Milk River Supplemental Water Supply Investigation

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Research & Science Note 3

Background

The Milk River provides the major source of water for domestic, municipal, agricultural, recreational, and industrial requirements in the southernmost portion of Alberta. Yet its catchment has an arid climate and an average annual precipitation of only about 300 mm (12”). As a result, on-going socio-economic activity in the watershed is periodically threatened and future growth and development in the region is limited. The most recent drought occurred in 2002 and periods of very low river flows also occurred in 2006 and 2007. Since 1985 there has been a moratorium on new water licenses for irrigation and industrial use in the watershed.

The long-standing water constraint in the watershed has been discussed and studied for many years. Studies of various on-stream storage alternatives (AE/PFRA, 1978-1985) were followed by a more recent study of a preferred on-stream alternative as well as six off-stream storage alternatives (KCBL, *et. al*., 2003). Water supplies remain a major concern (MRWCC, 2007) and no real progress has been made to alleviate the water shortage.

In 2008, the MRWCC commissioned two studies to:

a) determine if supplemental water could be supplied from the Milk River Ridge Reservoir;

b) evaluate these potential new supply options from an engineering, environmental, and economic perspective; and

c) compare the socio-economic feasibility of the new supply options to the socio-economic feasibility of the nine options evaluated in 2003.

Study Area

A map of the Milk River watershed is shown below. Water from the St. Mary River is conveyed by a siphon and canal to the North Milk River in Montana. After crossing the International Boundary, water from the North Fork flows about 80 km before meeting the larger unregulated mainstem Milk River. The combined north-south mainstem then flows 100 km to Writing-On-Stone Provincial Park and meanders an additional 130 km eastwards before re-entering Montana at the Eastern Crossing.

Map 1.

Engineering & Environmental Assessment

(Klohn Crippen Berger Ltd. 2008)

The supplemental water supply investigation aimed to determine the feasibility of augmenting summer flows in the Milk River with water drawn from the Milk River Ridge Reservoir located on the Waterton-St. Mary Headworks system (Klohn Crippen Berger Ltd. 2008). The principal study objectives were to:

1) Identify and conduct a preliminary screening of possible diversion routes,
2) Prepare a conceptual design of selected routes, considering geological, topographic, hydrological, geotechnical, and environmental factors, including historical resources,
3) Prepare a preliminary design and cost esti mate (+/-30%) for the selected routes, and
4) Compare and further screen alternative conceptual designs using a comprehensive evaluation matrix.

Preliminary Screening

Canal and pipeline options were assessed for five routes. Both canal and pipeline options were considered for each route except Route 5 where only a pipeline was considered because of the steep terrain. These five routes are shown below in Map 2.

A preliminary screening based on estimates of capital and operating costs, environmental impacts, water quality and impacts on land use reduced the number of options to three canal routes and one pipeline route:

Route 2C (canal) – Ridge Reservoir- Middle Coulee-Warner, gravity, 75.4 km to near Coffin Bridge

Route 3C (pipeline/canal) – Ridge Reservoir and north of Milk River Ridge, pump/gravity, 46.2 km to near Town of Milk River

Route 4C (pipeline/canal) – Ridge Reservoir and north of Milk River Ridge (higher elevation), pump/gravity, 45.6 km to upstream of Town of Milk River

Route 4P (pipeline) – Ridge Reservoir and north of Milk River Ridge, 45.6 km to upstream of Town of Milk River

Only Route 2C would operate by gravity alone; the remaining two canal routes and the pipeline route would be supplied with water via a pump station at Ridge Reservoir. Further details are provided in Table 1.

Map 2. Potential water supply routes from Ridge Reservoir.

