Final Report for:

MD of ACADIA No. 34

Irrigation Feasibility Study
2019 Update

Date: January 2020
Project #: 4280-002-00

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January 9, 2020
File: 4280\002\IrrigationDevelopmentUpdate\R01

Attention: Mr. Jason Wallsmith
Chief Administrative Officer

Dear Mr. Wallsmith:

Re: 2019 Update to Irrigation Feasibility Study

We are pleased to present the Final Report for the 2019 Update to the 2005 Irrigation Feasibility Study. This study shows that although the capital and O&M costs have increased, the overall project viability remains similar to the 2005 study. With that said, it is essential that government funding be secured for the capital costs of the system, as well as the O&M costs for the River Pumpstation, to make it economically viable for farmers.

If you have any questions about the contents of the report please contact the undersigned.

Yours truly,

MPE ENGINEERING LTD.

Jeff Hust, P.Eng.
Project Manager

JH:mw
Enclosure

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MPE ENGINEERING LTD.

JEFFREY W. HUS

2020-01-09

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The Association of Professional
Engineers and Geoscientists of Alberta

EXECUTIVE SUMMARY

The Municipal District of Acadia No. 34 (MD) is located in Southeastern Alberta approximately 120 km north of the City of Medicine Hat, the project location is shown on Figure E1. The MD is one of the regions in Alberta most severely impacted by the lack of: precipitation, a secure water supply and economic growth and diversification. A change from dryland to irrigation farming could stabilize farm incomes, provide employment opportunities through the enhancement of new support industries and improve overall social conditions in the area. Earlier studies, carried out in the mid-1980's, examined water supply alternatives for both municipal and irrigation purposes.

In 2004 the MD, through Alberta Agriculture and Forestry (AAF) commissioned an irrigation feasibility study. This study was completed in 2005 by MPE Engineering Ltd. (MPE, 2005) and provided several scenarios in which irrigation would be feasible in the MD.

The primary focus (purpose) of this study is to update the 2005 Study to 2019 standards in terms of industry practice, project assumptions, environmental and regulatory changes, capital and operation cost estimates, economic justification, etc. This Update Study is still a "conceptual engineering" level study with a few value-added components to help understand possible risks, and provide a better definition/discussion of next steps.

A summary of the findings of this Update Study is provided below:

1) Development Scenarios
    - The irrigation development scenarios as identified in the 2005 Study were accepted as a reasonable representation of the most feasible irrigation development areas within the MD, based on physical, technical and water supply limitations (Refer to Figure E2).

Table E1 - Irrigation Development Scenarios	
Scenario 1	13,500 acres (5,464 ha)
Scenario 2	22,000 acres (8,904 ha)
Scenario 3	27,000 acres (10,927 ha)

    - The irrigation development was divided into blocks which were chosen using criteria such as: limiting irrigation on crown land; limiting irrigation to only class 2 and 3 irrigable lands; avoiding high salinity areas; maximizing gravity conveyance and minimizing re-pumping; etc.
    - The maximum size of irrigation development is limited to the irrigation cap for the Red Deer River Basin set by the SSRB (South Saskatchewan River Basin) Regulation. On this basis, and considering headworks capacity, and water supply and secured allocation limits; the maximum irrigation development for the Acadia Irrigation Project is likely in the range of 11,000 ha to 12000 ha (27,000 – 30,000 ac) in size.

- Additional review and confirmation of the irrigation blocks will be required prior to adopting the "*final*" development scenario for project development. It is possible that some tweaking and trade-offs of irrigation area within the system or immediately adjacent to the irrigation blocks could be considered.

2) Crop Mix and Irrigation Methods
   - The 2005 Study used a crop mix that was predominantly forage and cereal (67.9 % forage; 28.2 % cereal; and 3.8 % Oilseed).
   - Based on current trends within the other Irrigation Districts in Alberta and to provide the largest benefit to the project, a crop mix similar to what is currently used in the SMRID was adopted for this project, which included less forage and considerably more oilseed and specialty crops such as lentils, peas, dry beans, etc.
   - The 2005 Study assumed a blend of High and Low Pressure Pivots, Wheel Moves, and even gravity irrigation; however, in recent years there has been an industry shift to more efficient irrigation methods such as low pressure pivots.
   - As such the irrigation method for this Update Study is assumed to be 95% Low Pressure Pivots and 5% wheel move lines for smaller fractional areas where pivots are not practical.
   - The crop mix and irrigation methods adopted for this Update Study are shown below.

Table E2 - Crop Mix	
Cereals	31%
Forages	26%
Oil Seeds	15%
Specialty Crops*	28%

*50% is pulse crops such as lentils, peas and dry beans

Table E3 - Irrigation Method	
Low Pressure Pivots	95%
High Pressure Pivots	0%
Wheel Moves	5%
Gravity	0%

3) Water Demand & Supply
   - Overall, the assumptions used in the 2005 Study for water demand appear to remain valid given available information and the level of work completed to date.
     - The updated crop mix (i.e. a shift from forages to specialty crops) is not anticipated to have much impact on the water demand requirements identified in the 2005 Study.
     - Changes to the irrigation methods may lead to a slightly lower overall demand; however, this could easily be offset by negative changes in climate data or other assumptions used in the modelling.
   - A review of the water supply assumption used in the 2005 WRMM modelling was completed.
     - Since the 2005 Study, the MD has secured two water allocation priorities for a total potential annual diversion of 56,700 dam^3 for this irrigation project.
     - Some changes to the river flow regime have occurred since the 2005 WRMM modelling, seem to be mostly positive for the project; however, there is still considerable

    uncertainty in how representative historic flow data is to predict future flows, and how to assess the potential impact of future climate change.
  - Overall, the assumptions used appear to remain valid and are perhaps slightly conservative based on the water supply modelling completed. This coupled with the fact that the overall water demand for this project may be slightly less due to improvements in irrigation method and crop mix; provides some assurance and buffer against the potential impact that climate variability and future climate change may have.
- Updated crop demand modelling (IDM) and water supply modelling (WRMM) will be required prior to adoption of the final irrigation development scenario and concept design. A water diversion license from the Red Deer River will also need to be secured prior to implementing the project.

4) <u>Environmental and Historical Resources</u>

- An updated desktop environmental and historical impact assessment was completed with this Update Study, with the intention of confirming the impacts that the project would have and the processes necessary to move forward.
- The assessment confirmed that the historical and environmental impacts of this project are similar to what was identified in the 2005 Study; however, there have been significant changes in regulatory processes.
- The most significant environmental and historical resource impacts that could affect the project are related to the native grassland areas and the river tributary systems, where there is potential for rare plant and wildlife impacts, fish habitat and wetland impacts, as well as historical and paleontological resources. This primarily impacts the river intake and pumphouse, supply pipeline, Reservoir A1, and select locations within the conveyance system.
- Based on this assessment, it was determined that a full Environmental Impact Assessment (EIA) will be required for the project, primarily due to the creation of Reservoir A1.
  - The EIA process is extensive and time consuming, requiring at least two years before any construction occurs.
  - Some pre-design work such as the historical resource assessment and wetland inventory can be completed ahead of time but most of the environmental work must be done within 2-3 years of construction.
- Extensive allowances and contingencies have been included in the cost estimates to account for the environmental and historical resource assessment, mitigation and compensation realities for this project.
- After project funding is secured, an EIA should be initiated, in accordance with legislation timeframe limitations, and should include all of the field surveys, investigations, design

accommodations, setbacks, compensations, and other processes that may result from the EIA process and/or required from applicable regulatory bodies.

5) Geotechnical Investigation
   - A limited geotechnical investigation was completed at the reservoir site (Reservoir A1), to provide preliminary indications of the reservoir's ability to hold water, and to confirm the foundation conditions at the two dams.
   - Overall, the site geology of the proposed reservoir and supply pipeline appears suitable from a constructability and operational standpoint.
   - Some sand layers were noted, but was generally shallow, dense and not flowing; and any isolated problematic locations could likely be mitigated.
   - Foundation conditions for the dams are favourable and the alignment of the proposed supply pipeline appears suitable and constructible.
   - To avoid excess instability of the river valley slopes, a minimum setback of 800 m is recommended from the reservoir to the edge of the Red Deer River valley.
   - A detailed geotechnical investigation should be completed during future phases of the project to confirm reservoir impermeability, locate seepage prone layers along the reservoir and river banks, identify borrow sources for the dams, and finalize the dam cross-section and supply pipeline route. Investigations at other infrastructure locations within the system will also be required.

6) Infrastructure Updates
   - A critical look at the headworks and conveyance systems was completed based on current industry standards and practice.
   - The river pumpstation was relocated approximately 3 km upstream to shorten the supply pipeline, limit environmental requirements, improve circulation in the reservoir, and lessen capital costs. The river morphology is also more favorable as the river channel is concentrated at the new location.
   - The pump sizing in the Red Deer River Pumpstation was adjusted to reduce the number of pumps from 7 to 4 which in turn reduced the mechanical, electrical and footprint requirements of the pumpstation, providing overall cost savings.
   - Conveyance canal and pipeline sizes were slightly increased to meet current irrigation and industry standards.
   - The routing of the pipeline that supplies Block 3 was adjusted. The gravity syphon across Kennedy Coulee was twinned and an additional pumpstation was added to supply Block 3 independently from Block 4. This led to pro and con infrastructure changes, but overall lowered the capital cost.

- The layout of the East and West Dams of Reservoir A1 remained the same; however, based on the favourable results from the Geotechnical Investigation, the cross section of both dams was refined, which reduced the embankment fill (as compared to the 2005 Study).
- Refer to Figure E2 for the revised infrastructure layout.

7) Project Costs

- Capital costs have increased since the 2005 Study at a rate similar to normal inflation over that time period (i.e. approximately 2.3%/year).
- O&M costs have not increased as significantly as capital cost, mostly due to the more competitive power market since 2005.
- Scenario 3 has the lowest per-acre capital and annual O&M cost, followed by Scenario 1 and then Scenario 2.

Table E4 - Updated Capital Costs

Description	**Scenario 1**	**Scenario 2**	**Scenario 3**
2019 Capital Costs	$ 78,755,000	$ 113,860,000	$ 137,615,000
2019 Capital Cost Per Acre	$ 5,834	$ 5,175	$ 5,097
Percent Increase from 2005	45.2 %	43.9 %	42.2 %

Table E5 - Annual O&M Costs

Description	**Scenario 1**	**Scenario 2**	**Scenario 3**
Total Annual O&M Cost*	$ 1,559,500	$ 2,703,500	$ 2,852,500
O&M Cost Per Acre	$ 116	$ 123	$ 106
Percent Increase from 2005	0 %	15 %	8.2 %

* Includes pressure surcharge credit for Blocks 3 and 4

** Approximately 75% of the annual O&M cost is attributed to the power and operating cost of the Red Deer River Pumpstation.

8) Economic Analysis

- The Update Study considered three types of analysis to provide insight into the socio-economic viability of this project: i) Provincial Benefit-Cost Analysis; ii) Provincial Impact Analysis; and iii) Farm Capacity-to-Pay Assessment.
- When regional impacts are not considered a net benefit to the province, the Provincial Benefit-Cost analysis (based on direct project costs and benefits only) tentatively concludes:
  - The Internal Rate of Return (IRR) is estimated to range from 0.7% per year to 1.08% per year for Scenarios 1/2, and 3 respectively. The estimated Benefit-Cost (B/C) ratio, at a 4% discount rate, is 0.77 for Scenario 1, 0.78 for Scenario 2, and 0.79 for Scenario 3.

  - The corresponding sensitivity analysis indicates that for Scenario 3 (the economically "best case"), the confidence band that brackets the B/C ratio of 0.79 could be as low as 0.65 or as high as 0.97.
  - In today's financial markets, a project zero real social rate of return (after inflation) might be acceptable. Based on a 0% discount rate, the B/C ratio for Scenario 3 is 1.09, but could be as high as 1.33 and as low as 0.89.
  - These results are very similar to the 2005 Study and to numerous other "irrigation" studies in Southern Alberta. Sixteen such studies calculated B/C ratios which averaged about 0.80 and ranged from 0.33 to 1.47. Only four of these 16 studies had a B/C ratio >1 based only on direct project costs and benefits.
- The regional impact analysis (i.e. includes direct spin-offs to the regional and provincial economy) determined the following:
  - The MD of Acadia Irrigation Development Project would spur regional development that in turn leads to sustainable socio-economic growth.
  - The B/C ratio (at a 4% interest rate) for Scenario 3 is a very strong 1.41, the net present value is about $163 million over 50 years, and the internal rate of return is a healthy 8.19% per annum.
  - This analysis clearly shows that when regional spin-offs generated by the irrigation project are considered, the net economic impact is irrefutably positive.
- The farm financial analysis (farm capacity-to-pay) determined the following:
  - On-farm profitability is highly dependent upon the amount the farmer has to contribute to the irrigation system's capital and operating costs.
  - The maximum farmer contribution to the overall project (Capital and O&M) is approximately $50/ac/year. This allows reasonable farm net income and rate of return; however, the incentive to convert from dryland to irrigation may still be marginal.
- Based on this, Table E6 provides several contribution options that could be considered.
  - For all options it is assumed that the O&M costs for the distribution system is always covered 100% by irrigators, and any contributions to capital is based on a 20 year amortization period with 4% annual interest.
  - Red shaded options (A's) are where farmers contribute more than $50/acre/yr, resulting in poor on-farm profitability.
  - Yellow shaded options (B's) are where farmers contribute $50/acre/yr, resulting in moderate profitability; but possibly not enough to incentivize switching from dryland.
  - Green shaded options (C's) are where farmers contribute < $50/acre/yr, resulting in good profitability and incentive to switch from dryland to irrigation.
  - Therefore, on-farm profitability relies on no capital or O&M contribution towards the Headworks system, and limited (0-15%) contribution towards the distribution system capital.

Table E6 – Cost-Sharing Options and Farm Profitability

Option	Contribution to Capital by Irrigators		Contribution to O&M by Irrigators		Level of Farm Profitability
	Headworks System	Distribution System	Headworks System	Distribution System	
A1	**25 %**	**25 %**	**25 %**	**100 %**	**Poor**
A2	**10 %**	**10 %**	**0 %**	**100 %**	**Poor**
B1	**0 %**	**0 %**	**31 % ($25/ac)**	**100 %**	**Moderate**
B2	**7 %**	**7 %**	**0 %**	**100 %**	**Moderate**
B3	**0 %**	**15 %**	**0 %**	**100 %**	**Moderate**
C1	**0 %**	**10 %**	**0 %**	**100 %**	**Good**
C2	**0 %**	**0 %**	**0%**	**100 %**	**Very Good**

1. A options (red shading) relate to a poor farm-level investment (i.e. farm income and rate of return is insufficient and farmers would not convert from dryland to irrigation)
2. B options (yellow shading) relate to a moderate farm-level investment (i.e. farm income and rate of return are acceptable; however, the incentive to convert from dryland to irrigation is marginal).
3. C options (green shading) relate to a good farm-level investment (i.e. farm income, rate of return and incentive to convert from dryland to irrigation is high).

- In conclusion, Provincially, this Update Study confirms a strong economic viability when regional impacts and benefits are considered; however, to ensure farm profitability and adequate incentive to switch from dryland to irrigation, securing outside (Provincial and Federal Government) funding support is vital, including:
  - Government funding of 100% of the Headworks system (capital and O&M), an arrangement similar to other Irrigation Districts in Alberta.
  - Government funding of 90-100% of the Distribution System capital cost.

9) Next Steps

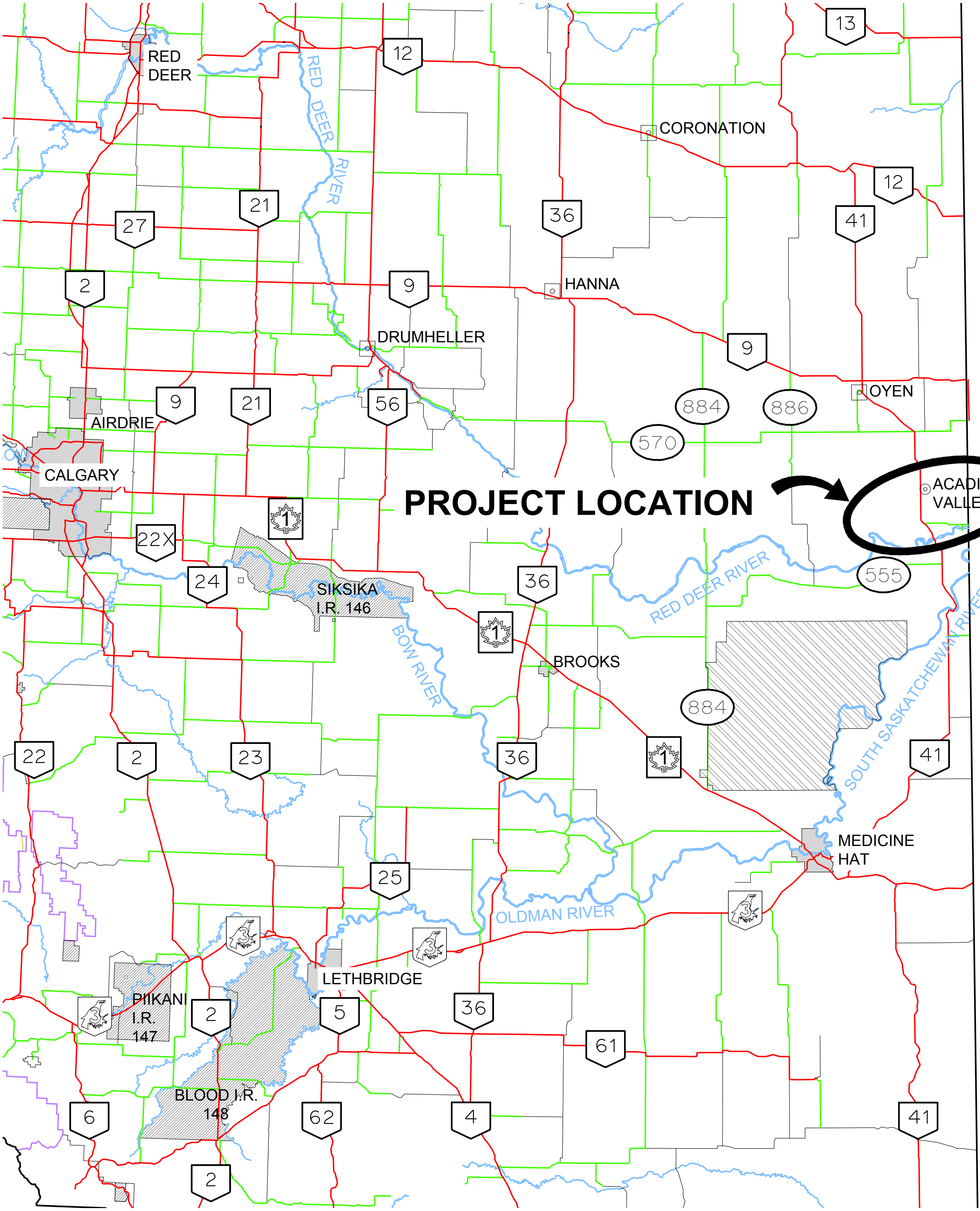
- This Update Study is still conceptual in nature and considerable future assessments and next steps are required to further the project to development, as follows:
  - ***Marketing:*** The MD should proceed with marketing this project, starting with obtaining support from local MD residents; getting regional support from nearby municipalities; and then lobbying the provincial and federal government partnership for project funding, as well as commitment to update the IDM and WRMM modelling.
  - ***Environmental / Historical:*** Once funding commitments are secured and a firm project timeline is established, the EIA should be initiated along with all required environmental and historical resource assessments.
  - ***Irrigation Development:*** Concurrent with the EIA, the final Irrigation Development scenario should be completed, along with any updated land classification requirements and updating the IDM and WRMM modelling.
  - ***Preliminary Engineering Study:*** The preliminary engineering study would follow, including finalizing the concept and completing preliminary design of all infrastructure components.

  - ***Regulatory Approvals:*** After completion of the EIA, finalization of the development area, and the preliminary engineering study, all applications for regulatory approvals should be made.
  - ***Detailed Design:*** Final design of the infrastructure can proceed during the regulatory application process, including preparation of contract documents.
  - ***Construction:*** Finally, project contracts can be tendered, and construction completed.

- The entire timeline for this project is anticipated to take about 5-7 years from funding approval to water delivery, as per the following project implementation schedule.

Table E7 Project Timeline

Key Items	Year 1				Year 2				Year 3				Year 4				Year 5				Year 6				Year 7			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Environmental and Historical Resources																												
Field Surveys and Assessments	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩																				
Mitigative Measures					🟩	🟩	🟩	🟩																				
Finalization of Irrigation Development Design		🟥	🟥	🟥	🟥																							
Preliminary Engineering Design					🟥	🟥	🟥	🟥																				
Regulatory and Other Approvals									🟨	🟨	🟨	🟨	🟨	🟨														
Detailed Design and Tendering											🟪	🟪	🟪	🟪														
Construction																												
Reservoir A1															🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦				
Supply Pipeline and River Pumpstation															🟦	🟦	🟦	🟦	🟦	🟦	🟦							
Secondary A Canal																		🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦		
Conveynace Pipelines and Laterals																		🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦		
Commissioning and Reservoir Filling																							🟦	🟦	🟦	🟦		
System Operational																								🟦	🟦	🟦		



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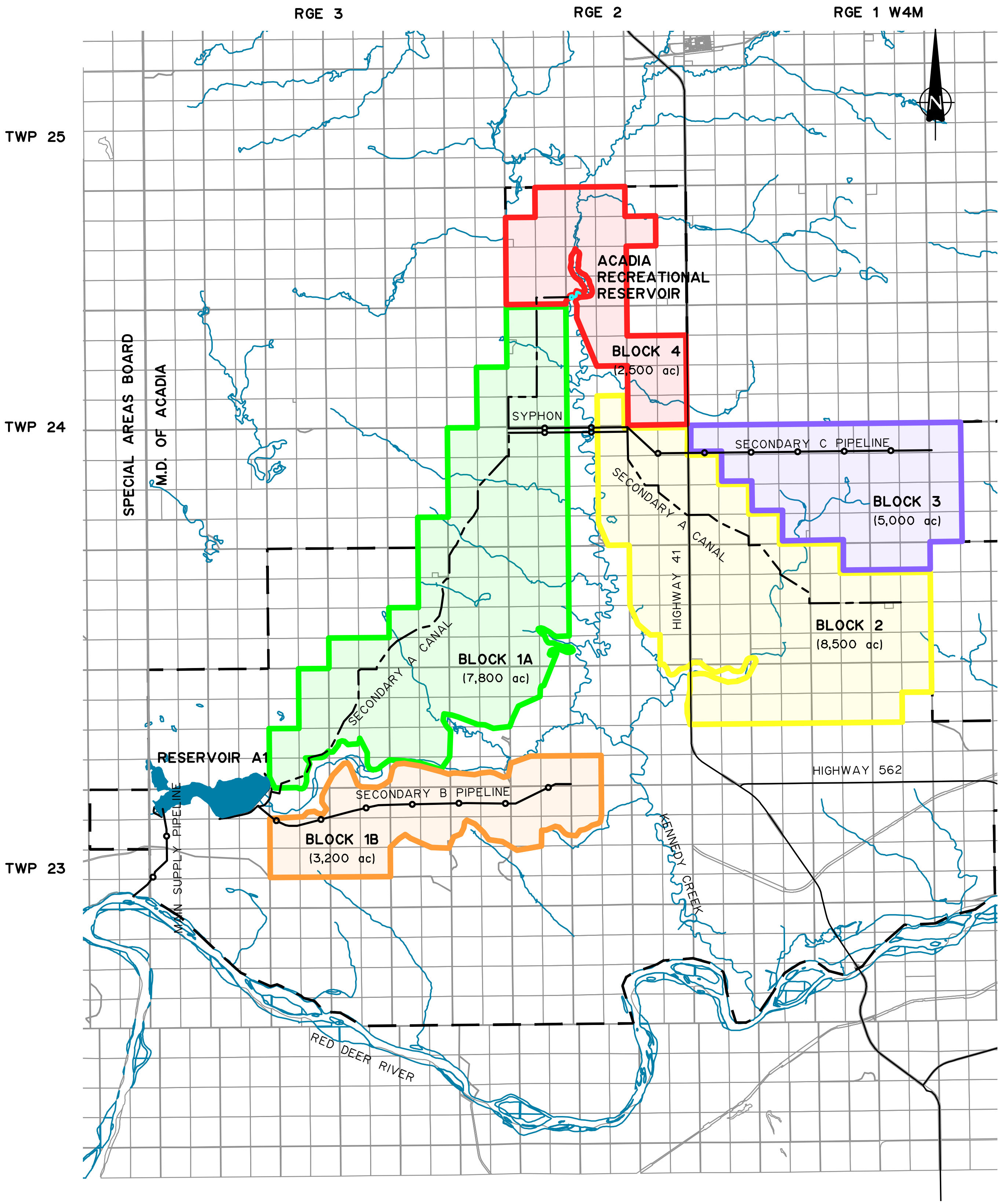
M.D. OF ACADIA NO. 34

IRRIGATION DEVELOPMENT STUDY GUIDE
LOCATION PLAN

SCALE: NTS	DATE: NOVEMBER 2019	JOB: 4280-002-00	FIGURE: E1



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M.D. OF ACADIA NO. 34

IRRIGATION DEVELOPMENT STUDY UPDATE

DEVELOPMENT SUMMARY

SCALE: 1:75 000	DATE: NOVEMBER 2019	JOB: 4280-002-00	FIGURE: E2

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FIGURES

1.0 INTRODUCTION

The Municipal District of Acadia No. 34 (MD of Acadia; or MD) is located in Southeastern Alberta approximately 120 km north of the City of Medicine Hat. The MD of Acadia is one of the regions in Alberta that is most severely impacted by a lack of precipitation, a secure water supply and economic growth and diversification. A change from dryland to irrigation farming could stabilize farm incomes, provide employment opportunities through the enhancement of new support industries and improve overall social conditions in the area. Earlier studies, carried out in the mid-1980's, examined water supply alternatives for both municipal and irrigation purposes. However, the benefit/cost ratios were less than favourable and further investigations were not implemented.

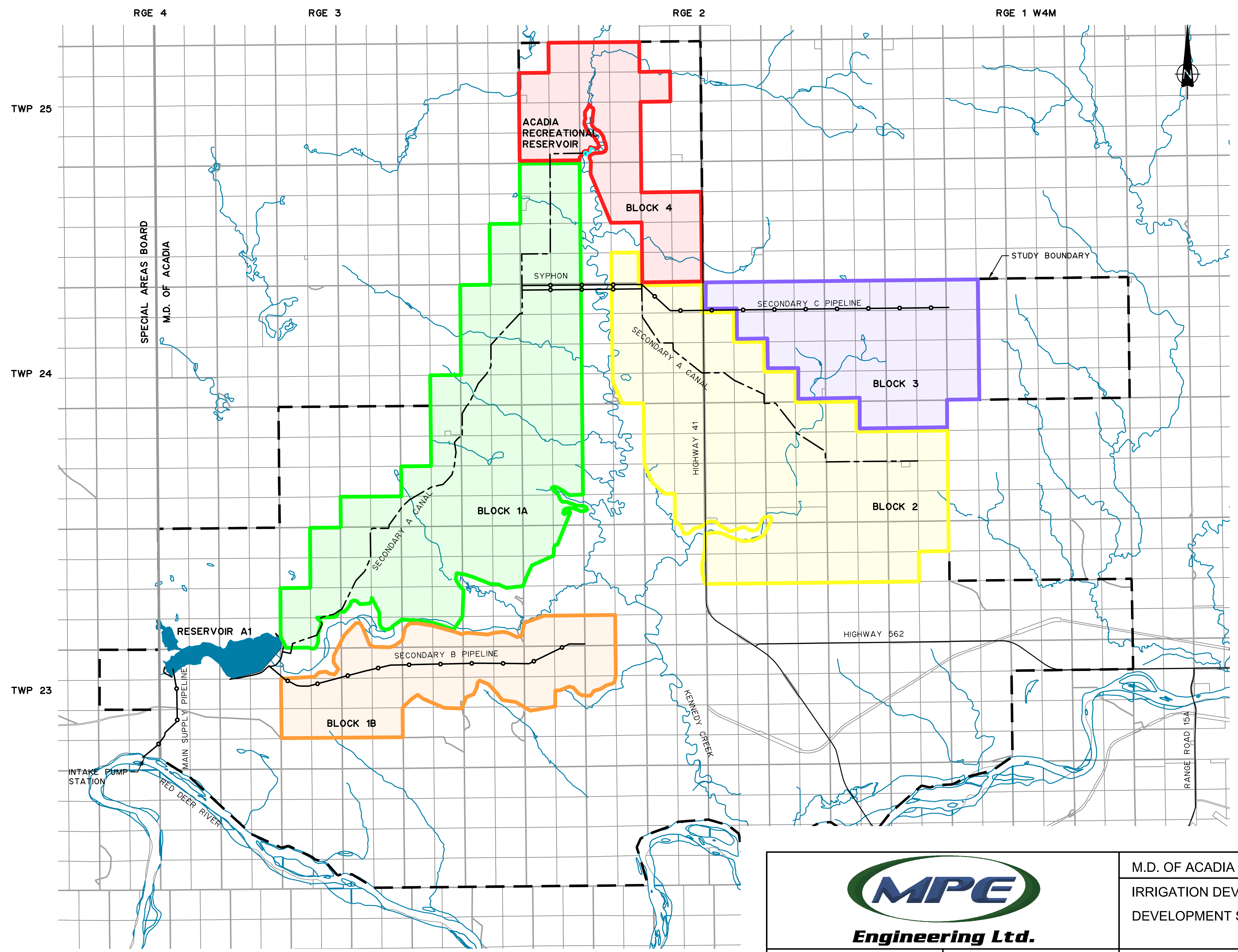
Since the mid-1980's, development of the Valley South Water Co-op, and the implementation of privately operated irrigation systems on irrigable land within the MD (near the Red Deer River), significantly impacted project parameters for the potential irrigation projects studied in the 1980's. In 2004 the MD, through Alberta Agriculture and Forestry (AAF), commissioned an irrigation feasibility study. This study was completed in 2005 by MPE Engineering Ltd. (MPE, 2005) and provided several scenarios in which irrigation would be feasible in the MD.

1.1. BACKGROUND

The 2005 Study identified three irrigation development scenarios ranging in size from 5,500 Ha to 11,000 Ha. The project area, irrigation blocks, and infrastructure components are displayed on Figure 1.1. The 2005 Study concluded that Scenario 2 & 3 had the best benefit/cost (B/C) ratio, suggesting that the optimal irrigation development area was between 8,900 Ha and 11,000 Ha. The Study also concluded that alternative sources of revenue / funding would be necessary to offset both the capital and O&M costs to ensure economic viability of irrigation development within the MD. One main issue highlighted in the Study was the high O&M costs associated with pumping the water from the Red Deer River to Reservoir A1.

1.2. CURRENT STUDY GOALS

The primary focus (purpose) of this study is to update the 2005 Study to current (2019) standards in terms of industry practice, project assumptions, environmental and regulatory changes, capital and operation cost estimates, economic justification, etc. This Update Study is still at a "conceptual engineering" level, with a few value-added components to help understand possible risks, and a better definition /discussion of next steps.



DEVELOPMENT SUMMARY

SCENARIO	BLOCKS
1	1A, 1B, 4
2	1A, 1B, 2, 4
3	1A, 1B, 2, 3, 4

IRRIGABLE ACRES

BLOCK	HECTARES	ACRES
BLOCK 1A	3 157 ha	7 800 ac
BLOCK 1B	1 295 ha	3 200 ac
BLOCK 2	3 440 ha	8 500 ac
BLOCK 3	2 023 ha	5 000 ac
BLOCK 4	1 012 ha	2 500 ac

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M.D. OF ACADIA No. 34

IRRIGATION DEVELOPMENT STUDY UPDATE

DEVELOPMENT SUMMARY

SCALE: 1:100 000
DATE: SEPTEMBER 2019
JOB: 4280-002-00
FIGURE: 1.1

The Update Study allows the MD of Acadia to:

- Have a report that is current in terms of agricultural use (crop mix, equipment type, etc.), environmental, engineering, cost estimates and economic realities.
- Better understand risks, challenges and unknowns to inform them on next step requirements.
- Have a tool that is current and adequate to market the project and lobby for funding and partnering opportunities; as well as to better inform MD residents on the potential risks and opportunities this project would offer.

The 2005 Study is outdated and requires updates in a number of areas, including:

- Crop use and on-farm equipment water-use efficiency assumptions are outdated, and do not reflect current standards and industry trends, or the economic potential irrigation development could bring to the area. This should be updated and any potential water use reductions and or economic improvements quantitatively identified.
- Environmental and historical assessment data was a desk-top study that is now outdated due to regulatory changes and industry “best management” practices. The desk-top study should be updated to represent a current (credible) review of potential environmental and historical impacts, costs and next steps. This will particularly focus on implications for the proposed headworks system (supply pipeline and reservoir), and if an Environmental Impact Assessment (EIA) will be required.
- Infrastructure technology (in terms of pumping and irrigation delivery infrastructure) has evolved somewhat and the infrastructure assumption should be reviewed, and updated if appropriate, to meet current practice and possibly identify potential areas for capital or operational cost savings.
- The storage reservoir is a critical component of the project and the geotechnical viability of the reservoir and associated dams was only completed at a desk-top level in the 2005 Study. A limited geotechnical field investigation at the reservoir site would be valuable at this stage to better understand potential viability, limitations, costs and next steps regarding the feasibility of the storage reservoir.
- Capital and operation cost estimates do not reflect current market values. This may impact the project cost/benefit and should be updated to provide current (credible) economic values.
- The next steps identified to advance the project are outdated and need to be better defined, including priority and approximate costs. This includes next steps involving marketing, identifying funding options, environmental & historical studies, geotechnical and engineering investigations and assessments, etc.

2.0 CONCEPT REVIEW

A critical review of the 2005 Study in terms of the assumptions and overall system was completed to identify any changes in technology or industry practice that have occurred since 2005, and/or any other system improvements that would make the project more viable.

2.1. IMPROVEMENTS / ADVANCEMENTS

In general since the 2005 Study, there have been some changes to current industry standards and best practices. This includes crop mix and irrigation methods; however, there have also been some improvements in conveyance infrastructure such as the ability to use larger diameter PVC pipe (up to 1500 mm) that will be discussed.

2.1.1. *Crop Mix*

The 2005 Study used a crop mix that leaned more heavily towards forage crops, as the Committee felt that the specialty crop market was a considerable distance from the area and the irrigation would be more likely to support livestock driven markets. Table 2.1 shows the assumptions in the 2005 Study versus Alberta Irrigation District averages from the 2005 and 2017 Alberta Irrigation Districts Summary Reports (AAF 2005, AAF 2017).

Table 2.1: Crop Mix Changes 2005-2017

Crop Group	2005 Study	2005 Alberta Avg.	2017 Alberta Avg.
Cereals	28.2 %	30.4 %	28.8 %
Forages	67.9 %	45.8 %	33.1 %
Oil Seed	3.8 %	8.8 %	12.9 %
Specialty	0 %	12.9 %	23.7 %
Other	0 %	2.2 %	1.5 %
Total	100 %	100 %	100 %

The trend shows that for other irrigation districts in Alberta, the percentage of cereal crops has stayed relatively constant near 30%, forage crops have decreased from around 46% to 33%, oil seeds have increased from 13% to 24%, and specialty crops have increased from 13% to 24%. Therefore, the percentage of forage crops used in the 2005 Study appears to be over-estimated for current realities. Growing forage crops with irrigation is usually a poor use of resources as forages have high water demand and low value providing a poor rate of return. Typically forage percentages in irrigation areas are much lower than the 2005 Study assumed unless there is a local or regional cow/calf market which can support increased forage production.

This issue was discussed with the Irrigation Secretariat at AAF, with the following location factors identified:

- Isolation and distance from major food processors: Acadia Valley is a fair distance from the established food processing industries in Alberta mostly centered around Lethbridge and Taber; for this reason the amount of specialty crops may be less than other Irrigation Districts. This isolation however may be an advantage for seed producers.
- The latitude of the proposed irrigation district is further north than the majority of Alberta's irrigation districts, though heat units are similar.
- Farmers in the area are not experienced in irrigation or with specialty crops.
- Based on the above factors, AAF suggested that the crop mix may be closer to the Western Irrigation District (WID) or Magrath Irrigation District (MID), both of which have relatively low specialty crops and a higher percentage of forage crops.

AAF comments were reviewed with the MD and the project team. It was determined that comparison to the WID and MID was not realistic for the Study Area; and establishing and marketing higher value crops will be critical to ensure the viability of this project. As such, the crop mix from the St. Mary River Irrigation District (SMRID) was accepted as a comparable for the study area, which contains a higher percentage of specialty crops and would provide a better profit margin for the local farmers and a higher overall benefit to cost ratio. Additionally, even though the percentage of specialty crops in the SMRID is 28%, almost half of this is pulses (lentils, dry beans, and peas), which is already commonly grown in the MD of Acadia, so this is a realistic comparable.

Table 2.2 shows the recommended crop mix compared to the 2005 Study. For reference, 2017 data from the WID, MID, and SMRID are also shown.

Table 2.2: Recommended Crop Mix

Crop Group	2017 WID	2017 MID	2017 SMRID	2005 MD of Acadia Study	2020 MD of Acadia Update Study
Cereals	25.7 %	34.7 %	31 %	28.2 %	31 %
Forages	36.7 %	43.5 %	26 %	67.9 %	26 %
Oil Seed	16.3 %	20.3 %	15 %	3.8 %	15 %
Specialty	7.8 %	1.5 %	28 %	0 %	28 %*
Other	13.4 %	0 %	0 %	0 %	0 %
Total	100 %	100%	100 %	100 %	100 %

* 15 % of all crops (~1/2 of the specialty crops) are pulses such as: lentils, beans, and peas

2.1.2. *Irrigation Methods*

Since 2005 there has been a steady conversion of a large portion of the irrigation systems in Southern Alberta to Low Pressure Pivots; for example the Bow River Irrigation District (BRID) is currently 85% low pressure pivots. Table 2.3 shows the irrigation method assumptions in the 2005 Study versus Alberta Irrigation District averages from the 2017 Alberta Irrigation Districts Summary Reports (AAF, 2018).

Table 2.3: Irrigation Methods 2005 to 2017

Irrigation Method	2005 Study	2017 Alberta Avg.
Flood	0 %	7.0 %
Hand Move	5 %	0.9 %
Wheel Move	10 %	8.1 %
High Pressure Pivots	35 %	6.7 %
Low Pressure Pivots	50 %	77.3 %

Since 2005, most new irrigated land is serviced using low pressure pivots. Based on discussion with AAF it is very likely that the new development for the MD of Acadia would have a system that is almost entirely low pressure pivots. This means that the pressurized systems in Block 3 and Block 4 could be run at a lower pressure, reducing pumping requirements and potentially result in cost savings. Recently subsurface drip irrigation has begun to occur around the Lethbridge area as well; however, it is geared more toward specialty crops and is not anticipated to be incorporated for the MD of Acadia project. Therefore, since this project would be new, it is anticipated that low pressure systems will largely be used, with the exception of some hand or wheel move lines for smaller fractional areas where pivots are not practical.

For the purpose of this Update Study, the following irrigation method mix was used:

- 95% low pressure pivots
- 5% hand or wheel move lines.

2.1.3. *Conveyance System*

The conveyance network proposed in the 2005 Study is comprised of the following components, beginning at the upstream end of the system:

- River Pumpstation - this is the main pumpstation on the Red Deer River, with capacity of 2 m^3/s for Scenario 1 and 4 m^3/s for Scenarios 2 and 3. This pumpstation supplies all the water for the irrigation system.
- Main Supply Pipeline - this is a large diameter pipeline that conveys water between the River Pumpstation and Reservoir A1; it is required to be constructed from steel due to the high line pressure required to lift water out of the Red Deer River Valley.
- Reservoir A1 - this is the main supply reservoir for the project required to balance the peak flow demands of the irrigation network with the water supply realities from the River. The reservoir stores between 7,200 and 17,000 dam^3 depending on the irrigation scenario.
- Secondary A Canal - this is a lined open channel canal, which feeds irrigation blocks, and varies in capacity from 3.25 to 7.50 m^3/s.
- Kennedy Coulee Syphon - this is a gravity PVC inverted syphon, that conveys water across Kennedy Coulee on the Secondary A Canal system, with a design capacity of 2.85 m^3/s.

- Secondary B Pipeline - this is a gravity PVC pipeline that is fed from Reservoir A1 that supplies Block 1; the system is comprised of PVC pipelines.
- Secondary C Pipeline - this is a pressurized pipeline system fed from the Acadia Recreational Reservoir, comprised of a PVC pipeline and laterals.
- Block 4 Pressurized System - this is a pressurized pipeline system fed from the Acadia Recreational Reservoir, comprised of a PVC laterals.

