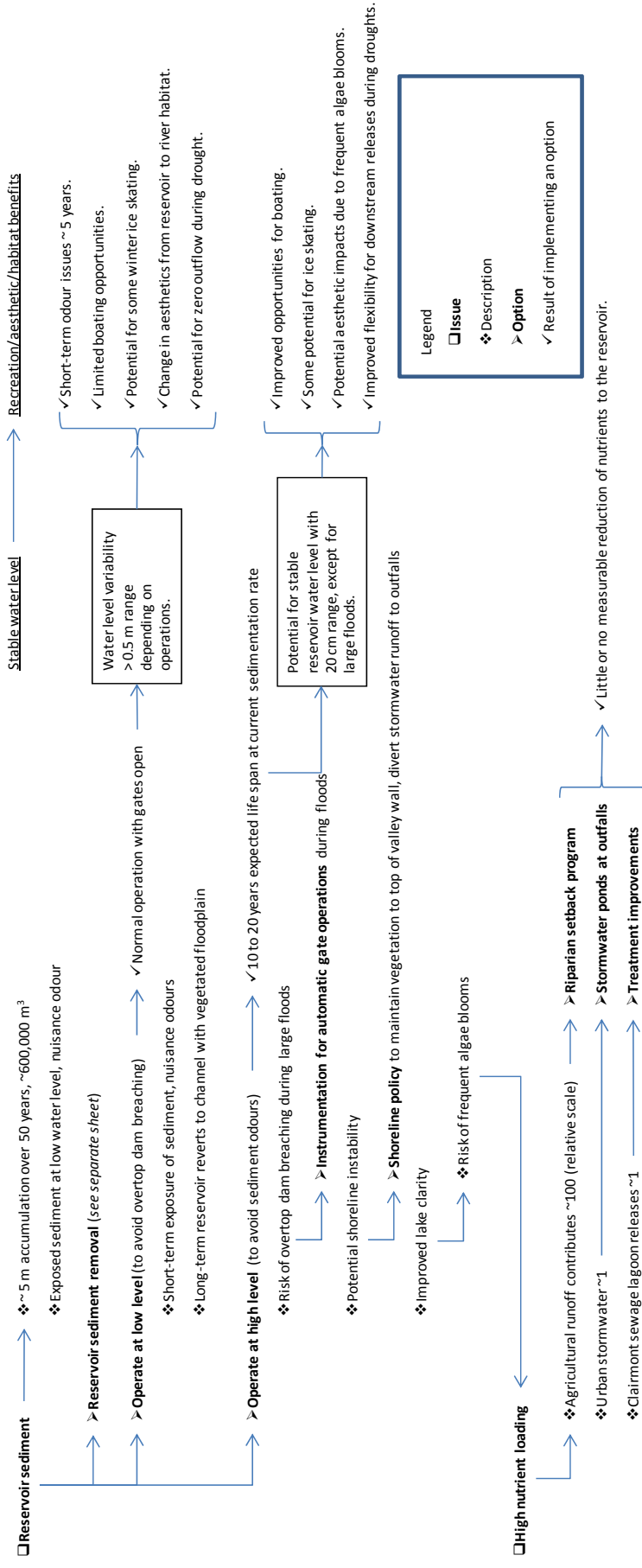


Figure 13: Reservoir Management Issues and Opportunities



RESERVOIR FEASIBILITY STUDY

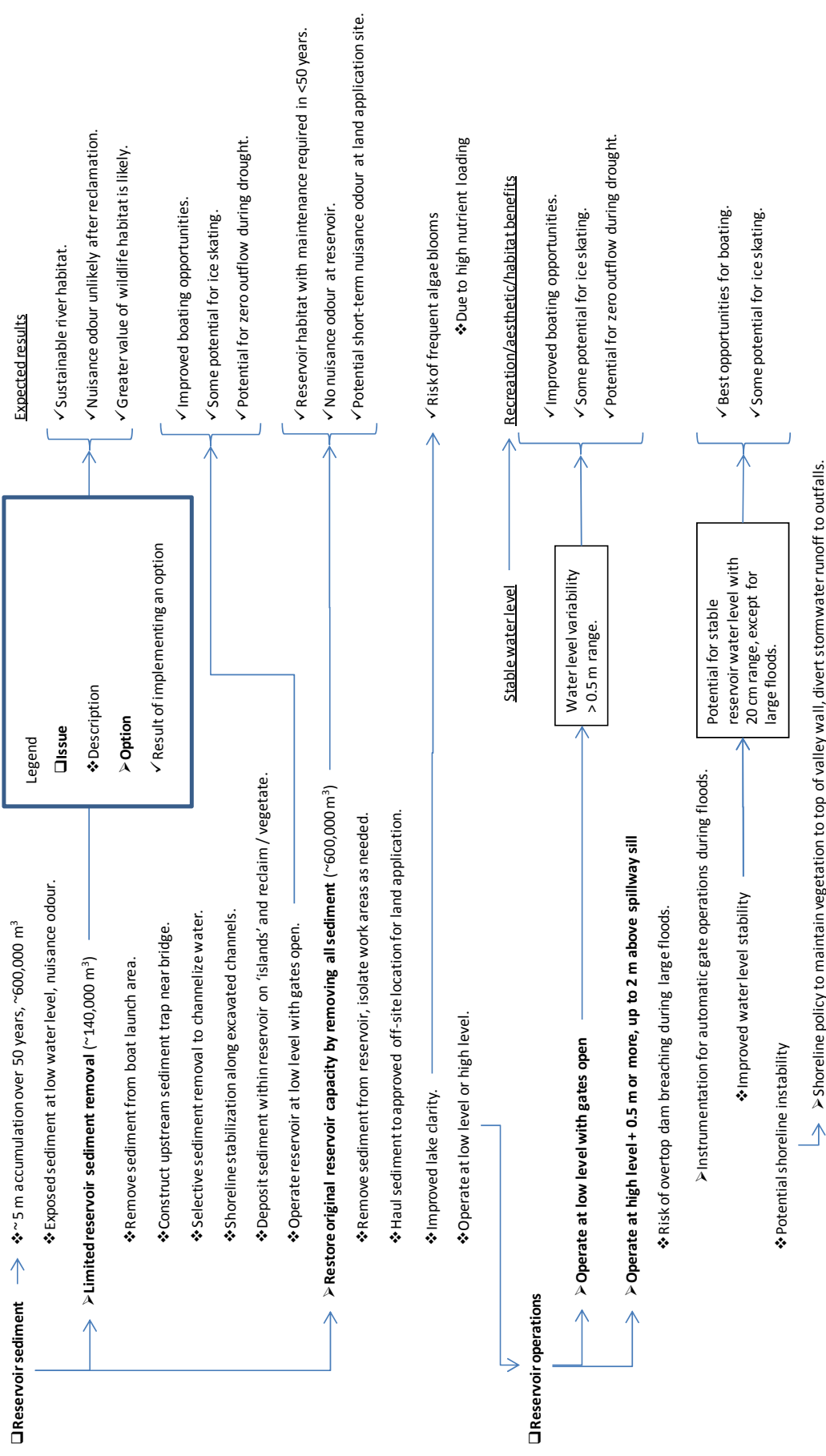


Figure 14: Reservoir Sediment Management Options.