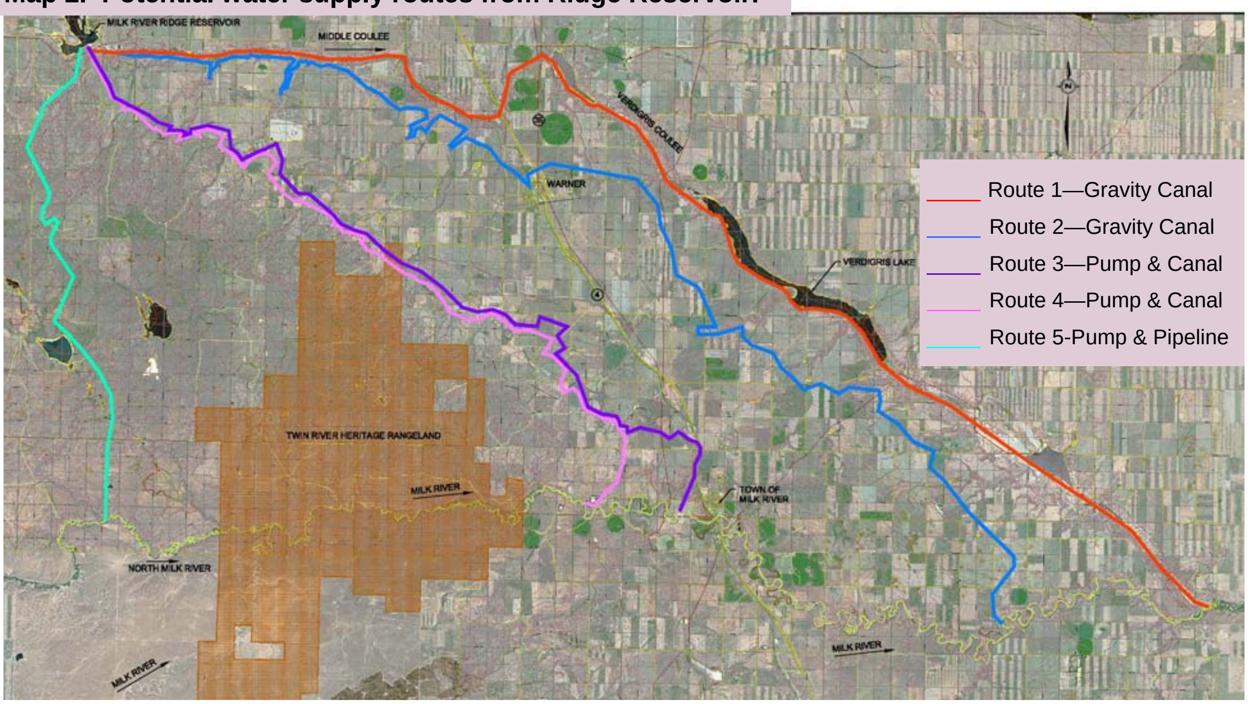

Table 1. Pre-Screening & Final Engineering and Environmental Assessment of Ridge Reservoir –Milk River Diversion Options