Upon review of the 2005 Study system, a number of improvements were identified based on current standards and practice:

- River Pumpstation/Supply Pipeline - there appears to be some merit in changing the location of the river pumpstation.
    - The proposed location of the river pumpstation is not ideal from a river morphology perspective; there is a large island immediately upstream and downstream of the pumpstation which may lead to channel re-routing or costly river training in the future.
    - The original pumpstation site also required a long (5 km) pipeline which discharges near the outlet structures for Secondary A Canal and Secondary B Pipeline; this would result in poor circulation in the reservoir and excess silt transport, as the water from the supply pipeline does not have much time to settle out.
    - An alternate site, 3 km upstream on the river, appears to be better from a river morphology perspective. This location also requires a shorter supply pipeline (2.5 km), and discharges into the west end of the reservoir away from the outlet structures which will lead to better circulation and water quality. However, the terrain for the new pipeline route is slightly steeper and it would require a slightly longer access road and connection to the power grid.
- Secondary C Pipeline and pumpstation - based on review of the pipeline and pumpstation there are some ways the design could be modified to reduce the capital costs.
    - The current location of the pumpstation at the Acadia recreational reservoir, means that there is over 4700 m of pipeline before the first delivery within Block 3. This is large diameter PVC pipe which is quite expensive. The PVC pipe must also be DR 32.5 to handle the pressure ratings which further increases the cost.
    - There is also 5,000 m of canal from the Syphon to the Acadia Recreational Reservoir that requires upsizing to carry the flows for Block 3, increasing the capital costs.
    - There is no operational benefit to using the Acadia Reservoir as it contains little storage and requires additional infrastructure to serve as the start of the Secondary C Pipeline.
    - Block 3 essentially starts at the end of the Kennedy Coulee Syphon; therefore, it is proposed to move the Block 3 Pumpstation to the end of the syphon, which allows gravity pressure to prime the pumps. This means that centrifugal pumps can be used, resulting in a reduced pumpstation footprint.
    - The new pumpstation location also means that the syphon twinning is 1,500 m shorter than the original pipeline from Acadia Reservoir. Additionally, reducing the pipeline

  - length from the pumpstation to the first delivery, decreases headloss and reduces the required horsepower from 1,250 hp to 1,000 hp, which in turn will lead to lower operation and maintenance costs.
  - On the negative side, the new pumpstation location requires a separate power service as compared to a shared one with the Block 4 Pumpstation, which does add some additional costs. The syphon across Kennedy Coulee will also increase in width which may slightly increase the environmental implications.
- Pipeline and Canal Design - based on the Current IRP Standards (AARD, 2017), there appears to be some updating required to the conveyance flow capacity assumptions used for the 2005 Study.
  - Assumptions in the 2005 Study for the number of parcels operating at any time on the pipelines is lower than the current IRP Standards allow. For example, in the 2005 Study the Secondary B pipeline uses utilization as low as 68%, whereas the current IRP standards never allow for utilization below 80%.
  - The 2005 Study assumptions of flow for a single parcel are also less than the 2017 IRP Standards. For the pipeline designs in the 2005 Study a parcel flow rate of 0.056 m^3/s (900 USGPM) was used, which is the standard flow rate of a 130 acre low pressure pivot; however, the 2017 IRP Standards require parcels 130 acres and larger be designed for 0.069 m^3/s (1100 UGPM).
  - The 2005 Study does state that the flows for the Secondary A Canal were based on the results of the WRRM modelling, but as a check, the large block flow equations do show that larger peak flows are expected than presented in the 2005 Study. This will not change the overall water volume requirements but rather just the peak flows required to make sure no irrigator is short on supply.

The rest of the concept in terms of the conveyance system, design, and the routing appears to be sound for the detail required at this level of study. The impacts and full assessment of the potential changes discussed above, are provided in Section 3.0.

2.1.4. *Energy*

There have been several changes to the electrical system since the 2005 Study. The price of power has been fairly stable and low since 2014; however, the fees for transmission and distribution have changed quite significantly since 2005, and an update to the annual power costs for the pumpstations will be required.

3.0 CONCEPT UPDATE

This section provides the details of the changes and adjustments that will be used in the Update Study, based on the concept review in Section 2.0, and provides updates to the project capital and operation and maintenance costs.

3.1. SCENARIOS

Since this study is intended to update (not change) the 2005 Study report, the study area and development scenarios remain the same for this Update Study. The following provides a brief summary of the irrigation development assumptions.

- The South Saskatchewan River Basin (SSRB) Regulation specifies a maximum acreage cap for irrigation development within the Red Deer River Basin of 39,254 ha (97,000 acres).
    - The 2005 Study included a review of the irrigation development still available considering all existing licenses, preliminary certificates, and all current applications and determined that approximately 7,862 ha (19,428 ac) of irrigation was still available.
    - The above calculation allowed 10,117 ha (25,000 ac) for SAWSP (Special Areas project); but the study conceded that the actual development area in SAWSP would likely be less; therefore, a scenario (Scenario 3) of 27,000 ac was considered.
    - Since the 2005 Study, the irrigation development for the SAWSP project has been reduced to 3240 ha (8005 ac); therefore, the available acreage for irrigation development could be as high as 13,357 ha (33,000 ac), depending on the amount of other irrigation development planned since 2005. Therefore it appears that up to approximately 30,000 acres of irrigation development appears feasible under the SSRB irrigation cap.
- The irrigation development in the 2005 Study was divided into blocks which were chosen using certain criteria such as: limiting irrigation on crown land; land classification (limiting irrigation to only class 2 and 3 irrigable lands); avoiding high salinity areas (east half of Range 1); maximizing gravity conveyance and distribution; minimizing re-pumping, and and/or the amount of pressure for pumped systems (on or off-farm); topography (avoiding very steep land for irrigation equipment); etc.
- The irrigable lands and soil classification is shown on Figure 3.1 and the landownership within the study area is shown on Figure 3.2. Table 3.1 summarizes the irrigation block areas adopted in the 2005 Study and carried forward in this Update Study.

Table 3.1: Irrigation Block Irrigable Acres

Irrigation Block	Irrigated Area	
	(Hectares)	(Acres)
Block 1A	3,157	7,800
Block 1B	1,295	3,200
Block 2	3,440	8,500
Block 3	2,023	5,000
Block 4	1,012	2,500
Total	***10,927***	***27,000***

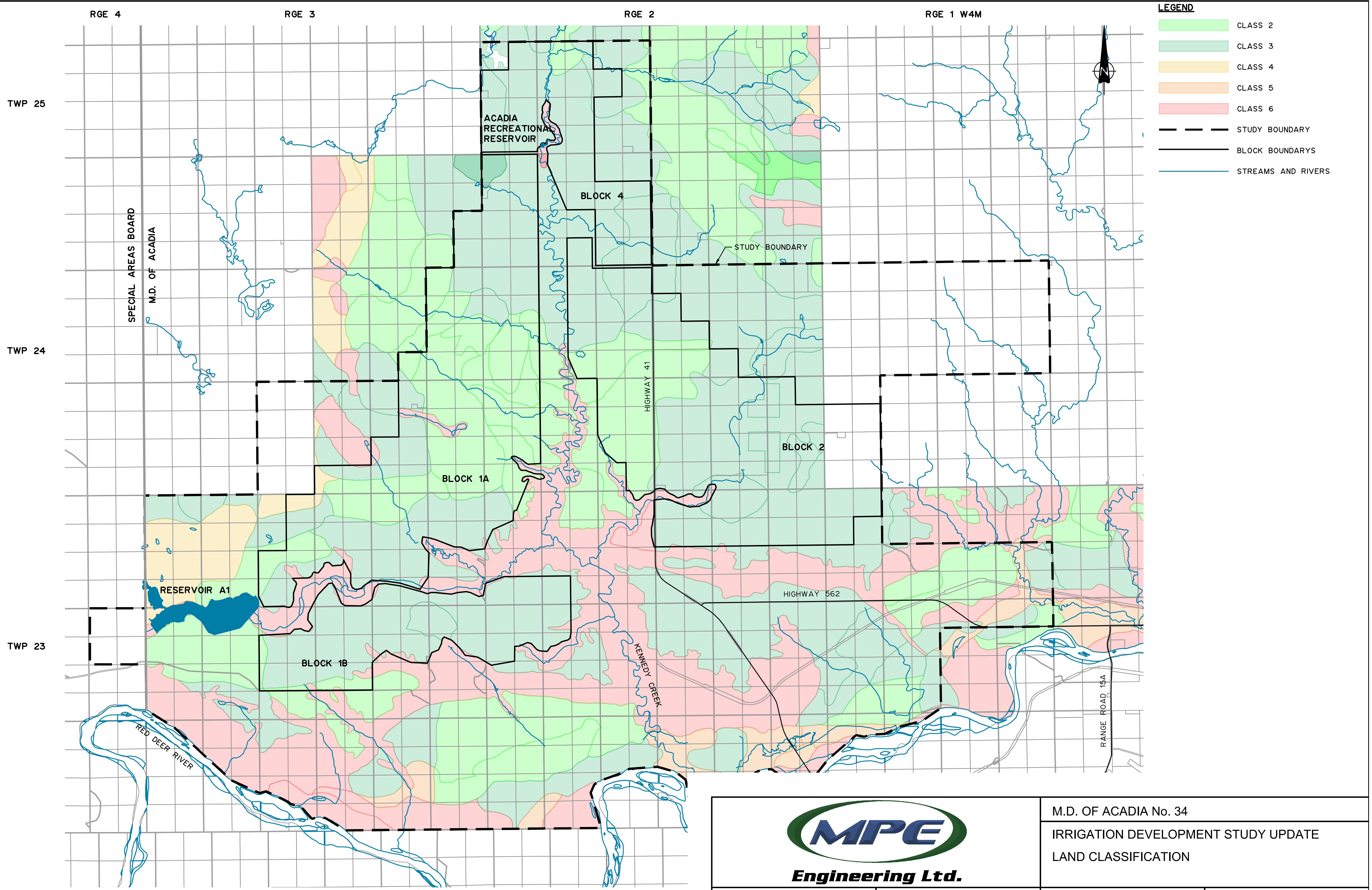
Table 3.2 summaries the three development scenarios. Figures of the scenarios and the major project components are shown in Figures 3.3 to 3.5. Infrastructure requirements for the three scenarios are detailed further in Section 3.5.

Table 3.2: Irrigation Development Scenarios

Development Scenario	Irrigation Blocks	Total Irrigated Area	
		(Hectares)	(Acres)
Scenario 1	Blocks - 1A, 1B & 4	5,464	13,500
Scenario 2	Blocks - 1A, 1B, 2 & 4	8,904	22,000
Scenario 3	Blocks - 1A, 1B, 2, 3 & 4	10,927	27,000

It should be noted that additional review and confirmation will be required as part of “next steps” prior to finalizing the irrigation blocks and scenarios.

- Some tweaking and trade-offs within the system or even immediately adjacent to the boundaries is possible considering that: i) some of the identified land is not yet classified, ii) some crown land is included in the irrigation blocks (325 ha or 800 ac) that may be difficult to convert to cultivated land; and iii) some landowner interest on the fringes of the boundaries may turn out to be feasibly serviced.
- There also may be some limited interest for irrigation west of the MD boundary within the Special Areas; however, this would require direct pumping from Reservoir A1 and most of the land in the vicinity is Public Lands.
- The context of any changes to the irrigation development scenarios and overall development acreage, should be in context with the SSRB Regulation Irrigation Cap and the available water supply from the Red Deer River. In short, these criteria will likely limit the total irrigation acreage to a maximum of about 11,000 – 12,000 ha (or about 27,000 - 30,000 ac).



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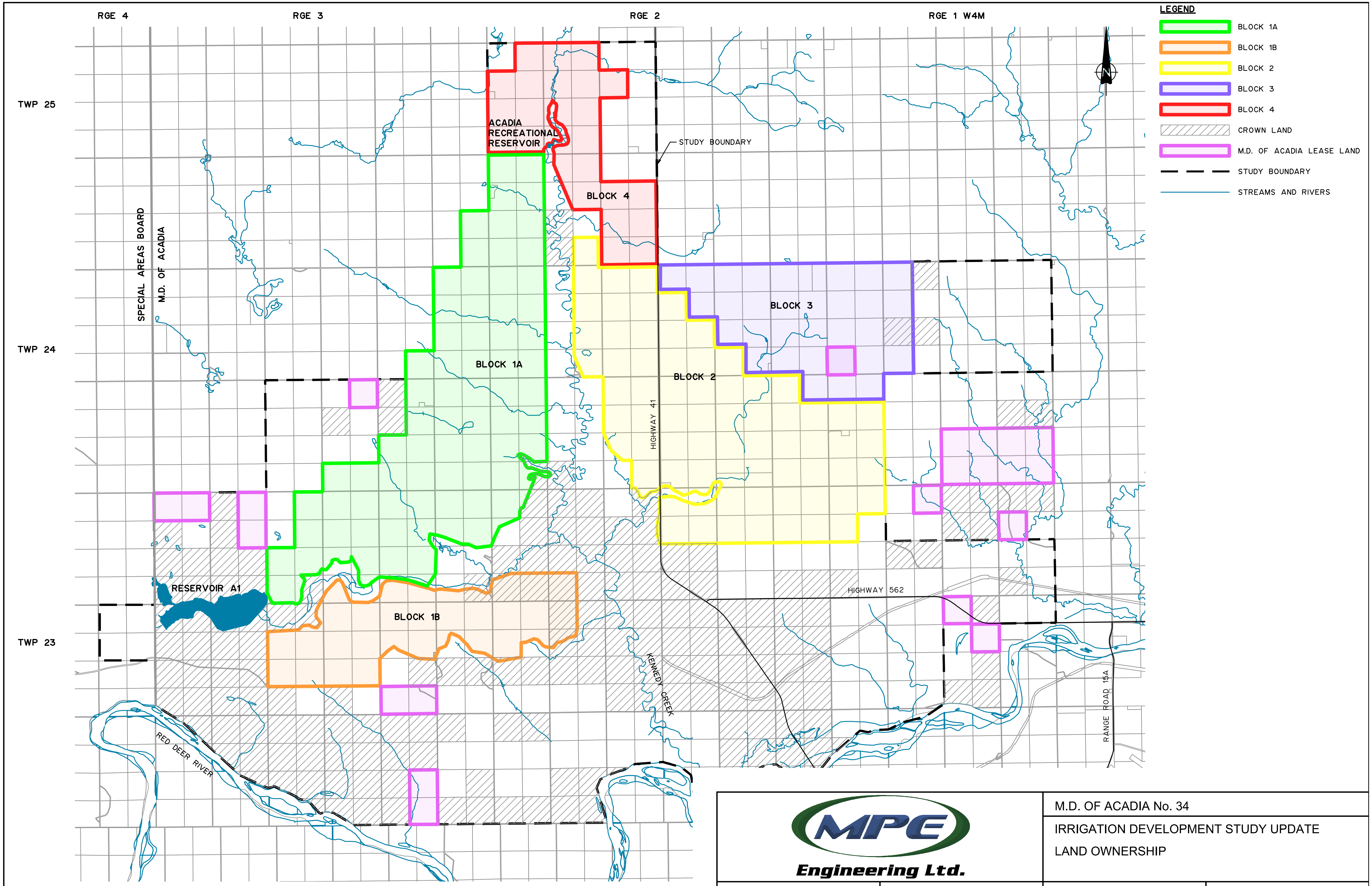
IRRIGATION DEVELOPMENT STUDY UPDATE

LAND CLASSIFICATION

SCALE: 1:100 000	DATE: SEPTEMBER 2019	JOB: 4280-002-00	FIGURE: 3.1



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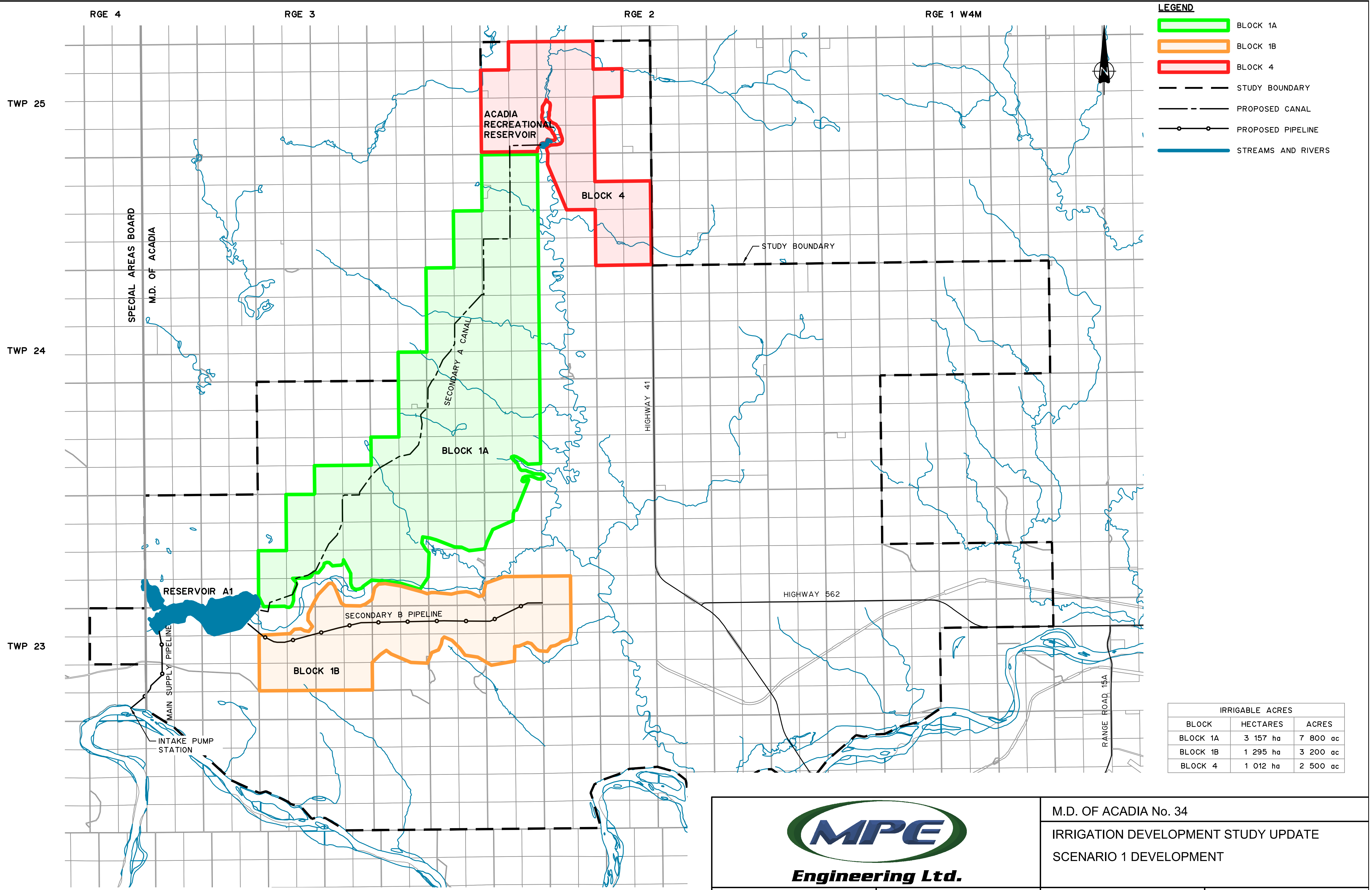
IRRIGATION DEVELOPMENT STUDY UPDATE

LAND OWNERSHIP

SCALE: 1:100 000
DATE: SEPTEMBER 2019
JOB: 4280-002-00
FIGURE: 3.2



IRRIGABLE ACRES		
BLOCK	HECTARES	ACRES
BLOCK 1A	3 157 ha	7 800 ac
BLOCK 1B	1 295 ha	3 200 ac
BLOCK 4	1 012 ha	2 500 ac

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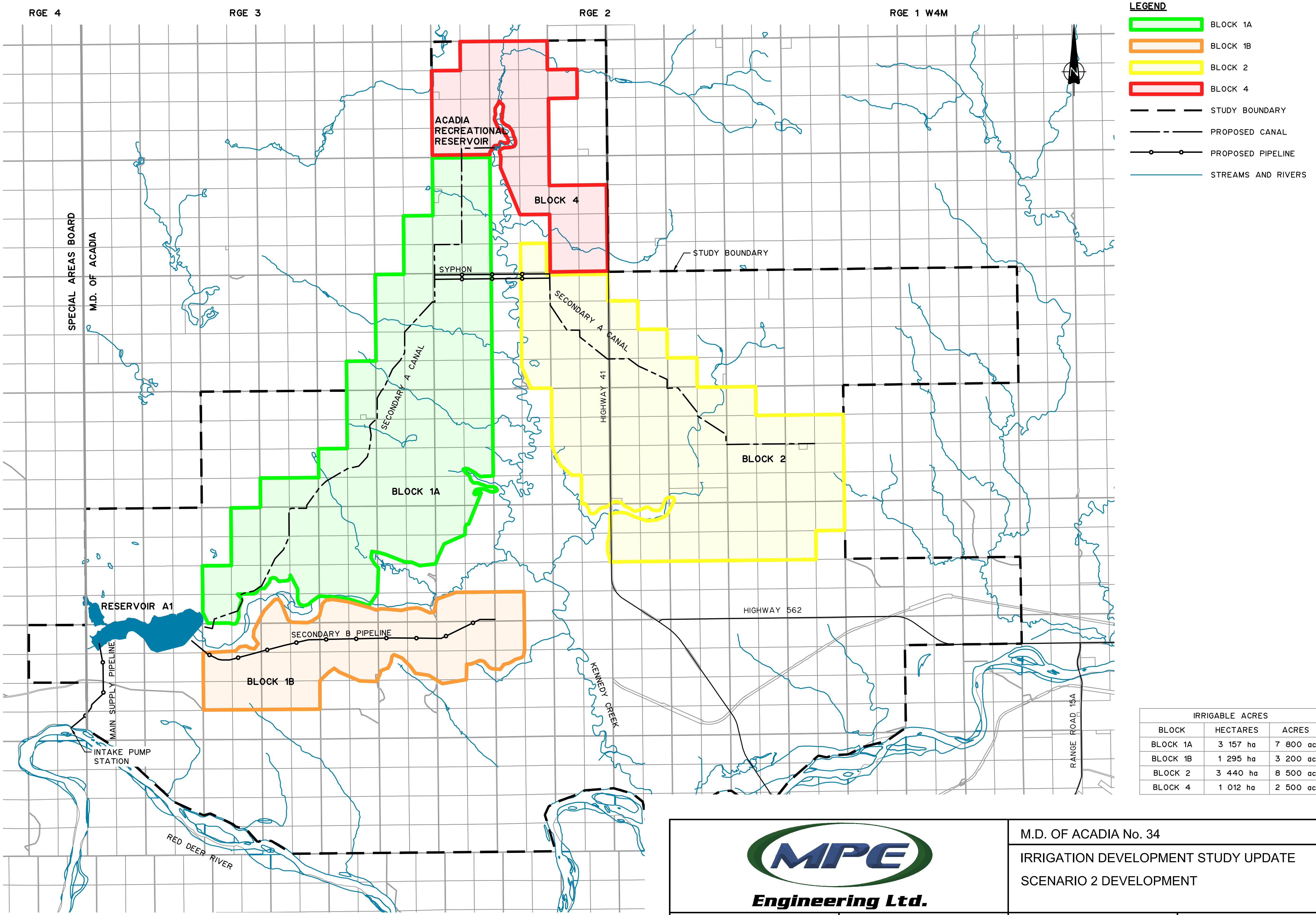
IRRIGATION DEVELOPMENT STUDY UPDATE

SCENARIO 1 DEVELOPMENT

SCALE: 1:100 000
DATE: SEPTEMBER 2019
JOB: 4280-002-00
FIGURE: 3.3



IRRIGABLE ACRES

BLOCK	HECTARES	ACRES
BLOCK 1A	3 157 ha	7 800 ac
BLOCK 1B	1 295 ha	3 200 ac
BLOCK 2	3 440 ha	8 500 ac
BLOCK 4	1 012 ha	2 500 ac

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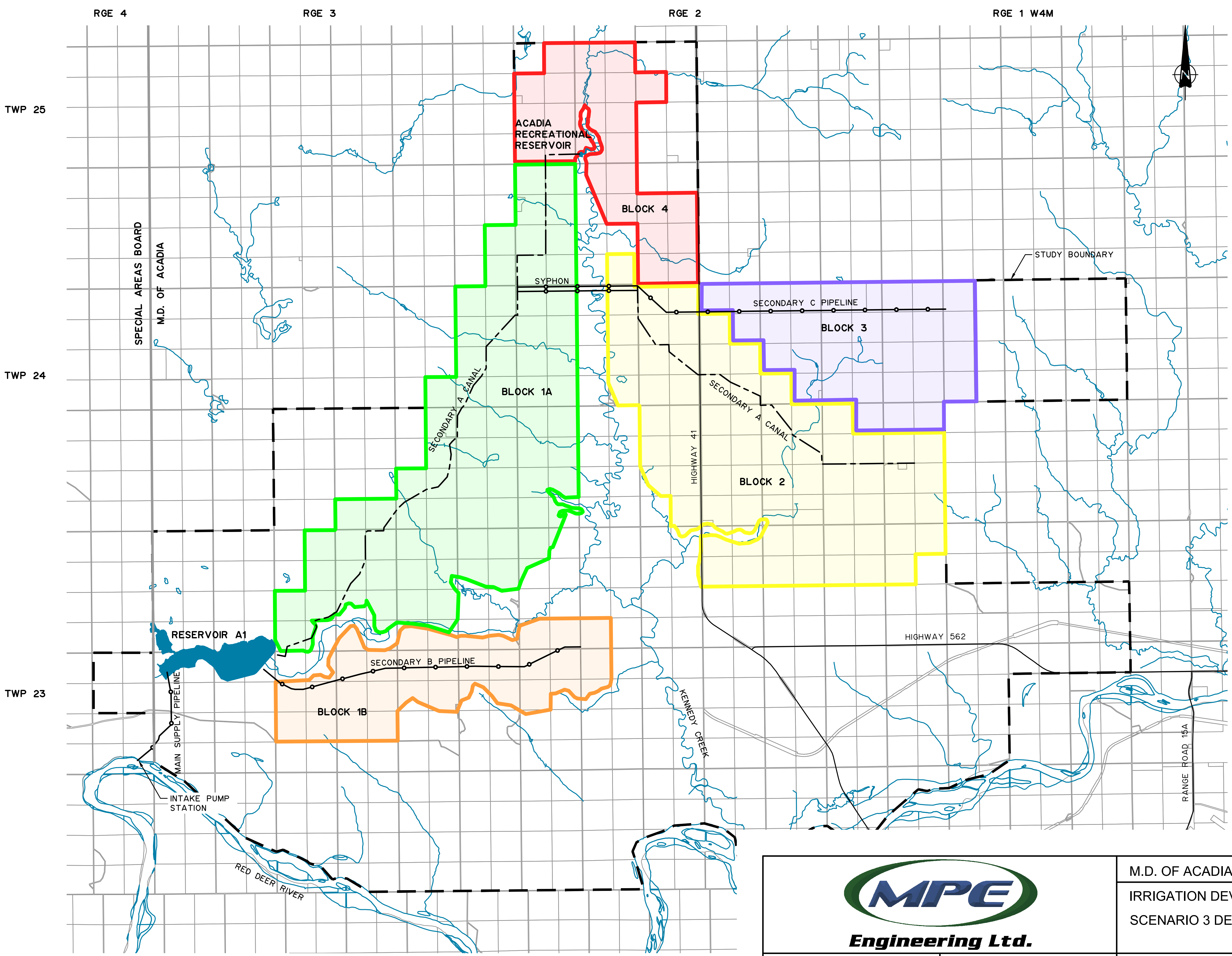
IRRIGATION DEVELOPMENT STUDY UPDATE

SCENARIO 2 DEVELOPMENT

SCALE: 1:100 000
DATE: SEPTEMBER 2019
JOB: 4280-002-00
FIGURE: 3.4



LEGEND

- 🟩 BLOCK 1A
- 🟧 BLOCK 1B
- 🟨 BLOCK 2
- 🟪 BLOCK 3
- 🟥 BLOCK 4
- — — STUDY BOUNDARY
- —·— PROPOSED CANAL
- —o—o— PROPOSED PIPELINE
- —— STREAMS AND RIVERS

IRRIGABLE ACRES		
BLOCK	HECTARES	ACRES
BLOCK 1A	3 157 ha	7 800 ac
BLOCK 1B	1 295 ha	3 200 ac
BLOCK 2	3 440 ha	8 500 ac
BLOCK 3	2 023 ha	5 000 ac
BLOCK 4	1 012 ha	2 500 ac

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IRRIGATION DEVELOPMENT STUDY UPDATE

SCENARIO 3 DEVELOPMENT

SCALE: 1:100 000
DATE: SEPTEMBER 2019
JOB: 4280-002-00
FIGURE: 3.5

3.2. WATER DEMAND

As indicated in Section 2, assumptions from the 2005 Study need to be updated in terms of the crop mix and irrigation equipment, which could have an impact on water demand requirements. The WRRM and IDM modelling completed in the 2005 Study was not updated as part of this Update Study; however, the potential impacts are discussed below.

3.2.1. *Crop Mix*

The proposed crop mix for this Update Study, as identified in Section 2.1.1, includes: 26% forage, 31% cereal, 15% oilseed, and 28% speciality crops. This basically is a considerable reduction of forages (by 31.9%) and shifting to specialty crops and some additional oilseed and cereals.

In essence, forages and specialty crops have similar water requirements; however, cereals and oilseeds tend to have a lower water demand. Therefore, since most of the forage shift from the 2005 Study is to specialty crops, the overall system water demand is not anticipated to change much for the new crop mix identified in this Update Study. It's possible that water demand could be slightly lower with a small increase in cereal and oilseeds; however, this is considered within the range of error for the assumptions used in the initial IDM modelling, including the potential for climate variability in the future.

3.2.2. *Irrigation Equipment*

Based on the proposed irrigation method mix identified in Section 2.1.2 (i.e. 95% low pressure pivots and 5% hand/wheel moves), the new system will be slightly more efficient than the 2005 Study. The overall impact to water demand however, is not anticipated to be significant enough to justify a change in the 2005 Study assumptions. With that said, it is fair to say that the slightly more efficient system does provide some additional buffer against potential climate variability in the future.

Therefore, the crop mix and irrigation method changes identified in this Update Study, do not warrant any changes to the water demand requirements identified in the 2005 Study.

3.3. WATER SUPPLY

A brief overview of the 2005 Study WRRM model, river flow conditions, and internal flows was conducted as part of the Update Study, to identify any concerns or issues that may affect the overall water allocation and diversion requirement for the project.

Based on the recommendations of the 2005 Study, the MD of Acadia applied for, and received two "pending" water allocation approvals for the project:

- 43,200 dam^3 (2005)
- 13,500 dam^3 (2006)

These two approvals provide a total water allocation of 56,700 dam^3. (It appears that the initial 2005 application only considered the "mean annual" water demand for Scenario 3; therefore, the 2006 application was made to take into account the water demand for dryer years

The total water allocation (56,700 dam^3) is about 10% less than the maximum annual water demand (62,586 dam^3) identified in the 2005 Study WRMM modelling for Scenario 3. This is likely acceptable given the uncertainty of the irrigation demand inputs, the fact that slightly less water demand is anticipated with the updated crop and equipment mix assumptions, and the fact that some demand shortage is normal and acceptable for these types of projects. However, this limitation should be investigated further in the next stages of investigation (i.e. updated IDM and WRMM modelling) to ensure the repercussions are understood.

It should be noted that only the water allocation has been secured at this time; the project does not yet have a water diversion license and this will need to be done during preliminary/final design stages of the project.

Since the 2005 Study, there have been a few positive changes to the river flow regime and/or upstream demands.

- Minimum releases from Gleniffer Reservoir have increased from 16 m^3/s to 17.5 m^3/s (16 m^3/s was used in the 2005 Study). This has a positive impact on available flow in the River for this project.
- The 2005 Study assumed a WCO (Water Conservation Objective) of 50% for Instream Flow Needs (IFN) in the Red Deer River. In 2006, the SSRB water management plan was approved, identifying the WCO in this reach as 45% of natural flow rates, or a minimum flow of 10 m^3/s from April to October. This also has a slightly positive impact for this project.
- In recent years, the Special Areas Water Supply Project (SAWSP) concept has been revised, lowering the size of the irrigation development to 3240 ha (from 8,093 ha), which reduces the required water allocation volume considerably, as well as reducing the maximum diversion rate to 2.5 m^3/s (from 7 m^3/s). This will have a positive impact on water availability for the MD of Acadia Irrigation Project.
- In 2014, SSRB Water Storage Opportunities Steering Committee completed a review and update of the South Saskatchewan River Basin (SSRB) Water Supply Study (AMEC 2009).
  - The SSRB update reflected changes in the demand database; a more detailed reach by reach analysis of performance in meeting demands; and changes in operational practices (including updated municipal demand values, incorporating new and planned storage projects within the SSRB, and the minimum flow release change at Gleniffer reservoir).
  - Results of the Base Case analysis suggested that meeting the (WCO is significantly improved over the 2009 study due to the increased minimum flow release from

Gleniffer Reservoir; and that the MD of Acadia irrigation project performance remained positive, largely a factor of being supported by off-stream storage.

On the other hand, there is the possibility that the 2005 Study WRMM modelling assumptions underestimate the impact of historic climate variability and future climate change impacts:

- The WRMM modelling completed for the 2005 Study was based on simulation of the historical weather and stream flow conditions from 1928 to 2001. There has been some concern regarding the applicability of this period of record to predict future flows. Some researchers (based on tree ring, lake sediment and other paleo-climatic indicators) have concluded that stream flows may have been relatively high on the Canadian Prairies during the 20th Century, compared with earlier centuries (Sauchyn, 1997; Case et al., 2003).
- Studies have been conducted to assess the potential impacts of climate change on stream flow on the Canadian Prairies based on scenarios of economic conditions and societal trends and the output of Global Climate Models. The potential impact to the MD of Acadia project is not clear; however, the potential is there that future climate change could negatively impact water supply availability in the Red Deer River.

Given the pros and cons of the above discussion, the assumptions used in the 2005 WRMM modelling regarding water supply availability in the Red Deer River appear to remain valid and perhaps are now slightly conservative based on the historic streamflow analysis completed. This coupled with the fact that the overall water demand for this project may be slightly less than the 2005 Study assumptions (due to the improvements in the irrigation methods and crop mix) provides some assurance and buffer against the potential that climate variability and future climate change may have.

In summary, it appears that the water supply modelling completed in 2005 still provides a realistic picture of water availability, and the MD of Acadia Irrigation Project remains viable from a water demand/supply perspective. With that said, during future engineering phases (Preliminary Engineering) and prior to a formal water diversion license application under the Water Act, it would be prudent to update the irrigation demand (IDM) and water availability (WRMM) modelling to accurately reflect the most up-to-date water demand/supply realities for this project, given the approved annual allocation allotment of 56,700 dam^3.

3.4. SUPPLY SYSTEM (HEADWORKS)

The original headworks concept of a river pumpstation, a main supply pipeline and a storage reservoir from the 2005 Study remains much the same for the Update Study. However, based on a review of the topography of the area there appears to be merit to relocating the pumpstation further to the west to reduce the length of the supply pipeline and to improve water quality within the reservoir.

3.4.1. *River Pump Station*

The river intake, wet well, screening and other (mechanical/electrical) requirements are very similar to the 2005 Study. Pump flow rates are also similar as the development scenarios and water requirements are unchanged:

- Scenario 1 Diversion Rate - 2.0 m^3/s (31,700 USGPM)
- Scenario 2 & 3 Diversion Rate - 4.0 m^3/s (63,400 USGPM).

The 2005 Study assumed that all the pumps would be the same size (1,500 hp). This was re-examined to determine if some cost savings could be realized:

- Overall the total horsepower required is 6,000 hp for Scenario 1 and 10,500 hp for Scenario 2 and 3.
- The 2005 Study used 4 – 1,500 hp pumps in Scenario 1 and 7 - 1,500 hp pumps for Scenario 2 and 3.
- The high head (140 - 160 m) to pump out of the Red Deer River valley governed the horsepower requirements.

Each pump in the pumpstation requires a soft starter, butterfly valve, check valve, and piping to connect it to the main discharge header. If the number of pumps can be reduced, there could be some savings in the mechanical and electrical components.

- It was determined that a capital cost savings of $150,000 to $200,000 / pump could be realized for each pump you remove from the pump station, even considering the cost of a larger motor.
- Fewer pumps also reduces the pumpstation footprint.
- By using fewer pumps, it was determined that approximately $1.4 million could be saved for Scenario 2 and 3.
- If a configuration with fewer, larger pumps is used, there still needs to be a smaller pump (~250 hp) included to fill the line in the spring, as large (2,000 -2,750 hp) pumps would likely fill the line too fast, potentially creating high surge pressures in the system, which should be avoided.

Based on the above, the configurations shown in Table 3.3 are proposed for the River Pumpstation:

Table 3.3: Pumpstation Configurations

Scenario[3]	Diversion Rate (m^3/s)	Pump Sizes	Total Horsepower
1	2.0	1 -250 hp 3 – 2,000 hp	6,250
2	4.0	1 – 250 hp 4 – 2,750 hp	11,250
3	4.0	1 -250 hp 4 – 2,750 hp	11,250

The pump wet well will be a 13 m high reinforced concrete tank, with two chambers for sediment management. The pump station is assumed to be a combination of concrete block and pre-finished metal cladding on a steel frame.

The pumps are designed to be installed on the pump station main floor with the intake shafts down into the wet well. The pump intakes would be set a minimum of 1 m above the invert of the wet well. The invert of the wet well is set low enough to maintain at least 5 m of water in the wet well to provide adequate pump suction submergence.

The discharge side of the pumps would be connected to a main pipe header equipped with control valves. The discharge header would connect to the main supply pipeline.

The pump house would be equipped with steel support beams for an overhead crane to facilitate the pump installation and removal. The pump house would also contain an operating control room as well as electric switch gear, motor starters etc. The building is supplied with natural gas service for the building heating system.

3.4.2. *Supply Pipeline*

Hydraulics

A review of the pipeline hydraulics and sizing required was performed. The velocity in the supply pipeline for Scenarios 2 and 3 is quite high (3.57 m/s), therefore an increase in pipe size is recommended to match current industry practice and IRP design guidelines. Results of the revised hydraulic design are summarized in Table 3.4.

Table 3.4: Supply Pipeline Details

	2005 Study		2019 Update Study	
Scenario	**Diameter (mm)**	**Velocity (m/s)**	**Diameter (mm)**	**Velocity (m/s)**
1	1050	2.35	1050	2.35
2	1200	3.57	1500	2.27
3	1200	3.57	1500	2.27

Pipe Material

Large diameter pipe is required to accommodate the high diversion rates, and the pipeline is subjected to high pressure because of the static lift (~140 m) to pump out of the deep Red Deer River valley. This combination (large diameter pipe and high pressure requirements) precludes the use of PVC pipe and limits the pipe material selection to either steel or concrete. Due to the nature of the terrain (especially from the pump station in the valley and up the river bank), steel is the preferred material choice. Once the pipeline has reached the top of the river valley, the static head (and related operating pressure) is substantially reduced and PVC pipeline can be used.

Routing

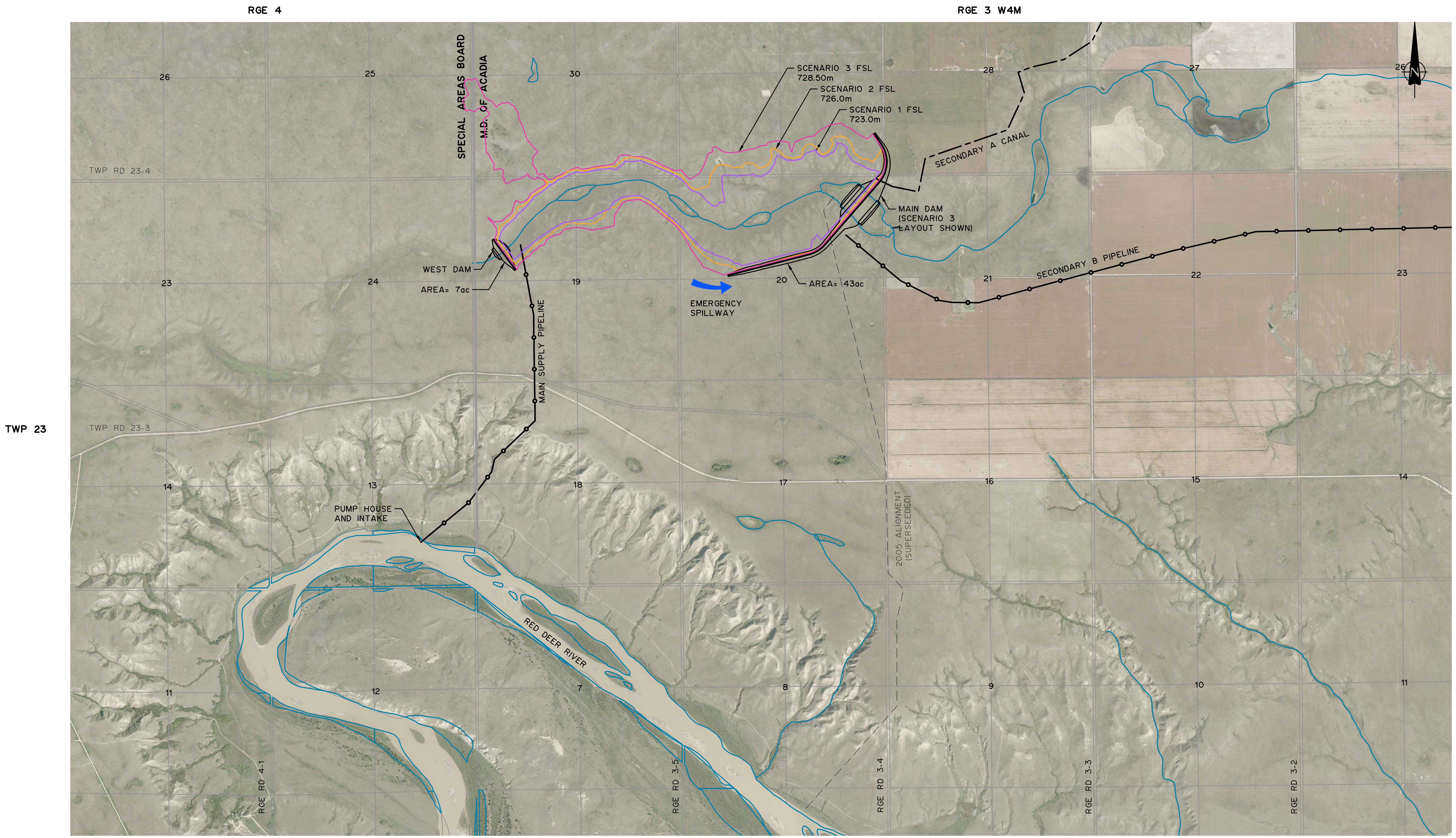
Overall pumping requirements are driven by the high static head to lift the water out of the river valley. Friction loss is actually quite minimal, therefore the route and length of pipeline does not significantly alter the overall pumpstation horsepower required. There are however, material and installation savings related to a shorter pipeline length; therefore, for the cost analysis the new (shorter) pipeline alignment was chosen as the preferred alternative. Figure 3.6 and 3.7 show the updated alignment of the supply pipeline (the 2005 alignment is also shown for reference). A geotechnical review of the valley slopes is provided in Section 3.6 and Appendix A, which indicates that the new alignment has similar geotechnical characteristics as the 2005 alignment and appears feasible. In future design phases, the final alignment of the supply pipeline still needs to be carefully assessed and selected based on detailed geotechnical and environmental considerations.