4.0 RESERVOIR MANAGEMENT OPTIONS

Four main reservoir management options were identified from the discussion of issues and opportunities:

- Continue to operate seasonally or permanently at a high reservoir level;
- Operate permanently at a low water level;
- Re-grade reservoir sediment and operate at a low reservoir level; and
- Remove reservoir sediment and operate at a low reservoir level.

4.1 Continue Existing Operations

Summary of Existing Operations

Current operations consist of the following gate operations:

- Winter period reservoir levels at the spillway sill (650.44 m) with the gates fully open;
- Gates closed after spring freshet to raise the reservoir level up to the top of the closed gates (652.58 m), thereby inundating the reservoir sediment. One gate may remain slightly open to provide a small (undefined) riparian release;
- Gates opened as needed in the summer during flood emergencies, opened manually based on observations of City staff; and
- Gates opened in the fall to release water and draw down the reservoir level to the spillway sill for winter operations.

Similarly, the City may choose to operate permanently at a high reservoir level with the gates closed. This option is possible due to recent improvements to the gates. We understand from the City that the gates have been strengthened to withstand winter ice conditions at water levels near the top of the closed gates.

Potential Operating Risk during Floods

Operating at or above the top of the closed gates in summer creates a risk of dam overtopping if the gates are not opened in a timely manner during a large flood. Without opening the gates, the dam would overtop during the 10-year return period flood. During a large flood, similar to the flood that occurred in 1990 (approximately the 100-year return period flood), the dam would overtop if the gates are not opened quickly. Likewise, opening the gates relatively late or too quickly may cause the downstream flood peak to be exaggerated. Overtopping of the dam may result in a breach and loss of the structure.

To operate at a high level in summer, instrumentation should be installed to monitor and operate the gates automatically and/or remotely, and City staff may need to be allocated for flood operations.

Reservoir Sediment

The reservoir sediment, in places, has accumulated to a level equal to the top of the gates. It is therefore starting to be exposed during summer operations despite the operation of the reservoir with the gates closed. Continuation of existing operations will allow sediment to further accumulate in summer. Sediment will become increasingly exposed. Nuisance odours will likely become increasingly common despite the high reservoir level in summer.



Stable Water Level

With appropriate operating procedures, a stable water level could be maintained within a 20 cm range for most flood events. However, this would require constant adjustments to the gate settings to manage variable reservoir inflows.

Nuisance Odours

Operating at a high water level in summer will minimize the exposure of sediment to the air, reducing the nuisance odours in the short term. However, due to gradually increasing sediment exposure, long term nuisance odours will remain an issue.

Recreation Uses

High summer water levels currently provide very limiting boating opportunities on the reservoir due to reservoir sedimentation near the boat launch. Continuing these existing operations will provide minimal recreational benefit for boating.

Wildlife Habitat

The current conditions are not preferable for wildlife habitat. This is because the wide range of water levels between summer normal and winter normal levels has prevented emergent littoral and riparian vegetation to grow, a limiting factor for wildlife habitat and biodiversity.

Operating the reservoir permanently at a high water level may have some benefit from a terrestrial perspective. Stable water levels would be maintained, allowing emergent and riparian vegetation to grow, creating wildlife habitat and increasing biodiversity relative to existing seasonal water level changes.

Fish and Fish Habitat

The current operations provide fairly poor habitat conditions for fish in summer due to the shallow depth and lack of habitat diversity. The winter operations also likely provide poor over-wintering habitat due to reservoir drawdown and corresponding exposure of sediment in a significant portion of the reservoir. There would be no benefit to continuing to operate in this way, from a fisheries perspective.

Operating permanently at a high water level would likely provide some fisheries benefit by increasing the potential for fish overwintering in the reservoir.

Life Span

Current operations may continue for up to 5 years, but long-term use of the existing operating strategy will eventually fail. The current reservoir operations are not sustainable. Sediment will continue to accumulate in summer until gate operations are compromised by sediment deposits near the gates. At first, the sediment in front of the gates will tend to be flushed downstream when the gates are opened. Eventually, the sediment will start to control the upstream water level. At that time, gate operations may not be sufficient to prevent overtopping failure of the dam during a large flood.

Cost

The cost of this option is zero in terms of planned capital improvements, but the annual sediment maintenance cost will gradually increase each year to maintain an open waterway upstream of the gates. Eventually, the risk cost of this option will include an uncontrolled overtopping of the dam. The instrumentation cost for the gates were not estimated as part of this study, but likely costs between \$100,000 and \$200,000.



4.2 Operate at Low Water Level

Description

The option to operate at low water levels would gradually transform the reservoir into a river environment upstream of the dam. The option would consist of the following changes:

- Permanent normal water level (target) near the spillway sill, with one gate fully open and one gate fully closed. The open gate would release water from the reservoir as a run-of-river operation with the releases roughly equal to the inflows. Therefore, the reservoir would have a stable water level slightly above the spillway sill for normal flow conditions. Flood flows would result in higher water levels. For large floods, a high water level trigger would be used to signal the second gate to open. Gate operations would be required for the second gate about once every 10 years after water levels exceed a pre-determined threshold.
- Stabilization and reclamation of the exposed sediment in the reservoir, reclaiming up to 10 ha of exposed sediment by planting trees, shrubs, and grass. By operating at a lower level, a large area of sediment would be exposed in the reservoir. These areas would need to be reclaimed to avoid nuisance odours.