Description	Route 1— Verdigris Coulee		Route 2— Warner		Route 3— Around Ridge Lower		Route 4— Around Ridge Upper		Route 5—Over Ridge
Option	1C	1P	2C	2P	3C	3P	4C	4P	5P
Driver—Static Head	Gravity	Gravity	Gravity	Gravity	Pump (42 m)	Pump (42 m)	Pump (48 m)	Pump (48 m)	Pump (255 m)
Carrier	Canal	Pipeline	Canal	Pipeline	Pipeline/Canal	Pipeline	Pipeline/Canal	Pipeline	Pipeline
Length (km)	68.7	68.7	75.4	75.4	46.2	46.2	45.6	45.6	26.6
Acre-Feet/Yr	11,300	11,300	11,300	11,300	11,300	11,300	11,300	11,300	11,300
Capital Cost	Intermediate	Intermediate	92,918,000	Very High	68,320,000	Intermediate	68,305,000	97,637,000	Low
O & M Cost/Yr	Minimal	Minimal	420,000	Minimal	530,000	-	530,000	460,000	-
Energy Cost/Yr	-	-	0	-	380,000	Moderate	480,000	1,030,000	High
Net Present Value (NPV) Cost 50 yrs.*	Intermediate	Intermediate	102,000,000	Very high	88,000,000	Intermediate	90,000,000	130,000,000	Intermediate
Capital Cost/Acre-Foot	-	-	8,223	-	6,046	-	6,045	8,640	-
Approx. Earthworks (1000m^3): Excavation	10,000	-	3,000	-	1,000	-	1,000	-	-
Embankment Fill	1,000	-	2000	-	700	-	900	-	-
Other Benefit Considerations	-	-	Water to Warner	Water to Warner	Water to Warner & Town of Milk River	Water to Warner & Town of Milk River	Water to Warner & Town of Milk River	Water to Warner & Town of Milk River	-
Water Quality									
Conveyance losses	High?	None	High @ 8%	None	High @ 5%+	None	High @ 5%	Negligible	Minimal
Runoff impacts	-	-	High	-	Moderate	-	Moderate	None	-
Irrigation Delivery									
Delivery location (% irrigation downstream)/ irrigation efficiencies	Farthest downstream (32%)	Farthest downstream (32%)	Near Coffin Bridge. Farthest downstream of top 4 (41%)	Near Coffin Bridge, downstream of Town of Milk River (41%)	Upstream of Town of Milk River (70%)	Upstream of Town of Milk River (70%)	Upstream of Town of Milk River (79%)	Upstream of Town of Milk River (79%)	Upstream of Milk River-N.Milk confluence (93%)
Infrastructure/Land Impacts									
Crossings (#)	17	17	17 (Most significant)	17 (Most significant)	17	17	12	12	13
Land severance (# quarter sections)	38	None	58	None	42	None	38	None	22
Geotechnical Considerations									
Seepage Issues	High	-	High	-	Moderate	-	Moderate	Low	-
Slope Stability Issues	-	-	High	-	Low	-	Low	Low	-
Environmental Concerns (low to high)									
Vegetation & wildlife	-	-	High	-	Moderate	-	Moderate	Moderate	-
Water quality/ fisheries	-	-	High	-	Moderate	-	Moderate	Low	-
Historical resources	-	-	Moderate	-	Moderate	-	Moderate	Moderate	-

Water Supply-Demand Simulations

Models were used to estimate the flow that would occur in the proposed supply system in response to irrigation demands and instream flow needs using the Water Resources Management Model. Historical climate and hydrology for the period 1928-2001 were simulated on a weekly time increment. Priming, evaporation, evapotranspiration and seepage losses were not simulated.

The water supply system was sized to support 3,320 ha (8,200 acres) of existing irrigation as well as 4,050 ha (10,000 acres) of irrigation expansion. Alberta Agriculture provided crop water demands for the simulation based on an anticipated future crop mix of alfalfa, grass hay, barley, pasture and HRS wheat.

Regardless of the route selected, the required design capacity of the system was estimated at 3.5 m^3/second, amounting to an annual volume of about 14,000 dam^3 (11,300 acre-feet) conveyed by the system. On average, the volume translates into about 2" more water (gross) for the 3,320 ha (or 8,200 acres) of existing irrigation and about 12" of water (gross) for the projected 4,050 ha (10,000 acres) of new irrigation. Due to the limitations in water supply in Ridge Reservoir, some irrigation deficits would still occur in the very dry years.

The location of water delivery to the Milk River was not important in the model since there is generally sufficient water in the river to supply Canadian users provided that apportionment shortfalls are redeemed before the river returns to the United States. Nevertheless, delivery points further upstream on the Milk River are generally preferred because of considerations of water quality, instream habitat, municipal and recreation use, as well as protection against extreme river flow variability.