3.4.1. *Reservoir A1*

Layout

The water supply modelling (WRMM) completed for this project in the 2005 Study identified that an off-stream reservoir is critical for the viability of the project. The location, layout, capacity and operational requirements of Reservoir A1 identified in the 2005 Study generally appears to appropriate.

The major Reservoir A1 components include a Main Dam (East Dam) at the east end of the reservoir complete with outlet structures to the Secondary A Canal and Secondary B Pipeline; and a secondary containment dam (West Dam) at the west end. In theory, the reservoir could back flood up the coulee to the west (into Special Areas) instead of cutting it off with the West Dam at the MD Boundary; however, The 2005 Study determined the West Dam necessary to limit permanent flooding in the coulee west of the MD Boundary, because the coulee swings sharply towards the River and gets very close to the steep escarpment known as Dune Point Springs. At its closest point, the tributary coulee is about 300 m from the top of the bank of the Red Deer River. Historically, the river bank in this location is subject to erosion and movement, and available geology information indicate that layers of sands and gravels are prevalent in the area. The reservoir water level would be considerably higher than the River (140 – 150 m); therefore, seepage from the coulee is very possible, which in turn could lead to bank instability and sloughing concerns on the river valley slopes, as well as possibly unacceptable loss of water volume in the reservoir. For these reasons, a minimum 800 m setback of the reservoir from the river bank was established in the 2005 Study. A review of the geology in this area confirmed this concern, therefore the need and location of the West Dam was confirmed as necessary in this Update Study.



LEGEND

PROPOSED CANAL

PROPOSED PIPELINE

STREAMS AND RIVERS

SCENARIO 1 FSL

SCENARIO 2 FSL

SCENARIO 3 FSL

RESERVOIR A1		
SCENARIO	TOP OF DAM	FSL
1	725.0 m	723.0 m
2	728.0 m	726.0 m
3	730.5 m	728.5 m

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IRRIGATION DEVELOPMENT STUDY UPDATE

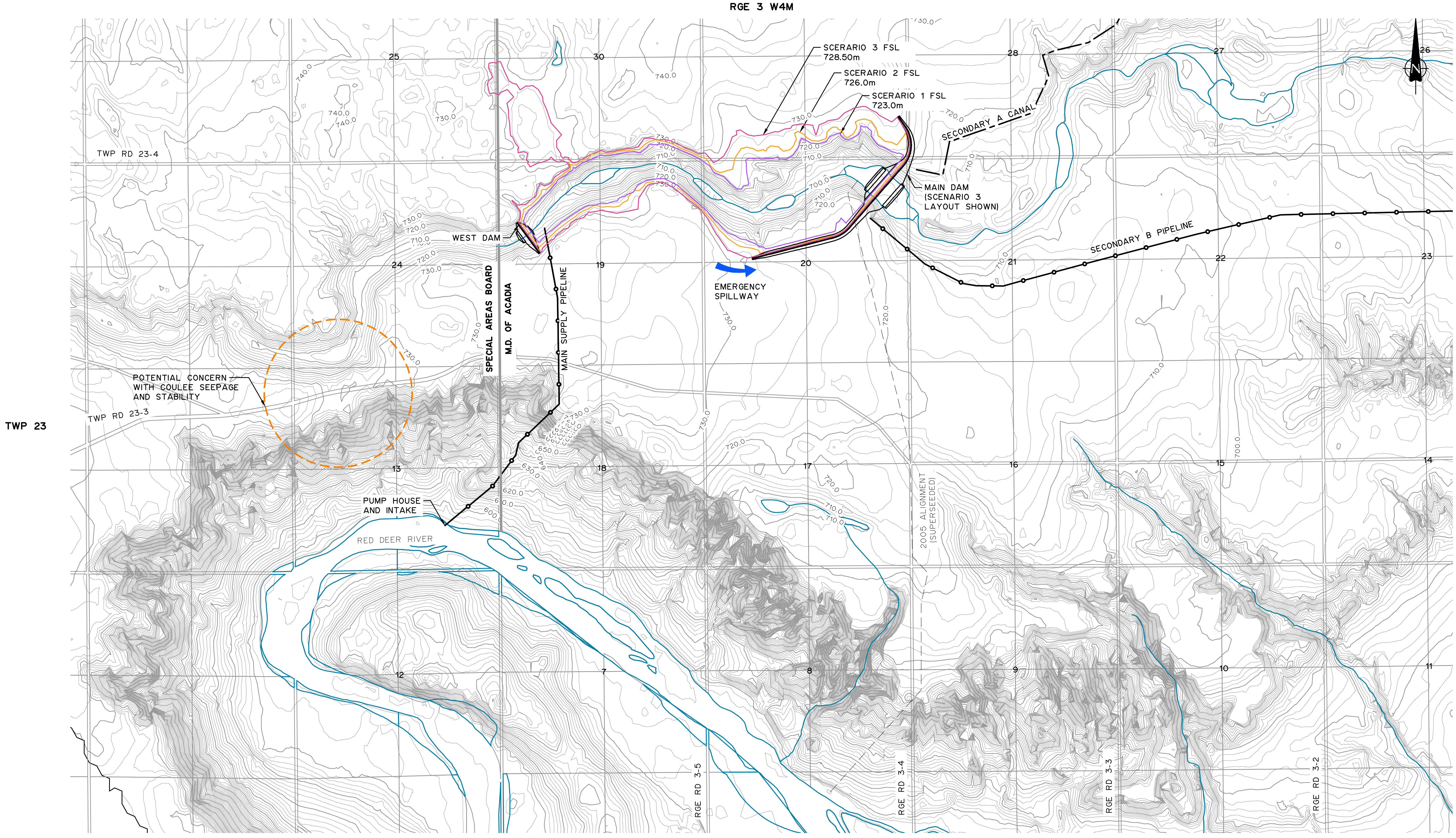
DIVERSION WORKS AND RESERVOIR A1 SITE PLAN

SCALE: 1:30 000

DATE: NOVEMBER 2019

JOB: 4280-002-00

FIGURE: 3.6



LEGEND

- PROPOSED CANAL
- PROPOSED PIPELINE
- STREAMS AND RIVERS
- SCENARIO 1 FSL
- SCENARIO 2 FSL
- SCENARIO 3 FSL

RESERVOIR A1		
SCENARIO	TOP OF DAM	FSL
1	725.0 m	723.0 m
2	728.0 m	726.0 m
3	730.5 m	728.5 m

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M.D. OF ACADIA No. 34

IRRIGATION DEVELOPMENT STUDY UPDATE

RESERVOIR A1 SITE CONTOUR PLAN

SCALE: 1:30 000	DATE: NOVEMBER 2019	JOB: 4280-002-00	FIGURE: 3.7

It is recommended that the West Dam be investigated further as part of future design phases of this project, which should include sufficient field investigation to confirm the location (and presence) of seepage prone layers, and the need and ideal location of the West Dam. If it is determined that the West Dam is not necessary or can be moved further west, this would provide additional reservoir storage volume and perhaps facilitate the potential for additional irrigated acres for the project, including to the west within the Special Areas.

Infrastructure

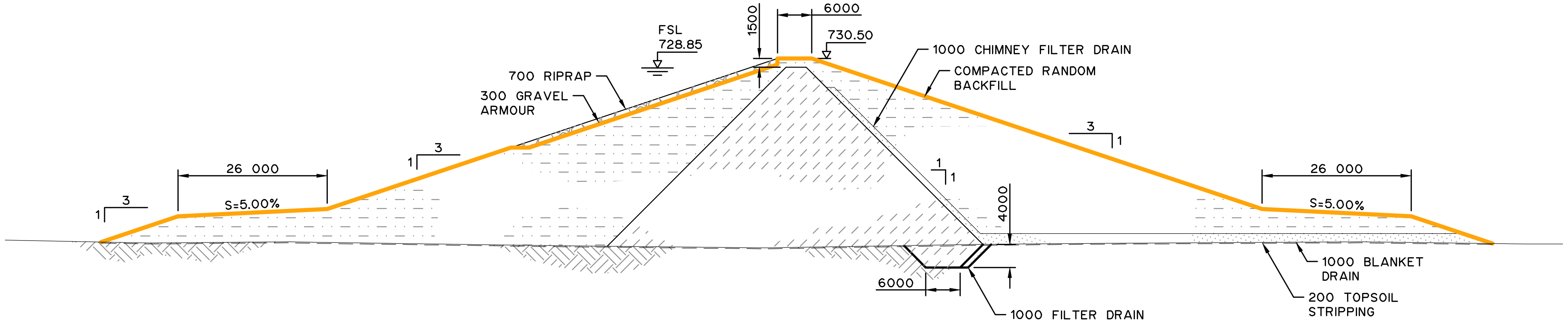
A limited geotechnical evaluation and drilling program was completed as part of this Update Study (Refer to Appendix A and Section 3.6), which included a stability analysis of the two dams. Based on this information, the design cross sections of the dams were modified (overall footprint was reduced) to account for foundation conditions that were better than assumed in the 2005 Study. The updated East and West Dam cross sections for Scenario 3 are shown in Figure 3.8. The new design cross sections led to a lower quantity of fill required, which leads to some reduction in capital costs.

The capacity of the Secondary A Canal and Secondary B Pipeline have increased slightly since the 2005 Study (See Section 2.1.3) requiring slightly larger outlet structures from the Reservoir.

A summary of the Reservoir A1 characteristics and infrastructure is provided in Table 3.5

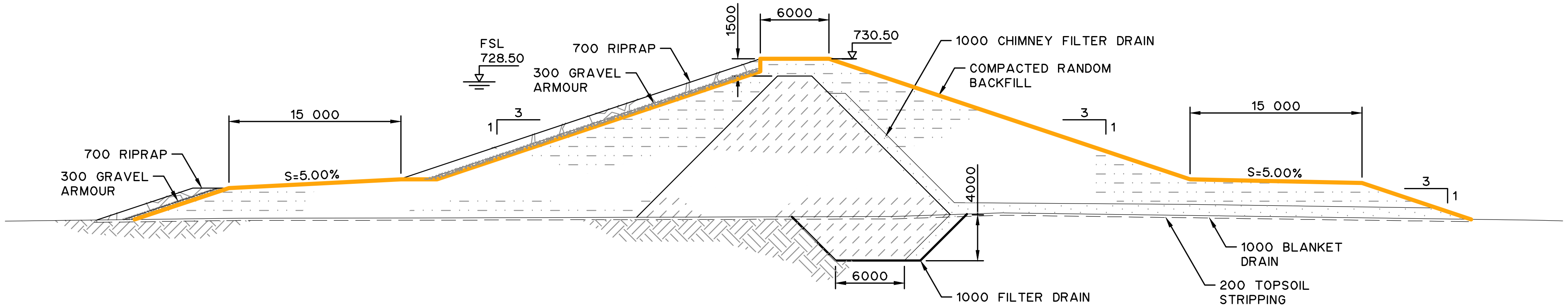
Table 3.5: Reservoir A1 Characteristics

Description		Unit	Quantity		
			Scenario 1	Scenario 2	Scenario 3
Reservoir	FSL	m	723	726	728.5
	Capacity @ FSL	dam^3	7,200	12,300	17,000
	Area @ FSL	km^2	1.32	1.62	2.19
	Maximum Length	km	3	3	3
	Average Width	km	0.5	0.54	0.6
	Max. Depth @ FSL	m	23	26	28.5
East Dam	Top of Dam	m	725	728	730.5
	Max. Height of Dam	m	25	28	30.5
	Crest Length	m	1630	1865	2100
	Crest Width	m	6	6	6
	Freeboard @ FSL	m	2	2	2
West Dam	Top of Dam	m	725	728	730.5
	Max. Height of Dam	m	9	12	14.5
	Crest Length	m	235	290	330
	Crest Width	m	6	6	6
	Freeboard @ FSL	m	2	2	2
Secondary A Canal Outlet Structure	Conduit Dimension (W * H)	mm	1220 * 1550	2130 * 2130	2430 * 2130
	Conduit Length	m	130	150	160
	Minimum Capacity	m^3/s	4.3	7.6	9.6
Secondary B Pipeline Outlet Structure	Conduit Diameter	mm	1200	1200	1200
	Conduit Length	m	140	160	170
	Minimum Capacity	m^3/s	1.0	1.0	1.0



EAST DAM SCENARIO 3 CROSS SECTION

1:1000



WEST DAM SCENARIO 3 CROSS SECTION

1:500

RESERVOIR A1				
SCENARIO	TOP OF DAM	FSL	EAST DAM HEIGHT	WEST DAM HEIGHT
1	725.0 m	723.0 m	27.0 m	10.0 m
2	728.0 m	726.0 m	30.0 m	13.0 m
3	730.5 m	728.5 m	32.5 m	15.5 m

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M.D. OF ACADIA No. 34

IRRIGATION DEVELOPMENT STUDY UPDATE

EAST AND WEST DAM CROSS SECTIONS

SCALE: AS SHOWN
DATE: SEPTEMBER 2019
JOB: 4280-002-00
FIGURE: 3.8

Dam Classification Review

A review of the safety classification for both dams was performed, since there have been significant changes to the Alberta Dam Safety Legislation and the Canadian Dam Association (CDA) Guidelines, since the 2005 Study. The safety classification of a dam determines the design requirements such as flood passage, seismic, and freeboard. The dam classification is based on the incremental consequences incurred in the event of a dam failure such as: population at risk, loss of life, economic damages, and environmental and cultural losses. The 2007 CDA Guidelines (CDA, 2007) introduced five consequence categories (from Low to Extreme) which also match the Provincial consequence classifications (AEP, 2018). The findings of the classification review is provided below.

1) West Dam

There would be limited consequences in the event of a failure of the West Dam. The flood wave and water volume would be contained within the upstream tributary valley. Since there are no dwellings in this valley, there would be no potential for loss of life. The economic impacts would relate to the cost to rebuild the dam and the loss of ability to irrigate until the dam is rebuilt. Environmental and Cultural damage would also be limited to some minor loss of native prairie and some cultural sites. As such the West Dam is considered to be a “Low” consequence dam.

2) East Dam

The East Dam is the larger structure and consequences of a failure are higher than the West Dam. Based on a quantitative overview of the downstream flood plain, the following summarizes the downstream impacts of an East Dam failure:

- There is limited infrastructure downstream of the dam; there is one farmyard located near the floodplain along the Red Deer River; however, it is unlikely to be swept away as it is near the flood fringe, and quite a bit higher than the channel bottom.
- There are 4 county roads that would be washed out during a dam breach; however, there would not be any impacts to the provincial Highway network.
- Economic losses would be primarily from the loss of irrigation (crop damages) for a considerable period of time (up to one season), and the cost to re-build the dam.
- Environmental and Cultural losses would be low to significant, mostly related to the cultural sites in Kennedy Coulee.
- Overall the East Dam is likely to fall into the “Significant” consequence category mostly due to Economic Damages related to lost irrigation, some flooding to one downstream resident, and the potential for impact to temporary population on the downstream road crossings.

Since the East Dam is considered to be a “Significant” consequence dam, it is recommended that the reservoir (including both dams) be designed to the criteria identified for this consequence classification, as follows:

- Freeboard under normal operations: No overtopping of the Dam by the 95% wave caused by a 1:1000 year wind.
- Freeboard under IDF operations: No overtopping of the Dam by the 95% wave caused by a 1:10 year wind.
- Inflow Design Flood (IDF): Given the significant height and storage impounded by the East Dam, the reservoir should be designed to safely handle the 1:1000 year flood as the IDF.
- Seismic Design: The EGDM (earthquake design ground motion) should be the 1:1000 year event.

The above design parameters are satisfied with the proposed reservoir and dam design criteria adopted for this Update Study.

3.5. CONVEYANCE NETWORK

The distribution system consists of one main gravity canal (Secondary A Canal), which delivers water from Reservoir A1 to Block 1A along the west side of Kennedy Coulee and tails out into Acadia Reservoir. A syphon from this canal delivers water across Kennedy Coulee into an extension of Secondary A Canal to feed Block 2 for Scenarios 2 & 3.

Block 1B is gravity fed off of Reservoir A with a closed pipeline system. Block 3 and 4 are fed through pressurized pipelines out of the Acadia Recreational Reservoir, though an update to how Block 3 is fed is discussed below, which is in turn fed via the Secondary A Canal. The updated alignment of the irrigation infrastructure is shown in Figure 3.3.

3.5.1. *Updates*

There was one major change to the conveyance network, which was to move the Block 3 Pumpstation to the East End of the Kennedy Coulee syphon and twin the syphon to feed Block 3.

Block 3 Changes

As discussed in Section 2.1.3 there are some benefits and capital cost savings in altering the conveyance network that supplies water to Block 3. Essentially there are capital and operational benefits to modifying this system that are summarized below, as well as a few disadvantages:

Advantages:

- Reduces the length of pipeline from 4,700 m to 3,200 m prior to the first delivery in Block 3.
- Reduces the pressure rating and wall thickness of the pipeline from DR 32.5 to DR 41, which has cost saving implications.
- Eliminates the need to upsize the Acadia Reservoir Feed Canal.
- Reduces the required pumpstation horsepower from 1,250 hp to 1,000 hp, which in turn reduces annual power cost.
- Uses gravity pressure to prime the pumps, enabling use of centrifugal style pumps (vs vertical turbine pumps), reducing pumpstation footprint and construction costs.

- The total capital savings is approximately $3,000,000, as compared to the 2005 Study concept.

Disadvantages:

- A second pump station is required (i.e. one for Block 4 and one for Block 3).
- Some additional environmental considerations at the Kennedy Coulee crossing due to increased pipeline width; however, this is considered relatively minor.
- A second power service is required for the separate Block 3 Pumpstation.

Overall the benefits of modifying the alignment for the Secondary C Pipeline and the Block 3 Pumpstation seem to outweigh the risks and disadvantages. The design details for the Kennedy Coulee Syphon are summarized in Table 3.6. The new alignment changes are reflected in the figures, and the capital costs and operation and maintenance costs are updated accordingly.

Table 3.6: Kennedy Coulee Syphon Design Details

Scenario	Flow Rate (m^3/s)	Syphon Size	Velocity (m/s)	Maximum Pressure (psi)
Scenario 1 and 2	3.54	1500 mm PVC	2.00	21.2
Scenario 3	5.00	1500 mm and 1200 mm PVC	1.75	22.2

The design of the pipeline and open channels was updated according to the new peak flow information to determine the cost estimates. An overview of the Secondary A Canal design elements is shown in Table 3.8.

The remaining conveyance network alignments were not changed as part of this Update Study; however, the canal and pipeline laterals were assessed and updated for the flow requirements based on the 2017 IRP Standards. Overall the increase in the peak flows required for the conveyance network to meet the 2017 IRP Standards does not change the design significantly as the existing pipeline design are largely unchanged and enlarging the canals is a relatively small capital cost. A summary of the system design flows is presented in Table 3.7 below.

Table 3.7: Conveyance Network Maximum Flow Rates

	Maximum Flow Rate (m^3/s)		
	Scenario 1	**Scenario 2**	**Scenario 3**
Secondary A Canal West of Kennedy Creek	4.30	7.65	9.62
Secondary A Feed to Acadia Reservoir	1.08	1.08	1.08
Kennedy Coulee Syphon	-	3.54	5.00
Secondary A Canal East of Kennedy Creek	-	3.54	3.54
Secondary B Pipeline	1.17	1.17	1.17
Block 3 Pressure System	-	1.47	1.47
Block 4 Pressure System	-	-	1.10

Table 3.8: Secondary A Canal Conceptual Design Characteristics

Secondary A Canal	**Length**	**Q**	**Bed Slope**	**Bed Width (B)**	**Water Depth (D)**	**Total Depth**	**B/D**	**N**	**Side Slopes**	**Velocity**
	km	**m³/s**		**m**	**m**	**m**			**H:V**	**m/s**
Scenario 1										
West of Kennedy Cr (out of valley)	3.0	4.30	0.00050	3.30	1.24	1.91	2.7	0.035	2.5:1	0.55
West of Kennedy Cr (remainder)	10.3	4.30	0.00050	3.30	1.24	1.91	2.7	0.035	2.5:1	0.55
Feed to Acadia Reservoir	5.0	1.08	0.00120	1.30	0.60	1.31	1.8	0.040	2.5:1	0.49
Scenario 2										
West of Kennedy Cr (out of valley)	3.0	7.65	0.00050	4.50	1.49	2.25	3.0	0.035	2.5:1	0.63
West of Kennedy Cr (remainder)	10.3	7.65	0.00050	4.50	1.49	2.25	3.0	0.035	2.5:1	0.63
East of Kennedy Creek	8.0	3.53	0.00070	3.00	1.06	1.66	2.8	0.035	2.5:1	0.59
Feed to Acadia Reservoir	5.0	1.08	0.00120	1.30	0.60	1.31	1.8	0.040	2.5:1	0.49
Scenario 3										
West of Kennedy Cr (out of valley)	3.0	9.62	0.00050	5.00	1.61	2.41	3.1	0.035	2.5:1	0.67
West of Kennedy Cr (remainder)	10.3	9.62	0.00050	5.00	1.61	2.41	3.1	0.035	2.5:1	0.67
East of Kennedy Creek	8.0	3.53	0.00070	3.00	1.06	1.66	2.8	0.035	2.5:1	0.59
Feed to Acadia Reservoir	5.0	1.08	0.00120	1.30	0.60	1.31	1.8	0.040	2.5:1	0.49

3.6. GEOTECHNICAL

As part of the Update Study, a limited high level overview of the Geotechnical conditions for Reservoir A1 and the supply pipeline routing was completed. The scope of work included a geotechnical testing program which drilled 8 boreholes on the West and East Dam sites.

The basic goals of the geotechnical program were: i) to better define the proposed dam cross section, ii) determine if there is appropriate cohesive impervious material to construct an embankment dam, iii) provide recommendations on pipeline routing, and iv) comment on coulee setbacks for the reservoir. The full geotechnical assessment Study is included in Appendix A. The following provides a brief overview and summary of the report's conclusions.

- Soil stratigraphy at the site is generally comprised of a layer of topsoil (90 mm - 300 mm) underlain by sand, silt, and clay layers. The majority of the boreholes contain silty clay between 1.9 m to 24 m below grade. The clay is fairly hard with moisture content between 7 and 20% and is suitable for embankment construction.
- Some sand layers were noted in the boreholes, but the sand was generally shallow, dense, and not flowing. At preliminary design stage a more detailed drilling program is required to better define the sand layers and their extents. If occasional layers are found that could lead to loss of reservoir storage, sealing these areas with a clay liner could be considered.
- Groundwater seepage was only noted at one borehole during the drilling program (19BH004 at 3 m).
- The dam cross section should have sideslopes with a minimum of 3H:1V upstream and downstream, a toe berm should be constructed on the upstream and downstream toes, with a filter chimney and blanket drain downstream of the core to intercept seepage through the core and the foundation. A key trench with a depth of 4.0 m was also included to mitigate seepage through shallow sand lenses. Proposed cross sections of the East and West Dams (Scenario 3) are shown on Figure 3.8.
- Seismic hazard at the reservoir location is fairly low and is not expected to have a major impact on dam stability or the design.
- In general the site conditions were favourable for dam construction, and no immediate concerns were noted. However, wet conditions in the valley bottom at the East Dam may have some implications to construction cost.
- The alignment of the proposed supply pipeline appears suitable and based on the landslide history in the area the river valley slopes are generally stable.
- To avoid inducing excess instability to the river valley slopes, a minimum setback of 800 m is recommended from the reservoir to the coulee edge. Confirmation of seepage prone layers will need to be identified and assessed during the final design.

Based on geotechnical information gathered and the assessment of the site geology, the proposed reservoir site appears suitable from both a constructability and operational standpoint.

3.7. ALTERNATIVE ENERGY

The 2005 Study assessed 4 options for alternative energy supply for the main pumpstation. The options assessed were: i) small scale hydro within the irrigation conveyance network, ii) run of river hydroelectric plant on the Red Deer River, iii) dedicated wind farm, and iv) purchase of wind energy. The 2005 Study concluded essentially that the flows and head for hydro within the irrigation infrastructure were too low, the environmental considerations and costs of a run of the river plant were too high, the costs and utilization rate for wind energy is also unfavorable.

Most of the assumptions and assessments of alternative energy are still valid from the 2005 Study. Developing a renewable/alternative energy source that is reliant on Green Energy is impractical for operation of an irrigation system. The only alternative energy source different than those listed in the 2005 Study is solar energy, and the utilization rate of solar is only marginally better than wind power.

Developing a bank of generators either fed by diesel or natural gas may be an option for power supply; however, the fuel costs and capital costs are similar or more than electricity supplied through the power grid. There is also additional maintenance and operation costs to these setups as well as permitting. The generator of nearly 8 MW of power would be a unique design.

Use of reservoir A1 as a storage reservoir for pumped storage hydro could be investigated further in the preliminary design; however, the diversion volume in the water licence could easily be exceeded as there is no credit given for water returned to the river.

Therefore, the use of alternative energy sources to power the Red Deer River pumpstation appears to be limited, as in most cases a connection to the power grid is still required to ensure reliable operation. However investigation into alternative energy sources should not be ruled out entirely.

4.0 PROJECT COSTS

4.1. GENERAL

This section provides a summary of the capital costs, as well as the annual operation and maintenance (O&M) costs for the three development scenarios. The capital costs have been determined for each major component of work with detailed cost information summarized in Appendix B. On-farm costs are addressed in the economic analysis is Section 6.0 and Appendix C.

4.2. CAPITAL COSTS

The capital costs are based off of recent tenders completed within Southern Alberta and Saskatchewan for other irrigation systems. Pricing for specialized components such as gates, and pumps is based off quotes from suppliers and tender information. There can be significant variability in construction costs particularly for the supply of steel and PVC pipelines which can be impacted by import duties, trade wars, and other external factors. The most accurate pricing information available was used in this Update Study; however, the costs estimates should be considered as a snapshot in time.

4.2.1. *River Pumpstation and Supply Pipeline*

The River Pumpstation and Supply Pipeline components consists of the river intake, pumpstation, supply pipeline, and various utility costs to bring natural gas and electrical power to the pumpstation.

There are some items in this portion of the project which may have significant price variability including:

- Cofferdam in the Red Deer River for the intake, which may require specialized products and installation.
- Installation of the supply pipeline which given the coulee terrain may require both a mix of open cut and trenchless installation. There may also be compensation required from the environmental perspective for a loss of habitat.
- Installation of electrical transmission, this may require a large upgrade to the grid, also the pumpstation is located 15 km from the nearest transmission main in the MD.

The total capital costs of the pumpstation and supply pipeline are summarized in Table 4.1, which excludes engineering, and contingencies; the cost estimate from the 2005 Study is also included as a comparison.

Table 4.1: River Pumpstation and Supply Pipeline Cost Estimate Summary

Pumpstation and Supply Pipeline	Scenario 1	Scenario 2	Scenario 3
2019 Capital Cost Estimate:	***$ 15,242,500***	***$ 18,852,000***	***$ 18,852,000***
2005 Capital Cost Estimate:	$ 12,020,000	$ 16,630,000	$ 16,630,000
Percent Increase	26.8 %	13.4 %	13.4 %

The length of the supply pipeline as well as the pumpstation have actually decreased in quantity; however, the overall component cost has increased from 2005, due to inflationary increases, as well as some notable market increases for pumps, pumpstation construction, electrical components, and pipeline installation.

4.2.2. *Reservoir A1*

The construction costs for Reservoir A1 include two Earth Dams (East Dam and the West Dam); two outlet structures (Secondary A Canal and Secondary B Pipeline); and associated appurtenances and miscellaneous costs.

Quantities for the dam components, such as impervious fill, random fill, granular drainage blanket, etc., were calculated using AutoCAD Civil 3D 2018 with a 10% allowance added to the estimated values. Pricing was developed based on recent tenders with considerations for economies of scale for some of the quantity volumes.

The total capital costs for Reservoir A1 are summarized in Table 4.2, which excludes engineering, and contingencies; the cost estimate from the 2005 Study is also included as a comparison.

Table 4.2: Reservoir A1 Capital Cost Estimate Summary

Reservoir A1	Scenario 1	Scenario 2	Scenario 3
2019 Capital Cost Estimate:	***$ 14,583,750***	***$ 19,162,000***	***$ 23,270,750***
2005 Capital Cost Estimate:	$ 10,830,000	$ 12,750,000	$ 14,820,000
Percent Increase	34.7 %	50.3 %	57.1 %

The earthwork quantities actually have decreased; however, the cost increase shown for Reservoir A1 in this Update Study are primarily inflationary in nature, as well as some considerable market increases for granular materials (i.e. filter drain, bedding gravel, and riprap), as well as cast-in-place concrete, and electrical systems. Additionally, environmental mitigation was included, which was not addressed in the 2005 Study.

4.2.3. *Distribution System*

The distribution system component essentially includes the conveyance network downstream of Reservoir A1 to the farmer delivery point. Costs included for the distribution system are the open canals, gravity and pressure pipelines, lateral pipelines off the Secondary A Canal, turnouts, Kennedy Coulee Syphon, and the pumpstations for Block 3 and Block 4.

Costs for the open canals were calculated on a per km basis with an assumption that the cut/fill volumes balance, and that the canal side slopes are armoured but not the canal bed. No significant environmental compensation is anticipated; therefore, it is felt that the allowed contingency adequately covers any that becomes necessary.

The total capital costs of the distribution system are summarized in Table 4.3, which excludes engineering, and contingencies; the cost estimate from the 2005 Study is also included as a comparison.

Table 4.3: Distribution System Capital Cost Estimate Summary

Distribution System	Scenario 1	Scenario 2	Scenario 3
2019 Capital Cost Estimate:	***$ 23,468,200***	***$ 39,701,600***	***$ 51,907,775***
2005 Capital Cost Estimate:	$ 15,120,000	$ 27,120,000	$ 37,200,000
Percent Increase	55.2 %	46.4 %	39.5 %

The cost increase from 2005, is primarily due to inflation; however, some additional costs are related to the canal and pipeline upsizing requirements to meet current IRP and industry standards.

4.2.4. *Capital Cost Summary*

The total capital costs for each major component for the three development scenarios are summarized in Table 4.4, including a 25% contingency, an allowance for environmental, historical and regulatory assessments and permitting, and 15% engineering for preliminary design through to construction supervision and commissioning.

The overall capital costs vary from $78.8 million for Scenario 1 to $137.6 million for Scenario 3; with per acre costs from $5,834/ac for Scenario 1 to $5,097/ac for Scenario 3. Per-acre costs and percent increases from the 2005 Study are also summarized for comparison.

Table 4.4: Capital Cost Summary

Description	**Scenario 1**	**Scenario 2**	**Scenario 3**
Diversion and Supply (Headworks)			
River Intake, Pumpstation, and Power Supply	$ 9,612,500	$ 11,980,000	$ 11,980,000
Supply Pipeline	$ 5,630,000	$ 6,872,000	$ 6,872,000
Subtotal	***$ 15,242,500***	***$ 18,852,000***	***$ 18,852,000***
Reservoir A1 (Headworks)			
General Requirements	$ 1,750,000	$ 1,900,000	$ 2,000,000
East Dam	$ 8,982,500	$ 12,310,500	$ 15,239,000
West Dam	$ 1,576,250	$ 2,109,000	$ 3,064,250
Secondary A Canal Outlet Structure	$ 1,640,000	$ 2,162,500	$ 2,250,000
Secondary B Pipeline Outlet Structure	$ 635,000	$ 680,000	$ 717,500
Subtotal	***$ 14,683,750***	***$ 19,262,000***	***$ 23,580,750***
Distribution System			
Secondary A Canal (Block 1A)	$ 10,010,000	$ 12,662,500	$ 14,747,500
Kennedy Coulee Syphon	$ -	$ 3,265,000	$ 5,480,000
Secondary A Canal (Acadia Reservoir Feed)	$ 2,275,000	$ 2,275,000	$ 2,275,000
Secondary A Canal (Block 2)	$ -	$ 5,850,000	$ 5,850,000
Secondary A Gravity Pipeline Laterals	$ 3,353,000	$ 7,818,900	$ 7,818,900
Secondary B Gravity Pipeline	$ 3,291,900	$ 3,291,900	$ 3,291,900
Secondary C Pressure Pipeline and Pumpstation (Block 3)	$ -	$ -	$ 7,906,175
Block 4 Pressure Pipelines and Pumpstation (Block 4)	$ 4,538,300	$ 4,538,300	$ 4,538,300
Subtotal	***$ 23,468,200***	***$ 39,701,600***	***$ 51,907,775***
Other			
Contingencies (25%)	$ 13,349,000	$ 19,454,000	$ 23,585,000
Environmental, Historical Resource Assessment and Permitting	$ 2,000,000	$ 2,000,000	$ 2,000,000
Preliminary and Detailed Engineering Design (15%)	$ 10,012,000	$ 14,590,000	$ 17,689,000
TOTAL CAPITAL SYSTEM COSTS	**$ 78,755,000**	**$ 113,860,000**	**$ 137,615,000**

Table 4.5: Per Acre Capital Costs

Description	Scenario 1	Scenario 2	Scenario 3
Total Irrigated Area (ac)	13,500	22,000	27,000
2019 Capital Cost Per Acre	**$ 5,834**	**$ 5,175**	**$ 5,097**
2005 Capital Cost Per Acre	$ 4,017	$ 3,597	$ 3,584
Percent Increase	45.2 %	43.9 %	42.2 %

The lowest cost per acre is Scenario 3 at $5,097/ac, which is an increase of 42.2% over the 2005 Study. This essentially breaks down to an average annual increase of around 2.3%, which can primarily be attributed to inflation (i.e. the Canadian Price Index has increased by 33% over this time period, and the average annual inflation rate for a basket of goods and services in Alberta over this period was about 2%).

4.3. OPERATION AND MAINTENANCE COSTS

The Operation and Maintenance (O&M) costs for the system are important as they drive the annual irrigation rates, which is critical since it represents an ongoing cost to the farmers. The major cost component for O&M for this project are the energy costs (primarily for the Red Deer River pumpstation, and secondarily for the Block 3 & 4 pumpstations There are also costs for operation and maintenance of the supply and distribution system.

The costs for power were estimated using information from ATCO power, who is the local power distributor. The power cost is broken into three major components: transmission, distribution, and energy. Deregulation of the electrical market has fully occurred since the 2005 Study. Overall power costs are approximately the same in 2019 (as compared to 2005) due to deregulation, with actual energy costs decreasing but transmission and distribution increasing. The total power costs for the pumpstations are based on the mean annual volume pumped at each pumpstation; which means that some years it will be less and some years it will be higher.

- For the Red Deer River Pumpstation the annual diversion volume can vary significantly year to year from a maximum of 62,586 dam^3 to as little as 9,518 dam^3, with a mean of annual diversion volume 43,235 dam^3 for Scenario 3 (MPE, 2005).
- Maximum irrigation demand of 414 mm/ha was used to calculate the annual volume pumped for the Block 3 and Block 4 pumpstations which was converted to the yearly power demand.
- The power costs for the drainage pumpstation at the West Dam was estimated to be as much as $40,000 in a high runoff year (1:1000 year runoff), but most years no power is used and the only fees are for the grid connection; approximately $25,000 per year. Operation and Maintenance on this pumpstation is accounted for in the overall operation and maintenance fees. A standby generator may also be a better option for operation of this pumpstation rather than a connection to the electrical grid given its infrequent use. This could be considered during future engineering phases.

The O&M costs to operate the system basically consists of two components:

1. An annual surcharge for O&M on the Distribution System and Reservoir A1 based on the acres irrigated. This was estimated based on a review of the 2018 O&M costs for 5 major Irrigation Districts (Eastern, Bow River, St. Mary, Taber, and Lethbridge Northern). These districts all operate similar infrastructure including open canals, pipelines, reservoirs, and pumpstations. The average O&M cost for these five districts was $23.87 per acre, which was rounded up to $25 per acre for this Update Study. Even though the reservoir is part of the Headworks it is likely to be operated and maintained as part of the distribution network.
2. The MD of Acadia project also includes a large pumpstation (Red Deer River), which none of the other irrigation districts have; therefore, an annual operation and maintenance fee of 3% of the associated capital cost, was included to account for this additional O&M.

A detailed breakdown and summary of the projected O&M costs are shown in Table 4.6.

Table 4.6: Annual Operation and Maintenance Costs

DESCRIPTION	SCENARIO 1	SCENARIO 2	SCENARIO 3
Total Acres Irrigated	13,500	22,000	27,000
Pumpstation Energy Charges			
Red Deer River Pumpstation	$ 909,503	$ 1,769,506	$ 1,813,913
Block 3 Pumpstation	$ -	$-	$ 255,316
Block 4 Pumpstation	$ 161,769	$ 161,769	$ 161,769
Subtotal	*$ 1,071,272*	*$ 1,931,275*	*$ 2,230,997*
Operation and Maintenance			
Red Deer River Pumpstation Operation and Maintenance (3.0% of Capital Cost)	$ 288,375	$ 359,400	$ 359,400
Distribution System and Reservoir A1 O&M Costs ($25.00 Per Acre)	$ 337,500	$ 550,000	$ 675,000
Subtotal	*$ 625,875*	*$ 909,400*	*$ 1,034,400*
TOTAL ANNUAL OPERATION AND MAINTENANCE	**$ 1,697,000**	**$ 2,841,000**	**$ 3,265,000**
TOTAL ANNUAL OPERATION AND MAINTENANCE / ACRE	**$ 125.70**	**$ 129.14**	**$ 120.93**

4.4. ADDITIONAL SURCHARGES

As in the 2005 Study, irrigators in Block 3 and Block 4 would be connected directly to pressurized pipeline systems. This means that the irrigators in these areas do not require additional booster pumps and electrical services to run their pivots as adequate pressure will be supplied. For this increased level of service, a pressure surcharge is typically applied. For this project, the surcharge is based on the costs of power for the Block 3 and Block 4 pumpstations. This fee was determined to be $55.00 per acre. The effects of this surcharge are summarized in Table 4.7. Note that Irrigators in Block 3 and 4 would be charged an additional $55.00/acre in addition to the rates above, to put all irrigators in the system at the same cost level.

Table 4.7: Operation and Maintenance Costs Including Pressure Surcharge for Block 3 & 4

Description	Scenario 1	Scenario 2	Scenario 3
Total Annual O&M	$ 1,697,000	$ 2,841,000	$ 3,265,000
Pressure Surcharge Credit ($ 55.00/acre for Blocks 3 & 4)	$ 137,500	$ 137,500	$ 412,500
Remaining O&M Costs	$ 1,559,500	$ 2,703,500	$ 2,852,500
2019 O&M Cost Per Acre* (Incl. Pressure Surcharge Credit)	**$ 116**	**$ 123**	**$ 106**
2005 O&M Cost per Acre*	$ 116	$ 107	$ 98
% Change (from 2005)	0 %	15.0 %	8.2 %

* Rounded to the nearest $

Since the 2005 Study, the O&M cost for Scenario 1 has effectively stayed the same; it has gone up by 15% for Scenario 2 and 8.2 % for Scenario 3; which is very good considering 14 years have passed.

4.5. PROVINCIAL CONTRIBUTION TO HEADWORKS OPERATION

Most irrigation districts in Alberta are delivered water through a provincially owned and operated headworks system. A similar example to the Acadia development would be the Deadfish/Sheerness Irrigation systems where the Province owns the river pumpstation, main supply pipeline, reservoirs, and canals. However, for the other Irrigation Districts in Alberta that don't have pumping systems, the Province typically owns the supply infrastructure from the river diversion up to and including the first major reservoir.

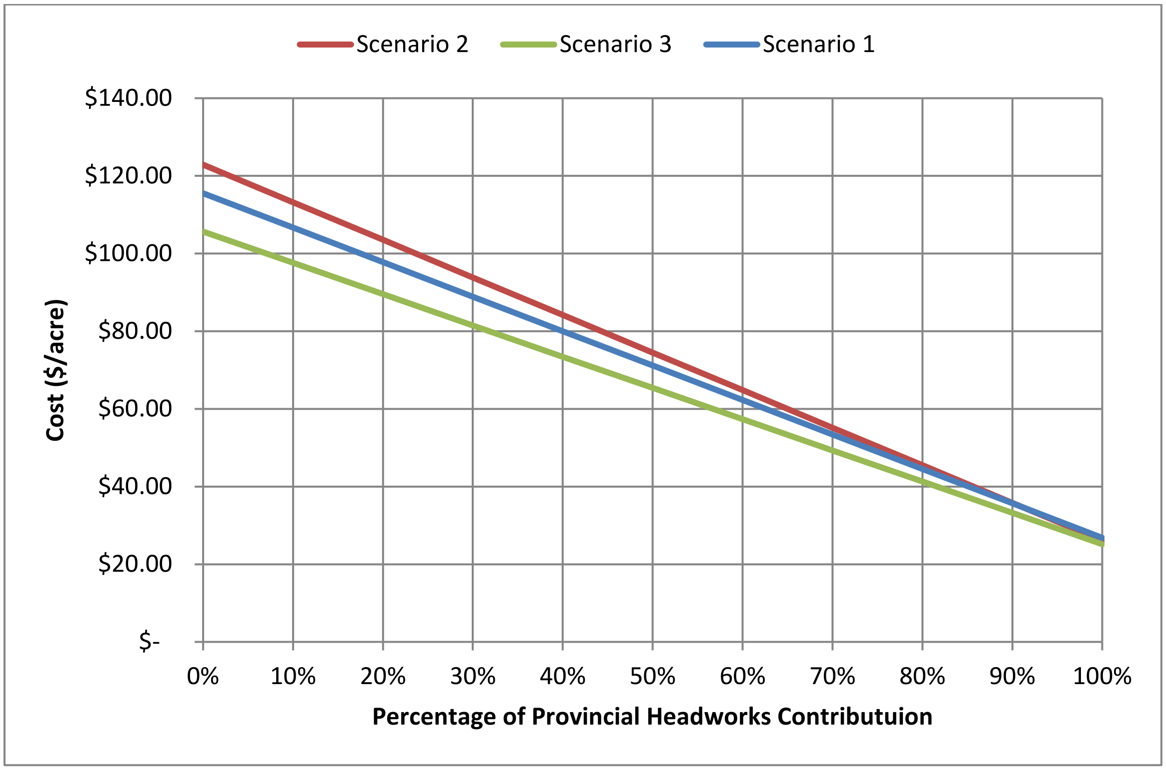
Contribution to the project by the Province is not a guarantee given the current fiscal climate. However, for comparison to other irrigation districts in Alberta, and to determine the effect of Provincial contribution to this project, it was assumed that the Province would own and provide some contribution to the annual O&M for the Headworks (which includes the Red Deer River Pumpstation and the Supply Pipeline). O&M for Reservoir A1 is included in the distribution network O&M of $25/acre/year.