Potential Operating Risk during Floods

Operating with one gate fully open and one gate fully closed creates a risk of dam overtopping if the remaining closed gate is not opened in a timely manner during a large flood. With only one gate open the dam would overtop during the 50-year return period flood.

Future Reservoir Sediment Conditions

The reservoir would continue to accumulate sediment until a stable river habitat is formed upstream of the dam. The reservoir would stabilize when the water is sufficiently shallow to flush excess sediment downstream of the dam during floods.

Stable Water Level

A stable water level would prevail, with a normal range from 0.11 m below the spillway sill to about 1 m or more above the spillway sill during floods.

Nuisance Odours

Operating at a low water level will result in the exposure of sediment to the air, which will not improve the nuisance odours in the short term. The areas of exposed sediment would be reclaimed to reduce or eliminate nuisance odours in the long term.

Recreation Uses

This option would provide a stable water level but would not provide boating opportunities as the boat launch would likely be inundated with sediment and open water areas would likely be too shallow for boating.

Wildlife Habitat

A permanent normal water level with normal fluctuations for floods and droughts would allow littoral and riparian vegetation to become established along the margins of the reservoir, and reclamation of exposed sediment would create islands in the reservoir. This would provide a net benefit to wildlife by providing new access to diverse habitat near water. The potential wildlife habitat benefits may be similar to the next option to re-grade the reservoir sediment.



Fish and Fish Habitat

Similar to wildlife habitat benefits, operating at a low water level on a permanent basis would likely improve the fish habitat by providing vegetated littoral and riparian habitat. However, the overwintering habitat would continue to be limited and the reservoir would eventually provide river habitat only – similar to upstream Bear River.

Life Span

This option is a permanent solution with little or no maintenance expected, except for periodic clearing of debris in front of the gates. In the long term, the reservoir would revert to river habitat.

Cost

This option would likely cost about \$300,000 depending on the selected species and temporary access requirements. The costs include the following:

- Reclamation costs of about \$100,000; and
- Shoreline stabilization costs of about \$200,000 to install gravel substrate along select locations up to 500 m in length within the reservoir.

The cost estimate does not include the potential cost of adding an optional 'lip' with a low flow notch to the spillway structure.

4.3 Re-grade Reservoir Sediment

Design Concept

The design concept for this option is to operate the reservoir at a low level near the spillway sill, and to re-grade the reservoir sediment within the existing reservoir footprint. The sediment would be contoured to create a combination of deep water areas and islands, thereby avoiding a long haul to a deposit location that has not yet been identified. The design concept is illustrated on Figure 15.

This option expands on the previous low water option (i.e. Option #2) by creating deep water areas for boating. Up to 140,000 m³ of sediment would be dredged and deposited onto reservoir areas that already have exposed sediment at low water. In particular, the sediment would be removed from the middle of the reservoir to create the deep water areas between 3 m and 1 m deep, extending from the dam upstream to the boat launch and further to the pedestrian bridge. The sediment would be stacked on islands that would be reclaimed with trees, shrubs, and grass. The islands would set back from the existing forested valley walls, allowing shallow 'streams' along the margins of the reservoir. At two locations along the valley wall, the concept includes a large boulder barrier to prevent high flows from washing out or accumulating sediment along constructed side channels such as near the boat launch.

A gate operation protocol similar to Option #2 would be implemented, regularly having one gate fully open and one gate fully closed. During flood events a high water level trigger would be used to signal the second gate to open. Gate operations would be required for the second gate about once every 10 years after water levels exceed a pre-determined threshold.



RESERVOIR FEASIBILITY STUDY

The construction method will need to be confirmed later, but there are several possible methods and at least some are expected to be feasible. The hauling option, using large excavators and trucks, will require water management methods to dewater the bottom of the reservoir, and the sediment deposits will need to be trafficable for trucks. For a dredging option to be feasible, we may need to confirm that the dredged sediment deposit can be stacked at a reasonable slope. Another method would dredge material from the bottom of the reservoir, filter the sediment laden water through Geotubes (i.e. similar to long socks), and stack the Geotubes filled with sediment on the islands. This, or similar methods, would be used if the sediment does not stack naturally at 4H:1V slope or similar.

Potential Operating Risk during Floods

Operating with one gate fully open and one gate fully closed creates a risk of dam overtopping if the remaining closed gate is not opened in a timely manner during a large flood. With only one gate open the dam would overtop during the 50-year return period flood. Management measures will be needed to ensure that the closed gate is opened after the water level exceeds a defined threshold.

Future Reservoir Sediment Condition

The reservoir would continue to accumulate sediment in the open water areas, similar to existing sedimentation rates.

Stable Water Level

A stable water level would prevail, with a normal range from 0.11 m below the spillway sill to about 1 m or more above the spillway sill during floods.

Nuisance Odours

The sediment islands would be reclaimed, mitigating the nuisance odours that currently occur. The reclamation is possible because of the stable water level.

Recreation Uses

Boating would be facilitated in the open water areas, which are likely to be about 0.06 km² compared to the original 0.16 km² reservoir area. The open water area includes a fetch length of about 300 m, plus additional meandering portions of the reservoir where boating is likely possible.

Wildlife Habitat

The extent of emergent and riparian vegetation zones will be greatly increased by operating the reservoir at a stable but lower level and by re-grading the reservoir sediment to form a variety of islands, peninsulas, bays and channels. The islands will create areas that are relatively free of terrestrial predators, a benefit to ground-nesting birds including waterfowl. The sinuosity of the channels will create visual barriers that will increase habitat security for nesting waterfowl and other wildlife. As well, migrating birds will likely make greater use of the reservoir if islands are developed within the reservoir – a significant benefit because Grande Prairie lies in the Rocky Mountain Flyway for birds migrating between southern climes and northern breeding areas.

Stable shorelines could allow beavers to create bank burrows along the channels without the necessity for dams. Stable emergent vegetation zones will provide feeding habitat for waterfowl and aquatic rodents like muskrat. Increased wildlife habitat availability and wildlife diversity will provide benefits to small carnivores like mink and weasels. Overall, this option will increase biodiversity substantially relative to the existing conditions. These benefits could include benefits to provincially and federally listed species at risk.



Fish and Fish Habitat

Re-grading the sediment will likely provide a benefit to the fish within the reservoir by providing vegetated littoral and riparian habitat. Gravel bed side-channel streams, constructed along the valley walls, have also been identified as features in this design option that may provide additional habitat benefits.