Environmental Overview (Routes 2, 3 and 4)

- All routes have the potential to affect provincial and international Environmentally Significant Areas (ESA's).
- All routes have a similar potential for affecting native prairie, wetlands, rare species and rare ecological communities. A detailed assessment is required to determine potential effects.
- The same number of wildlife species at risk were observed along and near Routes 2 and 3 (14) whereas Route 4 has a slightly higher number (16). Each suggests the need to carefully establish parameters for mitigation prior to construction.
- More information on water quality in the Ridge Reservoir is required to determine the actual effect of supplemental water in the Milk River.
- A potential issue common to all routes is fish movement from the Reservoir to the Milk River and potential fish kills due to entrapment in the system.
- All routes avoid significant palaeontology sites..

Cost Estimates

Conceptual designs were prepared for Options 2C, 3C, 4C and 4P. Capital costs (in $2008) ranged from $68 million for either 3C or 4C to $98 million for the pure pipeline option 4P. Initial costs for Route 2C amounted to $93 million. Energy costs also varied considerably; Options 3C and 4C required $400,000-$500,000 per year and the pipeline option (4P) required about $1 M per year, with other annual operating and maintenance costs in the $400,000-$500,000 per year range. Further details are provided in Table 1.

Final Engineering & Environmental Evaluation

A final assessment of the four remaining options considered all costs, water quality, irrigation delivery, infrastructure and land impacts, geotechnical considerations, and environmental and historical resource impacts. On this basis, option 3C was rejected because it is very similar to 4C except that it would have more infrastructure, land, and irrigation delivery issues. Subject to the findings of a complimentary economic analysis (see following), the preferred option was Option 4C. This option would consist of a pump station and 1.9 km pipeline to convey water along a 43.7 km canal just east of the Milk River Ridge and then spill into the Milk River about 9 km (6 miles) west of the Town of Milk River. For additional details, refer to Table 1.

Economic Assessment (Marv Anderson 2009)

An economic assessment was conducted to identify the most economically feasible water supply route from Ridge Reservoir and compare the socio-economic feasibility of these supply options with the water management options first evaluated in 2003.

Methods

A conventional discounted cash flow analysis was used in the economic evaluation of water supply routes, followed by a regional (i.e., Milk River watershed) impact analysis.

Discounted cash flow analysis (or “benefit-cost” analysis) determines if a proposed investment would or would not use Alberta resources efficiently. This is conducted from a provincial perspective and generally employs three evaluation criteria: Internal Rate of Return (IRR), Net Present Value (NPV), and Benefit-Cost (B/C) Ratio (see **Glossary of Terms**).

To be considered economically feasible at a specified interest (discount) rate, the B/C ratio must be greater than one, the NPV must be positive, and the IRR must exceed a prescribed minimum annual (real) rate of return. Excluding inflation, the prescribed minimum annual rate of return on public investments in Alberta is now estimated to be about 4% per annum.

If the calculated IRR is greater than 4%, then the NPV will be positive and the B/C ratio >1. This means the project should be economically feasible. Conversely, if the calculated IRR is less than 4%, then the NPV will be negative and the B/C ratio < 1. This means the project is probably not economically feasible. If the calculated IRR is exactly 4% and the discount rate employed to calculate the corresponding NPV and B/C ratio is also 4%, then NPV = 0 and B/C = 1.

A complimentary ***regional impact analysis*** considers both the direct and indirect impact of all regional activities generated by a proposed project on the local economy, in this case the Milk River watershed. Utilizing this calculus, all expenditures in the region generated by a water supply project, whether during or after construction, are considered a benefit to the region. These benefits translate into additional employment, incomes, and growth in the watershed.

Results of Benefit-Cost Analysis

"Benefit-cost analysis is only one of many screening processes required by a community before committing to an idea."

" A comprehensive benefit-cost framework encourages everyone to ponder trade-offs and avoid unintended consequences."

"The price of something and the value of something are not always the same. Know the difference and be true to your values."