Table 4.8 and Figure 4.1 show a range of irrigation rate structures (for off-farm O&M costs) for a varying level of Provincial contribution towards the Headworks O&M. It is likely that without the Province covering operation and maintenance of the Headworks (at least partially) the Irrigation Development Project will not be feasible.

Table 4.8: Effects of Provincial Headworks Operation

Percent Contribution to Headworks Operation	Rate Required to cover Off-Farm O&M ($/ac)		
	Scenario 1	Scenario 2	Scenario 3
0%	$115.52	$122.89	$105.65
10%	$106.65	$113.21	$97.60
20%	$97.77	$103.53	$89.55
30%	$88.90	$93.86	$81.50
40%	$80.03	$84.18	$73.45
50%	$71.15	$74.50	$65.40
60%	$62.28	$64.83	$57.35
70%	$53.41	$55.15	$49.30
80%	$44.53	$45.47	$41.25
90%	$35.66	$35.79	$33.20
100%	$26.79	$26.12	$25.16

Figure 4.1: Irrigation Rates Based on Provincial Contribution



It should be noted that the above rates do not include amortized contribution towards capital costs for the system. Refer to the Economic Analysis section for further discussion on capital cost contributions.

5.0 ENVIRONMENTAL REQUIREMENTS

As part of this study Ghostpine Environmental Services Ltd. (GES) was contracted to complete a desktop environmental and historical impacts report, the full report is attached in Appendix D. This report aimed to identify the potential environmental and historical resources issues with the proposed irrigation development project. The rough scope of the report is summarized below:

- Outline changes in applicable regulations since the 2005 Study.
- Identify and discuss approaches and costs for an Environmental Impact Assessment (EIA) mitigation and monitoring that may be required.
- Determine critical path items that could impact schedule/budget on the project.
- Outline what mitigation strategies could be implemented to manage environmental/historical issues with a range of costs.
- Suggest routing changes for irrigation canals and pipelines, if needed, to avoid or minimize impacts to areas with environmental/historical sensitivities.

In preparation of the Update Study, both the Provincial and Federal regulating bodies were provided a basic project description to receive input on some of the regulatory requirements that could be expected for the project. The provincial and federal regulators have both indicated that a full Environmental Impact Assessment (EIA) is likely to be required for this project, mostly due to impacts caused by Reservoir A1.

5.1. ENVIRONMENTAL REQUIREMENTS

There are two major components that were assessed as part of the project:

- Environmental impacts which includes: land use, vegetation and wildlife, fisheries, and wetlands.
- Historical Resources which includes: archaeological and Palaeontological Resources.

Some of the potential issues, applicable legislation, and procedures required to deal with these components are summarized in the following sub sections. More detailed mitigation information and next steps information is available in the full report in Appendix D.

5.1.1. *Land Use/Vegetation Cover*

Dominant land use within the Study Area is annual cropland, with the remaining land use predominantly native prairie grassland with scarce wetlands, shrubland and improved pasture. Reservoir A1, the Supply Pipeline from the river, and the Intake and Red Deer River Pumpstation traverse native prairie, of which portions are also Crown land. Most of the grassland occurs within the coulee systems to the Red Deer River. Most of the proposed irrigation blocks and proposed canal and pipeline systems traverse annual cropland, with the exception of small isolated areas and the Kennedy Coulee Syphon, which traverse grassland, some of which are grassland.

Where required, Crown land applications and assessments are likely, including: conservation assessments on native prairie, disposition supplements, targeted wildlife and vegetation surveys according to the Sensitive Species Inventory Guidelines, and pre-construction wildlife sweeps (Government of Alberta [GOA] 2013a and 2018a).

The proposed project is required to undergo an Environmental Impact Assessment (EIA) under the Environmental Protection and Enhancement Act (EPEA [GOA 2000a]). Additional work, such as multiple years of targeted wildlife and rare plant surveys may be required to supplement the EIA.

5.1.2. *Vegetation and Wildlife*

Much of the vegetation within the Study Area has been altered from its original state and is used as cropland. However, there is a high potential for vegetation and wildlife species of concern in the native prairie grasslands, coulees, riparian areas and wetlands, within the Study Area.

Clearing/construction of the project, especially during the high-risk period for migratory birds and other species of concern, could lead to project delays and/or potential contravention of wildlife legislation (i.e., the Alberta Wildlife Act [GOA 2000b], Migratory Birds Convention Act [Government of Canada {GC} 1994] and Species at Risk Act [GC 2002]) if wildlife is disturbed or killed. As with the federal Migratory Birds Convention Act and Species at Risk Act, the proponent must show due diligence under the provincial Wildlife Act that wildlife is not harmed as a result of the project.

There are development setback standards on Crown-owned land for wildlife species of concern site-specific habitats (i.e., nest and dens) and rare plants which are listed under the *Alberta Wildlife Act* (GOA 2000b; GOA 2018a). The proponent must provide justification for development within setbacks of a wildlife species of concern site-specific habitat or listed rare plant according to the *Master Schedule of Standards and Conditions* (GOA 2018a). The *Recommended Land Use Guidelines for Protection of Selected Wildlife Species and Habitat within Grassland and Parkland Natural Regions of Alberta* (Alberta Sustainable Resource Development 2011) also provide guidance for development setbacks and timing constraints from site-specific habitats of species of concern. Although rare plant species which only are tracked or watched by Alberta Conservation Information Management System have no government protection, best management practices would be to avoid or mitigate disturbance of rare plants where feasible

5.1.3. *Fisheries*

The proposed project potentially affects the Red Deer River (Intake and pumphouse), an unnamed tributary to Kennedy’s Coulee (Reservoir A1), as well as a number of watercourses that are crossed by proposed canals, pipelines and syphons. Information deficiencies and data gaps pertaining to fish and aquatic resources should be identified and subject to a desktop assessment, a field assessment, or both. In addition, fish and fish habitat assessments should be completed wherever project infrastructure overlaps with potential watercourses and fisheries resources.

Water diversions (i.e., withdrawal, storage and release), and the construction of associated infrastructure (i.e., intakes, dams, pipeline crossings, irrigation canals, and discharge structures), have the potential to adversely affect fish and fish habitat. As such, the project is required to adhere to the requirements of the *Water Act* (GOA 2000c), the *Fisheries Act* (GC 1985a) and the *Navigation Protection Act* (GC 1985b). Outfalls and watercourse crossings (i.e., pipeline and temporary construction access) should also adhere to the *Code of Practice for Outfall Structures on Waterbodies*, the *Code of Practice for Watercourse Crossings* (GOA 2013b and 2013c), and the *Guide to the Code of Practice for Watercourse Crossings, Including Guidelines for Complying with the Code of Practice* (Alberta Environment 2000a). In the event that the requirements listed in these Codes of Practices and the Fisheries and Oceans Canada's (DFO) *Measure to Avoid Causing Harm to Fish and Fish Habitat* (2018) cannot be met, and effects to fish and fish habitat are anticipated, the project will be subject to approvals (s) under the *Water Act*, and *Fisheries Act*

Request-for-Review(s) or Authorization(s), including but not limited to DFO offsetting requirements and associated monitoring. These regulatory processes will require written specifications and recommendations of a Qualified Aquatic Environmental Specialist (QAES).

5.1.4. *Wetlands/Ephemeral Waterbodies*

Marsh, shallow open water wetlands and ephemeral drainages occur throughout the Study Area. Two known springs also occur in the Study Area, one along Secondary A Canal and one on the border of Block 4. Wetland habitat exists within the footprint of the proposed Reservoir A1, and some wetland habitat is likely within all of the irrigation blocks, and likely to be traversed by pipelines and canals within these blocks.

A *Water Act* Application including Wetland Assessment and Impact Report (WAIR) or a Wetland Assessment and Impact Form may be required for any permanent impacts to wetlands, depending on the type of proposed development. A review under the *Public Lands Act* (GOA 2000b) may also be required for any potentially permanent wetlands. AEP requires proof of effort put into the project design to avoid and minimize impacts to wetlands.

The wetland assessments for the WAIR must be completed within the growing season (approximately May to September) to align with the *Alberta Wetland Policy* (Alberta Environment and Sustainable Resource Development 2013). Current review times by AEP are in the range of 6 months to two years (or more), depending on regulator workload, the number of impacted features, and the complexity of the system.

Government consultation is recommended on application requirements for flooding wetlands due to irrigation as the scope of approval for this type of activity is not clear in the regulatory documentation.

5.2. HISTORICAL RESOURCES

A Historical Resources Application is required for all components of this project, as per the *Historical Resources Act* of Alberta.

Reservoir A1, Supply Pipeline, Red Deer River Intake and Pumpstation, syphon, and small portions of the Irrigation Blocks and pipelines traverse native prairie and erosional slopes. The potential for undiscovered archaeological and palaeontological resources in these areas is extremely high. Several previously recorded archaeological resource sites are in conflict with key components of the project. A Historical Resources Impact Assessment (HRIA) will be required in order to compile a complete inventory of historical resources within the project disturbance footprint, evaluate the potential impacts to these resources, and to develop mitigation strategies for each project component.

Wherever archaeological or palaeontological resources exist within the proposed disturbance footprint, archaeological or palaeontological mitigative excavation and/or sampling may be required. The probability of at least some level of mitigative excavation being required is very high. This type of mitigation can sometimes extend for many months and may require additional phases of excavation based on initial findings.

With cultural resources such as archaeology or palaeontology, stakeholder/First Nations interest or concerns may create unforeseen pressures on the project timeline or budget.

5.3. ENVIRONMENTAL AND HISTORICAL RESOURCES SUMMARY

Since the project will trigger a full EIA, the requirements for field surveys, mitigation, and monitoring are going to be quite extensive. The regulations are consistently changing and as time passes the requirements for environmental and historical resources are evolving.

It is anticipated that at least two full years of environmental work would have to occur prior to any construction. It is difficult to complete much of the environmental work ahead of time as there are limits to how long a survey or report is valid.

It is possible to complete the Historical Resources Impact Assessment (HRIA) work, and wetland studies ahead of time. Rare plant and wildlife surveys, and fisheries assessments are not recommended until the design progresses into the preliminary phase. The design elements can also be enhanced and refined with input from the environmental sub-consultant.

Costs for the anticipated environmental work based on current legislation are included in the capital cost estimates. There is a significant project contingency allowance provided in the capital cost estimate, which should cover the impacts of changing legislative framework and potential cost overruns for environmental and historical resource mitigation.

6.0 SOCIO-ECONOMIC ANALYSIS

This analysis is divided into five parts:

- Section 6.1 Socio-Economic Profile - a brief overview of the existing socio-economic structure of the Municipal District of Acadia No. 34 (MD of Acadia).
- Section 6.2 Incremental Costs and Benefits – estimates of all the quantifiable incremental economic costs and benefits associated with the proposed irrigation development in MD Acadia.
- Section 6.3 Provincial Benefit-Cost Analysis – an economic cash flow analysis comparing the incremental real direct benefits over time to the incremental real direct costs over time. This employs a provincial accounting stance and is universally employed to rank provincial investment opportunities from a purely economic perspective.
- Section 6.4 Provincial Impact Analysis – an analysis of how irrigation development in the MD of Acadia would impact the provincial economy, both in the short-term and in the long term. The focus here is on GDP, income and employment spin-offs, both in the project area and elsewhere. In this context, a Direct + Indirect Benefit-Cost comparison is also conducted.
- Section 6.5. Farmer Capacity-to-Pay & Cost Sharing – a brief farm financial analysis to determine the probable financial capacity of irrigation farmers' in MD Acadia to contribute to the annual operation and maintenance (incl. electrical energy) and/or the initial capital cost of the proposed irrigation distribution system.

6.1. SOCIO-ECONOMIC PROFILE

The MD of Acadia is a relatively small Alberta municipality with a land area of about 418 square miles 1,070 km^2); approximately 260,000 acres (81,000 ha); about 22 miles (35 kms) N-S and 18 miles (29 kms) E-W. Its southern border is the Red Deer River, its western border is Special Area #2 (approx. Hwy #886), its northern border is Special Area #3 (just south of Oyen and Hwy #9), and its eastern border is the provincial border with Saskatchewan. It has a total population of about 495 people, approx. 1.2/mi^2 (0.5/km^2).[1] The only urban area is the Hamlet of Acadia Valley with a population of about 135 people and it has one general store, two churches, a community hall, curling facility, arena complex, firehall, MD office, and MD shops.[2]

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[1] GOA**, Municipal District of Acadia No. 34, Statistics Profile**, June 2019.

[2] See the Hamlet of Acadia Valley website.

Highway #41 (Buffalo Trail), bisects MD of Acadia from north to south and runs from Medicine Hat to Cold Lake. Highway #565 bisects MD of Acadia from west to east. Oyen (pop. 1,000, immediately north), Empress (pop. 175, immediately south), and the centrally-located hamlet of Acadia Valley (pop.135) are the three closest service centres. The principal trading centres for larger purchases are Medicine Hat (125 kms), Hanna (150 kms), Brooks (150 kms), Drumheller (190 kms), Leader (75 kms), or Kindersley (105 kms).

The topography and climate are both similar to much of the southern Prairies and the Palliser Triangle. It is relatively flat, semi-arid short-grass prairie (brown soil), and largely devoid of native trees. The area is one of the warmest and driest in the province. Precipitation only averages about 325 mm (12.7") per annum, which is less precipitation than in most Irrigation Districts in Southern Alberta.[3] The strong winds and high summer temperatures also contribute to the mean moisture deficit and this is further exacerbated by the shallow snow depth and relatively few days of continuous snow cover. Compared to Special Areas #2 and #3, however, MD #34 still survived the Dirty Thirties relatively unscathed.

The existing land base within the MD of Acadia is approximately:

Dryland Cultivation	170,000 acres
Native Grasslands	85,000 acres
Improved pasture/hay	5,000 acres
Total	260,000 acres

The brown soil is largely Canada Land Inventory (CLI) classes 3, 4 and 5; all dryland, which has limitations that restricts the range of crops that can be grown or requires special conservation practices. Most grazing land is CLI class 6 (about 60,000 acres (25,000 ha)) and is generally Crown lease land. Cultivated dryland (Classes 3, 4, & 5) currently sells for about \$2,000/acre (\$5,000/ha), compared to, say \$8,000/acre in the Edmonton-Calgary corridor and \$10,000/irrigated acre in the Lethbridge-Taber area.[4]

Employment in the region is highly-dependent upon agriculture and other resource-based activities, primarily oil and gas. Most other employment is in the service sector and almost no one is engaged in manufacturing or construction. Of the approximately 350 people who live and work in MD Acadia, more than 200 are engaged in primary agriculture – generally either (zero-till) dryland crop production and/or cow-calf operations. Wheat, canola, barley, and peas are the principal dryland crops grown. The livestock is predominately beef cattle.

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[3] Data for Oyen extracted from: Heywood, R. T., **et. al., Agroclimatic Atlas of Alberta**, AAFRD, Lethbridge, 1990.
[4] See, especially, **Agricultural Real Estate Transfers, M.D. of Acadia No. 34, 1999-2018**, AAF/GOA, March 2019.

With perhaps 100 dryland farmers[5] in the MD, the average (non-Hutterite) farm size is about 2500 acres. But there are perhaps 50 relatively larger (say > 4,000 acres) commercial farmers and ranchers in the municipality and many of these (if not most) are well-established 3rd or 4th generation operations. The Acadia Hutterian Brethren Colony (population 50) is also located in the south-central part of the MD just east of the study boundary.

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[5] Very approximate. Original information from Gary Peers, MD Acadia #34, January 2005.

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1 Welcome to MD Acadia #34 on Highway #41
2 Welcome to the Hamlet of Acadia Valley
3 Aerial view of the Hamlet of Acadia Valley
4 Dryland crop production MD Acadia #34
5 Existing recreation site in MD Acadia #34
6 Red Deer River; the potential water source for irrigated agriculture in MD Acadia #34
7 Potential reservoir site for water storage

6.2. INCREMENTAL COSTS AND BENEFITS

A provincial discounted cash flow analysis **c**ompares quantifiable projected incremental benefits with quantifiable projected incremental costs into the foreseeable future. What, then, are the quantifiable incremental costs and incremental benefits which would arise with the proposed irrigation development in the MD of Acadia.

6.2.1. *Incremental Costs*

Five incremental costs have been identified and are described following.

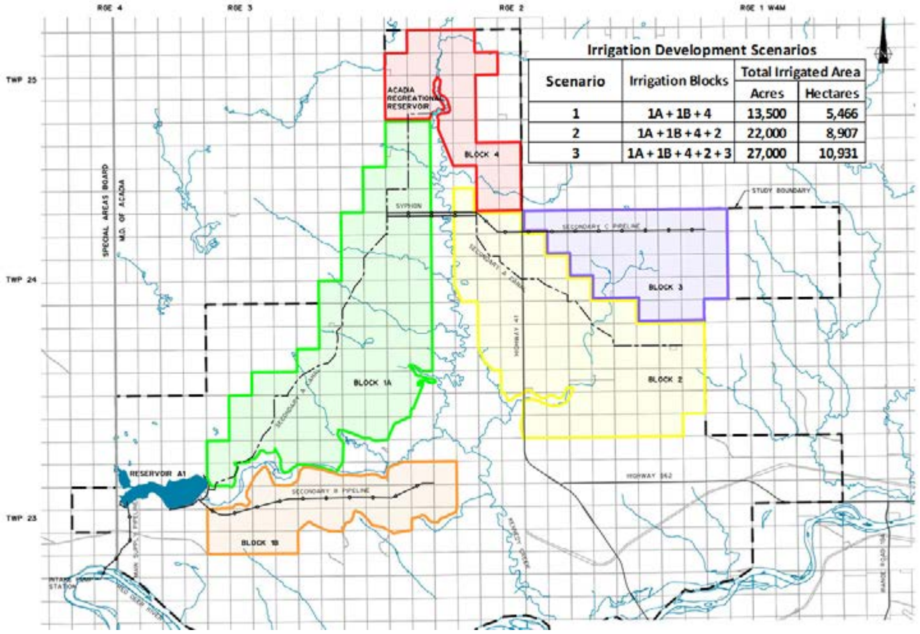
- Construction Costs & O&M
- On-Farm Irrigation Equipment Costs
- On-Farm Supplementary Equip. Costs
- Annual change ins Crop Production Costs
- Annual change in Livestock Production Costs

Construction Capital & O&M Costs

There are three potential irrigation development scenarios, as illustrated in Figure 6.1:

- Scenario 1 includes Blocks 1A, 1B and Block 4 and totals about 13,500 acres (5,500 ha.).
- Scenario 2 adds Block 2, increasing the total irrigated acreage to about 22,000 acres (8.900 ha.)
- Scenario 3 adds Blocks 2 and 3, increasing the total irrigated acreage to about 27,000 acres (10,900 ha.). Blocks 3 and 4 would be serviced by a pressurized system such that farmers would not require any additional on-farm pumping to run their irrigation system.

Figure 6.1: Schematic of Potential Irrigation Development MD of Acadia



Irrigation Development Scenarios

Scenario	Irrigation Blocks	Total Irrigated Area	
		Acres	Hectares
1	1A + 1B + 4	13,500	5,466
2	1A + 1B + 4 + 2	22,000	8,907
3	1A + 1B + 4 + 2 + 3	27,000	10,931

Projected capital costs for the respective developments are summarized in Table 6.1 and indicate an off-farm capital requirement of about $5,000 per acre. The design-construction period is estimated to be three years and it is expected that Reservoir A1 would be filled in Year 3 and thus allow for initial on-farm irrigation development in Year 4.

Table 6.1: Summary of Off-Farm Capital Costs, Years 1-3

Item	Scenario 1	Scenario 2	Scenario 3
Diversion and Supply	$ 15,242,500	$ 18,852,000	$ 18,852,000
Reservoir and Outlets	$ 14,683,750	$ 19,262,000	$ 23,580,750
Distribution System	$ 23,468,200	$ 39,701,600	$ 51,907,775
Subtotal	**$ 53,394,450**	**$ 77,815,600**	**$ 94,340,525**
Contingencies (25%)	$ 13,349,000	$ 19,454,000	$ 23,585,000
Subtotal	**$ 66,743,450**	**$ 97,269,600**	**$ 117,925,525**
Engineering Design (15%)	$ 10,012,000	$ 14,590,000	$ 17,689,000
Environmental/Historical Assessment/Permitting	$ 2,000,000	$ 2,000,000	$ 2,000,000
GRAND TOTAL	**$ 78,755,000**	**$ 113,860,000**	**$ 137,615,000**
Total Irrigated Area (acres), fully developed	13,500	22,000	27,000
Off-Farm Capital Cost per Acre	$ 5,834	$ 5,175	$ 5,097
3-Year Expenditure Pattern: /year	**$ 26,251,667**	**$ 37,953,333**	**$ 45,871,667**

Subsequent annual energy costs are estimated to amount to between $67 per acre per year (Scenario 3) and $82 per year per year (Scenario 2). Blocks 3 and 4 would have a pressurized system which would eliminate on-farm pumping costs in those Blocks. A surcharge of $55 per acre per year would be applied to Block 3-4 farmers to recover the actual cost. Annual system costs would also include operation and maintenance of the main Red Deer River Pump Station, about 3 percent of the initial capital cost per annum. Additionally, distribution O&M costs are expected to be about $25/irrigated acre per annum, very similar to prevailing water rates in existing Irrigation Districts in southern Alberta (Table 3.2). The total (net) annual O&M cost is expected to range from $106 per acre per year (Scenario 3) to $123 per acre per year (Scenario 2).

Table 6.2: Summary of Annual Operation and Maintenance Costs, Full Development

Item	Scenario 1	Scenario 2	Scenario 3
Total Acres Irrigated, fully developed	13,500	22,000	27,000
Energy Charges:			
Red Deer River Pumpstation	$ 909,503	$ 1,769,506	$ 1,813,913
Block 4 Pumpstation (2,500 acres)	$ 161,769	$ 161,769	$ 161,769
Per Irrigated Acre*	*$ 64.71*	*$ 64.71*	*$ 64.71*
Block 3 Pumpstation (5,000 acres)			$ 255,316
Per Irrigated **			*$ 51.06*
Subtotal	$ 1,071,272	$ 1,931,275	$ 2,230,998
less Pressure Surcharge (Blocks 3 &4) @$55/acre	137,500	137,500	412,500
Net Energy Cost	**$ 933,772**	**$ 1,793,775**	**$ 1,818,498**
Net System Energy Cost/acre/year	69.17	81.54	67.35
Other Operation & Maintenance:			
Red Deer River Pumpstation (3% K-cost)	$ 288,375	$ 359,400	$ 359,400
Distribution O&M @ $25/acre***	$ 337,500	$ 550,000	$ 675,000
Subtotal	**$ 625,875**	**$ 909,400**	**$ 1,034,400**
Other O&M/acre/year	46.36	41.34	38.31
NET O&M TOTAL	**$ 1,559,500**	**$ 2,703,500**	**$ 2,852,500**
NET O&M TOTAL/acre/year	**115.52**	**122.89**	**105.65**

Average = $55.61

* $64.71 - $48 for on-farm estimate = $16.71 more. ** $51.06 - $48 for on-farm estimate = $3.06 more.

*** Existing Irrigation District water rates in Alberta average $22/acre.

On-Farm Irrigation Equipment Costs

Associated on-farm irrigation development costs include the purchase and annual operation of an irrigation system and (if electrically-driven) access to three-phase power. The weighted average cost of this new equipment (including a 3-phase power line) is estimated in Table 6.3 to amount to about $995/acre. ($2,458/hectare).

Table 6.3: On-Farm Capital Costs of Irrigation Equipment ($ 2019)

Type	**WHEEL**	**Pivot LP**
Percent*	**5.0%**	**95.0%**
COST SUB-TOTAL	50000	110000
3-Phase Electricity	25000	25000
TOTAL	75000	135000
Area/Unit (Acres)	160	132
TOTAL/ACRE	**$ 468**	**$ 1023**
Total/Hectare	$ 1,156	$ 2,527
WEIGHTED AV./ACRE	**$ 995.25**	
Weighted Av./Ha.	$ 2,458.27	

- See GOA, **Alberta Irrigation Information**, 2018.

The purchase of used irrigation equipment would reduce realized farm costs. A sub-optimal irrigation development configuration would increase estimated 3-phase electricity installation costs.

The corresponding annual operating and maintenance cost is estimated to average about $48 per acre, ranging from $41/acre to $78/acre, depending upon the crop grown. This is based on an average annual water application rate of about 393 mm (15.5”). These costs are incorporated into the annual crop budgets estimated in the sub-sections below.

On-farm irrigation equipment costs would be incurred when the respective irrigation acreages were actually developed.

Supplementary On-Farm Building-Machinery Costs

Much more intensive crop-livestock production will also require more related machinery and on-farm buildings. Based upon 2019 AgriProfit crop budgets prepared by AAF, these order-of-magnitude estimates are:[6]

	Total
Irrigation	$ 723
Dryland	$ 195
Difference	$ 528/acre ($ 1,304/ha)

This is in addition to the $835/acre required for irrigation equipment as detailed above.

These supplemental building and machinery costs would also be incurred when the respective irrigation acreages were actually developed.

Annual Incremental Crop Production Costs

Annual incremental crop production costs are based on a weighted average of individual crop budgets for both dryland and irrigation, detailed in Annex Tables C.1 and C.2.

In total, operating expenses for enhanced crop production are projected to increase from $218/acre to $657/acre, a difference of $439/acre (or $1,084/ha). (Table 6.4). Irrigation production cost estimates include on-farm pumping costs of between $41/acre and $78/acre (Appendix C Table C.2).

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[6] A weighted average for crops, forages, and specialty crops. Assumes a depreciation rate of 15% per annum.

Table 6.4: Annual Incremental Crop Production Costs with Irrigation

Item	Irrigation	Dryland	Difference	
	$/Acre	**$/Acre**	**$/Acre**	**$/Ha.**
Gross Revenue	919.44	275.61	643.83	1590.26
Costs-of-Production*	**656.94**	**217.98**	**438.96**	**1084.23**
Gross Margin	262.50	57.63	204.87	506.03

Source: Appendix Tables C.1 and C.2.

The total annual incremental crop production cost is also linked to the total area irrigated.

Annual Incremental Livestock Production Costs

In Southern Alberta, livestock operations dependent upon irrigation for feedstuffs are often considered their most important "specialty crop". Livestock densities in Lethbridge County, for example, are presently about 8 or 9 times those of MD of Acadia.[7]

For simplicity, annual incremental livestock/on-farm processing cost estimates for the present study are calculated on the basis of an assumed 25 percent incremental value-added (or gross margin) that can be secured from the increased production of feedstuffs in the region.[8] As an average value-added for the entire livestock industry (beef, pork, poultry, etc.), this is a relatively low value-added estimate vis-à-vis crops.

Inflating the potential gross margin (or value added = VA) of all feedstuffs by 25 percent generates a weighted average VA value of $16.09 and $3.07 for irrigation and dryland, respectively.[9] This increase arises because of both crop composition changes and crop yield changes. Thus, with costs-of-production expected to be 3 times value-added, the respective cost-of-production estimates for livestock are $48.26 and $9.20 for irrigation and dryland, respectively.[10] And this, in turn, implies an annual incremental livestock production cost of $39.06/acre (or $96.48/hectare) (Table 6.5). This is a regional on-farm potential.

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[7] Approximate. Based on the **Census of Agriculture, 2001.**

[8] Also see: Heikkila, R., **Irrigation Development in the Red Deer River Valley: Financial Feasibility Component**, AAFRD, Edmonton, September 1988.

[9] A 25% increase in the gross margin is roughly equivalent to a 10% increase in crop prices.

[10] Logically, if VA = 25%, variable costs must be 3X as large and revenue 4X as large.

Table 6.5: Annual Incremental Livestock Production Costs with Irrigation

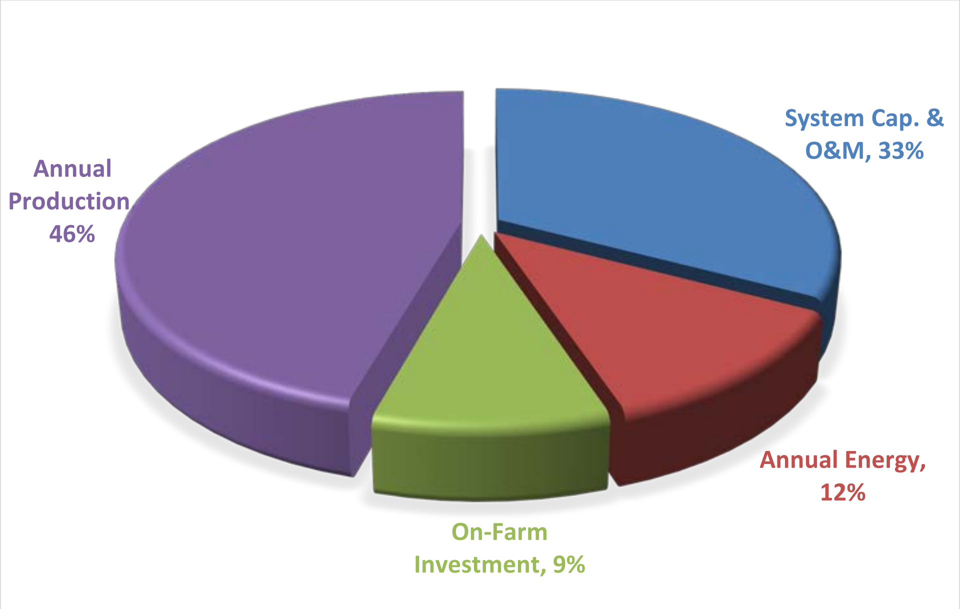
Item	Irrigation	Dryland	Difference	
	$/Acre	$/Acre	$/Acre	$/Ha.
Gross Revenue	64.35	12.27	52.08	128.64
Costs-of-Production	**48.26**	**9.20**	**39.06**	**96.48**
Gross Margin	16.09	3.07	13.02	32.16

The total annual incremental livestock production cost is then based on the total area irrigated.

Net Incremental Cost Summary

Cumulative incremental costs over the economic life of the proposed project (53 years) are divided into: annual production costs 46%; system capital and O&M costs 33%; annual energy costs 12%; and on-farm investment costs 9 percent. (Figure 6-2)

Figure 6.2: Relative Incremental Real Costs @ 4% Discount Rate, Scenario 3



Source: Appendix Table C-5.

This breakdown highlights which cost-savings would have a relatively large or small impact on the economic viability of the proposed project.

6.2.2. *Incremental Benefits*

Three net benefits are particularly important and are described following.

Incremental Benefits

- Annual change in Crop Revenue
- Annual change in Livestock Revenue
- Other Incremental Benefits (livestock water, domestic water, recreation, drought mitigation)

Annual Incremental Crop Revenue

Annual incremental crop revenue estimates are based on a weighted average of individual crop budgets for both dryland and irrigation.

In total, annual crop revenue with enhanced crop production is projected to increase from $276/acre to $919/acre, a difference of $644/acre (or $1590/ha). (Table 6.6).

Table 6.6: Annual Incremental Crop Revenue with Irrigation

Item	Irrigation	Dryland	Difference	
	$/Acre	$/Acre	$/Acre	$/Ha.
Gross Revenue	**919.44**	**275.61**	**643.83**	**1590.26**
Costs-of-Production*	656.94	217.98	438.96	1084.23
Gross Margin	262.50	57.63	204.87	506.03

Source: Appendix Tables C.1 and C.2.

The total annual incremental crop revenue is dependent upon the total area irrigated.

Annual Incremental Livestock Revenue

Additional livestock production again includes both on-farm vertically integrated production/processing and regional intra-farm production dependencies.

Similar to the corresponding incremental cost estimates, annual incremental livestock revenue estimates for the present study are calculated on the basis of an assumed 25 percent incremental value-added (or gross margin) that can potentially be secured from the increased production of feedstuffs in the region.

As already noted, since revenues are expected to be 4 times value-added, the respective gross revenue estimates are $64.35 and $12.27 for irrigation and dryland, respectively.[11] This, in turn, implies an annual incremental livestock revenue of $52.08/acre (or $128.64/hectare) (Table 6.7). Once again, this is a regional on-farm potential.

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[11] Logically, if VA = 25%, variable costs must be 3X as large and revenue 4X as large.

Table 6.7: Annual Incremental Livestock Revenue with Irrigation

Item	Irrigation	Dryland	Difference	
	$/Acre	$/Acre	$/Acre	$/Ha.
Gross Revenue	**64.35**	**12.27**	**52.08**	**128.64**
Costs-of-Production	48.26	9.20	39.06	96.48
Gross Margin	16.09	3.07	13.02	32.16

The total annual incremental livestock revenue is then based on the total area irrigated.

Other Incremental Benefits

Although this is primarily an irrigation project, there are a number of other benefits which should also be quantified, wherever possible. This serves two purposes: 1) it at least flags their potential existence; and 2) it at least provides some indication of their order-of-magnitude (i.e. Are they likely to represent 1% or 10% of direct net irrigation benefits?).

The potential benefits of particular concern are:

- enhanced livestock water availability
- enhanced urban-rural domestic water access
- enhanced recreational amenities
- drought mitigation

Livestock Water Availability

Livestock require an ample and good quality water supply and existing water limitations have limited livestock expansion in the region, particularly intensive livestock operations (ILO's).[12] The proximity of water for irrigation would also make this supply available to ILO's.

For illustrative purposes, with irrigation, we assume that there will be a 10 - fold increase in the number of confined livestock requiring a reliable water supply in the MD Acadia.

The value of water for livestock varies widely, with a reported average value of $355 per dam^3 (220,000 gallons).[13] Similarly, it has been estimated that in the Special Areas the cost of filling a ½ million gallon dugout is about $750. This is equivalent to 0.15 cents per gallon or $330 per dam^3, almost an identical value. Thus, based on a gross AU water requirement of 10 gallons per day, the value of the water for

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[12] For details, see: Watrecon Consulting, **Socio-Economic Assessment of the Special Areas Water Supply Project**, Special Areas Board, 2004.

[13] One dam3 = 1 M litres. For details, see Marv Anderson & Associates, **Profile of Irrigation in the Highwood-Little Bow** (draft), Edmonton, January 2003, and related documents. The same estimate is provided in: MPE Engineering/Russell Consulting, **Southern Regional Stormwater Management Plan**, Regional Drainage Committee, Lethbridge, February 2016, p. 28.

the projected increase in livestock numbers on an annual per-acre basis would be equal to approximately 0.9 AU X 10 gal. X 365 days X 0.15 cents = **$4.93 per acre per annum.**

In the Lethbridge area, with numerous intensive livestock operations (ILO's) and higher population densities dependent upon potable water access, the comparable number is about $34 per irrigated acre.[14]

Urban-Rural Potable Water Access

It is not known to what extent the proximity to water for irrigation would allow nearby rural or urban households to also access this for domestic purposes and, thus, the economic analysis does not ascribe a dollar benefit to this water. At the same time, it should be noted that the unit value of this water (however much is extracted) could be assumed to be worth at least as much as it costs to use Henry Kroeger HKRWC pipeline water; about $960/dam^3 plus distribution costs, or approximately 0.4 cents per gallon.[15]

Enhanced Recreational Amenities

Recreation here includes, in particular, fishing, upland bird hunting, big game hunting, and non-consumptive recreation (camping, boating, bird-watching, etc.). How these activities would be impacted by the proposed "irrigation" project in question is unclear.

Nevertheless, there is ample evidence to indicate that increased biomass generally enhances the environment and wildlife habitat and this, in turn, enhances recreational opportunities in and around a new irrigation area.[16]

To put this anticipated benefit into context, we rely on recent research in the neighbouring Special Areas.[17] We then estimate that the annual Acadia Valley benefit would be about 20% as large as that of the proposed SAWSP project to the north. The resulting estimates are shown in Table 6.8:

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[14] Estimated from Paterson Earth & Water Consulting Ltd., **Economic Value of Irrigation in Alberta**, AIPA, Lethbridge, 2015, p. 66.

[15] HKRWC estimate from: Watrecon Consulting**, Socio-Economic Assessment of the Special Areas Water Supply Project**, Special Areas Board, 2004. Again, this is very similar to average water values typical of municipal and residential users elsewhere in Canada; about $1,220/dam^3 and $1,681/dam^3, respectively. Source: MAA, **Profile of Irrigation in the Highwood-Little Bow** and related documents. Also see: MPE Engineering/Russell Consulting, **Southern Regional Stormwater Management Plan**, Regional Drainage Committee, Lethbridge, February 2016, p. 28.

[16] See, for example: AIPA, **Irrigation Impact Study: Accomplishments & Opportunities,** Vol. 7, UMA/AIPA, Lethbridge, May 1993.

[17] : Watrecon Consulting**, Socio-Economic Assessment of the Special Areas Water Supply Project**, Special Areas Board, 2004.

Table 6.8: Estimated Value of Enhanced Recreation, Acadia Valley $2019

Type of Recreation	Marginal Extra-Market Value*	20% SAWSP Total Person-Days	Total Annual Value
Fishing	20% of $28.95/day= $5.79	2,448	$13,950
Upland Bird Hunting	20% of $17.10/day= $3.42	2,091	$7,150
Big Game Hunting	20% of $18.50 = $3.70	11,500	$42,550
Non-Consumptive	20% of $9.90 = $1.98	16,040	$31,760
TOTAL			**$95,400**
Total/Acre Irrigated**			**$3.53/acre**

- Extra-market value is the value over and above that which is actually paid. Marginal value is estimated to equal 20% of total extra-market value. ** Assumes a 27,000 acre development.

This is the current 2019 value which we anticipate will then increase (in real terms, net of inflation) at a rate of about 1.4 percent per year for the duration of the proposed project. This acknowledges that over time leisure will likely become increasingly important to the public.[18]

Although very approximate, this recreational benefit of (say) 2% of irrigation benefits is quite similar to prior research findings elsewhere in the province.[19]

Drought Mitigation

The MD of Acadia is one of the warmest and driest areas in the province. Precipitation only averages about 325 mm (12.7”) per annum and this is less precipitation than in most Irrigation Districts in southern Alberta. [20] The strong winds and high summer temperatures also contribute to the mean moisture deficit and this is further exacerbated by the shallow snow depth and relatively few days of continuous snow cover. Average annual precipitation also obscures the extreme weather variability that characterizes this part of the province. Under dryland conditions, periodic droughts are almost inevitable. Consequently, dryland crop yields and livestock feed availability are both highly variable.

To some extent, this is reflected in AFSC crop insurance premiums. The greater the risk, the higher the premium. Irrigation will insulate farmers from much of this risk and this has recently been valued at about **$6.67/acre per annum**.[21]

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[18] This methodology was first employed in the **Little Bow-Highwood Diversion Plan, Environmental Impact Assessment: Socio-Economic Assessment**, Vol. 4, Alberta Public Works/Golder, Calgary, 1995.

[19] McNaughton, R. B., **Irrigation Impact Study: Recreation, Vol. 3,** AIPA, Lethbridge, May 1993.

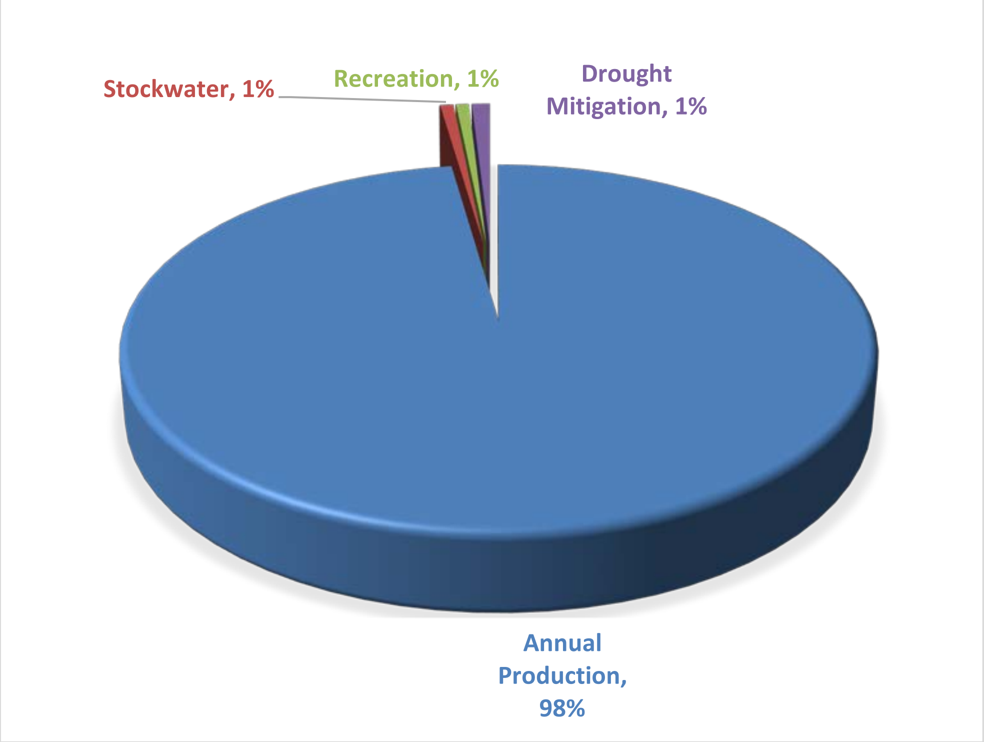
[20] Data for Oyen extracted from: Heywood, R. T., **et. al., Agroclimatic Atlas of Alberta**, AAFRD, Lethbridge, 1990.