Life Span

This option will likely require maintenance to remove about 100,000 m³ of sediment from the open water areas every 20 to 30 years on average.

Cost

The capital cost of this option is expected to be about \$2.1 million, based on typical bid costs at a unit rate of \$15 per m³ for dredging reservoirs (source: Wagner 2004 plus experience with previous dredging projects in Alberta).



4.4 Remove Reservoir Sediment

Design Concept

The design concept for this option is to remove the reservoir sediment and to operate the reservoir at a low level near the spillway sill. The reservoir sediment that has accumulated over the years would be removed, returning the reservoir to a similar open water condition as compared to the original dam and reservoir constructed over 60 years ago. By removing the sediment, open water areas will be restored to a depth ranging from 5 m near the dam to about 1 m near the upstream highway bridge. The concept is illustrated on Figure 16. A suitable construction method will need to be identified, similar to Option #3.

The quantity of sediment to be removed is about 600,000 m³, based on the estimated natural channel gradient and the available LiDAR topographic information for existing conditions. Original ground contour information was not available. The sediment will need to be hauled off-site to a deposit location that has not yet been identified. The ideal location for such a large quantity is an existing pit or ground depression.

Potential Operating Risk during Floods

Operation of the gates would likely be similar to the re-grade sediment option (Option #3) or the option to operate at low water levels (Option #2), whereby one gate would remain open and one gate would remain closed except during large floods. Gate operations would be required for the second gate about once every 10 years after water levels exceed a pre-determined threshold.

Operating with one gate fully open and one gate fully closed creates a risk of dam overtopping if the remaining closed gate is not opened in a timely manner during a large flood. With only one gate open the dam would overtop during the 50-year return period flood. Management measures will be needed to ensure that the closed gate is opened after the water level exceeds a defined threshold.

Future Reservoir Sediment Conditions

The reservoir would continue to accumulate sediment in the open water areas, similar to existing sedimentation rates.

Stable Water Level

A stable water level would prevail, with a normal range from 0.11 m below the spillway sill to about 1 m or more above the spillway sill during floods.

Nuisance Odours

The removal of the reservoir sediment would eliminate the nuisance odours at the reservoir location over the long term. However, short term nuisance odours at the sediment deposition location would be expected until the sediment surface is reclaimed.

Recreation Uses

The removal of the sediment would allow for significant benefits to recreation on the reservoir; increasing the area for boating to nearly 0.16 km².



Wildlife Habitat

The stable water levels created by this option would allow emergent and riparian vegetation to grow, eliminating the potential for soil erosion and creating wildlife habitat and increasing biodiversity relative to the status quo. However, the areal extent of emergent and riparian vegetation zones in this option is less than in the re-grading sediment option, which results in less benefit to wildlife habitat and biodiversity.

Fish and Fish Habitat

Fish habitat would be improved by providing over-wintering habitat in deep open water areas.

Life Span

This option will likely require maintenance to remove up to 600,000 m³ of sediment every 50 years on average.

Cost

The cost of this option is expected to be about \$12 million, based on a unit rate of \$20 per m³ including an allowance for long distance haul. The cost depends on the selected deposit location and haul distance for sediment from the reservoir.



5.0 COMPARISON OF OPTIONS

The options presented in this report offer some tradeoffs for the City to consider. Primarily, the cost of removing some or all of the sediment provides some benefit in terms of boating, wildlife habitat, and a likely reduction of nuisance odour complaints. There are several options for achieving these benefits, and further tradeoffs among them.

The least cost option is to reclaim the existing sediment and operate at a low water level, although this would provide no opportunity for boating. Boating opportunities come at a cost to remove or relocate the reservoir sediment that has accumulated over the past 60 years. The cost will vary between \$2.1 million and \$12 million depending on the selected configuration, and these options will require further maintenance in the future after the reservoir accumulates additional sediment. The options are summarized in Table 6.

We understand that the City has a preference, on a preliminary basis, for Option #3 to re-grade the sediment within the reservoir. This preliminary preference was based on the discussion of issues and opportunities in Chapter 3. Whether this preference holds will depend on further discussions by the City. The preference for re-grading the sediment is illustrated on Figure 17, based on the assumed relative importance (weights) included with Table 6. Option #2 to operate at low levels would be preferred, as shown on Figure 18, if the *Capital cost* and *Life span* decision criteria had a relatively high importance rating of three (3). The relative performance calculations follow the compromise analysis (distance metric) methodology, a standard multi-criteria decision analysis technique.

Table 6: Comparison Summary for Selected Options.

	Units	Worst	Ideal	Options				Assumed Relative Importance
Decision Criteria	-	-	-	Continue Existing Operations	Operate at Low Levels	Re-grade sediment	Remove Sediment	
Capital Cost	\$ millions	12	0	0.2	0.3	2.1	12	1
Life Span	Years	0	50	5	50	20	50	1
Return Period Flood Control Benefit	Years	0	50	10	50	50	50	1
Erosion Control Benefit	Positive (0 to 1)	0	1	0	0.2	0	0	0
Boating Use Benefits	Positive (0 to 1)	0	1	0	0	1	1	1
Nuisance Odour Complaints	Negative (0 to 1)	1	0	0.5	0	0	0	1
Aesthetic Value	Positive (0 to 1)	0	1	0.2	0.6	0.8	0.8	1
Wildlife Benefits	Positive (0 to 1)	0	1	0	1	1	0.5	1
Reservoir Fish and Fish Habitat Benefits	Positive (0 to 1)	0	1	0	0.2	1	0.5	1
Downstream Fish and Fish Habitat Benefits	Positive (0 to 1)	0	1	0	0	0	0	0

Note: Return period flood control benefit assumes no gate operations in response to a large flood.