The incremental direct costs quantified over a 50 year time frame include:

- Diversion construction & operating costs (including energy costs)
- On-farm irrigation expansion costs
- Annual incremental on-farm production costs

The corresponding incremental direct benefits quantified over a 50 year time frame are:

- Enhanced existing irrigated crop-livestock development (8,200 acres)
- New irrigated crop-livestock development (10,000 acres)
- Enhanced recreational/tourist opportunities (park activities, river rafting, related)
- Improved rural domestic and livestock water supplies

Option values, preservation values, and existence values were not quantified.

The resulting discounted cash flow tabulations indicate that the imputed internal rate of return (IRR), as well as the respective net present values (NPV) and benefit/cost ratios (both calculated using a 4% discount rate) are summarized in Table 2.

Table 2. Summary of Economic Analysis, Ridge Reservoir Diversions.

Option/Criterion	IRR %	NPV @ 4%	B/C Ratio @ 4%
East Gravity Canal Option 2C	3.01	-19.0 million	0.89
West Pump-Canal Option 4C	4.68	+10.5 million	1.06
West Pump-Pipeline Option 4P	2.90	-22.3 million	0.89

For Option 4C, the estimated (real) IRR is almost 5% per annum, the estimated NPV is a positive $10.5 million after 50 years of operation and the B/C ratio is about 1.06. From a provincial perspective, Option 4C should be an economically feasible water supply option and is also the preferred option as determined by the engineering/environmental analysis.

From an economic perspective, Option 2C and Option 4P (pressure pipe) are similar. Each have an estimated real IRR of about 3.0% per annum, a B/C ratio of about 0.90, and a NPV of about minus $20 million over a 50 year period. Neither of these options, as presently conceived, is likely to be economically feasible.

Pipelines generally have some advantages over canals that are not reflected in the cost or benefit estimates. Pipelines:

- Do not sever land parcels,
- Are easier to operate under conditions of very low or intermittent flow,
- Do not have the same potential for water quality issues related to runoff or seepage inflows, and
- Have negligible conveyance losses compared to the priming, seepage, evaporation, and evapotranspiration losses experienced with canals (5%-8%).

Additionally, with all the risk and uncertainty implicit in 50-year projections, errors and omissions are inevitable. An error of +-20% in the IRR, NPV or B/C ratio is quite possible.

Results of the Regional Impact Analysis

For all Ridge Reservoir supply routes, the Milk River watershed regional impact analysis highlighted the following:

- Regional Gross Domestic Product (GDP) would increase about 4–5% per year during the construction period; about 2% per year thereafter.
- Regional employment would increase by between 50 and 80 persons per year (or 3%-5%) during the construction period; about 30 per year (or 2%) thereafter.
- Regional incomes would mirror the projected GDP and employment changes. Total regional income would increase 5%-8% during the construction period; about 2%/year thereafter.

Three other very important regional benefits include:

- Increased income stability, reflecting lower crop/livestock production variability, thereby resulting in less government-sponsored drought and crop insurance assistance.
- Improved relative income levels to the rest of Alberta (e.g., narrowing an existing average income disparity of about 25%).
- Accelerated growth and development (presently subject to water constraints) that uses the regions' unique agro-climatic and ecological features, its strategic highway-railway linkages, and its close proximity to USA markets.

Results of the Comparative Supply Option Analysis

The 2003 water supply study examined three on-stream reservoir sizes at the Milk River Forks site in addition to a number of off-stream storage alternatives (Table 3). These earlier water supply options were compared to the three most favourable water supply routes from Ridge Reservoir under 2008 economic conditions.