[21] Estimated from Paterson Earth & Water Consulting Ltd., **Economic Value of Irrigation in Alberta**, AIPA, Lethbridge, 2015, p. 66.

Net Incremental Benefit Summary

In terms of their relative importance, over a 53 year period, real **net** incremental benefits are divided approximately as follows: irrigated crops and livestock 98%; stock water, recreation, and drought mitigation each about 1 percent.

Figure 6.3: Relative Incremental Real Benefits @ 4% Discount Rate, Scenario 3



Very obviously, the economic viability of the proposed project depends, overwhelmingly, on the relative profitability of irrigated crop production and related livestock operations.

6.3. PROVINCIAL CASH FLOW ANALYSIS

6.3.1. *Methodology*

a. Standards & Precedents

There are well-established and widely-used standards and procedures for conducting a discounted cash flow analysis of potential investment opportunities. The methodology employed in this analysis is generally consistent with that of the World Bank, as well as what has repeatedly been utilized in other recent water management studies in Alberta: The most recent and the most relevant to the present study are:

- MPE Engineering Ltd., MD of Acadia #34 Irrigation Development Study, AE, 2005.
- Watrecon Consulting, Socio-Economic Assessment of the Special Areas Water Supply Project, Special Areas Board, 2004.
- Golder Assoc., Meridian Dam Preliminary Feasibility Study (update), AE, 2013.

b. Criteria

The four criteria utilized to gauge how economically profitable a proposed investment would be are the Internal Rate of Return (IRR), the Benefit-Cost (B/C) Ratio, the Net Present Value (NPV), and the Payback Period:

Table 6.9: Economic Evaluation Criteria

CRITERIA	DESCRIPTION
1. Internal Rate of Return (IRR)	That interest (i.e. discount) rate where the cumulative discounted benefits are exactly equal to the cumulative discounted costs over a given time period. Preferred by many (e.g. World Bank) because it avoids pre-determining what the most appropriate social discount (i.e. interest) rate should be. However, politically, this still requires establishing a minimum acceptable rate of return.
2. Benefit-Cost Ratio (B/C Ratio)	The ratio of cumulative discounted benefits to cumulative discounted costs over a given time period for a particular interest rate. Different methodologies can generate different ratios <> unity. No units. Measures efficiency ("bang for the buck") but not scale.
3. Net Present Value (NPV) of Incremental Socio-Economic Benefits	Cumulative discounted benefits minus cumulative discounted costs over a given time period for a particular interest rate. Measures the incremental cumulative absolute dollar value over time. Probably the best economic measure when selecting between Investment A and Investment B if both opportunities have a B/C ratio > 1.
4. Pay-back Period	The number of years required to recover the capital and on-going discounted cost of a proposed investment.

To be considered economically feasible from a provincial perspective, the IRR must exceed a politically prescribed minimum annual rate-of-return. At the same time, for a specified interest (or discount) rate the B/C ratio must be greater than one, the NPV must be positive, and the pay-back period should not exceed a maximum number of years approximated by 70/interest rate, e.g. at 4% ⇒ 18 years.

This "benefit-cost analysis" helps determine if a proposed investment would or would not use Alberta resources efficiently. These are all efficiency criteria which entirely ignore equity considerations**.** These criteria also ignore who actually pays or who actually benefits. The rationale for this is that if NPV>0 and B/C>1 for the province, then it should always be possible for those who gain from the implementation of a particular investment to compensate those who lose (if, indeed, there are losers) from project implementation. At the same time, this simple calculus also fails to consider (without further refinements) the possibility that a dollar may be worth more to a relatively poor community than to a relatively wealthy community.

c. Procedures

Methodological procedures include:

- Time frame: Construction period plus 50 years = 53 years
- Costs and prices: Constant 2019 dollars for a 53 year period
- Social Discount Rate: Uncertain, but probably ranges from 2% to 4% per annum (net of inflation)
- Economic Prices: Adjustments to account for non-market financial price distortions (called "shadow pricing"). No adjustments.
- Scheduling: Irrigation assumed to begin after construction at a rate of 3300 acres per annum until full development with all annual costs and revenues being linked to this development schedule.

6.3.2. *Cash Flow Analysis*

Utilizing the above methodological framework, a discounted cash flow analysis was conducted for each of the three development proposals:

- Scenario 1: 13,500 acres (5,500 ha.)
- Scenario 2: 22,000 acres (8,900 ha.)
- Scenario 3: 27,000 acres (10,850 ha.)

For each Scenario, the quantified incremental costs and benefits are:

Table 6.10: Incremental Costs and Benefits Summary

Incremental Costs	Incremental Benefits
1. Construction Costs & O&M	1. Annual change in Crop Revenue
2. Energy Costs (system & on-farm)	2. Annual change in Livestock Revenue
3. On-Farm Irrigation Equipment Costs	3. Other Incremental Benefits (livestock water, domestic water, recreation, and drought mitigation)
4. On-Farm Supplementary Equip. Costs	
5. Annual change in Crop Production Costs	
6. Annual change in Livestock Production Costs	

Total estimated capital costs (over three years) are $78.8 M, $113.9 M, and $137.6 M for Scenarios 1, 2, and 3, respectively (Table 6.1). The corresponding O&M costs (excl. energy costs), at project maturity, are estimated to be $625.9 thousand, $909.4 thousand, and $1.03 M per year. The corresponding energy costs for pumping the water from the Red Deer River (a deep valley) to the principal reservoir (A1) located at a much higher elevation are $933.8 thousand, $1.8 M, and $1.8 M, for Scenarios 1, 2, and 3 respectively (Table 6.2).

The estimated annual energy cost for the pressured Block 4 system is $64.71 per acre per annum; $16.71 per acre per year more than the farm budgets (@$48 per acre per year) allocate. Similarly, for the pressurized Block 3 system the estimated annual energy cost is $51.06 per acre per year; some $3.06 per acre per year more than the farm budgets allocate to energizing an on-farm system (Table 3.2). In the following benefit-cost analysis (Section 4), these cost differentials are an add-on. This annual cost, however, is not a system cost because it is recouped by applying an annual $55/acre surcharge to the respective farmers in Blocks 3 and 4.

On-farm irrigation equipment costs are expected to average $995/acre with a 25 year life span; supplementary equipment costs about $528/acre with a 20 year life span. Incremental per-acre costs of production for crops and livestock are estimated to be about $439/acre and $39/acre, respectively. All farm-related costs are linked to projected irrigation development rates.

With respect to projected incremental revenues, the incremental per-acre revenue estimates for crops and livestock are $644/acre and $52/acre, respectively. These revenue streams are also linked to projected irrigation development rates. Other relatively minor incremental benefits are expected to arise from improved access to livestock water ($5 per acre/year), enhanced recreational amenities (initially about $4/acre/year), and drought mitigation ($7 per acre/year).

The resulting cash-flow simulations for Scenarios 1,2, and 3 are provided in excruciating detail in accompanying Annex Tables C-3, C-4, and C-5, respectively and the principal results are indicated in Table 6.11.

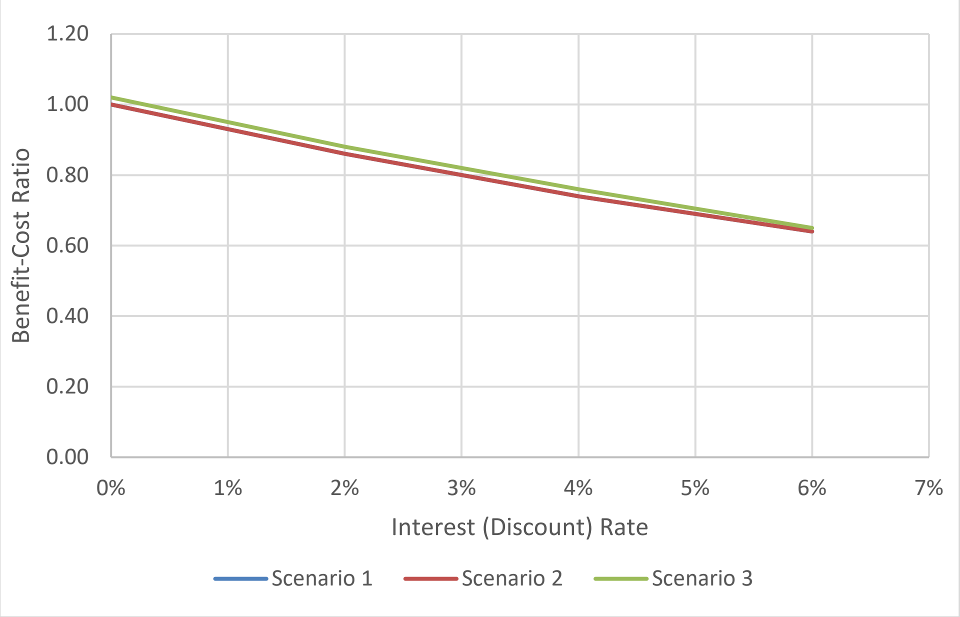
Table 6.11: Summary of Provincial Cash Flow Analysis

Criteria	Scenario 1	Scenario 2	Scenario 3
IRR %	**0.70**	**0.73**	**1.08**
B/C Ratio:			
0%	1.06	1.06	1.09
2%	0.90	0.91	0.93
4%	0.77	0.78	0.79
6%	0.66	0.66	0.67
NPV: ($M)			
0%	25.8	40.0	73.5
2%	-30.1	-43.7	-39.1
4%	-52.0	-76.2	-84.0
6%	-60.6	-88.8	-102.1

The Internal Rate of Return (IRR) is estimated to range from 0.7%/year to 1.08%/year for Scenarios 1, 2, and 3, respectively. These are relatively low although the best IRR is Scenario 3, estimated to be about 1.08 percent/annum. In today's financial markets (characterized by historically very low interest rates), however, a projected **1% real social rate of return (after inflation) might be acceptable.**

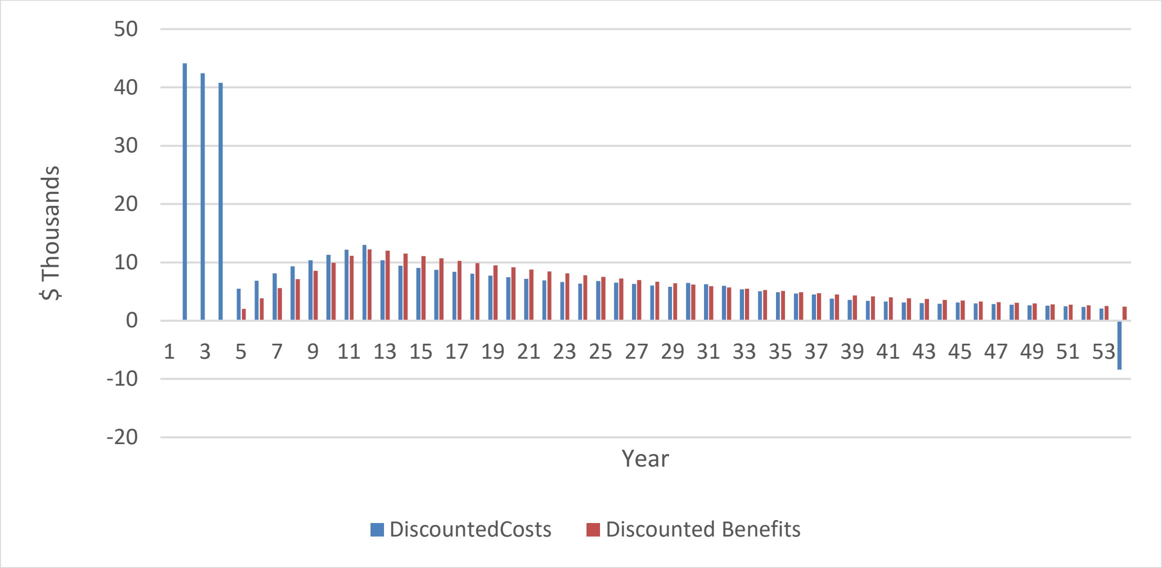
Estimated Benefit-Cost ratios are consistent with the corresponding IRR's. At a 4% interest (discount) rate, the provincial B/C ratio is estimated to be 0.77 or 0.78 for Scenarios 1 and 2 and only slightly better at 0.79 for Scenario 3. These differences are not statistically significant. At a zero real social interest rate (after inflation), the respective B/C ratios are between 1.06 and 1.09, again suggesting provincial economic viability if a zero real social rate of return is deemed acceptable. (Figure 6.4)

Figure 6.4: Benefit –Cost Ratio at Various Interest Rates



Discounting future costs and benefits at various rates effectively gives more emphasis to costs and benefits which arise early in the project cycle; less to costs and benefits which arise late in the project cycle. For most "irrigation" projects, costs tend to be concentrated in the near-term; benefits in the longer-term. (Figure 6.5)

Figure 6.5: Scenario 3 – Discounted Costs and Discounted Benefits



This highlights the importance of synchronizing capital expenditures (to the extent that it is technically possible), to the rate of actual on-farm irrigation development.

A provincial cash-flow projection is particularly useful as a means of systematically and comprehensively looking at all of the socio-economic variables on one spreadsheet.

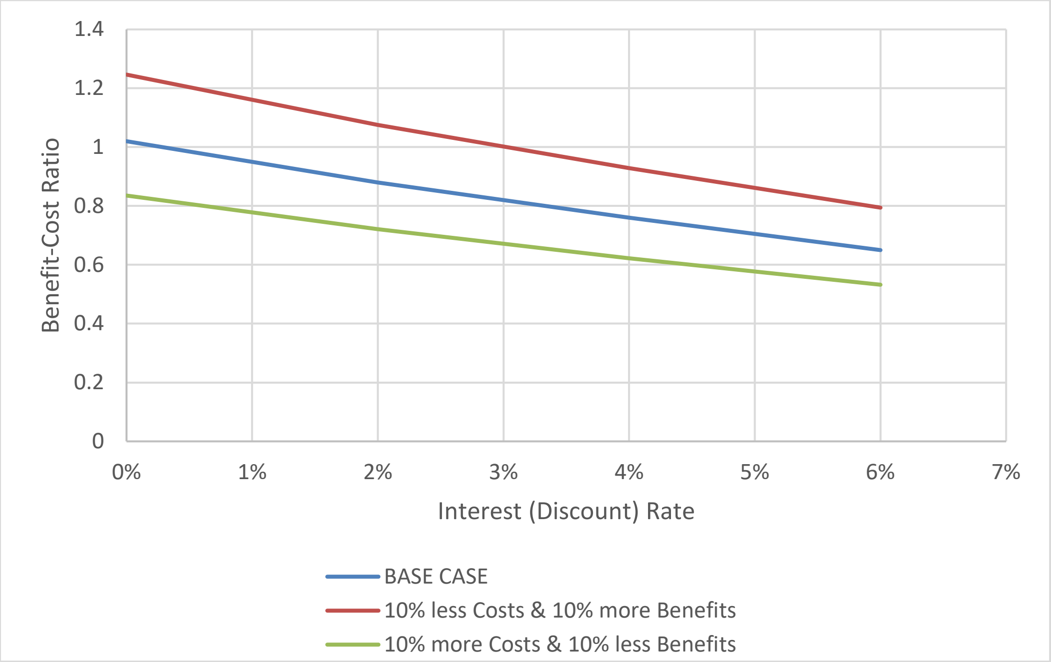
6.3.3. *Sensitivity Analysis*

An accompanying sensitivity analysis is invaluable for at least three reasons:

1. There is risk and uncertainty. No one knows exactly how the future will unfold.
2. Errors and omissions. Sometimes accurately expressing everything in dollars may be difficult.
3. To facilitate optimum project design.

The focus here is on six variables which are often the most important, problematic, or uncertain: 1) irrigation development rates; 2) real agricultural prices; 3) real agricultural costs-of-production; 4) real project capital cost changes; 5) real operating and maintenance cost changes; and 6) energy cost changes. This analysis indicates that for Scenario 3 (the economically “best” case), at a 4% interest (discount) rate, the confidence band which brackets the B/C ratio of 0.79 could be as low as 0.65 or as high as 0.97. Once again, we also see that at a 0% interest (discount) rate, the B/C ratio could be as high as 1.33 or as low as 0.89.

Figure 6.6: Benefit-Cost Confidence Band, Base Case, Scenario 3



6.3.4. *Provincial Cash Flow Analysis Summary*

Five final points should be highlighted:

1. Focusing on Scenario 3 (the slightly better option), the imputed Internal Rate of Return (where B / C) is about 1.08 percent while the Benefit-Cost Ratio utilizing a 4% interest (discount) rate is about 0.79. This suggests that if we assume this historical real rate of interest (of 4%) is the appropriate provincial rate-of-return, the proposed irrigation development in MD of Acadia is (from a provincial perspective) a marginal economic proposition. But this is subject to two qualifications: a) our analytical margin of error (about +-20%) means that the B/C ratio utilizing a 4 percent discount rate could be as high as 1.33 or as low as 0.89; and b) with historically low real rates of interest, is the 4% criteria appropriate? (At a zero discount rate, the B/C ratio is 1.09.)
2. A provincial B/C analysis does not distinguish between precisely who pays and who benefits. A farm financial analysis is required to determine if a given irrigation proposal is actually financially feasible for participating farmers. Relative farm profitability can also determine how much a new irrigation farmer could probably contribute to overall system capital requirements and/or annual operation and maintenance (Section 6.5).
3. The results of this analysis are very similar to numerous other “irrigation” studies in Southern Alberta. Sixteen such studies calculated B/C ratios which averaged about 0.80 and ranged from 0.33 to 1.47. Only four of these 16 studies had a B/C ratio >1 indicating economic feasibility. Development costs very often exceed the direct benefits of irrigation to farmers/ranchers.

4. Many other inputs, including social and environmental considerations, are also required in the political decision-making process.
5. From a regional development perspective, much broader socio-economic criteria must be employed (Section 6.4).

6.4. PROVINCIAL IMPACT ANALYSIS

Backward and forward linkages, together with primary agriculture, make up the agri-food complex; a relatively large industry that is integral to the socio-economic well-being of virtually all Canadians:

Agri-Industry Providers ⇔ Producers ⇔ Agri-Industry Processors/Intermediaries/Retailers ⇔Agri-Industry Consumers

Backward (input) linkages and forward (processing + wholesale + retail + food services) linkages with agricultural producers clearly generate a cumulative total impact on the economy which far exceeds the value of primary production itself. This is defined as the Total Agri-Food Sector GDP.

Economic multipliers provide a means to quantitatively measure and assess the impact of changes in an economy. When there is a change in the economy (irrigation development, business opening/closing/expanding/contracting, changes in the demands for a commodity, tax changes, interest rate changes, etc.), it impacts first on those firms, households and/or governments most directly affected. Then there is a ripple effect as this impact spreads throughout the economy affecting other firms, households, and governments.

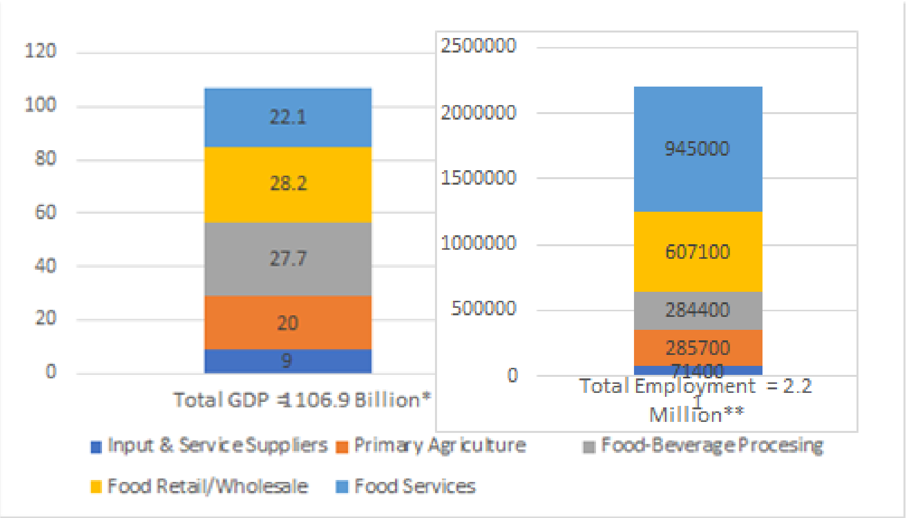
Any change effectively generates three types of effects:

- Initial direct industry impact
- Indirect ripple effects (sometimes called spinoffs), and
- An induced income effect as incomes are impacted which, in turn, affects consumption levels

When an industry increases its output, it must obtain more inputs which are provided by other industries. The expansion of these other industries means increased demands are placed on their suppliers, and so on through a chain of interdependent industries. This is referred to as the **direct and indirect industry effect.** In addition, as industries increase their production, they increase staff and thus pay more in wages. This increased income in the hands of consumers can generate additional consumption and subsequent increases in industry outputs. This is referred to as the **induced income effect**.

Estimates of the agri-food system's total impact on GDP (value-added) and employment in Canada are indicated in Figure 6.7.

Figure 6.7: GDP and Employment in the Agri-Food Sector, Canada, 2013



* 2016 total = $111.9 B. ** 2015 total = 2.1 million

Source: Basic data from AAFC, **An Overview of the Canadian Agriculture and Agri-Food System, 2015**, Ottawa, pp. 23 and 25.

Utilizing these implied ratios in conjunction with existing information on the economic impact of irrigation in southern Alberta[22] allows us to approximate the total annual economic impact of irrigation development in MD Acadia at project maturity. These estimates are provided in Table 6.12.

Table 6.12: Total Annual Economic Impact of Irrigation Development in MD of Acadia at Project Maturity (Scenario 3 - 27,000 acres) highlights how irrigation development in MD of Acadia would impact farm/ranch input providers (backward linkages), processors (forward linkages), and the subsequent food chain (indirect and income-induced affect). The direct beneficiaries of this irrigation development would probably only capture about 16 percent of the total GDP and income change. **The cash flow analysis (Section 6.3) focuses almost exclusively on this 16 percent.** About 50% of the additional employment generated would also be off-farm.

Still not included in this much broader perspective is the potential impact of irrigation development in MD of Acadia on tax revenues. Land assessments would increase, thereby generating more municipal revenue. Similarly, income tax revenues, both nationally and provincially, would also increase. It is estimated that government taxes from irrigation-related activity typically exceeds irrigated-related government expenditures by a ratio of about 3:1. [23]

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[22] Paterson Earth & Water Consulting Ltd., **Economic Value of Irrigation in Alberta**, AIPA, Lethbridge, 2015, p. 66.
[23] **Ibid**, p. 65.

Table 6.12: Total Annual Economic Impact of Irrigation Development in MD of Acadia at Project Maturity (Scenario 3 - 27,000 acres)

Scenario 3 (27,000 acres) **($ Thousands 2019)**

ITEM	GDP ($,000)	INCOME ($,000)	Employment (FTE's)
Primary Production			
Primary crop production	5,531	3,466	343
Primary livestock production	352	299	16
Backward linkages (crop production)	7,467	4,583	75
Backward linkages (livestock production)	158	97	2
Agricultural Processing			
Forward Linkages (value-added processing):			
Direct	8,148	5,039	81
Indirect & induced	14,796	9,150	148
Other Irrigation Benefits			
Drought mitigation	180	180	-
Water use (non-irrigation)	133	133	-
Recreation	95	57	3
Total Economic Value	$36,861	$23,004	668

Notes: 1. GDP estimates for crops, livestock, water use, and recreation from Section 2.
2. GDP estimates for drought mitigation imputed from Paterson.
3. Income/GDP and employment/income ratios imputed from Paterson.
4. Backward/Primary and Forward Primary ratios imputed from AAFC (Backward for crops X3)

Sources: Paterson Earth annd Water Consulting Ltd., **Economic Value of Irrigation in Alberta**, Alberta Irrigation Projects Association (AIPA), Lethbridge, 2015.
AAFC, **An Overview of the Canadian Agriculture and Agri-Food System, 2015**, Ottawa, 2016.

6.4.1. *Regional Benefit - Cost Estimates with Spin-Offs*

The provincial cash-flow analysis (Section 6.3) does **not** consider (secondary) spin-offs as a potential benefit. These are excluded because most alternative provincial/national investments generate spin-offs of a similar magnitude. Thus, it is argued, from a provincial or national perspective, they cannot legitimately be included when comparing or ranking the economic feasibility of Project A with the economic feasibility of Project B.

Nevertheless, when we revise the provincial cash-flow calculations by including the direct backward and forward linkages (but still excluding the indirect and induced impacts) a much more favorable assessment emerges. Pro-rated, according to the rate of irrigation development anticipated, projected regional cash flows simulated exactly like the provincial cash-flow analysis generates the following results:

Discount Rate	B/C Ratio	NPV ($,000)	IRR
2%	1.66	$361,567	
4%	1.41	$162,553	8.19%
6%	1.20	$60,141	
0%	1.95	$777,282	

Clearly, when the direct spin-offs generated by irrigation development (i.e. secondary net benefits) are also considered, the net economic impact is unambiguously and irrefutably positive. At a 4% interest (discount) rate, the B/C ratio is a very strong 1.41, the net present value (NPV) is about $163 million over 50 years, and the internal rate of return (IRR) is a very healthy 8.19 percent per annum.

This is the calculus utilized by regional proponents of irrigation development in their area of the province. The difference between a dryland farming area like MD Acadia and an irrigated farming area is patently obvious. Irrigation generates a regional dynamic which supports the growth of not only primary agriculture but also input providers, processors, wholesalers, retailers, service industries and public infrastructure which would otherwise simply not exist. Employment and incomes climb and sustainable socio-economic growth is more easily assured. Irrigation development is generally a very effective regional development tool.

Finally, what is the value of water security and the future (higher) option value of the water itself? Water is life. With anticipated climate change and projections that stream flows in the Red Deer Basin may eventually decrease, proceeding may be imperative. [24]

6.5. FARMER'S CAPACITY TO PAY & COST SHARING

The on-farm profitability of irrigation will depend heavily upon how much farmers must contribute to initial capital costs or the subsequent annual off-farm system operation and maintenance (O&M). At project maturity and exclusive of the annual estimated on-farm cost of water delivery[25], to what extent could an irrigation farmer in MD of Acadia actually afford to contribute to either the initial off-farm capital cost or the annual system O&M cost?

6.5.1. *Criteria and Methodology*

To answer these questions, a farm financial analysis must consider not only gross margins (as estimated for the provincial B/C analysis – Section 3) but also on-farm capital costs and unpaid farm labour costs (Annex Table C-6). With this "average" farm budget for irrigated crop production (Annex Table C-2 and Annex Table C-6), we then employ two criteria to infer (impute or simulate) how much "free" annual cash flow an "average" irrigation farmer in MD Acadia might have available to contribute to either initial system capital requirements or annual system O&M:

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[24] Martz, L., **et. al**. (eds.), **Climate Change and Water – SSRB Final Technical Report, Climate Change Impact and Adaptation Program**, Natural Resources Canada, Ottawa, 2007; and Golder Associates, **Hydro-Climate Modelling of Alberta South Saskatchewan Regional Planning Area**, Alberta Environment, Calgary, 2012.

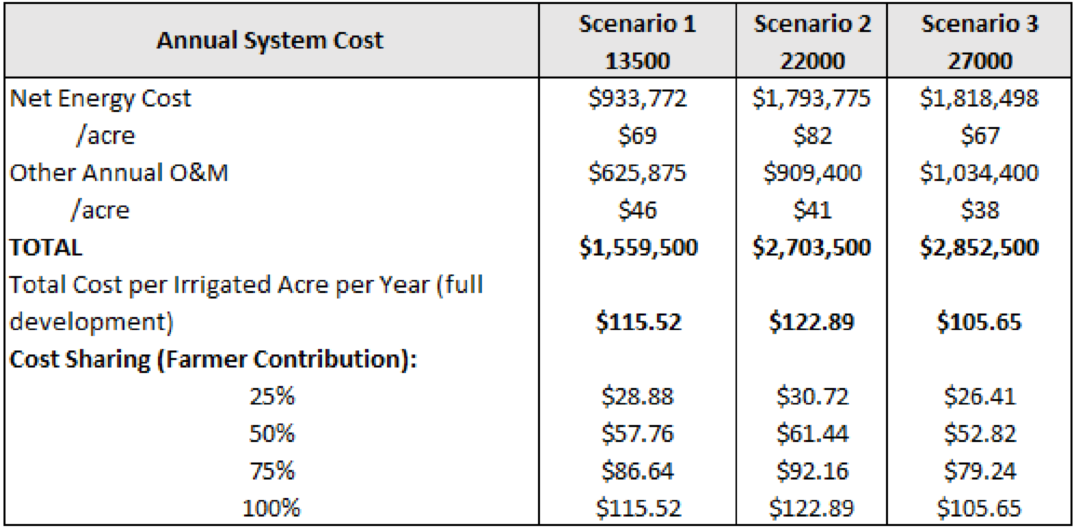
[25] This is an average cost. It varies depending upon the type of on-farm system installed (pivot, wheel, etc.), the crop grown, precipitation, soil moisture, etc. The same variables will affect the actual off-farm O&M pumping costs for Blocks 3 and 4.

- The annual **percent return to capital** must be **at least 4 percent per annum**. This is a real rate of return, exclusive of inflation. If farmers can't generate a 4 - 5%/annum return to capital, they might want to invest elsewhere. Real long-term rates-of-return to agriculture (net of inflation) have been about 4%/annum. Nominal long-term interest rates are now about 4 - 5% per annum. Given the need to adopt new production technologies, the need to secure new product markets, the relatively large capital investment involved, as well as the attendant risk, this is considered an absolute minimum.
- The annual **net farm income** should at least be approximately **$70,000 per farm.** If farmers can't generate a net farm income of $70,000/annum with 1000 acres of irrigation (i.e. $70/acre/year), it's probably not "worth it". This was the average net farm income from farming on the Prairies in 2016.[26] Excluding farm income from auxiliary enterprises (e.g. livestock), it is estimated that a dryland farmer in MD of Acadia would currently need about 5,000 cultivated acres to generate a similar net farm income.

6.5.2. *Annual System O&M Costs*

Anticipated annual O&M costs for the proposed system, including annual energy costs, are indicated in Table 6.1. To what extent could new irrigation farmers in MD of Acadia be expected to pay these annual O&M costs for the proposed system, given that the capital cost of the Headworks and Distribution System if fully grant-funded (i.e. not contribution by farmers)?

Table 6.13: Estimated Annual Irrigation O&M System Costs $2019



Annual System Cost	Scenario 1 13500	Scenario 2 22000	Scenario 3 27000
Net Energy Cost	$933,772	$1,793,775	$1,818,498
/acre	$69	$82	$67
Other Annual O&M	$625,875	$909,400	$1,034,400
/acre	$46	$41	$38
TOTAL	**$1,559,500**	**$2,703,500**	**$2,852,500**
Total Cost per Irrigated Acre per Year (full development)	**$115.52**	**$122.89**	**$105.65**
Cost Sharing (Farmer Contribution):			
25%	$28.88	$30.72	$26.41
50%	$57.76	$61.44	$52.82
75%	$86.64	$92.16	$79.24
100%	$115.52	$122.89	$105.65

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[26] Statistics Canada, Table 32-10-0052-01 (net farm income) and Table 32-10-0045-01 (farm cash receipts).

Including these alternative O&M costs in our irrigated crop budgets (Table C-2 and Table C-6) generates estimates of the on-farm return-to-capital, **annual percent return to capital**, return to equity (assets), **and net farm income,** as summarized in Table 6.2.

Table 6.14: Measures of Farm Profitability per Irrigated Acre, $2019

Scenario/Profitability Criteria	Farmer's Annual Contribution to Annual System O&M				
	0%	25%	50%	75%	100%
SCENARIO 1 (13,500 acres):		$28.88	$57.76	$86.64	$115.52
a. Return to Capital	214.26	185.38	156.50	127.62	98.74
b. Percent Return to Capital (Return/Total)	5.8%	5.0%	4.2%	3.4%	2.7%
c. Return to Equity (Assets)	69.21	40.33	11.45	-17.43	-46.31
d. Net Farm Income	117.45	88.57	59.69	30.81	1.93
SCENARIO 2 (22,000 acres):		$30.72	$61.44	$92.16	$122.89
a. Return to Capital	214.26	183.54	152.82	122.10	91.37
b. Percent Return to Capital (Return/Total)	5.8%	4.9%	4.1%	3.3%	2.5%
c. Return to Equity (Assets)	69.21	38.49	7.77	-22.95	-53.68
d. Net Farm Income	117.45	86.73	56.01	25.29	-5.44
SCENARIO 3 (27,000 acres):		$26.41	$52.82	$79.24	$105.65
a. Return to Capital	214.26	187.85	161.44	135.02	108.61
b. Percent Return to Capital (Return/Total)	5.8%	5.1%	4.3%	3.6%	2.9%
c. Return to Equity (Assets)	69.21	42.80	16.39	-10.03	-36.44
d. Net Farm Income	117.45	91.04	64.63	38.21	11.80

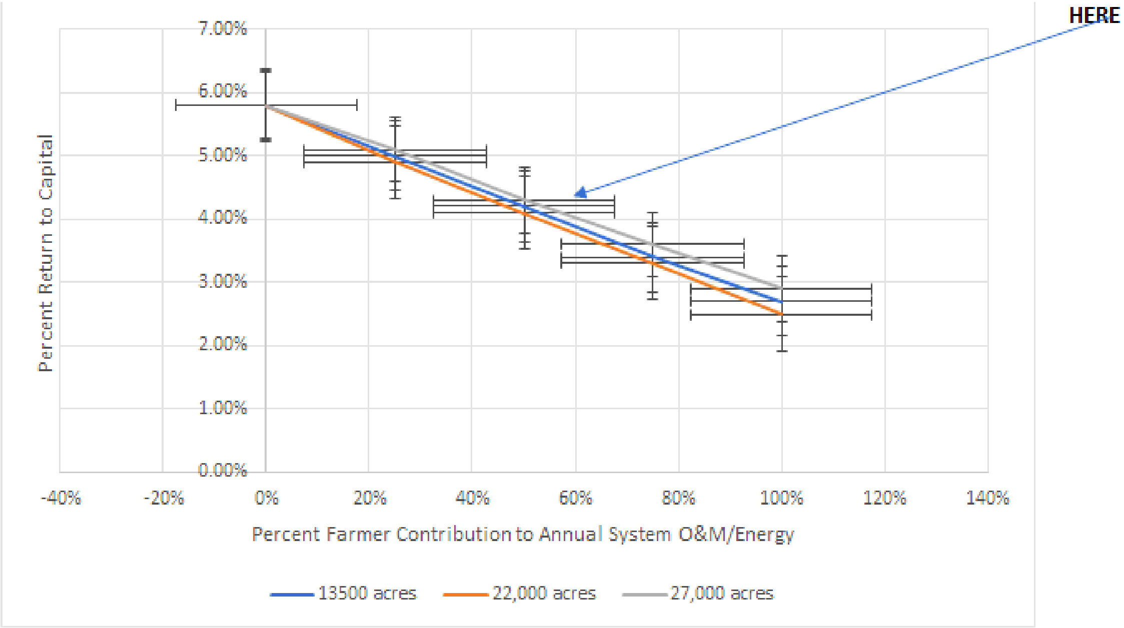
DEFINITIONS:

Return to Capital	Revenue less Variable Costs less Fixed Costs less return to Unpaid Family Labour. Also called "Return to Investment".	Return to Equity (Assets)	Gross Return less Variable Costs less Fixed Costs less Capital Costs less Unpaid Family Labour. Sometimes called "Farm Profit".
Percent Return to Capital	**Return to Capital as a percent of Total Capital investment.**	**Net Farm Income**	**Gross Revenue less Total Production Costs (i.e. variable costs, fixed costs, capital costs, and unpaid family labour costs). Also called "Annual Cash Flow" and "Return to Unpaid Labour". Pre-tax.**

Source: Calculated from Annex Table C-2 (for Revenue, Variable Costs, Fixed Costs and Gross Margin (Value-Added)) and the supplemental data in Annex Table C-6 (Capital and Unpaid Labour Costs).

Figure 6.8 illustrates how the **financial rate of return** for an irrigated farm in MD of Acadia is impacted by his/her contribution to system O&M. Given the margin of error inherent to these estimates (as indicated by the horizontal lines at each data point in Figure 6.1), the maximum farmer contribution is probably **about 60 percent; about $50 - $60 per year per irrigated acre**.

Figure 6.8: Irrigated Farm Percent Return to Capital vs System O&M Cost Sharing Contribution



Similarly, Figure 6.9 traces the corresponding impact on **net farm income** for different percentage contributions to system O&M. And, again, given the margin of error inherent to these estimates (i.e. the horizontal lines around each data point in Figure 6.2), we once again see that **the maximum farmer contribution is probably about 60 percent; about $50 - $60 per year per irrigated acre.** These calculations also suggest that the $70,000/year net farm income target could be met with about 1,000 acres of irrigated land; about two sections.

Thus, our two farm profitability criteria, at least in this instance, both suggest that the **maximum** farmer contribution to system O&M, at project maturity, is conservatively **about $50 per irrigated acre per year**.[27]

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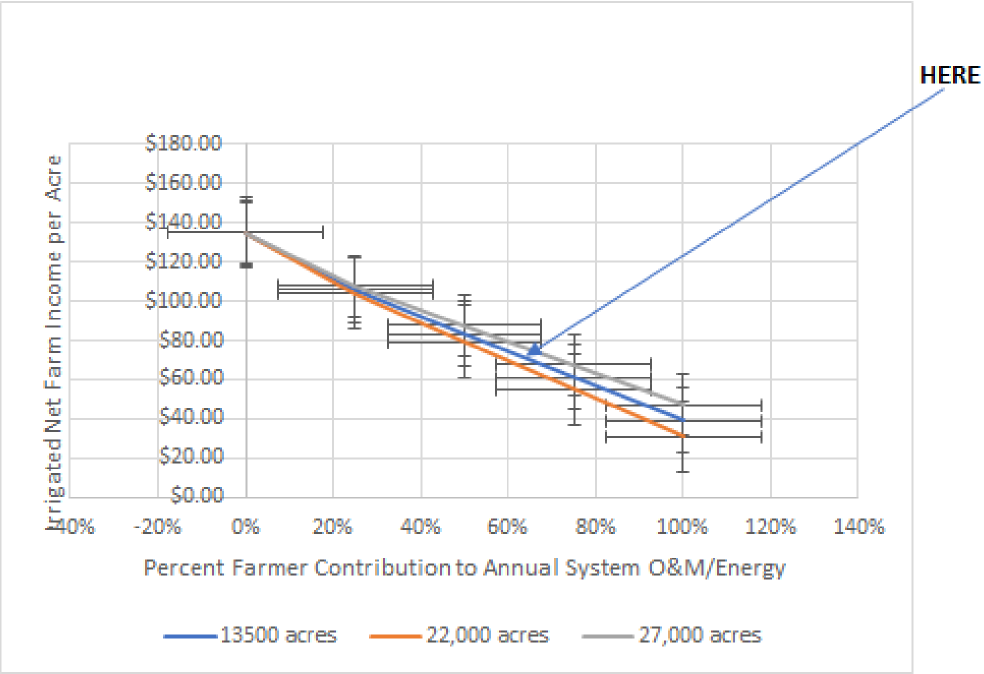
[27] This, of course, is in addition to on-farm irrigation costs estimated to average about $48/acre/year. Farmers with a pressurized system (Blocks 3 and 4) will, instead, pay a separate $55 surcharge.

Figure 6.9: Irrigated Net Farm Income per Arce vs System O&M Cost Sharing Contribution

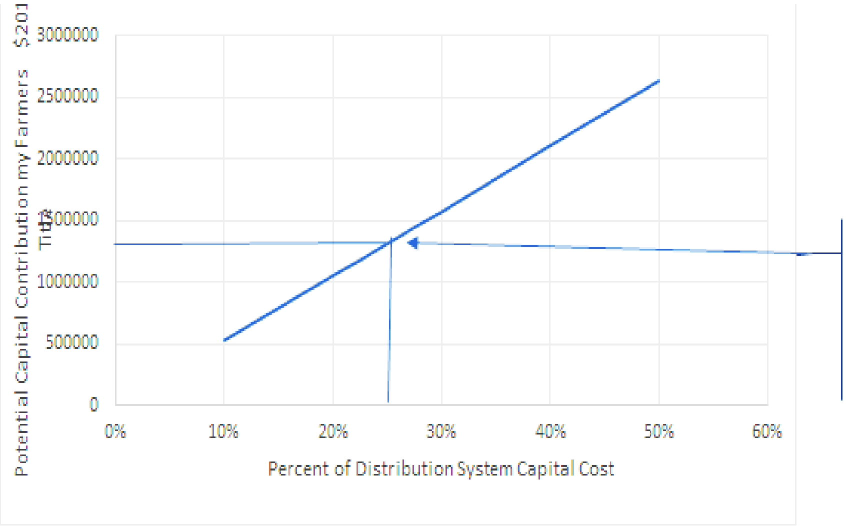


6.5.3. *Potential Capital Cost Sharing*

As an alternative to paying, say, $50/acre/year to support annual O&M, the new irrigation farmers could contribute to the initial capital cost of the Scenario 3 distribution system ($74.6 M, Table 6.1). We estimate that this percentage contribution could probably be about 25 percent (Figure 6.10). This assumes that there is $1.35 million available annually (with Scenario 3 at full development) to contribute to initial capital costs, annual O&M, or some combination of both. For illustrative purposes, we assume amortization of a 20 - year loan subject to an annual 4% interest rate.

However, it is reasonable to expect that irrigators should pay for the O&M costs associated with the Distribution System (i.e. $25/acre); therefore, contribution to capital would be limited to 15% of the Distribution System costs. This assumes a 20-25 year amortization period with 4% interest.

Figure 6.10: Potential Capital Contribution by Irrigation Farmers to Capital Costs assuming no O&M Payments



About 25% of the Capital Cost of the Distribution System could be paid for by irrigation farmers with annual debt payments for 20 Years (at 4% interest) of $ 1.35 million.

Assumes a 20 year loan at a 4% annual interest rate. Factor = .0706.

Total Distribution System Cost = $74.6 M. 25% = $18.7 M.

6.5.4. *Trust Fund for System Energy Costs*

For Scenario 3, at project maturity, annual system energy costs are currently expected to be about $1.8 million per year; about $67 per acre (Table 6.13). This is aside from the on-farm $48 - $55/acre requirement to operate their pivots.