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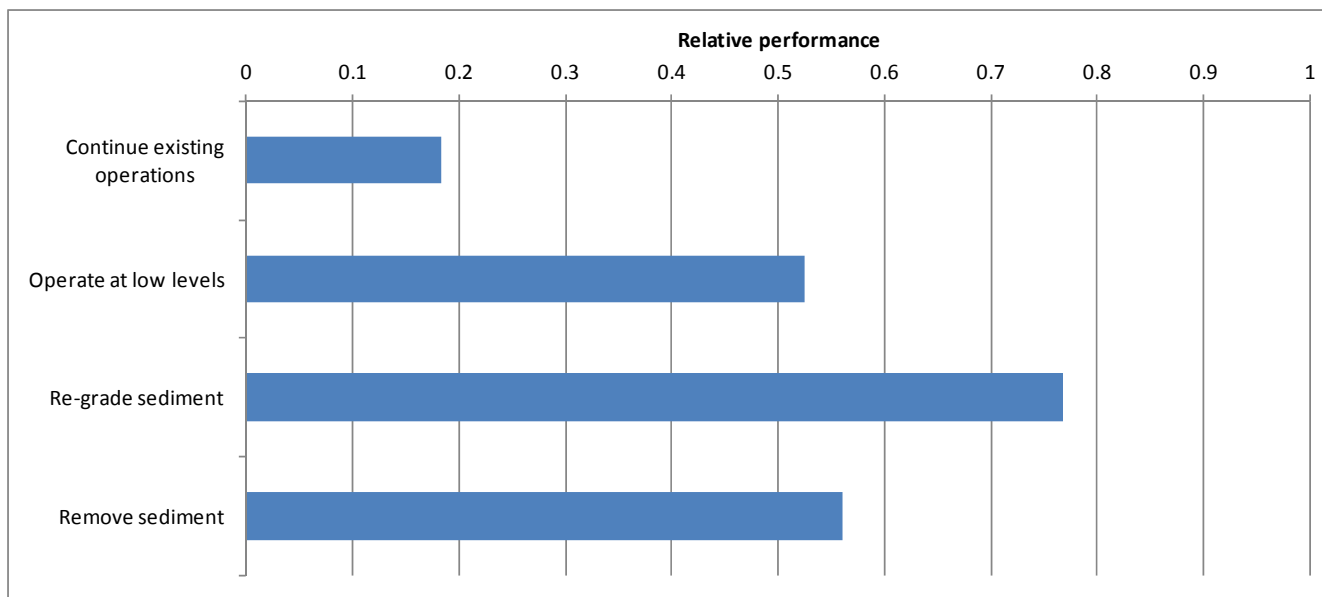


Figure 17: Relative Performance of Selected Options with Similar Importance to Economic and Socio-Environmental Criteria

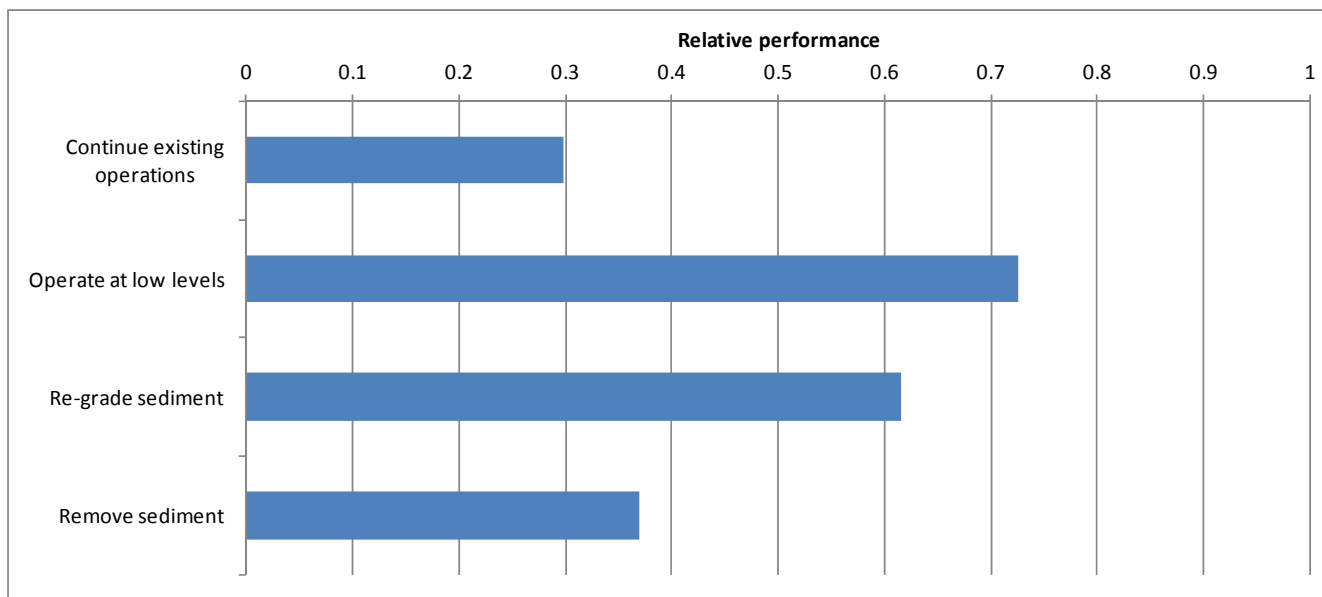


Figure 18: Relative Performance of Selected Options with High Importance Assigned to Cost and Life Span



6.0 RECOMMENDED NEXT STEPS

6.1 Overview

The following sections describe the recommended next steps for the City, assuming that the preferred option will be Option #3 to re-grade the reservoir sediment within the limits of the reservoir. However, many of the next steps are common among all of the options.

The next steps are:

- Select a preferred option, based on tradeoffs among costs and benefits;
- Implement management measures related to Bear River Control Structure:
 - Conduct a dam safety review;
 - Implement a reservoir operating policy for floods;
 - Update the emergency preparedness and response plans;
 - Install instrumentation to monitor reservoir water levels;
 - Identify suitable off-site sediment disposal locations for future maintenance; and
 - Implement a watershed management plan to coordinate activities and best practices within the Bear River watershed that may affect reservoir water quality, sediment loading, or Bear River stream flow.
- Conduct field studies to address key data gaps:
 - Survey the reservoir bathymetry to improve the estimate of earthworks required for sediment removal;
 - Fish habitat assessment and inventory to establish existing baseline characteristics for the reservoir prior to implementing the preferred option;
 - Water quality sampling to establish existing baseline characteristics prior to implementing the preferred option;
 - Reservoir sediment geotechnical testing to help determine an appropriate construction method for sediment removal and disposal; and
 - Reservoir sediment chemistry testing as part of an assessment for the disposal and reclamation of reservoir sediment.
- Feasibility level design of the preferred option to provide a basis for permitting, depending on the field study results;
- Applications for required permits and approvals; and
- Detailed design of the preferred option for the purpose of contract tendering.