Each water supply option was re-evaluated using 2008 dollar estimates for all major costs and benefits. A discounted cash flow analysis was conducted employing the same methods and 4% discount rate used in the present study. From an economic perspective, Option 4C was still the best overall option (Table 3). The on-stream options at the Forks Site (political-environmental issues aside) ranked second, followed by Option 4P or Option 2C. The various off-stream options considered in 2003 still fare relatively poorly with Lonely Valley probably being the preferred off-stream option. Results of this study should be considered cautiously:

- Economic feasibility is just one of many criteria to consider. Irrigation expansion and the extent to which the Canadian entitlement would be utilized are two other important considerations (Table 3).
- These empirical estimates are only generally indicative of the "real" values. An error of +/-20% in the IRR, NPV or B/C ratio is possible.
- There are advantages to a pipeline that are not well quantified in the present analysis; the study likely underestimates the relative profitability of Option 4P.
- With rapidly changing construction cost estimates, subsequent revisions may still be necessary.

Table 3. Summary of water supply options, characteristics and economic analysis.

Option		Reservoir Storage (dam^3)	Potential Irrigation Expansion (acres)	Unused Canadian Entitlement (dam^3)	IRR %	NPV	B/C Ratio	Rank
2008 - 2009	Option 2C	Existing	10,000	-	3.01	-18.96	0.89	4
	Option 4C	Existing	10,000	-	4.68	10.51	1.06	1
	Option 4P	Existing	10,000	-	2.90	-22.32	0.89	3
2003	Forks Site, Topographic Limit	292,800	34,290	4,700	3.9	-5.14	0.99	2
	Forks Site, High Level	231,800	30,735	8,900	3.9	-4.66	0.99	2
	Forks Site, Intermediate	150,700	25,655	14,900	4.0	-1.05	1.00	2
2003	Shanks Lake	32,200	4,635	43,300	1.6	-23.54	0.77	-
	Lonely Valley A	106,000	12,370	35,100	2.2	-40.91	0.79	7
	Lonely Valley B	106,000	11,115	34,800	2.3	-33.24	0.81	5
	Lonely Valley LD	-	-	-	-0.8	-54.20	0.25	-
	Verdigris Lake	126,000	14,480	29,500	1.5	-37.60	0.79	-
	MacDonald Creek	53,200	8,915	38,200	2.2	-30.81	0.79	6

Future Steps

The Milk River Watershed Council Canada (MRWCC) is a registered, non-profit watershed planning and advisory council established under the Province of Alberta's "*Water for Life Strategy*". Representatives on the MRWCC include multiple levels of government, non-governmental organization, industry, community groups, and landowners. The MRWCC commissioned the supplemental Milk River Ridge Reservoir Water Supply Investigations to facilitate ultimately finding a solution that would provide a secure water supply for the Milk River basin in years of drought, as well as allowing for further growth and development in the Watershed.

Recently the St. Mary and Milk River Water Management Initiative was struck to assist Montana and Alberta identify water management options that would benefit both countries. In December 2008, Montana Governor Brian Schweitzer and Alberta Premier Ed Stelmach approved the Terms of Reference.

The Initiative will 'explore and evaluate options for improving both Montana's and Alberta's access to the shared water of the St. Mary and Milk Rivers, and make joint recommendations on preferred options to both governments for their consideration and approval'. Focus will be on timing and access to each country's share of water from the two rivers under Article VI of the Boundary Waters Treaty Act (1909).

Glossary of Terms

Benefit-Cost (B/C) Ratio: Cumulative discounted benefits **divided** by the cumulative discounted costs, for a given interest (or discount) rate over the entire life of the project (say 50 years).

Existence Value: The benefit or non-use value that individuals assign to the knowledge that specific environmental assets simply exist.

Internal Rate of Return (IRR): That interest (or discount) rate where, over the entire life of the project (say 50 years), cumulative discounted benefits = cumulative discounted costs

Net Present Value (NPV): Cumulative discounted benefits **minus** cumulative discounted costs, for a given interest (or discount) rate over the entire life of the project (say 50 years).

Option Value: The premium or value that individuals place on ensuring that the possibility of directly using a good (e.g. water) in the future is preserved.

Preservation Value: The benefit or non-use value that individuals assign to ensuring that their offspring will have access to a specific good, e.g. clean water.

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