With project implementation, could a Trust Fund be established which could self-fund the Headworks system O&M (energy cost and pumpstation O&M) for the next 50 years, and, critically, what would this cost the Provincial Government at the onset? To approximate this, we make two assumptions: a) nominal energy costs will increase by 1.5% per year, and b) the Trust Funds will be invested such that they (nominally) yield an average 4% per annum. This simulation generates a best guess of about **$63 million** (Annex Table C.7). This would bring the total initial capital cost (for Scenario #3) to $137 M + $63 M = $200 million.

The remaining annual O&M cost for the distribution system (i.e. $25/acre) would still not be pre-funded and would, logically, be the responsibility of irrigation farmers, essentially an Irrigation District cost like elsewhere in the Province. The farmers could easily contribute this.

6.5.5. *Farmer Capacity to Pay Summary*

These farmer capacity to pay calculations highlight the following:

- The capacity of new irrigation farmers to pay a fraction of either the initial capital costs involved or the accompanying annual O&M costs anticipated is limited. For Scenario 3, at full development, we estimate that the farmer capacity-to-pay (farm-generated) funds is approximately $1.35 million per annum; about $50 per acre per year.

- Logically, priority should be given to funding annual O&M costs for the distribution system (similar to an annual Irrigation District fee), which is estimated to amount to about $25/acre/year. This is about ½ of the estimated funds available so, in turn, about ½ of these remaining funds could then be utilized to finance either capital or a portion of the other annual non-energy O&M costs. Table 6.15 shows various farm contribution options and the corresponding farm profitability. Only the options in yellow and green provide sufficient farm profitability; and the green options provide significant incentive to convert from dryland to irrigation.

Table 6.15: Cost Sharing Options and Farm Profitability

Option	Contribution to Capital by Irrigators		Contribution to O&M by Irrigators		Level of Farm Profitability
	Headworks System	Distribution System	Headworks System	Distribution System	
A1	25 %	25 %	25 %	100 %	Poor
A2	10 %	10 %	0 %	100 %	Poor
B1	0 %	0 %	31 % ($25/ac)	100 %	Moderate
B2	7 %	7 %	0 %	100 %	Moderate
B3	0 %	15 %	0 %	100 %	Moderate
C1	0 %	10 %	0 %	100 %	Good
C2	0 %	0 %	0%	100 %	Very Good

1. A options (red shading) relate to a poor farm-level investment (i.e. farm income and rate of return is insufficient and farmers would not convert from dryland to irrigation)
2. B options (yellow shading) relate to a moderate farm-level investment (i.e. farm income and rate of return are acceptable; however, the incentive to convert from dryland to irrigation is marginal).
3. C options (green shading) relate to a good farm-level investment (i.e. farm income, rate of return and incentive to convert from dryland to irrigation is high).

- Finally, the possibility of having the province initially establish a Trust Fund to fully fund the pump station energy and O&M costs (Headworks O&M for Scenario 3) for the next 50 years may also be a desired financial instrument since then no subsequent provincial budgetary allocations would be required. The anticipated annual O&M cost is about $2.15 million ($1.8 M energy & $0.315 M other O&M); approximately $80/acre with full development of Scenario 3. Thus, we calculate that this would require setting up a Trust Fund worth about $63 million, inflating the initial capital cost of the proposed irrigation development in MD of Acadia to about $200 million.

- This analysis, however, may still be over-estimating an irrigated farmer's capacity to contribute to initial capital requirements and/or annual system O&M in MD of Acadia because the simulations utilize a fairly intensive irrigated cropping pattern. We also assume "instantaneous" aerial development and the absence of a learning curve regarding irrigated crop production and marketing. Thus, regional considerations aside, the yellow options in Table 6.15 may not provide enough incentive for existing dryland farmers in MD of Acadia to convert to irrigation; and the green shaded funding options (especially C2) should be pursued if possible.

- During the decision-making process, existing cost-sharing agreements for irrigation developments elsewhere in southern Alberta (e.g. pressure systems around Bow Island) should still be utilized as an initial reference point.

7.0 NEXT STEPS

This Update Study is a conceptual level study intended to update the assumptions and costs from the 2005 Study. To guide future development of the project the next steps to be taken by the MD of Acadia are outlined below; and information on the critical project components is provided.

7.1. MARKETING AND PROJECT FUNDING

This project is not economically viable without some external financial cost share/grant funding. The proposed irrigation development compares well to other irrigation developments within Alberta and when the regional benefits are considered, the net benefit is positive, as long as farmers are not fully responsible for the initial capital outlay and the full operation and maintenance cost of pumping the water from the Red Deer River.

For the project to proceed and realize its full potential, it is imperative that higher levels of government (Federal and Provincial) provide financial contribution towards the capital and operational costs of the project. Ideally, an arrangement similar to other Irrigation Districts in Alberta should be pursued, where the initial project capital cost (including planning and engineering) is cost-shared to some level (i.e. say 75% by government) and the Headworks component (River Pump Station) be fully funded and operated by Government. If a commitment to long term operation for the Headworks cannot be secured, consideration of obtaining upfront capital in an operating trust could be pursued.

Going forward, the MD should consider lobbying the provincial and federal government for partnership in this project based on the positive regional impacts of the project; retaining a lobbyist or professional marketing firm may be a useful approach prepare project information sheets, videos, and other information on the project.

Cooperation and coordination from nearby municipalities such as the Town of Oyen, City of Medicine Hat, and Special Areas board could also be helpful. Projects that have included multi-level partnerships often gain more funding traction at the provincial level than stand-alone projects that only have a single stakeholder.

Marketing the project to local landowners within the MD, and gaining conditional commitment for willingness to convert from dryland to irrigation is also paramount for marketing success and ultimately a successful project.

Finally, as part of any government commitment to the project the MD of Acadia should attempt to obtain a commitment from Alberta Environment and Alberta Agriculture to update the IDM and WRMM model on their behalf.

7.2. ENVIRONMENTAL AND HISTORICAL RESOURCES

Coordination with an experienced environmental and historical resources consultant is critical for completion of the next phases of this component of work. The regulatory framework is constantly evolving and the requirements can be extensive.

Prior to obtaining regulatory approvals, an EIA for the project will be required, including a considerable amount of environmental and historical resource assessments, surveys, and mitigation/compensation measures will be required. The most sensitive and critical area of the project is the River Pumpstation, Supply Pipeline, and Reservoir A1;, which all traverse crown land and native prairie that are environmentally and historically significant.

It is possible that the findings of some of these assessment could require further work, mitigation or compensation than what was anticipated in this Update Study. However, it is believed that sufficient work has been completed to proceed with marketing and applications for funding; this includes a reasonable understanding of the impacts that this project will have on environmental and historical resources, and the necessary costs to complete the associated assessment, mitigation and compensation work. It is possible, that funding commitments will come with conditional approval, pending the findings of these assessments and the preliminary engineering design; this would be an acceptable approach for a project of this scale.

The Historical Resources Impact Assessment and the wetland inventory would be the only studies that could be done ahead of time. The remaining environmental assessments, surveys, and mitigation strategies cannot be completed ahead of time because of legislation limitations in terms of how current they need to be prior to construction (i.e. within about 2 years). Many of these surveys also span over multiple years, therefore, appropriate timeline expectations need to be considered as per Section 7.6. It is estimated that the total cost for all the environmental assessments for the project to meet the needs of the EIA and HRIA is approximately $500,000 including the application to the regulatory agencies. An additional $1 - $2 million in mitigation and compensation costs is anticipated before construction could begin.

7.3. IRRIGATION DEVELOPMENT

Prior to proceeding with the preliminary engineering design of the project infrastructure, the irrigation development must be finalized, including the following:

- A firm commitment to one specific Scenario should be made; it is assumed this will be Scenario 3, based on it being the most economically viable.
- It is possible that some tweaking and trade-offs of irrigation area is possible or desirable; therefore, the extents of the irrigation blocks need to be revisited and a firm commitment to the location and boundary of irrigated parcels should be made.
- Land classification for some of the land on the eastern edge of Blocks 3 and 2 is required to confirm that it meets the Class 2 and 3 criteria established for this project.

- Updated irrigation demand modelling (IDM) and water supply modelling (WRMM) need to be completed prior to submitting a formal application for water diversion from the River under the Water Act. This is required to reflect the most up-to-date water demand information (i.e. crop mix, irrigation methods, infrastructure efficiencies, etc.), as well as for the water supply realities (i.e. Red Deer River flow regime, upstream and priority water and diversion licenses and pending commitments, updated flow information, potential climate variability, SSRB limitations, etc.).

Based on the above, any necessary adjustments to the headworks and conveyance network should be identified, to be applied in the next steps for the infrastructure design.

7.4. INFRASTRUCTURE DESIGN

Once the project is funded, and the irrigation development has been finalized, design of the infrastructure components can begin.

- Preliminary Engineering Design would be the next step, which would progress the work to around an 80% design, as well as provide a much more accurate capital cost estimate for the project.
    - All of the headworks and conveyance infrastructure will be reviewed and optimized, taking into account the final irrigation development area, environmental, historical resource impacts and mitigation requirements, water demand and water supply realities and capacity changes, etc.
    - A detailed geotechnical investigation would be included in this stage of work, which would include a significant field drilling program for the proposed river intake site, supply pipeline, Reservoir A1 as well as key components of the conveyance system. The 800 m reservoir setback requirement from the Red Deer River should also be confirmed, and any significant sand layers in the reservoir identified.
    - An order of magnitude estimate of the cost to complete the preliminary engineering studies is typically around 5% of the capital cost for the project.
    - Further investigation into potential alternative energy sources, such as stand-alone onsite generation using natural gas or other sources to reduce O&M costs.

Final design and project tendering will progress after the preliminary engineering design is completed this will included detailed design drawings and specifications. The project will need to be spilt into multiple tenders and contracts, based on the sequencing determined in the preliminary engineering study. More information on the final design will be given in the preliminary engineering report. Generally this will require another 3-4% of the capital costs to complete.

7.5. REGULATORY APPROVALS

There are numerous approvals that will required for the project before construction can begin. Most of these approvals will require the preliminary engineering drawings and report to be completed, as well as all environmental, historical and water demand/supply modelling components.

- Water Act (River diversion, reservoir and dam sites, wetlands, etc.)
- Public Lands Act (diversion pipeline, reservoir, any irrigation land on Crown Land, etc.)
- Fisheries (River intake and impacts on tributaries)
- Navigable Waters (River intake and impacts on tributaries)
- Environmental Approvals (EIA)
- Historical Resources (primarily the headworks and reservoir)

These are the primary approvals required at the time of the writing of this report. Depending on the funding sources, there may be additional federal approvals needed. The approvals may change between the writing of this report and the implementation of the project.

7.6. PROJECT IMPLEMENTATION TIMELINES

This project will take 5-7 years to implement. Table 7.1 provides an overview of the expected timelines of the project.

Table 7.1: Project Implementation Schedule

	Year 1				Year 2				Year 3				Year 4				Year 5				Year 6				Year 7			
Key Items	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Environmental and Historical Resources																												
Field Surveys and Assessments	🟩	🟩	🟩	🟩	🟩	🟩	🟩	🟩																				
Mitigative Measures					🟩	🟩	🟩	🟩																				
Finalization of Irrigation Development Design		🟥	🟥	🟥	🟥																							
Preliminary Engineering Design					🟥	🟥	🟥	🟥																				
Regulatory and Other Approvals									🟨	🟨	🟨	🟨	🟨	🟨														
Detailed Design and Tendering											🟪	🟪	🟪	🟪														
Construction																												
Reservoir A1															🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦				
Supply Pipeline and River Pumpstation															🟦	🟦	🟦	🟦	🟦	🟦	🟦							
Secondary A Canal																		🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦		
Conveynace Pipelines and Laterals																		🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦	🟦		
Commissioning and Reservoir Filling																							🟦	🟦	🟦	🟦		
System Operational																								🟦	🟦	🟦		

8.0 CONCLUSIONS AND RECOMMENDATIONS

The following are the conclusions and recommendations of this Update Study for the MD of Acadia Irrigation Development Project:

1) The irrigation development scenarios as identified in the 2005 Study were accepted as a reasonable representation of the most feasible irrigation development areas within the MD, based on physical, technical and water supply limitations.

Table 8.1: Irrigation Development Scenarios

Irrigation Development Scenarios	
Scenario 1	13,500 acres (5,464 ha)
Scenario 2	22,000 acres (8,904 ha)
Scenario 3	27,000 acres (10,927 ha)

Recommendation: Additional review and confirmation of the irrigation blocks will be required prior to adopting the *"final"* development scenario for project development. It is possible that some tweaking and trade-offs of irrigation area within the system or immediately adjacent to the irrigation blocks could be considered.

2) The crop mix and irrigation methods from the 2005 Study were updated to reflect industry current trends and technology, as follows:

Crop Mix	
Cereals	31%
Forages	26%
Oil Seeds	15%
Specialty Crops*	28%

*50% is pulse crops such as lentils, peas and dry beans

Irrigation Method	
Low Pressure Pivots	95%
High Pressure Pivots	0%
Wheel Moves	5%
Gravity	0%

3) Overall, the assumptions used in the 2005 Study for water demand and water supply appear to remain valid. The project water demand may be slightly lower given the crop mix and irrigation method adjustments, and some upstream changes in the Red Deer River flow regime and allotment requirements are positive for the project water supply; however, these improvements are offset by the potential impact that climate variability and future climate change may have on the project.

Recommendation: Going forward, as part of future engineering phases and prior to a formal water diversion application under the Water Act, updated irrigation demand (IDM) and water availability (WRMM) modelling should be completed to accurately reflect the most current water demand/supply realities for this project. A commitment by Alberta Agriculture and Alberta Environment to undertake this work should be pursued along with any funding commitment made by the Province.

4) The environmental and historical resources impacts of this project are similar to the 2005 Study; however, there have been significant changes in regulatory processes and it has been determined that an EIA will be required, primarily driven by the Reservoir A1 component. For the most part the impacts are related to the native grassland areas and river valley and tributary systems, with some isolated influences in other locations of the project. It is anticipated that most of these issues can be accommodated and/or mitigated where necessary and associated costs have been allowed for in the capital cost estimate. There are limitations in the legislation as to the length ahead of time these surveys can be completed; therefore, only the wetland inventory and historical resources impact assessment could realistically be started more than 2-3 years ahead of construction.

   Recommendation: After project funding is secured, an EIA should be initiated, in accordance with legislation timeframe limitations, and should include all of the field surveys, investigations, design accommodations, setbacks, compensations, and other processes that may result from the EIA process and/or required from applicable regulatory bodies.

5) The limited geotechnical investigation completed for this Study identified favourable soil conditions for construction of the reservoir and supply pipeline, and confirmed the 2005 Study recommendation of 800 m setback of the reservoir from the top edge of the Red Deer River valley to avoid river bank instability and potential reservoir water loss.

   Recommendation: A detailed geotechnical investigation should be completed during future phases of the project to confirm reservoir impermeability, locate seepage prone layers along the reservoir and river banks, identify borrow sources for the dams, and finalize the dam cross-section and supply pipeline route. Investigations at other infrastructure locations (i.e. river pumphouse, Kennedy Coulee Syphon, and various locations along the conveyance system will also be required.

6) A number of key infrastructure adjustments were made to the 2005 Study concept to provide cost savings and meet current irrigation industry standards.

Table 8.2: Key Infrastructure Changes

Key Infrastructure Changes	
Relocate River Pumpstation	Shortens supply pipeline, reduces environmental impacts, and improves reservoir water quality, at a reduced capital cost.
Revise River Pump Configuration	Lowers overall costs.
Upsize Conveyance Systems	Satisfies current irrigation design requirements.
Add a new Pumpstation for Block 3	Lowers overall cost and provides some infrastructure efficiencies.
Revise Dam Cross-Sections	Reduces earth volume and lowers capital cost.

7) Capital costs have increased since the 2005 Study at a rate similar to inflation over that time period. O&M costs have not increased as significantly as capital cost, mostly due to a more competitive power market since 2005. Scenario 3 has the lowest per-acre capital and annual O&M cost, followed by Scenario 1 and then Scenario 2.

Table 8.3: Capital Costs Scenarios 1-3

Updated Capital Costs			
Description	**Scenario 1**	**Scenario 2**	**Scenario 3**
2019 Capital Costs	$ 78,755,000	$ 113,860,000	$ 137,615,000
2019 Capital Cost Per Acre	$ 5,834	$ 5,175	$ 5,097
Percent Increase from 2005	45.2 %	43.9 %	42.2 %

Table 8.4: O&M Costs Scenarios 1-3

Annual O&M Costs			
Description	**Scenario 1**	**Scenario 2**	**Scenario 3**
Total Annual O&M Cost*	$ 1,559,500	$ 2,703,500	$ 2,852,500
O&M Cost Per Acre**	$ 116	$ 123	$ 106
Percent Increase from 2005	0 %	15 %	8.2 %

* Includes pressure surcharge credit for Blocks 3 and 4

** Approximately 75% of the annual O&M cost is attributed to the power and operating cost of the Red Deer River Pumpstation.

8) When regional impacts are not considered a net benefit to the province, the Provincial Benefit-Cost analysis (based on direct project costs and benefits only) tentatively concludes:

- The Internal Rate of Return (IRR) is estimated to range from 0.7% per year to 1.08% per year for scenarios 1,2, and 3 respectively. The estimated Benefit-Cost (B/C) ratio, at a 4% discount rate, is 0.77 for Scenario 1,0.78 for Scenario 2, and 0.79 for Scenario 3.

- The corresponding sensitivity analysis indicates that for Scenario 3 (the economically "best case"), the confidence band that brackets the B/C ratio of 0.79 could be as low as 0.65 or as high as 0.97.
- In today's financial markets, a project zero real social rate of return (after inflation) might be acceptable. Based on a 0% discount rate, the B/C ratio for Scenario 3 is 1.09, but could be as high as 1.33 and as slow as 0.89.
- These results are very similar to the 2005 Study and to numerous other "irrigation" studies in Southern Alberta. Sixteen such studies calculated B/C ratios which averaged about 0.80 and ranged from 0.33 to 1.47. Only four of these 16 studies had a B/C ratio >1 based only on direct project costs and benefits.

9) The regional impact analysis (i.e. includes direct spin-offs to the regional and provincial economy) determined the following:
   - The MD of Acadia Irrigation Development Project would spur regional development that in turn leads to sustainable socio-economic growth.
   - The B/C ratio (at a 4% interest rate) for Scenario 3 is a very strong 1.41, the net present value is about $163 million over 50 years, and the internal rate of return is a healthy 8.19% per annum.
   - This analysis clearly shows that when regional spin-offs generated by the irrigation project are considered, the net economic impact is unambiguously and irrefutably positive.

10) The farm financial analysis (farm capacity-to-pay) determined the following:
   - On-farm profitability is highly dependent upon the amount the farmer has to contribute to the irrigation system's capital and operating costs.
   - The highest component of the system (off-farm) O&M costs relate to the annual cost of pumping the water from the Red Deer River to Reservoir A1 (For Scenario 3 - $80.49/ac). As such, this assessment considered the farmer's ability to contribute to the annual O&M for Scenario 3.
   - The maximum farmer contribution to the overall project (Capital and O&M) is approximately $50/ac/year. This allows reasonable farm net income and rate of return; however, to ensure adequate incentive to convert from dryland to irrigation, this contribution may need to be lower (i.e. $25/ac/year would be ideal and relates to the O&M cost for the distribution system).

   - Based on this, to ensure farm profitability and adequate incentive to switch from dryland to irrigation, securing outside (Provincial and Federal Government) funding support is vital, including:
     - Government funding of 100% of the Headworks system (capital and O&M), an arrangement similar to other Irrigation Districts in Alberta.

    - Government funding of 90-100% of the Distribution System capital cost.
- A long term government commitment to fund the annual energy and O&M of the River Pumpstation may be challenging to secure; therefore, one option may be to secure additional upfront capital funding to establish a Trust Fund that will cover 50 years of future O&M costs (Headworks only). For Scenario 3, this would require an additional $63 million of upfront capital, or $200 million in total (i.e. $137 M capital + $63 M O&M).

Recommendation: The MD should pursue alternative sources of revenue and/or funding for the initial capital outlay of Scenario 3, as well as for the operation and maintenance of the River Pumpstation (or upfront capital in kind), in order to make the MD of Acadia Irrigation Development project economically viable for farmers.

11) This Update Study is still conceptual in nature and considerable future assessments and next steps are required to further the project, which are briefly summarized below:
    - The MD should proceed with marketing this project, starting with obtaining support from local MD residents, regional support from nearby municipalities; and then lobbying the provincial and federal government partnership and project funding.
    - Once funding commitments are secured and a firm project timeline is established, the EIA should be completed along with all required environmental and historical resource assessments. (anticipated to take 2-3 years).
    - Concurrent with the EIA, the final Irrigation Development area should be completed, along with any updated land classification requirements and updating the IDM and WRMM modelling (anticipated to take 6-12 months)
    - The preliminary engineering study would follow, including finalizing the concept and completing preliminary design of all infrastructure components (anticipated to take 1 year).
    - After completion of the EIA, finalization of the development area, and the preliminary engineering study, all applications for regulatory approvals should be made (anticipated to take 12-18 months).
    - Final design of the infrastructure can proceed during the regulatory application process, including preparation of contract documents (anticipated to take one year).
    - Finally, project contracts can be tendered, and construction completed (anticipated to take 3 years).
    - The entire timeline for this project is anticipated to take about 5-7 years from funding approval to commissioning).

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APPENDIX A

GEOTECHNICAL INVESTIGATION REPORT

Report for:

MD OF ACADIA NO. 34

IRRIGATION DEVELOPMENT STUDY - 2019 UPDATE

GEOTECHNICAL EVALUATION

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Project #: 4280-002-00

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CORPORATE AUTHORIZATION

This report has been prepared by MPE Engineering Ltd. (MPE), for the sole use of MD of Acadia No. 34. Any use that a third party makes of this report, or reliance on or decisions made based upon it is the responsibility of the third party. MPE accepts no responsibility for damages, if any, suffered by a third party as a result of decisions made or actions taken based upon this report. This report represents MPE's best judgement, based on the information available at the time of report preparation.

Respectfully submitted,
MPE ENGINEERING LTD.

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PERMIT TO PRACTICE
MPE ENGINEERING LTD.
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The Association of Professional Engineers and Geoscientists of Alberta

TABLE OF CONTENTS

1 INTRODUCTION

This report presents the results of a geotechnical evaluation conducted by MPE Engineering Ltd., for the proposed update of 2005 Irrigation Development Study within the Municipal District of Acadia No. 34, AB. The work was undertaken at the request of MD of Acadia No. 34. The objective of the work was to observe the general subsurface conditions and prepare summary report identifying possible risks and challenges related to design and construction of the project.

Authorization to proceed with the work was received by Mr. Jason Wallsmith of MD of Acadia No. 34 in an email dated April 10, 2019.

2 PROJECT DETAILS

In 2004 the MD of Acadia #34 commissioned an irrigation feasibility study. This study was completed in 2005 by MPE and provided several scenarios in which farmland irrigation would be feasible in the MD. The 2005 Study identified three irrigation development scenarios ranging from 5,500 Ha to 11,000 Ha. The report concluded that Scenario 2 & 3 had the best benefit/cost (B/C) ratio, suggesting that the optimal irrigation development area was between 8,900 Ha and 11,000 Ha. The storage reservoir is a critical component of the project and the geotechnical viability of the reservoir and associated dams was only completed at a desk-top level in the 2005 Study.

This report is to be included in the 2019 Update of the Irrigation Study. This report provides a summary of limited geotechnical field investigation at the reservoir site to better understand potential viability, limitations, costs and next steps regarding the feasibility of the storage reservoir.

A brief desktop review of the study area was also completed in terms of geology and soils, to update the information presented in the 2005 Study report. A field inspection along the supply pipeline route and Reservoir A1 has been completed to provide geotechnical input into the pipeline routing and dam locations.

3 SCOPE OF WORK

The scope of work for this evaluation included three components: A field program comprising a total of eight boreholes, basic testing of recovered soil samples in MPE's laboratory, and engineering analysis/reporting.

The field program was carried out on June 17th and June 18th, using a drill rig contracted from Duzz All Drilling of Redcliff, AB. The drill rig was equipped with solid stem continuous-flight augers. Soil samples were retrieved at intervals of approximately 0.6 m. The soil was classified and logged by MPE's field representative, Mr. Cody Braun, E.I.T. Standard Penetration Testing was generally performed at regular intervals of 1.5 m and 3.0 m.

The site is depicted on Figure 1, with borehole locations shown. The borehole locations were selected by MPE based on a conceptual sketch. The approximate borehole locations were recorded using a handheld GPS, and the coordinates are shown on the borehole logs. Ground elevations were obtained by overlaying borehole locations on surface topography from Lidar data.

Boreholes were advanced at the following locations:

- Two boreholes were advanced at the east dam, at the locations illustrated on Figure 1 as 19BH001 and 19BH002.
- Three boreholes were at the bottom of the coulee where future Reservoir A1 is planned, at the locations illustrated on Figure 1 as 19BH003 through 19BH005.
- A borehole was advanced west of the West Dam, at the location illustrated on Figure 1 as 19BH006.
- Two boreholes were advanced just south of Range Road 232, where the main supply and alternate pipeline option are proposed, at the locations illustrated on Figure 1 as 19BH007 and 19BH008.

Laboratory testing (natural moisture content) was conducted on the soil samples to aid in the classification of soils. The test results are summarized on the borehole logs. This report presents the results of the field and laboratory work, provides a preliminary discussion on feasibility and outlines knowledge gaps for future work should the project proceed to the next phase.

4 SITE CONDITIONS

4.1 SITE DESCRIPTION

A visual site reconnaissance was conducted by MPE's geotechnical engineer, Mr. Trevor Curtis, P.Eng., on June 12, 2019. The site is characterized by sloped and undulating terrain, with a relatively flat surface between the coulee and the Red Deer River. The site has natural drainage with the excess water flowing to the Red Deer River or the existing coulee where Reservoir 1A is proposed. The study area is in use as pasture/hayland. The ground surface in the area of Reservoir 1A is surfaced with grass and used for livestock grazing. The study area is bounded on the south by the Red Deer River, on the north and on the east by the cultivated land, and on the west by the pasture.

No evidence of slope instability was noted in the reservoir area. While there is no creek along the coulee bottom, low points with lush vegetation are sporadically distributed. A small dugout pond was noted adjacent to borehole 19BH005.

4.2 SITE HISTORY FROM AERIAL PHOTOGRAPHS

MPE reviewed recent historical aerial photographs from 2004, 2008, 2011 and 2019 in order to gain an understanding of the site's recent history. Based on the aerial photograph from 2008, and the information available on AbaData some gas wells were installed between 2006 and 2008. Many of those gas wells were abandoned by 2014. Between 2008 and 2019, the available photographs did not indicate any notable changes to the site.

4.3 COAL MINING HISTORY

MPE reviewed the Alberta Energy Regulator's Coal Mine and Abandoned Wells Map Viewer to determine if the site has any history of coal mining. There are no records of such activities on the site.

4.4 LOCAL GEOLOGY

MPE reviewed surface geology and the existing bedrock formation mapping published by the Alberta Geological Survey (AGS).

According to the map[1], the site's surficial geology is classified as follows:

Stagnation Moraine – Reservoir:

"Till of uneven thickness, local water-sorted material; up to 30m thick, undulating with local relief generally less than 3 m and hummocky topography moderately to weakly developed, with irregularly shaped and poorly defined knobs and kettles, with local relief 3 to 10 m."

Ice-contact Lacustrine Deposit – Reservoir, supply line:

"Sand, silt and clay, local till; up to 20 m thick; deposited in supraglacial and ice-walled lakes or in proglacial lakes floored by ice; undulating to hummocky topography."

Stream and Slopewash Eroded Deposit - supply line:

"Exposed till and bedrock, local slump material; slopes of river valleys and meltwater channels, in places badland type terrain."

Fluvial Deposit – Intake pump station:

"Fine sediment: fine sand, silt and clay, minor gravel beds, includes till and bedrock exposures; up to 20 m thick; present on floors and terraces of river valleys and meltwater channels, and in deltas; flat to undulating topography."

As noted in the 2005 Irrigation Study, the proposed Reservoir A1 is located in a tributary valley to Kennedy Coulee. According to the mapping, this area consists of ice-contacted lacustrine, thin deposits of sand, silt and clay with minor sand and gravel in the valley and thin colluvial cover on the valley slopes.

The available bedrock geology[2] and topography[3] mapping was also reviewed. The mapping shows that the main bedrock formation underlying the study area are:

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[1] I.Shetsen, 1987 – Quaternary Geology, Southern Alberta, Alberta Research Council

[2] G.J.Prior, B. Hathaway, P.M.Glombick, D.I. Pana, C.J. Banks, D.C. Hay, C.L. Schneider, M.Grobe, R.Elgr and J.A Weiss, 2013 – Bedrock Geology of Alberta, Alberta Geological Survey Map 600

[3] K.E. MacCormac, N.Atkinson and S.Lyster, 2015 – Bedrock Topography of Alberta, Alberta Geological Survey Map 602

- The Oldman and Dinosaur Park Formation
- The Bearspaw Formation

Oldman Formation (Map Code: KO)

"Fine- to coarse – grained, light grey to yellow weathering sandstone; beds are commonly trough cross-bedded, finning upwards and lenticular; grey, muddy siltstone; grey to greenish-grey weathering mudstone commonly with carbonaceous fragments; dark grey to brown carbonaceous mudstone; concretionary sideritic layers; locally divisible into lower sandstone-dominated unit and upper siltstone unit; nonmarine."

Dinosaur Park Formation (Map Code: KDP)

"Pale grey, very fine to medium-grained, bentonitic to carbonaceous sandstone interbedded with grey to brownish-grey siltstone, carbonaceous siltstone to mudstone, and coal; disconformity at base; coal restricted to upper part; fluvial and estuarine, uppermost part marginal marine."

These formations are Upper Cretaceous strata.

The bedrock topography mapping shows that the bedrock elevation is approximately 600 m above sea level directly north of the Red Deer River, and rising in NW direction to approximately 760 m above sea level.

The bedrock mapping shows the local bedrock elevation to be approximately 685 m (2250') above sea level in the area of the Reservoir, whereas the study terrain model shows the valley bottom elevation varying from 705 m to 710 m (therefore bedrock appears to be 20 to 25m below surface in that area).

4.5 LANDSLIDE SUSCEPTIBILITY

MPE reviewed Map 605 Relative Landslide Susceptibility Model of the Alberta Plains and Shield Regions as well as a study[4] completed by the Department of Civil Engineering at the University of Alberta in Edmonton.

Based on Map 605, the majority of the subject study area appears to have minimal landslide susceptibility. Very low to medium relative landslide susceptibility appears to be along the valleys north of the Red Deer River, and west of the creek valley. Based on 1977 study by S.Thompson and N.R. Morgenstern, in the section between mile 65 and 12 (Km 105-19) the Red Deer River flows in the preglacial Calgary valley and landslide activity is low. Five landslide areas were noted with an average area of 5 ha and were circular slips in the overburden material. These areas appear to be located east of Bindloss.

Based on MPE's visual site reconnaissance, the coulee slopes within the reservoir area appear to be stable at this time. The river valley slopes were observed to be relatively stable at the two supply pipeline

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[4] S.Thompson, N.R. Morgenstern, Canadian Geotechnical Journal Vol. 14, 1977 – Factors affecting distribution of landslides along rivers in southern Alberta, Department of Civil Engineering, University of Alberta, Edmonton

locations, though the river valley slopes have a complex history and may be prone to instability if groundwater is introduced.

Filling the reservoir will change the groundwater regime in the immediate vicinity of the reservoir, but it is not known to what extent it would impact slope stability along the river valley. Soil layers with high horizontal hydraulic conductivity could conceivably reach the river valley and eventually induce slope instability.

Final supply pipeline alignment selection should include detailed geotechnical analysis to avoid slope instability. At this time, the "Alternate Pipeline Option" is preferred from a geotechnical standpoint, and should be adjusted to follow the bottom of the drainage gully located just west of the current alignment.

4.6 SEISMIC HAZARDS

Based on the AER and Earthquakes Canada websites, monitoring of seismic activity in Alberta began during the mid-60s with the installation of several seismographs. A significant increase in seismic activity was recorded from the mid- to late 1970s. Most of the seismic events recorded in Alberta were between micro (0 on the local magnitude [M_L]and minor (3 M_L) in size. Moderate earthquakes with a magnitude greater than 4 M_L are less common.

Based on the collected data from 1918 to 2019, most of Alberta's recorded earthquakes are distributed along the foothills and the Rocky Mountains, with some clusters of earthquakes detected east of the Rocky Mountain deformation belt. None of the earthquakes were recorded near or at the subject study area.

Based on the National Building Code of Canada's 2015 Seismic Hazard Map #10, the estimated Peak Ground Acceleration (PGA) for the site is 0.041g for the 2% in 50 years probability of exceedance (equivalent to a return period of 1 in 2,450 years). Seismic loading is not expected to have a significant impact on dam stability.

4.7 SOIL STRATIGRAPHY

The soil conditions at the site were generally comprised of surficial topsoil (90 mm to 300 mm thick), underlain by sand, silt and clay layers. A summary of the soil layers encountered is provided below. For a more detailed view of the soil conditions, refer to the borehole logs attached in Appendix A. A description of the terms and symbols used on the borehole logs is also included in Appendix A.

4.7.1 Sand

A layer of sand was encountered beneath the topsoil and below clay till in boreholes 19BH002 and 19BH008, below clay in borehole 19BH006. Sand extended to depths ranging between 1.0 m and 10.3 m. The sand was generally described as trace silt to silty, clayey, trace gravel, trace oxides, trace coal, fine grained, dense to very dense, light brown to brown, and damp to moist. Moisture contents of silt samples generally ranged between 3% and 7%.

Standard Penetration Testing within the silt indicated ‘N’ values between 30 and 60 blows per 300 mm of penetration, indicative of dense to very dense soil.

4.7.2 Silt

A layer of silt was encountered beneath the sand in borehole 19BH002 and clay in boreholes 19BH005 and 19BH007, extending to depths ranging between 6.1 m and 12.8 m below ground surface. The silt was generally trace sand to sandy, clayey, low to medium plastic (occasionally non plastic), very stiff to hard, light brown to brown, to grey, and dry to moist. Moisture contents of silt samples generally ranged between 4% and 14%.

Standard Penetration Testing within the silt indicated ‘N’ values between 20 and 60 blows per 300 mm of penetration, indicative of very stiff to hard consistency.

4.7.3 Clay and Clay Till

The predominant upper natural mineral soil encountered at this site was clay. A layer of silty clay was encountered beneath the topsoil at most borehole locations, extending to depth ranging between 1.9 m and borehole termination depth (24.4 m below ground surface). Clay till was encountered below depths ranging between 1.1 m and 12.8 m. The clay was generally described as trace sand, trace gravel, trace oxides, trace coal, low to medium plastic, stiff to hard, light brown to brown, and damp to moist. Occasional till textured features were noted, such as oxide staining and coal specks.

Moisture contents of silty clay samples generally ranged between 4% and 19%, while moisture content of clay till samples ranged between 7% and 20%.

Standard Penetration Testing within the clay and clay till indicated ‘N’ values between 5 and 60 blows per 300 mm of penetration, indicative of firm to hard consistency.

4.8 GROUNDWATER CONDITIONS

At the time of drilling, seepage was encountered at depths of about 3.0 m at borehole 19BH004. Sloughing of the borehole sidewalls was not encountered. Additional groundwater readings were not taken.

5 GEOTECHNICAL DISCUSSION

Preliminary discussion presented herein is based on the information available at the time of report preparation. Detailed analysis has not been completed at this time. Should the project move forward, significant analysis will be required. Further site investigation is required to provide a detailed geological, hydrogeological and geotechnical characterization of the site conditions.

5.1 SITE SUITABILITY

Alberta Environment and Parks (AEP) provides regulatory oversight to ensure dam owners take active responsibility for the integrity and safe operations of their dams through the Alberta Water Act, Part 6 of the Water (Ministerial) Regulation – Dam and Canal Safety, and the Alberta Dam and Canal Safety Directive. Alberta Dam and Canal Safety Directive, issued in December 2018, provides safety requirements for dams and canals. Design and construction of the new dams and canals should comply with the Alberta Dam and Canal Safety Directive. According to the Directive, these design considerations must be followed:

1. The reservoir must be able to withstand earthquakes.
2. A method of deformation analysis should be used if because of the seismic loading, the deformation or dynamic response is a critical design consideration.
3. Seepage must be controlled in the dam so that erosion does not occur in the interior of the embankments. A seepage analysis should be completed to demonstrate the impacts of seepage on the safety of structures.
4. The slopes must be stable under all possible conditions.
5. Erosion control and environmental monitoring should be undertaken during construction of the dam or canal.

Engineering analyses should be performed to demonstrate that the dam, foundation and abutments will remain stable under all hazards and loading conditions.

5.1.1 Seepage

Based on the limited geotechnical investigation, the soil conditions at this site range from fine sand to sandy and clayey silt, and to clay and clay till. As discussed in section 4.6, the sand was found at surface in borehole 19BH002. Both sand and silt were found as shallow as 2.0 m below surface in some of the boreholes within the proposed reservoir. This finding generally agrees with the geology mapping reviewed in the desktop study.

Occasional sand layers within the reservoir site could cause loss of stored water, depending on their lateral extent. A more detailed drilling program would be required to assess that possibility. Final design should include a cost analysis of creating a compacted clay liner over sand pockets to reduce infiltration and loss of stored water.

Seepage can also play an important role in dam stability and will require careful analysis. Seepage under or through the dam should be intercepted in a blanket drain on the downstream face of the core. The drainage blanket should also extend laterally for a distance of at least three times the height of the dam. The drainage blanket should have sufficient fill on top to provide surcharge pressure and prevent piping.

5.1.2 Settlement

Settlement due to consolidation of the dam and foundation materials must be considered in the design to prevent loss of freeboard and other related issues. At present, it appears that the east dam foundation soil is of reasonable strength (based on SPT results); suggesting excessive settlements are unlikely. With good construction and careful material selection, settlement of embankment fill should also be within normal limits. Similarly, settlement at the west dam is not a significant concern at this time.

The dam crest profile should include a camber (or "settlement allowance") as a means of preserving freeboard following long-term settlement of dam and foundation.

5.1.3 Stability

For preliminary consideration, dam side slopes should have a maximum gradient of 3 horizontal to 1 vertical (3H:1V), with a wide toe berm on both sides. The crest of the embankment should have a minimum width of 3 m to provide suitable width for maintenance vehicles.

The borrow material must be suitable for safe embankments. Finer material such as clay should be placed towards the center of the dam, while coarse material may be placed for the outer shell. Fill material and compaction are discussed in section 5.2.1.

The embankment stability must be evaluated for a few different design conditions:

- End of Construction
- Long-term steady state seepage
- IDF (Inflow Design Flood) Loading Condition
- Earthquake
- Rapid drawdown

The CDA minimum Factors of Safety for embankment dam slope stability are presented in Table B:

Table B – Factors of Safety for Embankment Dam Slope Stability

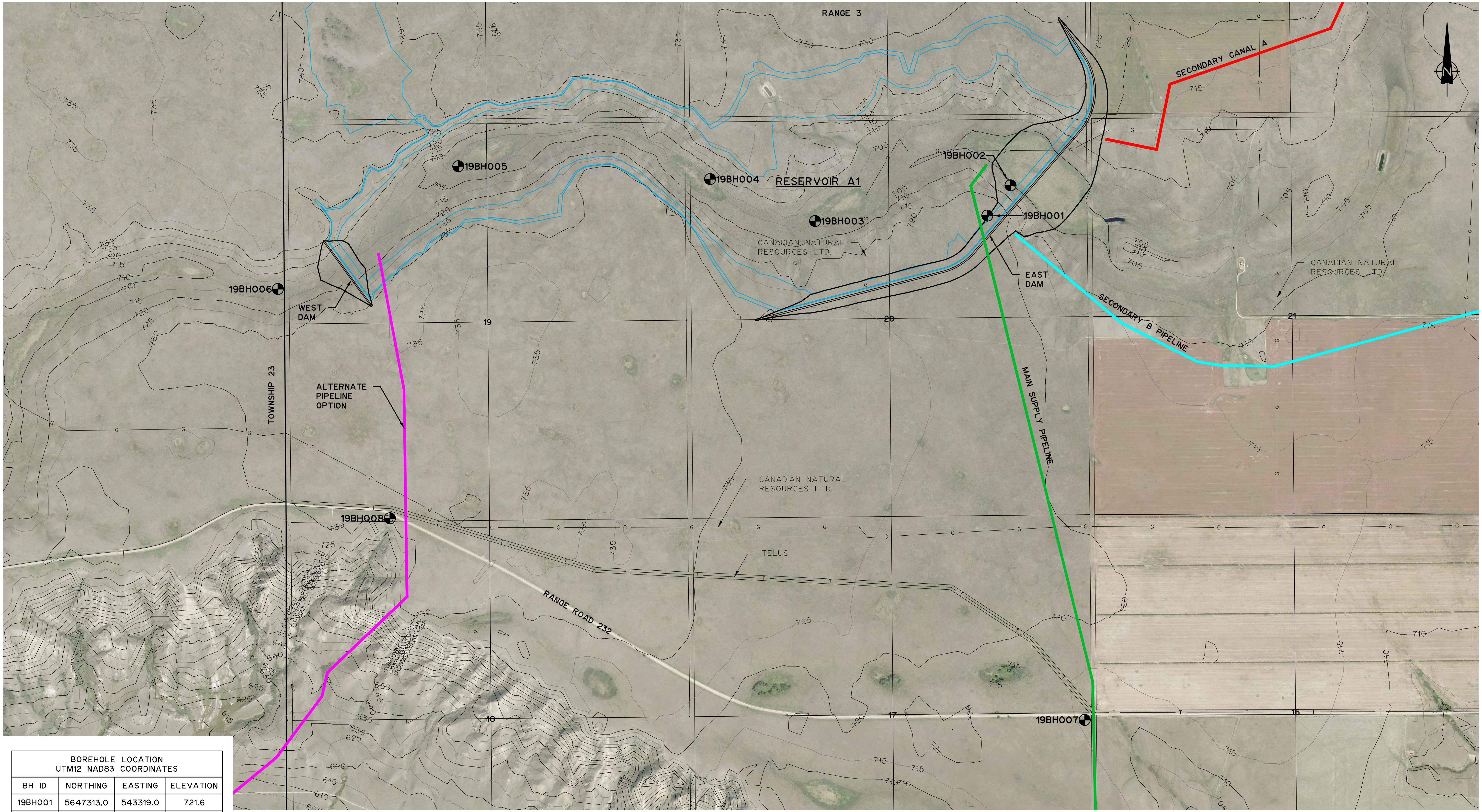
Loading conditions	Minimum factor of safety	Slope
End of construction before reservoir filling	1.3	Upstream and Downstream
Long-term (steady state seepage, normal reservoir level)	1.5	Upstream and Downstream
IDF loading condition	1.3	Upstream and Downstream
Full or partial rapid drawdown	1.2 to 1.3	Upstream Only
Pseudo-static	Greater than 1.0	Upstream and Downstream
Post earthquake	1.1	Upstream and Downstream

5.1.4 Earthworks

Based on the limited borehole investigation, the native clay and clay till soils are expected to be of sufficiently low hydraulic conductivity for construction of the dam's clay core. Some sand and silt layers should be expected, which must be stockpiled separately and used for embankment construction outside of the clay core. It is anticipated that normal construction techniques will be possible, though some difficulty is expected on the east dam due to soft/wet upper soil.