These next steps are discussed in further detail in the following sections.



6.2 Select a Preferred Option

The City will need to select a preferred option, based on the perceived tradeoffs among cost and benefits. We anticipate that the City will require some support to facilitate the interpretation and explanation of the study results.

6.3 Implement Management Measures

6.3.1 Dam Safety Review

The Bear River Control Structure is likely categorized as a low consequence dam with a design flow equivalent to the 100-year return period event. This will need to be confirmed by a dam safety review, based on Canadian Dam Association (CDA) guidelines. We are unaware of any previous dam safety review studies for this structure. The review would include a dam classification, a site inspection of the structure and the gates, geotechnical assessment of the embankment dam, and assessment of the operational safety for the dam. The results of this study will be used in part to support the dam safety review.

6.3.2 Reservoir Operating Policy for Floods

The City should have a formal operating policy for the gates, sufficient for training purposes, for communication with the public, and for due diligence purposes if a flood event results in downstream damage to private property.

The existing operation of the gates to maintain high water levels in summer will require continuous adjustments during a flood event to prevent either overtopping of the dam or releases from the dam in excess of the natural flood peak. A detailed reservoir operations study will be needed to optimize the rules, and the City may need to install instrumentation to automate the gate adjustments.

The gate operations can be simplified if the reservoir is operated near the spillway sill during summer. In this case, one gate should be closed for normal operations. The closed gate should be opened at a measured rate if the water level exceeds 651.8 m (2138.5 ft). The gate opening should coincide with rising water levels, such that the gate is fully open by the time the reservoir rises to the full supply level (FSL) of 652.58 m (2141 ft). The gate would be closed in a similar manner as the flood diminishes. One gate would remain open throughout the flood period, as per normal operations.

6.3.3 Emergency Preparedness Plan

The Emergency Preparedness Plan (EPP) should be updated to reflect recent changes to the gates, and to document the City's selected operating rules for the gates during flood emergencies.

6.3.4 Reservoir Water Level Gauge Installation

We recommend that a water level gauge be installed to measure the reservoir water level and to document the water level changes over time. This will also help the City to document the levels for future reservoir planning, or to communicate with the public after a flood or drought.

The gauge should be installed near the dam, based on standard procedures for water level gauges. The gauge should ideally be equipped with telemetry to transmit the water level data so that City staff can monitor the levels remotely in real time during a flood. A fence may also be required to restrict access to the instrumentation.



6.3.5 Sediment Disposal Options

The City should identify potential disposal locations for reservoir sediment. We understand that haul distance will have an effect on the short-term capital cost and long-term maintenance cost. The disposal locations would be needed in the short-term if the City selects Option #4 to remove the reservoir sediment and haul to an off-site location. Disposal locations may also be needed in the future for regular maintenance of reservoir sediment. For example, Option #3 to re-grade the reservoir sediment may also require future maintenance of reservoir sediment by hauling to an off-site location.

Suitable disposal options will depend in part on the (field study) characterization of sediment chemistry. It may be possible to dispose of the sediment by spreading it on cultivated fields, to utilize the sediment as fill material for City projects or developers, or to dispose the sediment in a landfill or similar disposal below ground in a gravel pit or wetland.

6.3.6 Watershed Management Plan

A watershed management plan for the Bear River would help the City to manage activities that may affect the reservoir. The overall goal of the plan would be to prevent further degradation of the reservoir water quality and management risks. Specifically, the City may need to track and influence the following activities:

- Culvert and bridge sizing of structures downstream of the reservoir, such that downstream releases are not further limited due to insufficient design of downstream structures;
- Stormwater management practices by the City affect the water quality of the reservoir. Preventative best practices and pre-treatment prior to the reservoir may both be considered;
- Upstream land use in agricultural areas can result in degradation of vegetation on the river bank, within a riparian buffer. This may affect the nutrient and sediment loading to the reservoir; and
- Upstream Bear Lake currently provides a significant benefit to the City by reducing the flood peak along Bear River near Grande Prairie. Bear Lake also results in very low summer inflows to the reservoir when Bear Lake levels are low. This can occur during dry years when Bear Lake evaporation exceeds the inflows, and can also result in a diversion of flow from Grande Prairie Creek to the lake.

One possible result of a watershed management plan would be to re-develop the (abandoned) stop log control structure near the Bear Lake outlet. A higher lake outlet elevation may benefit the City by preventing Grande Prairie Creek flows from diverting to the lake during dry years. As a result, the reservoir summer inflows may be greater in dry years. This would need to be confirmed by a survey of the Bear Lake outlet and nearby Grande Prairie Creek.

6.4 Conduct Field Studies to Address Key Data Gaps

6.4.1 Reservoir Bathymetry

It will be necessary to survey the bottom of the reservoir to confirm the earthworks quantity for Option #3 and #4. The existing LiDAR information provides an accurate measure of areas above the water line, but LiDAR does not provide bathymetric information below the water line. This is why the LiDAR information does not include any reservoir elevations below the 650.4 m spillway invert.

We assume that the bathymetry survey will occur in summer to allow for boat access.



6.4.2 Fish Habitat Assessment and Inventory

Reservoir fish inventory information is extremely limited. The current fish habitat and presence of fish species should be characterized as a baseline to support regulatory approvals for either Option #3 or Option #4. The work would consist of habitat mapping throughout the reservoir, and a fisheries inventory.

6.4.3 Water Quality Sampling

The reservoir water quality should be characterized as a baseline for future comparison, to document changes resulting from proposed reservoir management measures or watershed activities. About six samples will be collected and tested at accredited labs.

Samples will be tested from the summer water column to measure the following:

- General chemical parameters (carbonaceous BOD, TSS, COD, pH, EC and SAR);
- Nutrients (NO₃-N, NH₄-N, NO₂-N and TKN), total dissolved P, K, major cations and anions (Ca, Mg, Na, CO₃, HCO₃, alkalinity as total CaCO₃, SO₄ and Cl); and
- Metals (Al, As, B, Cd, Cr³⁺, Cr⁶⁺, Co, Cu, F, Fe, Pb, Li, Mn, Mo, Ni, Se, U, V and Zn).

6.4.4 Sediment Chemistry Characterization for Disposal

The reservoir sediment should be characterized to support a disposal plan and reclamation plan. About six samples will be tested at accredited labs.