APPENDIX A:

FIGURES



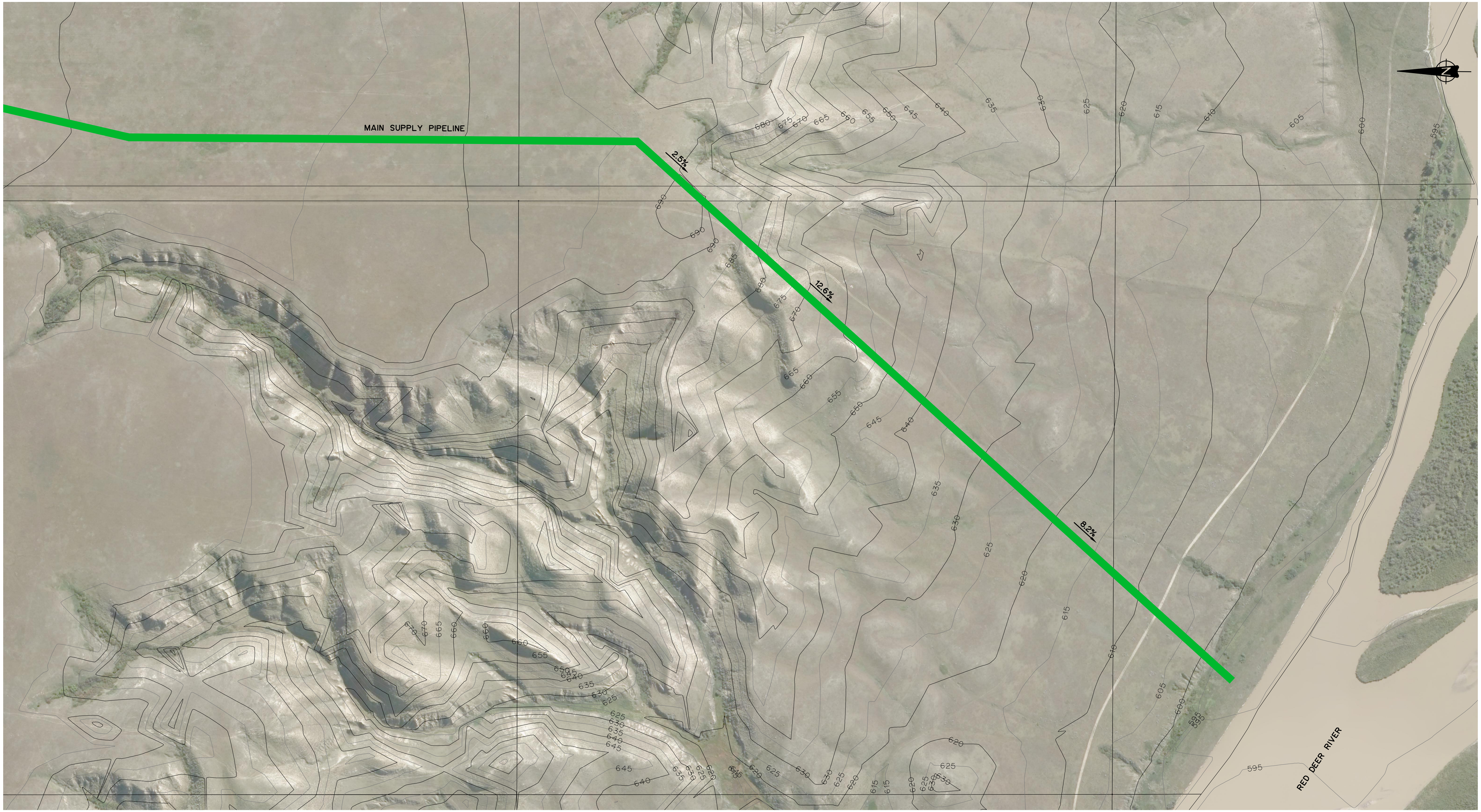
BOREHOLE LOCATION UTM12 NAD83 COORDINATES			
BH ID	NORTHING	EASTING	ELEVATION
19BH001	5647313.0	543319.0	721.6
19BH002	5647436.0	543413.0	701.3
19BH003	5647291.0	542620.0	703.2
19BH004	5647461.0	542194.0	704.7
19BH005	5647513.0	541173.0	703.8
19BH006	5647015.0	540442.0	711.9
19BH007	5645267.0	543714.0	714.2
19BH008	5646085.0	540896.0	729.4

Engineering Ltd.

M.D. OF ACADIA No. 34

IRRIGATION DEVELOPMENT STUDY UPDATE
RESERVOIR A1
BOREHOLE LOCATION PLAN

SCALE: 1:15 000
DATE: SEPTEMBER 2019
JOB: 4280-002-00
FIGURE: 1



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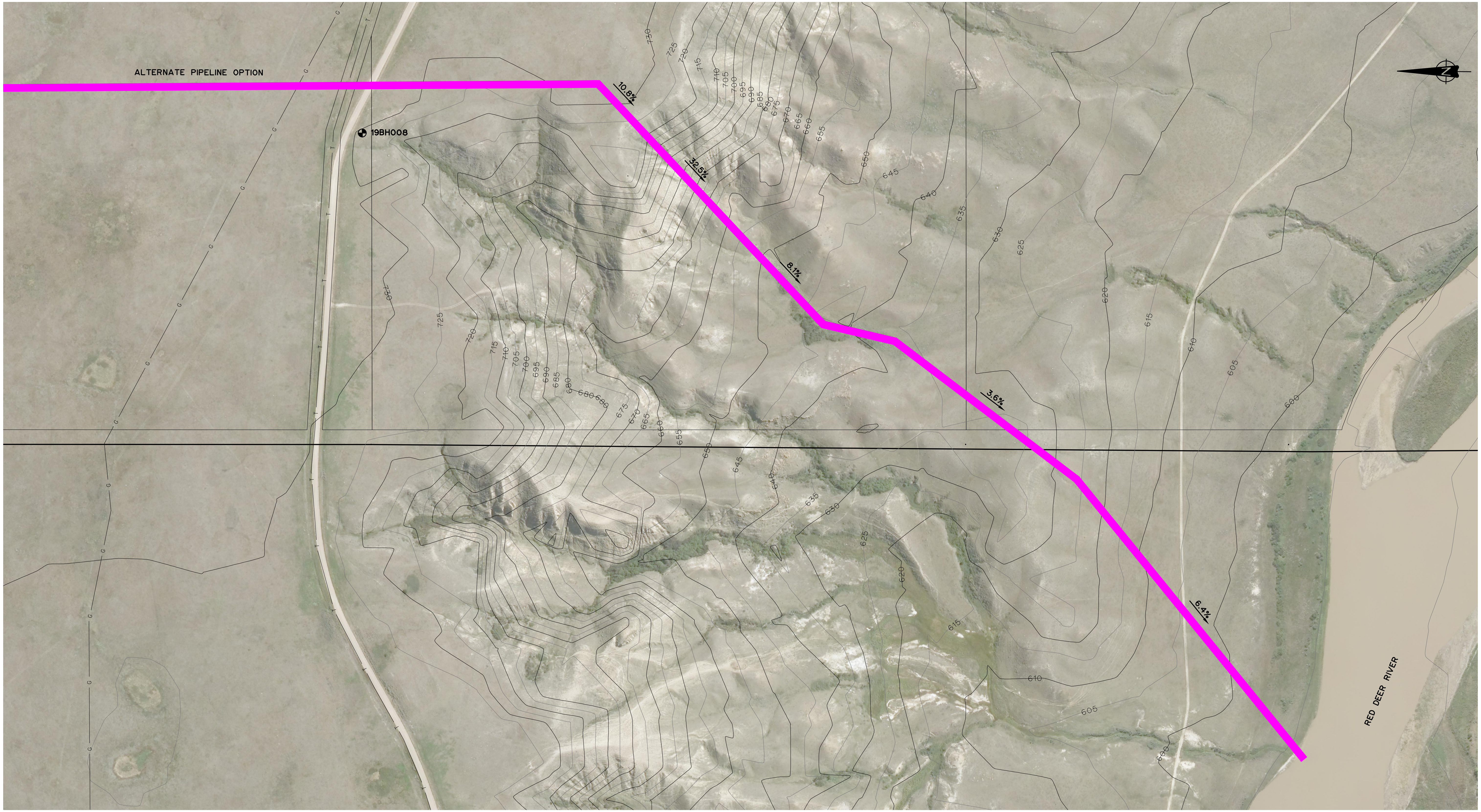
M.D. OF ACADIA No. 34

IRRIGATION DEVELOPMENT STUDY UPDATE
RESERVOIR A1
PIPELINE OPTIONS

SCALE: 1:10 000	DATE: SEPTEMBER 2019	JOB: 4280-002-00	FIGURE: 2



MPE Engineering Ltd.

M.D. OF ACADIA No. 34

IRRIGATION DEVELOPMENT STUDY UPDATE
RESERVOIR A1
PIPELINE OPTIONS

SCALE: 1:5000
DATE: SEPTEMBER 2019
JOB: 4280-002-00
FIGURE: 3

APPENDIX B:

BOREHOLE LOGS

TEST HOLE LOGS
EXPLANATION OF SYMBOLS AND TERMS

The symbols and terms used on the test hole logs to summarize the results of the field investigation and the laboratory testing are described on the following sheets.

Soils are classified and described according to their engineering properties and behaviour. The descriptions applied to the various soil units as shown on the logs follow the Unified Soil Classification system with slight modification to recognize inorganic clays to medium plasticity (CI). Such descriptions are judgmental in nature and may differ in detail from that actually encountered in the field. The descriptions noted in the logs from test holes are based solely on inspections of soil and rock samples recovered or cuttings observed. The actual nature of the materials between samples may vary.

Laboratory tests have been performed on the various samples noted, following standard testing procedures or protocol unless otherwise noted. The test results are intended to provide a general indication of some of the engineering properties of the material.

ABBREVIATIONS

w or MC	Moisture content (ASTM D2216)	PP	Pocket Penetrometer
W_P or PL	Plastic limit (ASTM D4318)	γ	Unit weight
W_L or LL	Liquid limit (ASTM D4318)	γ_d	Dry unit weight
I_P or PI	Plasticity Index	ρ	Density
NP	Non-plastic soil	ρ_d	Dry density
SY	Shelby tube sample	q_u	Unconfined compressive strength
GB	Grab sample	C_u	Undrained shear strength
SPT	Standard Penetration Test	SO_4	Concentration of water-soluble sulphate
VST	Vane Shear Test	RQD	Rock Quality Designation

SIZE RANGES OF SOIL COMPONENTS

Component	Size Range mm (US Sieve)
Boulders	Over 300 (12 inch)
Cobbles	75 (3 inch) to 300 (12 inch)
Gravel:	
Coarse	19 (3/4 inch) to 75 (3 inch)
Fine	5 (#4) to 19 (3/4 inch)
Sand:	
Coarse	2 (#10) to 5 (#4)
Medium	0.4 (#40) to 2 (#10)
Fine	0.08 (#200) to 0.4 (#40)
Clay and Silt	Less than 0.08 (#200)

SECONDARY CONSTITUENTS

Term	Percentage
and	35% - 50%
y/ey	20% - 35%
some	10% - 20%
trace	0 – 10%

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CONSISTENCY OF FINE GRAINED SOILS

Term	Undrained Shear Strength (kPa)	SPT N	Description
Very soft	< 12	< 2	Easily penetrated with fist
Soft	12 – 25	2 – 4	Easily penetrated with thumb
Firm	25 – 50	4 – 8	Moderate effort to penetrate with thumb
Stiff	50 – 100	8 – 15	Great effort to indent with thumb
Very Stiff	100 – 200	15 – 30	Easily indented with thumbnail
Hard	> 200	> 30	Effort required to indent with thumbnail

DENSITY OF COARSE GRAINED SOILS

Term	SPT N	Approx. Relative Density (%)
Very loose	0 – 4	0 – 15
Loose	4 – 10	15 – 35
Compact	10 – 30	35 - 65
Dense	30 – 50	65 – 85
Very Dense	> 50	85 - 100

TEST HOLE LOGS
EXPLANATION OF SYMBOLS AND TERMS

UNIFIED SOIL CLASSIFICATION SYSTEM (MODIFIED)

MAJOR DIVISION			GROUP SYMBOL	TYPICAL DESCRIPTION	LABORATORY CLASSIFICATION CRITERIA	
HIGHLY ORGANIC SOILS			PT	Peat and other highly organic soils	Strong colour or odor and fibrous texture	
COARSE-GRAINED SOILS MORE THAN HALF BY WEIGHT LARGER THAN 75µm	GRAVELS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75 mm	CLEAN GRAVELS (LESS THAN 5% FINES)	GW	Well-graded gravels, gravel-sand mixtures	$C_U=D_{60}/D_{10}$ >4	$C_C=(D_{30})^2/D_{10} \times D_{60}$ 1 to 3
			GP	Poorly graded gravels, gravel-sand mixtures	Not meeting all above requirements	
		GRAVELS WITH FINES (MORE THAN 12% FINES)	GM	Silty gravels, gravel-sand-silt mixtures	Atterberg limits below "A" line or PI < 4	
			GC	Clayey gravels, gravel-sand-clay mixtures	Atterberg limits above "A" line or PI > 7	
	SANDS MORE THAN HALF THE COARSE FRACTION LARGER THAN 4.75 mm	CLEAN SANDS (LESS THAN 5% FINES)	SW	Well-graded sands, gravelly sands	$C_U=D_{60}/D_{10}$ >6	$C_C=(D_{30})^2/D_{10} \times D_{60}$ 1 to 3
			SP	Poorly graded sands or gravelly sands	Not meeting all above requirements	
		SANDS WITH FINES (MORE THAN 12% FINES)	SM	Silty sands, sand-silt mixtures	Atterberg limits below "A" line or PI < 4	
			SC	Clayey sands, sand-clay mixtures	Atterberg limits above "A" line or PI > 7	
FINE-GRAINED SOILS MORE THAN HALF BY WEIGHT SMALLER THAN 75 µm	SILTS BELOW "A" LINE ON PLASTICITY CHART; NEGLIGIBLE ORGANIC CONTENT		ML	Inorganic silts and very fine sands, rock flour, silty sands of slight plasticity	LL < 50	SEE PLASTICITY CHART BELOW
			MH	Inorganic silts, micaceous or diatomaceous, fine sandy or silty soils	LL > 50	
	CLAYS ABOVE "A" LINE ON PLASTICITY CHART; NEGLIGIBLE ORGANIC CONTENT		CL	Inorganic clays of low plasticity, gravelly, sandy, or silty clays	LL < 30	
			CI	Inorganic clays of medium plasticity, silty clays	30 < LL < 50	
			CH	Inorganic clays of high plasticity	LL > 50	
	ORGANIC SILTS AND CLAYS BELOW "A" LINE ON PLASTICITY CHART		OL	Organic silts and organic silty clays of low plasticity	LL < 50	
			OH	Organic clays of high plasticity	LL > 50	

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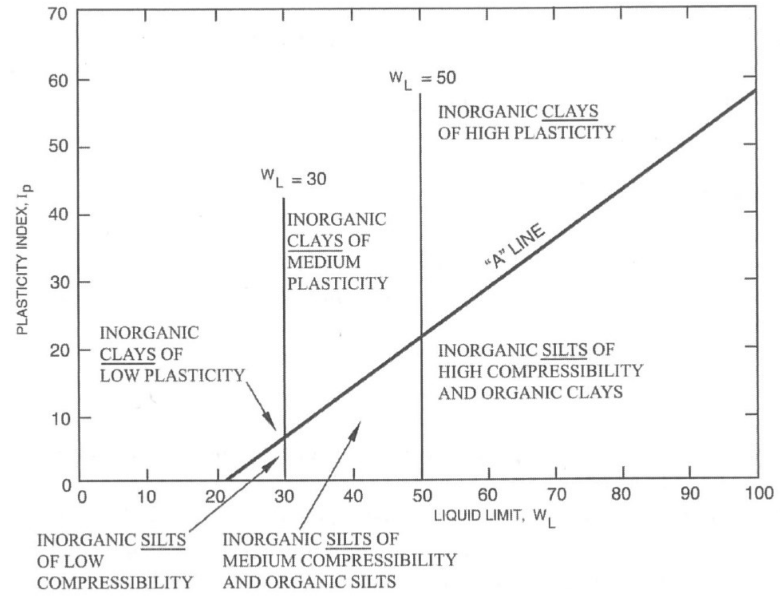

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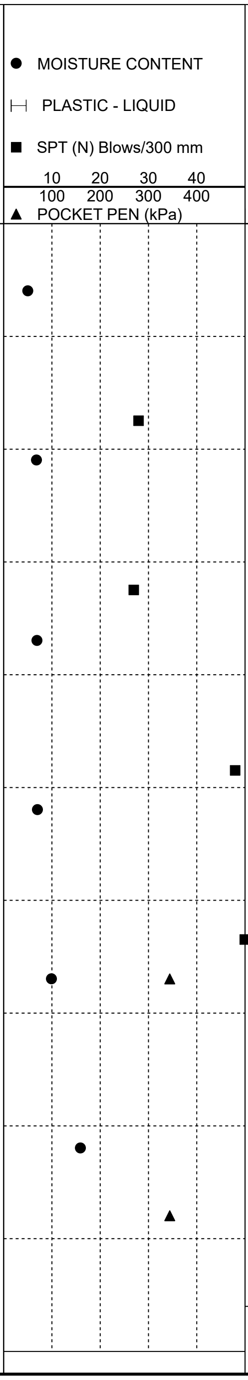
BOREHOLE No : **19BH001**

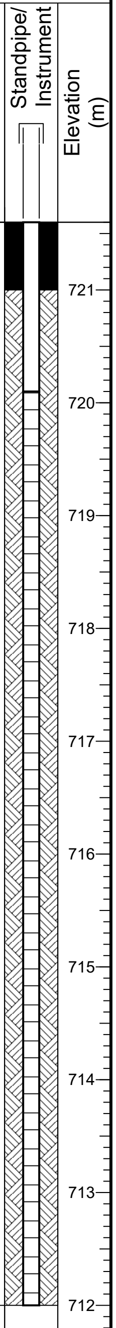
PAGE 1 0F 1

CLIENT: MD of Acadia No. 34
PROJECT NAME: Irrigation Development Study - 2019 Update
PROJECT NUMBER: 4280-002-00
PROJECT LOCATION: MD of Acadia No. 34
DATE STARTED: 07-02-2019 COMPLETED: 07-02-2019
GROUND ELEVATION: 721.60m N 5647313.000 E 543319.000
DRILLING CONTRACTOR: Duzz All Drilling
GROUND WATER LEVEL:
DRILLING METHOD: 6" SSA

Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)
TOPSOIL (90 mm)				
SILTY CLAY, trace fine sand, dry to damp, low to medium plastic, possible sulphates, stiff, brown	▬	AU1		5.1
...trace oxides, light brown to brown at 1.2 m	▬	AU2		
	☒	SPT1	28	
...gravel up to 40 mm at 2.0 m	▬	AU3		6.9
	▬	AU4		
CLAY TILL, some sand, trace angular gravel, damp, low to medium plastic, very stiff, brown	☒	SPT2	27	
...trace coarse gravel below 3.7 m	▬	AU5		7.0
	▬	AU6		
...hard below 4.6 m	☒	SPT3	48	
...SPT bouncing on possible cobbles at 5.0 m ...becoming moist below 5.2 m	▬	AU7		7.1
	▬	AU8		
	☒	SPT4	50	
...trace coal at 6.5 m	▬	AU9		10.0
	▬	AU10		
	☒	SPT5	60	
SILTY CLAY, trace fine gravel, trace oxides, some varving, moist, very stiff, grey	▬	AU11		16.0
CLAY TILL, some sand, trace angular gravel, moist, medium plastic, very stiff, brown	▬	AU12		
	☒	SPT6	51	
End of Borehole @9.6 m				



REMARKS



Notes:

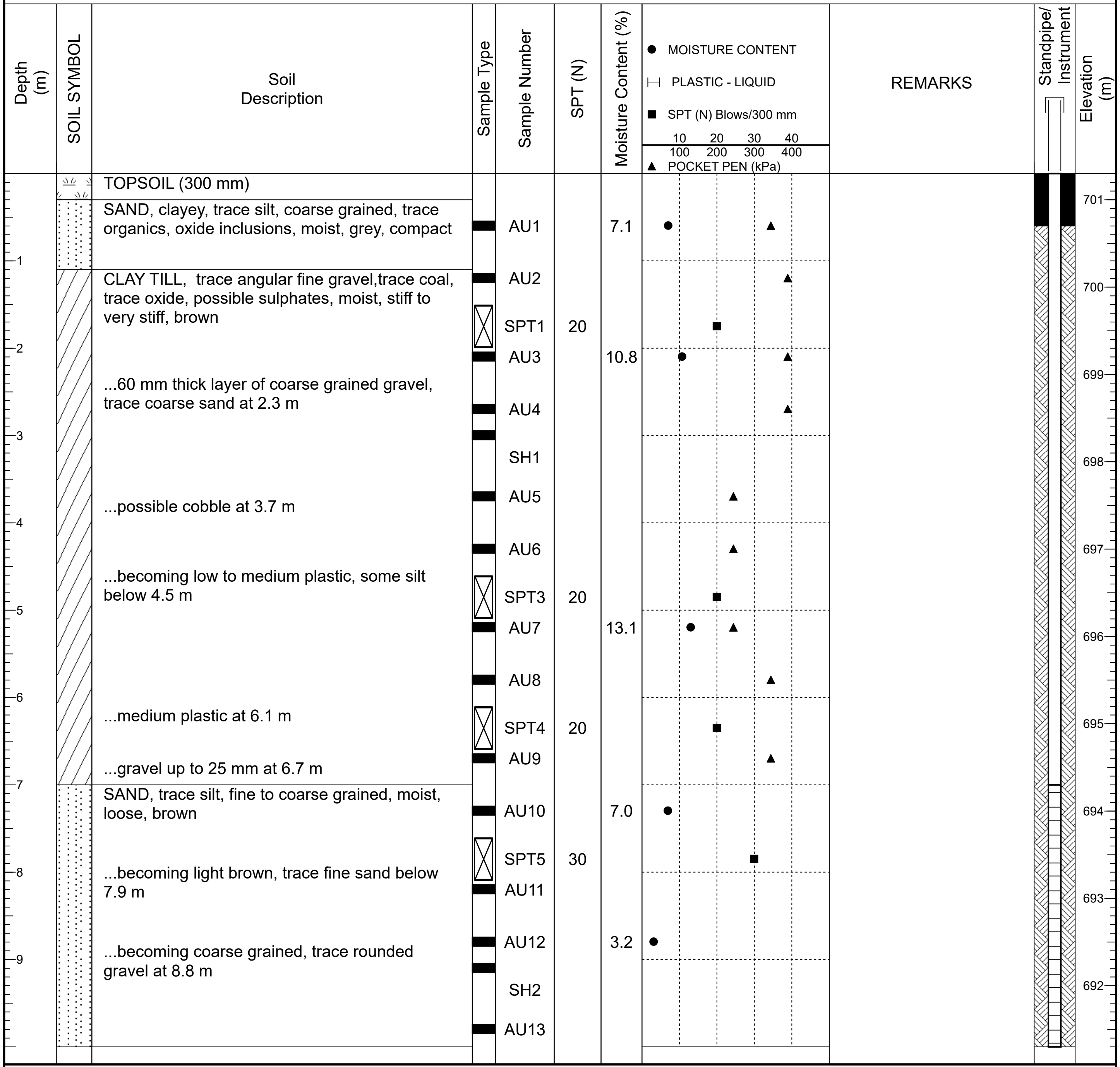
No seepage or sloughing encountered while drilling. 25 mm PVC Standpipe installed to 9.6 m, handslotted from 1.5 m to 9.6 m.

Logged By: CB
Reviewed By: TC

Engineering Ltd.

BOREHOLE No : 19BH002

CLIENT	MD of Acadia No. 34	PROJECT NAME	Irrigation Development Study - 2019 Update
PROJECT NUMBER	4280-002-00	PROJECT LOCATION	MD of Acadia No. 34
DATE STARTED	07-03-2019	COMPLETED	07-03-2019
GROUND ELEVATION	701.30m	N 5647436.000	E 543413.000
DRILLING CONTRACTOR	Duzz All Drilling	GROUND WATER LEVEL:	
DRILLING METHOD	6" SSA		



Soil Description

TOPSOIL (300 mm)

SAND, clayey, trace silt, coarse grained, trace organics, oxide inclusions, moist, grey, compact

CLAY TILL, trace angular fine gravel,trace coal, trace oxide, possible sulphates, moist, stiff to very stiff, brown

...60 mm thick layer of coarse grained gravel, trace coarse sand at 2.3 m

...possible cobble at 3.7 m

...becoming low to medium plastic, some silt below 4.5 m

...medium plastic at 6.1 m

...gravel up to 25 mm at 6.7 m

SAND, trace silt, fine to coarse grained, moist, loose, brown

...becoming light brown, trace fine sand below 7.9 m

...becoming coarse grained, trace rounded gravel at 8.8 m

Sample Number	SPT (N)	Moisture Content (%)
AU1		7.1
AU2		
SPT1	20	
AU3		10.8
AU4		
SH1		
AU5		
AU6		
SPT3	20	
AU7		13.1
AU8		
SPT4	20	
AU9		
AU10		7.0
SPT5	30	
AU11		
AU12		3.2
SH2		
AU13		

Notes:

No seepage or sloughing encountered while drilling. 25 mm PVC Standpipe installed to 24.4 m, handslotted from 7.0 m to 24.4 m. Shelby Tube Samples collected at 3.0 m, 10 m and 15 m.

Logged By: CB

Reviewed By: TC

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BOREHOLE No : 19BH002

PAGE 2 0F 3

CLIENT: MD of Acadia No. 34
PROJECT NAME: Irrigation Development Study - 2019 Update
PROJECT NUMBER: 4280-002-00
PROJECT LOCATION: MD of Acadia No. 34
DATE STARTED: 07-03-2019 COMPLETED: 07-03-2019
GROUND ELEVATION: 701.30m N 5647436.000 E 543413.000
DRILLING CONTRACTOR: Duzz All Drilling
GROUND WATER LEVEL:
DRILLING METHOD: 6" SSA

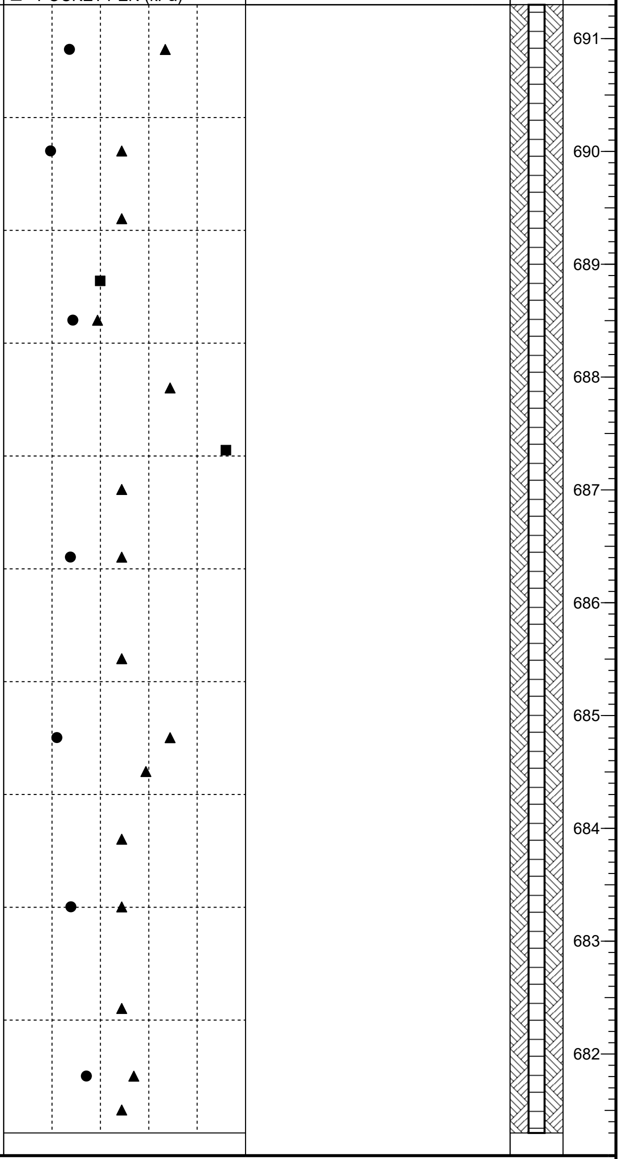
Soil Description	Sample Number	SPT (N)	Moisture Content (%)
...gravelly below 9.8 m gravel up to 20 mm			
SILT, sandy, trace clay, low to medium plastic, moist, stiff, light brown to brown	AU14		13.7
	AU15		
...gravel up to 30 mm	AU16		9.8
	AU17		
	SPT7	20	
	AU18		14.4
CLAY TILL, some silt, trace fine gravel, trace oxides, moist, medium plastic, very stiff, brown			
	AU19		
...becoming sandy, low plastic, moist at 13.7 m	SPT8	46	
	AU21		
...becoming medium plastic, trace sand below 14.9 m	AU22		13.9
	SH3		
	AU23		
	AU24		11.1
	AU25		
...grey below 17.3 m	AU26		
	AU27		14.0
...becoming brown below 18.3 m	SPT9	32	
	AU28		
...becoming homogeneous, trace gravel, trace sand below 18.9 m	AU29		17.2
	AU30		

● MOISTURE CONTENT
⊢⊣ PLASTIC - LIQUID
■ SPT (N) Blows/300 mm
10 20 30 40
100 200 300 400
▲ POCKET PEN (kPa)

REMARKS

Standpipe/ Instrument

Elevation (m)



Depth (m): 11, 12, 13, 14, 15, 16, 17, 18, 19

Notes:

No seepage or sloughing encountered while drilling. 25 mm PVC Standpipe installed to 24.4 m, handslotted from 7.0 m to 24.4 m. Shelby Tube Samples collected at 3.0 m, 10 m and 15 m.

Logged By: CB
Reviewed By: TC

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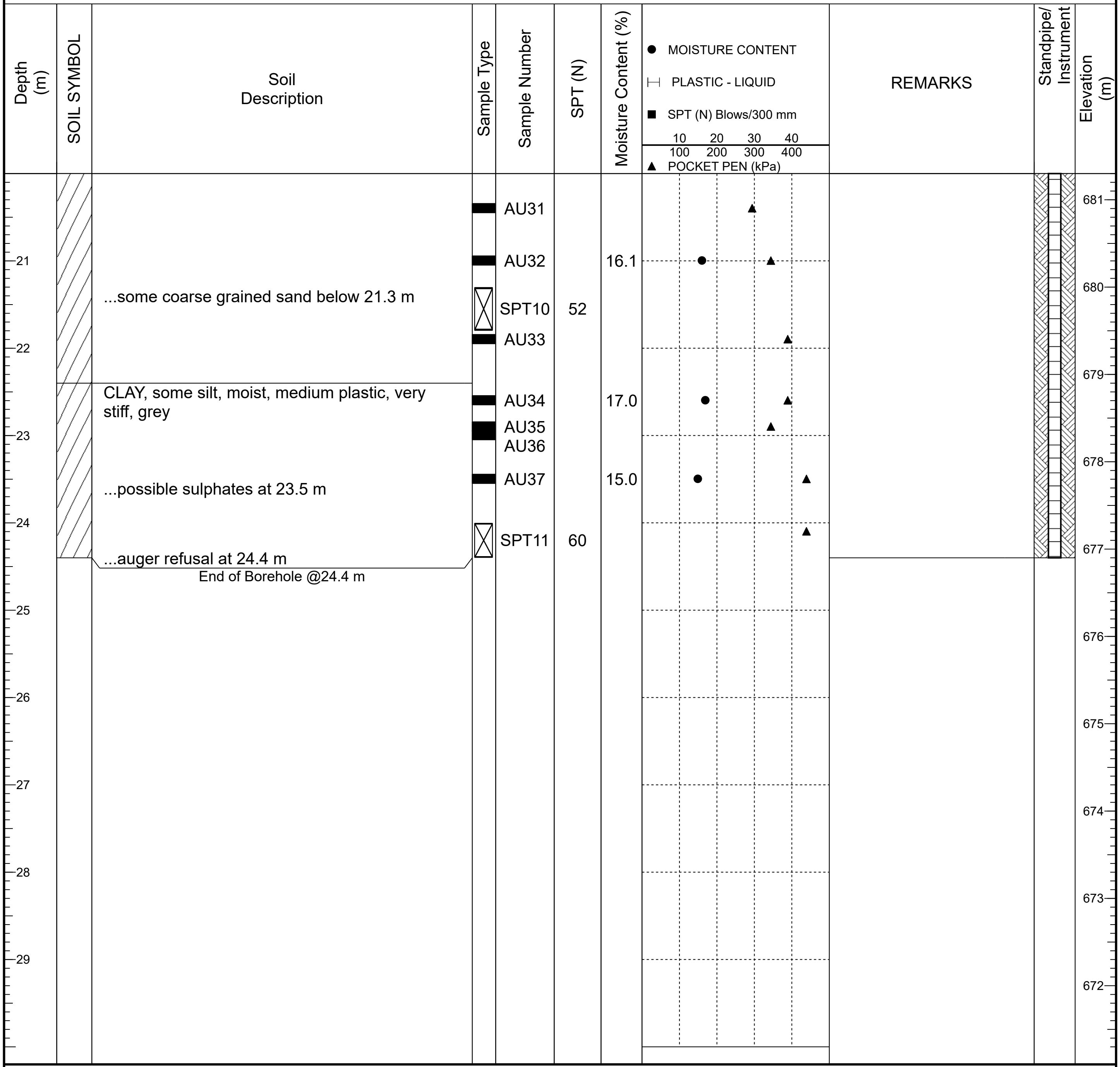
BOREHOLE No : 19BH002

PAGE 3 0F 3

CLIENT	MD of Acadia No. 34	PROJECT NAME	Irrigation Development Study - 2019 Update
PROJECT NUMBER	4280-002-00	PROJECT LOCATION	MD of Acadia No. 34
DATE STARTED	07-03-2019 COMPLETED 07-03-2019	GROUND ELEVATION	701.30m N 5647436.000 E 543413.000
DRILLING CONTRACTOR	Duzz All Drilling	GROUND WATER LEVEL:	
DRILLING METHOD	6" SSA		



Soil Description	Sample Number	SPT (N)	Moisture Content (%)
	AU31		
	AU32		16.1
...some coarse grained sand below 21.3 m	SPT10	52	
	AU33		
CLAY, some silt, moist, medium plastic, very stiff, grey	AU34		17.0
	AU35 AU36		
...possible sulphates at 23.5 m	AU37		15.0
...auger refusal at 24.4 m	SPT11	60	
End of Borehole @24.4 m			

Notes:

No seepage or sloughing encountered while drilling. 25 mm PVC Standpipe installed to 24.4 m, handslotted from 7.0 m to 24.4 m. Shelby Tube Samples collected at 3.0 m, 10 m and 15 m.

Logged By: CB

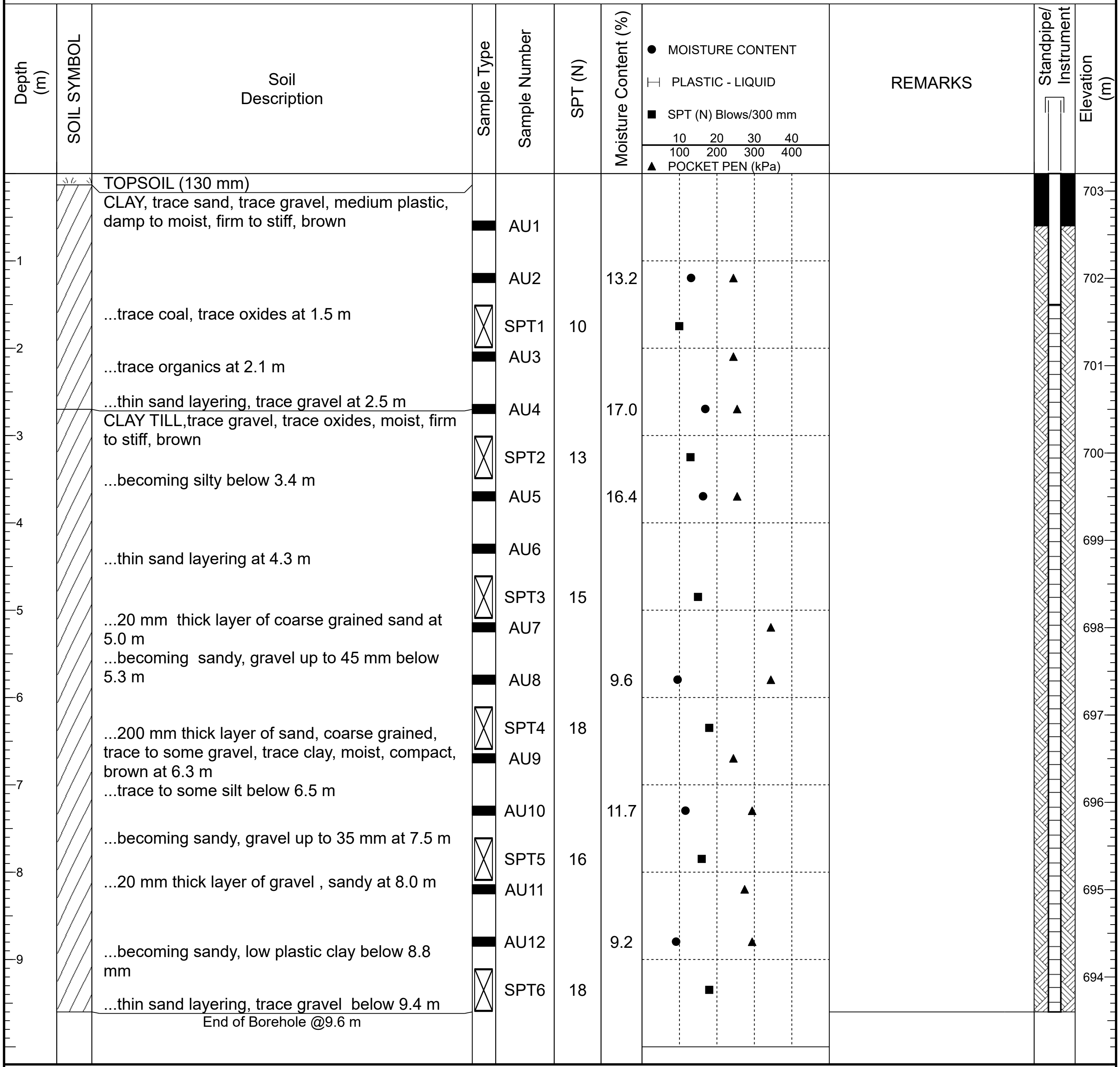
Reviewed By: TC

MPE Engineering Ltd.

BOREHOLE No : 19BH003

PAGE 1 0F 1

CLIENT	MD of Acadia No. 34	PROJECT NAME	Irrigation Development Study - 2019 Update
PROJECT NUMBER	4280-002-00	PROJECT LOCATION	MD of Acadia No. 34
DATE STARTED	06-18-2019 COMPLETED 06-18-2019	GROUND ELEVATION	703.20m N 5647291.000 E 542620.000
DRILLING CONTRACTOR	Duzz All Drilling	GROUND WATER LEVEL:	
DRILLING METHOD	6" SSA		



Soil Description

TOPSOIL (130 mm)

CLAY, trace sand, trace gravel, medium plastic, damp to moist, firm to stiff, brown

...trace coal, trace oxides at 1.5 m

...trace organics at 2.1 m

...thin sand layering, trace gravel at 2.5 m

CLAY TILL,trace gravel, trace oxides, moist, firm to stiff, brown

...becoming silty below 3.4 m

...thin sand layering at 4.3 m

...20 mm thick layer of coarse grained sand at 5.0 m

...becoming sandy, gravel up to 45 mm below 5.3 m

...200 mm thick layer of sand, coarse grained, trace to some gravel, trace clay, moist, compact, brown at 6.3 m

...trace to some silt below 6.5 m

...becoming sandy, gravel up to 35 mm at 7.5 m

...20 mm thick layer of gravel , sandy at 8.0 m

...becoming sandy, low plastic clay below 8.8 mm

...thin sand layering, trace gravel below 9.4 m

End of Borehole @9.6 m

Sample Number	SPT (N)	Moisture Content (%)
AU1		
AU2		13.2
SPT1	10	
AU3		
AU4		17.0
SPT2	13	
AU5		16.4
AU6		
SPT3	15	
AU7		
AU8		9.6
SPT4	18	
AU9		
AU10		11.7
SPT5	16	
AU11		
AU12		9.2
SPT6	18	

Notes:

No seepage or sloughing encountered while drilling. 25 mm PVC Standpipe installed to 9.6 m, handslotted from 1.5 m to 9.6 m.