Samples will be collected from exposed sediment locations (i.e. above the water line) and tested to measure the following:

- Salinity (pH, EC, SAR);
- Available macronutrients (N, P, K, S);
- Metals; and
- Total Nitrogen and Total Carbon.

The analytical results will be compared to the publication *Soil Quality Criteria Relative to Disturbance and Reclamation* (Alberta Agriculture 1987) to evaluate any reclamation limitations, and the metals content of the samples will be compared to the 2011 CCME *Soil Quality Guidelines for the Protection of Environmental and Human Health*.

6.4.5 Sediment Geotechnical Testing

Geotechnical sampling and testing of the reservoir sediment is necessary to determine an appropriate disposal plan in terms of stacking the sediment. The sediment will need to be handled and deposited, and the construction methods and final disposal plan both depend on the geotechnical characteristics of the sediment. For example, Option #3 will require the sediment to be stacked on islands at a final grade of about 4H:1V.

Approximately 10 sediment samples will be collected near the water line at low levels and on existing mounds of exposed sediment. The samples will be analyzed for the following properties:

- Particle distribution sieve and hydrometer tests; and
- Dry density, specific gravity, and solids content tests.



In addition to the sediment samples, a 20 L sample of the water column will be tested to determine particle settling characteristics. The settling test will help to determine potential water management issues during construction of Option #3 or Option #4.

6.5 Feasibility Level Design

The feasibility level design, assuming that the preferred option is to re-grade the reservoir sediment within the limits of the reservoir (Option #3), will include the following:

- Design basis report – a summary document will provide the overall description of the works, the selected design criteria, and a description of how the reservoir will be utilized for recreation, wildlife habitat, or fish habitat.
- Earthworks construction method – a key element of the feasibility design is to determine if appropriate construction methods are available. The contractor would then propose a method as part of the bid.
- Shoreline protection – portions of the shoreline may be exposed to high velocity flows due to the decreased width of the reservoir, requiring some shoreline protection for the erodible sediment deposits.
- Side channel habitat design – the re-grade reservoir sediment option includes a number of side channels along the toe of the valley wall, including some side channels designed to flow through from upstream to downstream. These channels may need to be lined with granular materials to prevent erosion of the fine sediment. Additional habitat features may also be included.
- Reclamation plan – the option to re-grade reservoir sediment will result in the creation of several islands within the reservoir (Option #2, Option #3). These areas will need to be reclaimed with suitable materials and vegetation.

The reclamation plan, in particular, will need to address the needs of both wildlife and people. There will need to be places where people can go particularly for wildlife viewing, and there will also need to be enclaves that are relatively free of human disturbance. Wildlife habitat enhancements to increase the likelihood of use will be considered (e.g., coarse woody debris, waterfowl nest boxes, perching locations, bat boxes). The plan will also account for the seasonality of current reservoir use by wildlife. In particular, the federal Migratory Bird Convention Act (1992) makes it an offence to destroy a migratory bird or its nest. The restricted activity period for the Act (bird nesting period) is 1 April to 31 August annually. Therefore, activities that could affect bird nesting may be limited to a window between September 1 and March 31.

6.6 Permit and Approval Applications

The preferred option may require a number of regulatory bodies' involvement at the planning stage, the list below summarizes anticipated involvement details:

- An Alberta Water Act licence is necessary to conduct instream work, remove sediment, and stabilize the shoreline;
- The proposed dredging plan would require a DFO review, and most likely a Section 35(2) Authorization; however, it could be presented as a habitat improvement project that would not require additional compensation and could potentially be used by the City as a habitat credit for future projects;



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- Navigable Waters Protection Act requirements and approval would be applicable. Transport Canada should be engaged early in the process; and
- ASRD should be consulted on the plans and the City should seek their input/approval to the proposed plans to ensure they align with ASRD's fisheries management objectives.

6.7 Detailed Design

A detailed earthworks design would require several aspects such as construction planning and staging as well as a disposal plan for sediment, assuming Option #3 or Option #4 is the preferred option. The detailed design will be required for tender purposes.

7.0 ESTIMATED FUTURE COSTS

Future costs will depend on the selection of a preferred option, but will likely include the costs as shown in Table 7. If all of the studies are implemented, the estimated future cost for planning and design will be about \$200,000 plus tax.

Table 7: Estimated Planning and Design Costs.

Item	Description	Cost	Assumption
1	<i>Select A Preferred Option</i>	\$5,000	Consultant to facilitate discussion.
2	<i>Management Measures:</i>		
2.1	Dam Safety Review	\$30,000	Standard procedures, low consequence dam.
2.2	Reservoir Operating Policy	\$0	Summer operation at low levels.
2.3	Emergency Plans	\$0	City to update.
2.4	Install Water Level Gauge	\$10,000	Instrumentation installation and setup.
2.5	Identify Sediment Disposal Locations	\$0	City to investigate.
2.6	Watershed Management Plan	\$0	City to assign staff.
3	<i>Field studies:</i>		Field studies to proceed concurrently for cost efficiency.
3.1	Reservoir Bathymetry	\$10,000	Detailed reservoir bathymetric mapping.
3.2	Water Quality Sampling	\$5,000	General chemistry, incl. nutrients, metals.
3.3	Fish Habitat Assessment	\$10,000	Habitat mapping and fish sampling.
3.4	Sediment Geotechnical Sampling	\$15,000	Particle sizes, dry density, specific gravity, solids content, settling test.
3.5	Sediment Chemistry Sampling	\$5,000	Salinity, metals, TN, TC, available macronutrients.
3.6	Management and Coordination	\$5,000	Mobilization, demobilization, coordination, QA.
4	<i>Feasibility Level Design</i>	\$60,000	Re-grade sediment option.
5	<i>Permit and Approval Applications</i>	\$5,000	Re-grade sediment option.
6	<i>Detailed Design</i>	\$40,000	Re-grade sediment option.
Total Estimated Planning And Design Cost		\$200,000	



8.0 RESERVOIR MANAGEMENT PLAN

8.1 Sediment Management Options

The Grande Prairie Reservoir was originally necessary to provide the City of Grande Prairie (City) with a drinking water source. Although it is no longer the source of drinking water, it still provides benefits as part of a park setting within the City. Over time, the reservoir has been accumulating sediment. The sediment is now mounded, in places, above the spillway sill of the dam. Based on current reservoir operations, the City will need to implement management measures within the next 5 years to avoid loss of capacity at the spillway. This loss of capacity will have a direct effect on the safety of the dam by increasing the risk of overtopping flows during a large flood similar to 1990.

The options presented in this study provide the City with a range of management measures. The final selection of a preferred option will depend on the City's priorities and available funding. The estimated capital costs range from \$200,000 to about \$12,000,000. Additional future planning costs may be \$200,000 depending on the selected option.

8.2 Reservoir Management Opportunities

Overall, this report describes the issues, feasibility of options, estimated costs, and next steps related to management of the reservoir. In that regard, it follows the original RFP. However, the study evolved from the original study objectives based on the assessment of issues and opportunities. The key issue to be addressed is the accumulation of sediment in the reservoir. Other study objectives had to be addressed in the context of managing the sediment. The following opportunities are summarized in terms of the original study objectives:

- 1) A reservoir restoration strategy to enhance water quality may be developed in the form of a watershed management plan. However, it is unlikely that the character of the existing water quality can be changed significantly. This is because the vast majority of the nutrient and sediment loading is due to upstream agricultural land use along Bear River near Grande Prairie, and due to agricultural land use further upstream along Grande Prairie Creek.
- 2) An erosion control and bank stabilization program for the reservoir will be addressed as part of the selected management option.
- 3) Active recreation uses such as boating, swimming, and skating within the reservoir were objectives for developing and comparing options. In particular:
 - a) The potential boating use was a key factor for the development of options, and will be possible assuming Option #3 or Option #4 or their equivalent are implemented.
 - b) The potential for swimming will likely be limited regardless of the selected management option, and this recreation use should not be used to select a preferred option. This is because the reservoir is, in part, a stormwater (pre-treatment) pond as a result of the seven stormwater outfalls. As well, the relatively high nutrient and sediment loading from upstream agricultural areas will likely prevent the reservoir from ever becoming a high value public swimming location.
 - c) Skating on the reservoir will depend on the formation of sufficient ice depth and minimal cracking. This requires a stable winter reservoir level and low water velocity under the ice. We anticipate that the reservoir level in winter will be stable, based on normal levels near the spillway sill. However, the suitability for skating will need to be evaluated each winter based on prevailing ice conditions.



- 4) Maintaining a stable water level was an objective for developing and comparing options. One permanent normal water level is recommended, instead of operating with seasonal levels that are different by more than 2 m (i.e. current operations). A permanent level is possible both at the FSL (i.e. top of the closed gates) and at the spillway sill. Operating near the spillway sill provides the best combination of dam safety and stable water levels while also increasing the wildlife habitat near the reservoir shoreline.
- 5) Increasing the wildlife habitat around the reservoir is possible with a permanent normal water level, by allowing riparian and littoral vegetation to become established along the shoreline. Fish, wildlife, and migratory bird habitat can also be increased by reclaiming sediment 'islands' within the reservoir.

8.3 Reservoir Management Guidelines

In addition to the management options for reservoir sediment, the recommended guidelines for reservoir management within a park setting are described below, assuming that Centennial Park will continue to function as an environmental reserve surrounding the reservoir.

The recommendations are based on site conditions, the available reservoir (sediment management) options, and on similar lake management planning documents in Alberta. Selected references in the literature included the *Caring for Shoreline Properties* brochure by the Alberta Conservation Association (ACA 1999) and the *Sylvan Lake Management Plan: 2000 Update* (Lacombe County 2000).

The selected reservoir management guidelines are:

- Select a year-round normal operating water level for the reservoir to minimize the potential for slope instability along the shoreline, and to promote re-vegetation of riparian and littoral shoreline areas;
- Setback all pathways and landscaping a minimum 10 m from the reservoir shoreline for normal reservoir levels (e.g. near the spillway sill elevation of 650.44 m);
- Park infrastructure around the reservoir to be designed, at least, for a 50-year return period flood level of 653 m. This flood level assumes that the spillway is operated with one gate open, and with the second gate initially closed and then opened as a part of the flood response;
- Reclaim riparian areas along the shoreline to restore native vegetation where necessary;
- Minimize the use of fertilizers for landscaping within Centennial Park;
- Consider the implementation of a public communication strategy for landowners with stormwater draining to the reservoir, to minimize the use of phosphorus-based fertilizers and other dumping of chemicals;
- Consider providing stormwater pre-treatment ponds or equivalent, where possible, for outfalls to the reservoir or for City outfalls located upstream of the reservoir;
- At the existing Rotary Campground and RV Park, provide containment and pre-treatment of stormwater runoff and best management practices for sanitary dumping of wastewater;
- Exclude public access to any reservoir islands, to protect and enhance wildlife habitat;
- Provide a single boat launch access location at the existing boat launch location, and limit boating to non-motorized craft;



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- Install and maintain public safety measures near the dam to alert boaters of the dangers of floating over the spillway. A safety boom and signage are standard measures;
- Install bank stabilization measures, where necessary, to stabilize soils and allow for re-vegetation of the bank. Standard measures should include gravel bedding and willow staking without large riprap;
- Actively manage the gates at the Bear River Control Structure based on a documented reservoir operating policy for both normal operations and flood emergencies;
- Provide flood emergency preparedness training to City staff in March each year. Update the Emergency Preparedness Plan to document changes, as needed; and
- Maintain the dam and spillway based on Dam Safety Review recommendations.

The selection of other reservoir management guidelines will depend on the selected option.

9.0 CONCLUSION

The City of Grande Prairie's reservoir within Centennial Park is a valuable asset as part of park setting. It requires maintenance to manage the sediment that has accumulated since the dam was originally constructed about 60 years ago. The exposure of this sediment during summer is the likely cause of nuisance odour complaints. This report summarizes the existing conditions, and describes the potential opportunities to manage the sediment while also improving the reservoir for other purposes including boating recreation and enhancing wildlife habitat. This study was therefore a Step 1 investigation towards identifying and implementing appropriate maintenance measures. The report also provides a basis for further park planning related to the Muskoseepi Park Master Plan.



Report Signature Page

We trust the above meets your present requirements. If you have any questions or require additional details, please contact the undersigned.

Yours truly,

GOLDER ASSOCIATES LTD.

APEGGA PERMIT TO PRACTICE 05122

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