Logged By: CB

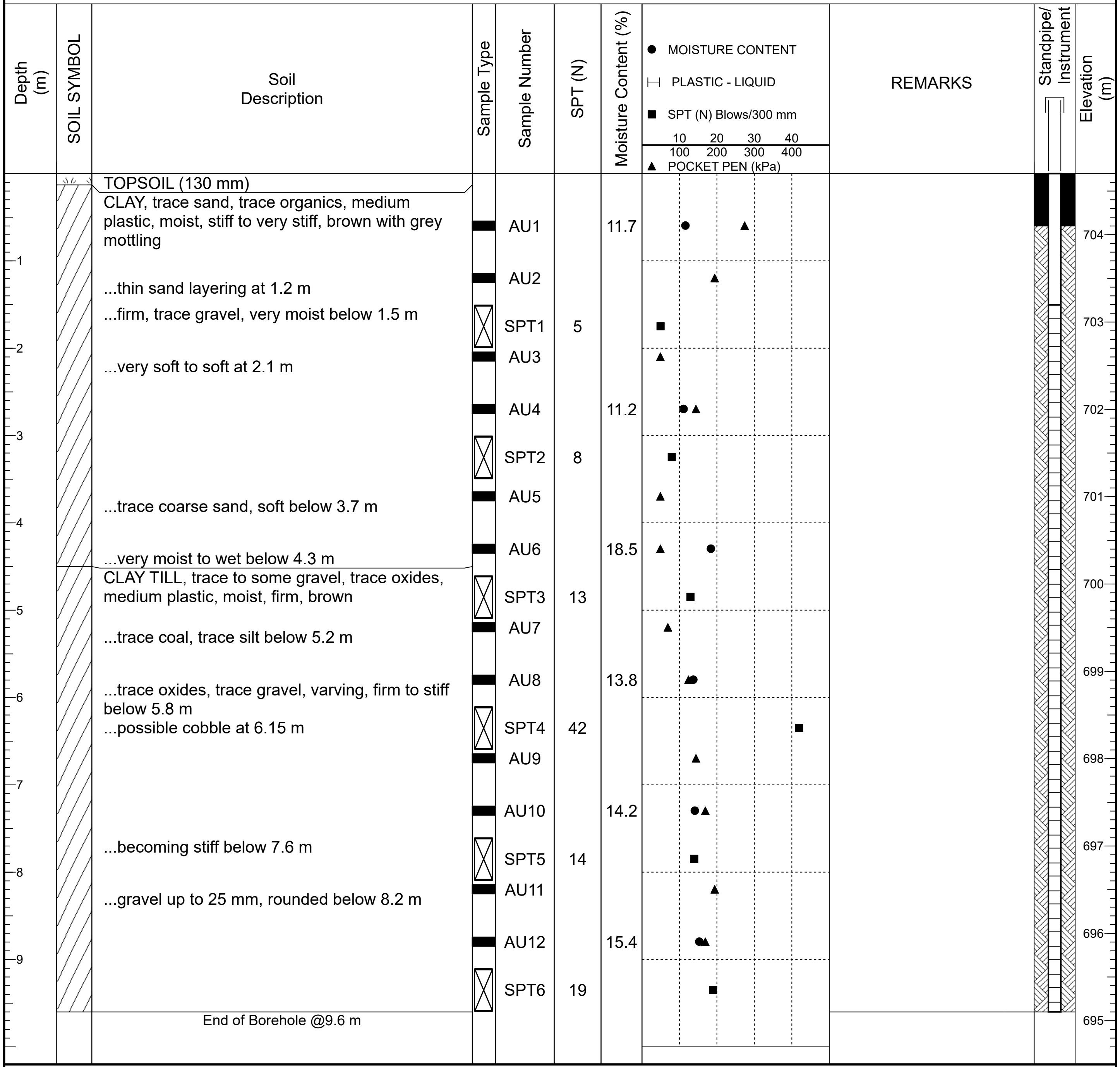
Reviewed By: TC

Engineering Ltd.

BOREHOLE No : 19BH004

PAGE 1 0F 1

CLIENT	MD of Acadia No. 34	PROJECT NAME	Irrigation Development Study - 2019 Update
PROJECT NUMBER	4280-002-00	PROJECT LOCATION	MD of Acadia No. 34
DATE STARTED	06-18-2019 COMPLETED 06-18-2019	GROUND ELEVATION	704.70m N 5647461.000 E 542194.000
DRILLING CONTRACTOR	Duzz All Drilling	GROUND WATER LEVEL:	
DRILLING METHOD	6" SSA		



Soil Description	Sample Number	SPT (N)	Moisture Content (%)
TOPSOIL (130 mm)			
CLAY, trace sand, trace organics, medium plastic, moist, stiff to very stiff, brown with grey mottling	AU1		11.7
...thin sand layering at 1.2 m	AU2		
...firm, trace gravel, very moist below 1.5 m	SPT1	5	
...very soft to soft at 2.1 m	AU3		
	AU4		11.2
	SPT2	8	
...trace coarse sand, soft below 3.7 m	AU5		
...very moist to wet below 4.3 m	AU6		18.5
CLAY TILL, trace to some gravel, trace oxides, medium plastic, moist, firm, brown	SPT3	13	
...trace coal, trace silt below 5.2 m	AU7		
	AU8		13.8
...trace oxides, trace gravel, varving, firm to stiff below 5.8 m ...possible cobble at 6.15 m	SPT4	42	
	AU9		
	AU10		14.2
...becoming stiff below 7.6 m	SPT5	14	
...gravel up to 25 mm, rounded below 8.2 m	AU11		
	AU12		15.4
	SPT6	19	
End of Borehole @9.6 m			

Notes:

Seepage observed below 3.0 m. No sloughing encountered while drilling. 25 mm PVC Standpipe installed to 9.6 m, handslotted from 1.5 m to 9.6 m.

Logged By: CB

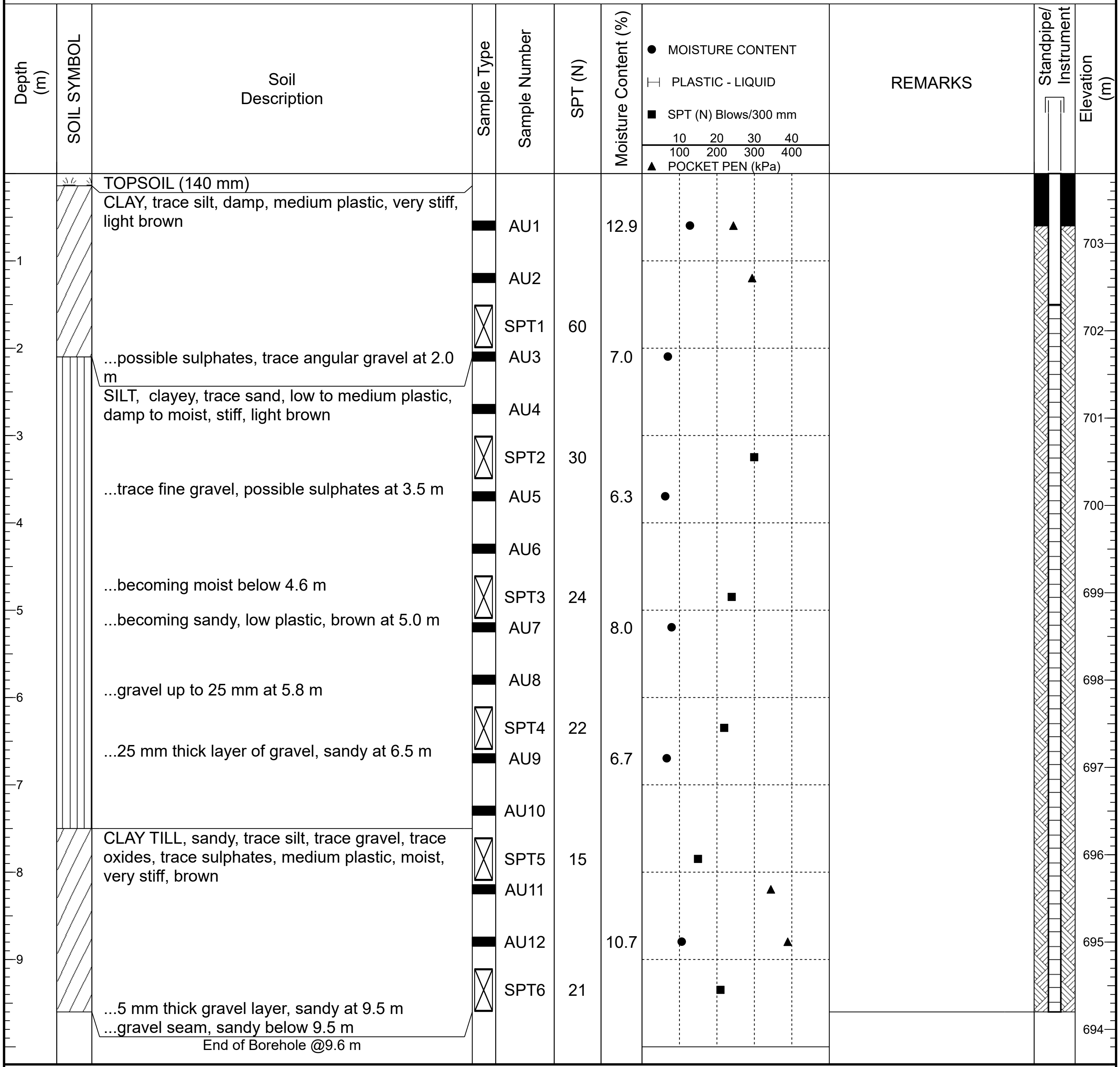
Reviewed By: TC

Engineering Ltd.

BOREHOLE No : 19BH005

PAGE 1 0F 1

CLIENT	MD of Acadia No. 34	PROJECT NAME	Irrigation Development Study - 2019 Update
PROJECT NUMBER	4280-002-00	PROJECT LOCATION	MD of Acadia No. 34
DATE STARTED	06-18-2019 COMPLETED 07-02-2019	GROUND ELEVATION	703.80m N 5647513.000 E 541173.000
DRILLING CONTRACTOR	Duzz All Drilling	GROUND WATER LEVEL:	
DRILLING METHOD	6" SSA		



Soil Description

TOPSOIL (140 mm)

CLAY, trace silt, damp, medium plastic, very stiff, light brown

...possible sulphates, trace angular gravel at 2.0 m

SILT, clayey, trace sand, low to medium plastic, damp to moist, stiff, light brown

...trace fine gravel, possible sulphates at 3.5 m

...becoming moist below 4.6 m

...becoming sandy, low plastic, brown at 5.0 m

...gravel up to 25 mm at 5.8 m

...25 mm thick layer of gravel, sandy at 6.5 m

CLAY TILL, sandy, trace silt, trace gravel, trace oxides, trace sulphates, medium plastic, moist, very stiff, brown

...5 mm thick gravel layer, sandy at 9.5 m

...gravel seam, sandy below 9.5 m

End of Borehole @9.6 m

Sample Number	SPT (N)	Moisture Content (%)
AU1		12.9
AU2		
SPT1	60	
AU3		7.0
AU4		
SPT2	30	
AU5		6.3
AU6		
SPT3	24	
AU7		8.0
AU8		
SPT4	22	
AU9		6.7
AU10		
SPT5	15	
AU11		
AU12		10.7
SPT6	21	

Notes:

No seepage or sloughing encountered while drilling. 25 mm PVC Standpipe installed to 9.6 m, handslotted from 1.5 m to 9.6 m.

Logged By: CB

Reviewed By: TC

MPE Engineering Ltd.

BOREHOLE No : **19BH006**

PAGE 1 0F 2

CLIENT: MD of Acadia No. 34

PROJECT NAME: Irrigation Development Study - 2019 Update

PROJECT NUMBER: 4280-002-00

PROJECT LOCATION: MD of Acadia No. 34

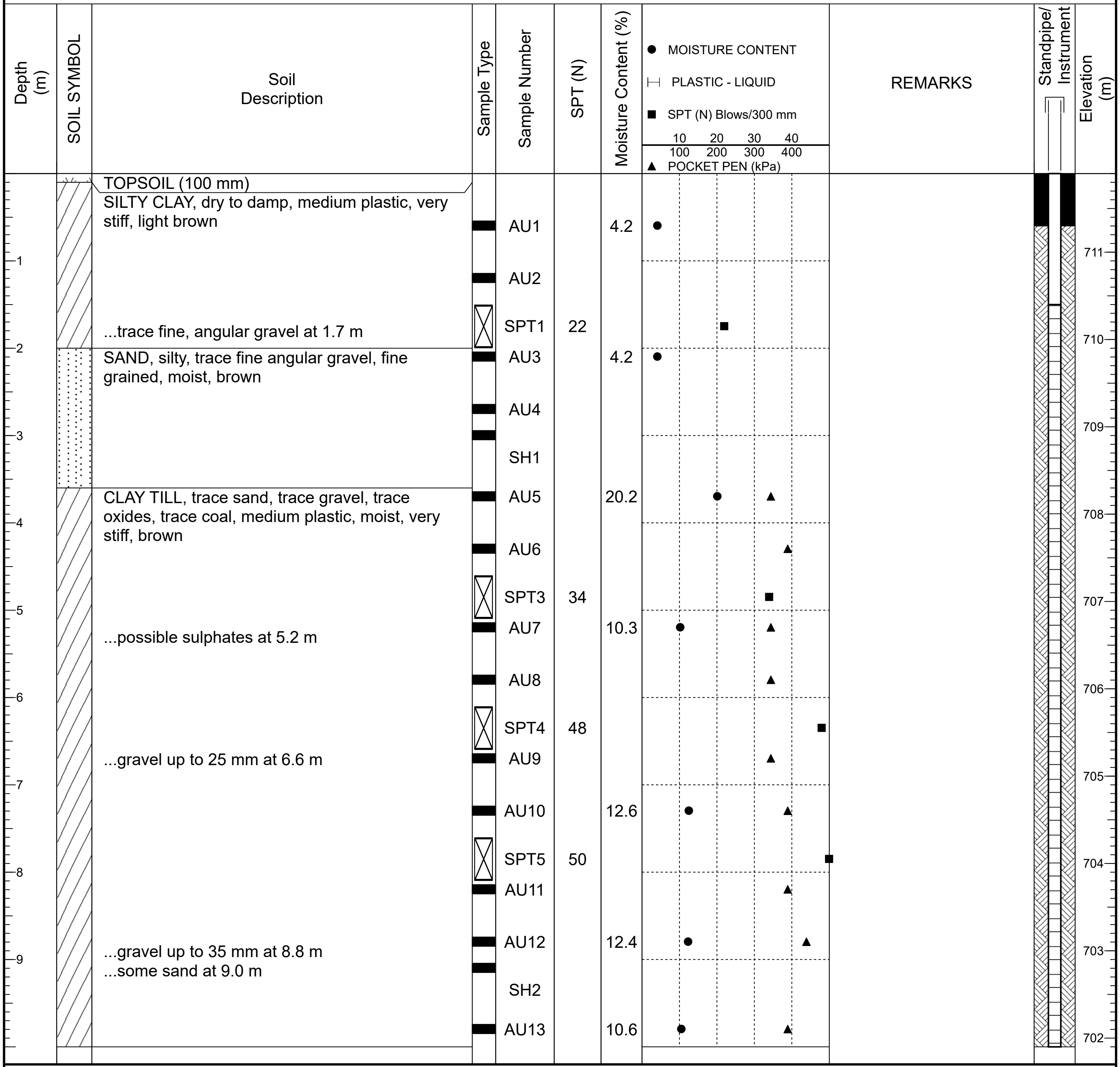
DATE STARTED: 07-02-2019 COMPLETED: 07-02-2019

GROUND ELEVATION: 711.90m N 5647015.000 E 540442.000

DRILLING CONTRACTOR: Duzz All Drilling

GROUND WATER LEVEL:

DRILLING METHOD: 6" SSA



Soil Description	Sample Number	SPT (N)	Moisture Content (%)
TOPSOIL (100 mm)			
SILTY CLAY, dry to damp, medium plastic, very stiff, light brown	AU1		4.2
	AU2		
...trace fine, angular gravel at 1.7 m	SPT1	22	
SAND, silty, trace fine angular gravel, fine grained, moist, brown	AU3		4.2
	AU4		
	SH1		
CLAY TILL, trace sand, trace gravel, trace oxides, trace coal, medium plastic, moist, very stiff, brown	AU5		20.2
	AU6		
	SPT3	34	
...possible sulphates at 5.2 m	AU7		10.3
	AU8		
	SPT4	48	
...gravel up to 25 mm at 6.6 m	AU9		
	AU10		12.6
	SPT5	50	
	AU11		
...gravel up to 35 mm at 8.8 m	AU12		12.4
...some sand at 9.0 m	SH2		
	AU13		10.6

Notes:

No seepage or sloughing encountered while drilling. 25 mm PVC Standpipe installed to 15.7 m, handslotted from 1.5 m to 15.7 m. Shelby Tube Samples collected at 3.0 m, 10 m and 15 m.

Logged By: CB

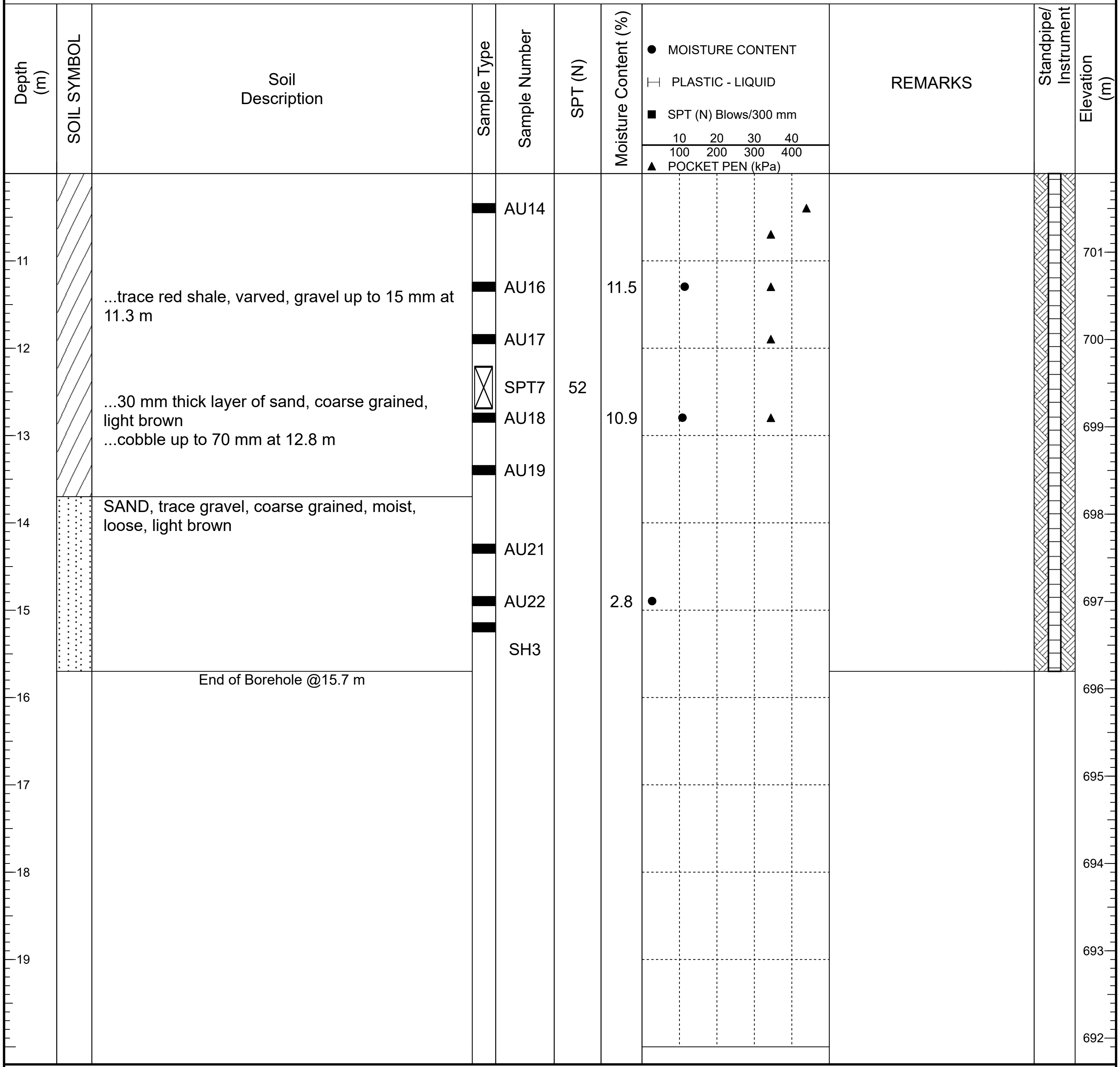
Reviewed By: TC

Engineering Ltd.

BOREHOLE No : **19BH006**

PAGE 2 0F 2

CLIENT: MD of Acadia No. 34
PROJECT NAME: Irrigation Development Study - 2019 Update
PROJECT NUMBER: 4280-002-00
PROJECT LOCATION: MD of Acadia No. 34
DATE STARTED: 07-02-2019
COMPLETED: 07-02-2019
GROUND ELEVATION: 711.90m N 5647015.000 E 540442.000
DRILLING CONTRACTOR: Duzz All Drilling
GROUND WATER LEVEL:
DRILLING METHOD: 6" SSA



...trace red shale, varved, gravel up to 15 mm at 11.3 m

...30 mm thick layer of sand, coarse grained, light brown
...cobble up to 70 mm at 12.8 m

SAND, trace gravel, coarse grained, moist, loose, light brown

End of Borehole @15.7 m

Sample Number	SPT (N)	Moisture Content (%)
AU14		
AU16		11.5
AU17		
SPT7	52	
AU18		10.9
AU19		
AU21		
AU22		2.8
SH3		

Notes:

No seepage or sloughing encountered while drilling. 25 mm PVC Standpipe installed to 15.7 m, handslotted from 1.5 m to 15.7 m. Shelby Tube Samples collected at 3.0 m, 10 m and 15 m.

Logged By: CB
Reviewed By: TC

MPE Engineering Ltd.

BOREHOLE No : **19BH007**

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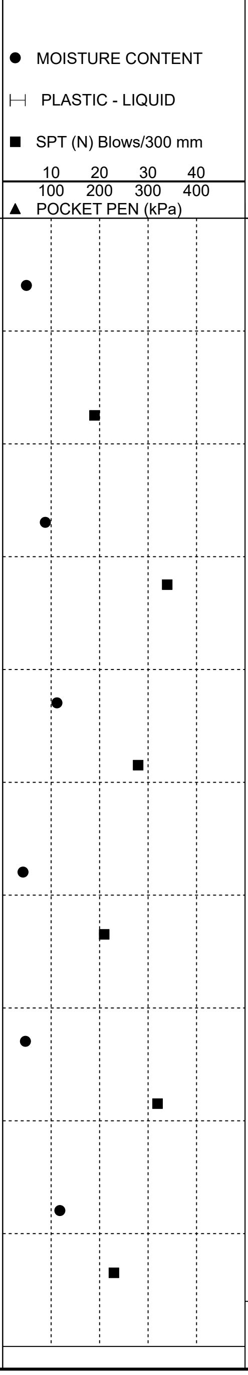
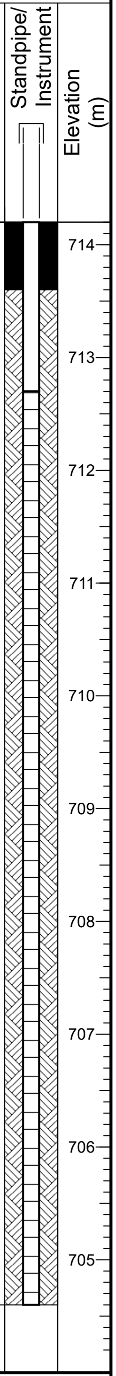
CLIENT MD of Acadia No. 34
PROJECT NAME Irrigation Development Study - 2019 Update
PROJECT NUMBER 4280-002-00
PROJECT LOCATION MD of Acadia No. 34
DATE STARTED 07-02-2019 COMPLETED 07-02-2019
GROUND ELEVATION 714.20m N 5645267.000 E 543714.000
DRILLING CONTRACTOR Duzz All Drilling
GROUND WATER LEVEL:
DRILLING METHOD 6" SSA

Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)
TOPSOIL (90 mm)				
SILTY CLAY, dry to damp, low to medium plastic, stiff, light brown	▬	AU1		5.0
	▬	AU2		
	☒	SPT1	19	
	▬	AU3		
	▬	AU4		8.9
	☒	SPT2	34	
	▬	AU5		
...becoming damp to moist at 3.7 m				
	▬	AU6		11.3
	☒	SPT3	28	
SILT, sandy, low to non plastic, dry to damp, light brown	▬	AU7		
	▬	AU8		4.3
SILTY CLAY, dry, medium plastic, very stiff, light brown	☒	SPT4	21	
	▬	AU9		
	▬	AU10		4.8
	☒	SPT5	32	
	▬	AU11		
	▬	AU12		11.9
	☒	SPT6	23	
End of Borehole @9.6 m				

REMARKS





Depth (m): 1, 2, 3, 4, 5, 6, 7, 8, 9

Notes:

No seepage or sloughing encountered while drilling. 25 mm PVC Standpipe installed to 9.6 m, handslotted from 1.5 m to 9.6 m.

Logged By: CB
Reviewed By: TC

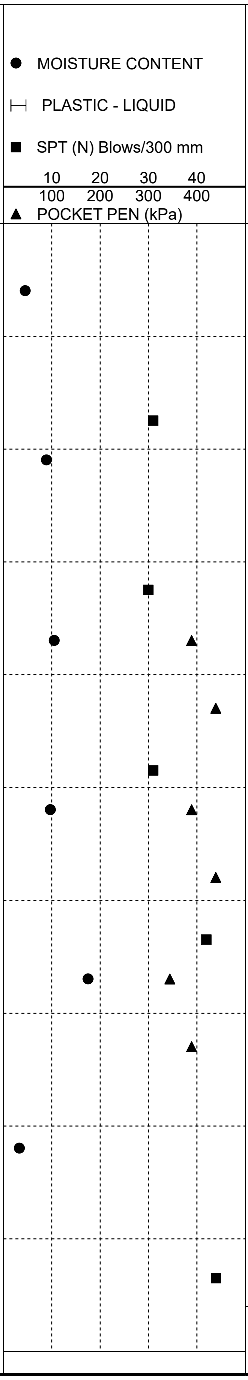
MPE Engineering Ltd.

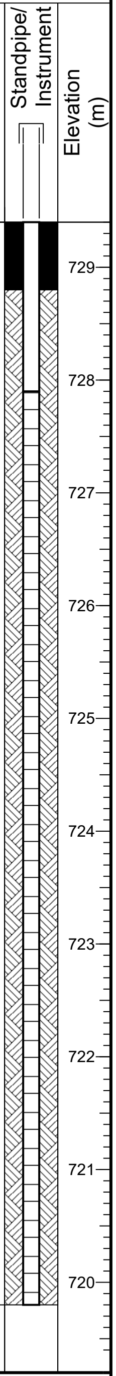
BOREHOLE No : 19BH008

PAGE 1 0F 1

CLIENT MD of Acadia No. 34
PROJECT NAME Irrigation Development Study - 2019 Update
PROJECT NUMBER 4280-002-00
PROJECT LOCATION MD of Acadia No. 34
DATE STARTED 07-02-2019 COMPLETED 07-02-2019
GROUND ELEVATION 729.40m N 5646085.000 E 540896.000
DRILLING CONTRACTOR Duzz All Drilling
GROUND WATER LEVEL:
DRILLING METHOD 6" SSA

Soil Description	Sample Type	Sample Number	SPT (N)	Moisture Content (%)	REMARKS
TOPSOIL (90 mm)					
SILTY CLAY, possible sulphates, dry to damp, low to medium plastic, stiff, light brown	▬	AU1		4.6	
...cobble up to 120 mm at 1.2 m	▬	AU2			
	☒	SPT1	31		
CLAY TILL, trace to some silt, trace gravel, trace oxides, possible sulphates, medium plastic, moist, hard, brown	▬	AU3		9.0	
	▬	AU4			
	☒	SPT2	30		
	▬	AU5		10.6	
	▬	AU6			
	☒	SPT3	31		
...gravel up to 35 mm at 5.0 m	▬	AU7		9.8	
	▬	AU8			
	☒	SPT4	42		
...gravel up to 55 mm at 5.0 m	▬	AU9		17.6	
	▬	AU10			
...suspect shale layer, 50 mm thick at 7.8 m	☒	SPT5	60		
SAND, fine grained, damp, very dense, light brown	▬	AU11		3.4	
	▬	AU12			
	☒	SPT6	44		
End of Borehole @9.6 m					





Notes:

No seepage or sloughing encountered while drilling. 25 mm PVC Standpipe installed to 9.6 m, handslotted from 1.5 m to 9.6 m.

Logged By: CB
Reviewed By: TC

APPENDIX C:

SITE PHOTOGRAPHS

Source: MPE Engineering Ltd., Jul 2019

Photo 1: Reservoir A1 near borehole 19BH001 & 19BH002

Source: MPE Engineering Ltd., Jul 2019

Photo 2: Reservoir A1 near borehole 19BH002

Source: MPE Engineering Ltd., Jul 2019

Photo 3: Reservoir A1 near borehole 19BH002

Source: MPE Engineering Ltd., Jun 2019

Photo 4: Reservoir A1 near borehole 19BH003

Source: MPE Engineering Ltd., Jun 2019

Photo 5: Reservoir A1 near borehole 19BH003

Source: MPE Engineering Ltd., Jun 2019

Photo 6: Reservoir A1 near borehole 19BH004

Source: MPE Engineering Ltd., Jun 2019

Photo 7: Reservoir A1 near borehole 19BH004

Source: MPE Engineering Ltd., Jul 2019

Photo 8: Reservoir A1 near borehole 19BH005


Source: MPE Engineering Ltd., Jul 2019

Photo 9: Reservoir A1 near borehole 19BH006


Source: MPE Engineering Ltd., Jul 2019

Photo 10: Main pipeline near borehole 19BH007


Source: MPE Engineering Ltd., Jul 2019

Photo 11: Alternate pipeline near borehole 19BH008

Source: MPE Engineering Ltd., Jul 2019

Photo 12: Alternate pipeline near borehole 19BH008

APPENDIX B

DETAILED COST ESTIMATES

MPE Engineering Ltd.

Irrigation Delivery Infrastructure
Capital Cost Estimate Summary

	DESCRIPTION	SCENARIO 1	SCENARIO 2	SCENARIO 3
	Diversion and Supply			
	River Intake, Pumpstation, and Power Supply	$ 9,612,500	$ 11,980,000	$ 11,980,000
	Supply Pipeline	$ 5,630,000	$ 6,872,000	$ 6,872,000
	Subtotal	***$ 15,242,500***	***$ 18,852,000***	***$ 18,852,000***
	Reservoir A1			
	General Requirements	$ 1,850,000	$ 2,000,000	$ 2,100,000
	East Dam	$ 8,982,500	$ 12,310,500	$ 15,449,000
	West Dam	$ 1,576,250	$ 2,109,000	$ 3,064,250
	Secondary A Canal Outlet Structure	$ 1,640,000	$ 2,162,500	$ 2,250,000
	Secondary B Pipeline Outlet Structure	$ 635,000	$ 680,000	$ 717,500
	Subtotal	***$ 14,683,750***	***$ 19,262,000***	***$ 23,580,750***
	Distribution System			
	Secondary A Canal (Block 1A)	$ 10,010,000	$ 12,662,500	$ 14,747,500
	Kennedy Coulee Syphon	$ -	$ 3,265,000	$ 5,480,000
	Secondary A Canal (Acadia Reservoir Feed)	$ 2,275,000	$ 2,275,000	$ 2,275,000
	Secondary A Canal (Block 2)	$ -	$ 5,850,000	$ 5,850,000
	Secondary A Gravity Pipeline Laterals	$ 3,353,000	$ 7,818,900	$ 7,818,900
	Secondary B Gravity Pipeline	$ 3,291,900	$ 3,291,900	$ 3,291,900
	Secondary C Pressure Pipeline and Pumpstation (Block 3)	$ -	$ -	$ 7,906,175
	Block 4 Pressure Pipelines and Pumpstation (Block 4)	$ 4,538,300	$ 4,538,300	$ 4,538,300
	Subtotal	***$ 23,468,200***	***$ 39,701,600***	***$ 51,907,775***
	Other			
	Contingencies (25%)	$ 13,349,000	$ 19,454,000	$ 23,585,000
	Environmental Impact Assessment, Historical Resource Assessment and Permitting	$ 2,000,000	$ 2,000,000	$ 2,000,000
	Preliminary and Detailed Engineering Design (15%)	$ 10,012,000	$ 14,590,000	$ 17,689,000
	TOTAL CAPITAL SYSTEM COSTS	**$ 78,755,000**	**$ 113,860,000**	**$ 137,615,000**
	Total Irrigated Area (ac)	13,500	22,000	27,000
	Capital Cost Per Acre	$ 5,834	$ 5,175	$ 5,097

MPE Engineering Ltd.

Red Deer River Pumpstation
Scenario 1

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Requirements					
1	Mobilization and Demobilization	1	LS	$ 400,000	$ 400,000
2	Care of Water	1	LS	$ 250,000	$ 250,000
3	Access Road	6	km	$ 75,000	$ 450,000
				Subtotal	***$ 1,100,000***
Pumpstation					
4	Excavation	26,500	m^3	$ 15	$ 397,500
5	Structure Backfill	23,000	m^3	$ 10	$ 230,000
6	Cast in Place Concrete	600	m^3	$ 1,500	$ 900,000
7	Fish Screen	1	LS	$ 600,000	$ 600,000
8	Building	1	LS	$ 250,000	$ 250,000
9	Supply and Install 2000 hp Pump and Motor	3	ea.	$ 450,000	$ 1,350,000
10	Supply and Install 250 hp Pump and Motor	1	ea.	$ 25,000	$ 25,000
11	Mechanical Valving and Surge Protection	1	LS	$ 300,000	$ 300,000
12	Steel Discharge Piping	1	LS	$ 80,000	$ 80,000
13	2000 hp Motor Soft Starters	3	ea.	$ 150,000	$ 450,000
14	250 hp VFD	1	ea.	$ 10,000	$ 10,000
15	Electrical Equipment	1	LS	$ 350,000	$ 350,000
16	SCADA System	1	LS	$ 150,000	$ 150,000
17	Natural Gas Supply	1	LS	$ 100,000	$ 100,000
				Subtotal	***$ 5,192,500***
River Intake					
18	Cofferdam/Environmental	1	LS	$ 1,000,000	$ 1,000,000
19	Cast in Place Concrete	30	m^3	$ 1,500	$ 45,000
20	Supply and Install Intake Screens and Wash System	1	LS	$ 75,000	$ 75,000
21	Riverbank Erosion Protection	1	LS	$ 500,000	$ 500,000
22	Intake Piping (Single 1500 mm)	200	m	$ 1,000	$ 200,000
				Subtotal	***$ 1,820,000***
Electrical Service					
23	Install 3 Phase High Voltage Power and Transformer	1	LS	$ 1,500,000	$ 1,500,000
				Subtotal	***$ 1,500,000***
				GRAND TOTAL	**$ 9,612,500**

MPE Engineering Ltd.

Red Deer River Pumpstation
Scenario 2 and 3

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Requirements					
1	Mobilization and Demobilization	1	LS	$ 500,000	$ 500,000
2	Care of Water	1	LS	$ 250,000	$ 250,000
3	Access Road	3	km	$ 75,000	$ 225,000
				Subtotal	***$ 975,000***
Pumpstation					
4	Excavation	34,500	m^3	$ 15	$ 517,500
5	Structure Backfill	28,500	m^3	$ 10	$ 285,000
6	Cast in Place Concrete	900	m^3	$ 1,500	$ 1,350,000
7	Fish Screen	1	LS	$ 800,000	$ 800,000
8	Building	1	LS	$ 400,000	$ 400,000
9	Supply and Install 2750 hp Pump and Motor	4	ea.	$ 500,000	$ 2,000,000
10	Supply and Install 250 hp Pump and Motor	1	ea.	$ 25,000	$ 25,000
11	Mechanical Valving and Surge Protection	1	LS	$ 400,000	$ 400,000
12	Steel Discharge Piping	1	LS	$ 175,000	$ 175,000
13	2750 hp Motor Soft Starters	4	ea.	$ 200,000	$ 800,000
14	250 hp VFD	1	ea.	$ 10,000	$ 10,000
15	Electrical Equipment	1	LS	$ 450,000	$ 450,000
16	SCADA System	1	LS	$ 150,000	$ 150,000
17	Natural Gas Supply	1	LS	$ 100,000	$ 100,000
				Subtotal	***$ 7,462,500***
River Intake					
18	Cofferdam/Environmental	1	LS	$ 1,000,000	$ 1,000,000
19	Cast in Place Concrete	45	m^3	$ 1,500	$ 67,500
20	Supply and Install Intake Screens and Wash System	1	LS	$ 75,000	$ 75,000
21	Riverbank Erosion Protection	1	LS	$ 500,000	$ 500,000
22	Intake Piping (Dual 1500 mm)	400	m	$ 1,000	$ 400,000
				Subtotal	***$ 2,042,500***
Electrical Service					
23	Install 3 Phase High Voltage Power and Transformer	1	LS	$ 1,500,000	$ 1,500,000
				Subtotal	***$ 1,500,000***
				GRAND TOTAL	**$ 11,980,000**

Supply Pipeline
Scenario 1

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Requirements					
1	Mobilization and Demobilization	1	LS	$ 250,000	$ 250,000
2	Care of Water	1	LS	$ 25,000	$ 25,000
3	Environmental Compenstation	1	LS	$ 500,000	$ 500,000
				Subtotal	**$ 775,000**
Supply Pipeline To Reservoir A1					
4	Supply 1050 mm Steel Pipeline	2400	m	$ 500	$ 1,200,000
5	Install 1050 mm Steel Pipeline (Open Cut)	1900	m	$ 800	$ 1,520,000
6	Install 1050 mm Steel Pipeline (Trenchless)	500	m	$ 3,500	$ 1,750,000
7	Air Release Structures	3	ea.	$ 25,000	$ 75,000
8	Cathodic Protection	1	LS	$ 100,000	$ 100,000
9	Road Crossing	1	LS	$ 10,000	$ 10,000
10	Reservoir Inlet Structure	1	LS	$ 200,000	$ 200,000
				Subtotal	**$ 4,855,000**
				GRAND TOTAL	**$ 5,630,000**

Supply Pipeline
Scenarios 2 and 3

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Requirements					
1	Mobilization and Demobilization	1	LS	$ 250,000	$ 250,000
2	Care of Water	1	LS	$ 25,000	$ 25,000
3	Environmental Compenstation	1	LS	$ 500,000	$ 500,000
				Subtotal	**$ 775,000**
Supply Pipeline To Reservoir A1					
4	Supply 1500 mm Steel Pipeline	2400	m	$ 755	$ 1,812,000
5	Install 1500 mm Steel Pipeline (Open Cut)	1900	m	$ 1,000	$ 1,900,000
6	Install 1500 mm Steel Pipeline (Trenchless)	500	m	$ 4,000	$ 2,000,000
7	Air Release Structures	3	ea.	$ 25,000	$ 75,000
8	Cathodic Protection	1	LS	$ 100,000	$ 100,000
9	Road Crossing	1	LS	$ 10,000	$ 10,000
10	Reservoir Inlet Structure	1	LS	$ 200,000	$ 200,000
				Subtotal	**$ 6,097,000**
				GRAND TOTAL	**$ 6,872,000**

Reservoir A1
Scenario 1

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Requirements					
1	Mobilization and Demobilization	1	LS	$ 500,000	$ 500,000
2	Care of Water	1	LS	$ 50,000	$ 50,000
3	Access Road	2	km	$ 100,000	$ 200,000
4	Instrumentation	1	LS	$ 100,000	$ 100,000
5	Environmental Compensation	1	LS	$ 1,000,000	$ 1,000,000
				Subtotal	***$ 1,850,000***
East Dam					
6	Topsoil Stripping and Replacement	38,500	m^3	$ 6.00	$ 231,000
7	Cutoff Excavation	22,000	m^3	$ 4.00	$ 88,000
8	Random Fill	540,000	m^3	$ 3.50	$ 1,890,000
9	Impervious Fill	265,000	m^3	$ 4.50	$ 1,192,500
10	Road Gravel	750	m^3	$ 60.00	$ 45,000
11	Supply and Install Riprap	13,800	m^3	$ 170.00	$ 2,346,000
12	Supply and Install Bedding Gravel	6,000	m^3	$ 100.00	$ 600,000
13	Filter Drain	37,000	m^3	$ 70.00	$ 2,590,000
				Subtotal	***$ 8,982,500***
West Dam					
14	Topsoil Stripping and Replacement	5,000	m^3	$ 6.00	$ 30,000
15	Cutoff Excavation	7,500	m^3	$ 4.00	$ 30,000
16	Random Fill	31,000	m^3	$ 3.50	$ 108,500
17	Impervious Fill	17,500	m^3	$ 4.50	$ 78,750
18	Road Gravel	150	m^3	$ 60.00	$ 9,000
19	Supply and Install Riprap	2,800	m^3	$ 170.00	$ 476,000
20	Supply and Install Bedding Gravel	1,100	m^3	$ 100.00	$ 110,000
21	Filter Drain	6,200	m^3	$ 70.00	$ 434,000
22	Seepage Pumping Station	1	LS	$ 300,000.00	$ 300,000
				Subtotal	***$ 1,576,250***
Secondary A Canal Outlet Structure					
23	Cast in Place Concrete	610	m^3	$ 1,500	$ 915,000
24	Cast Iron Sluice Gate (1530 x 1220) c/w actuator	2	ea.	$ 125,000	$ 250,000
25	Control Building	1	LS	$ 250,000	$ 250,000
26	Electrical and Controls	1	LS	$ 125,000	$ 125,000
27	Power Supply	1	LS	$ 100,000	$ 100,000
				Subtotal	***$ 1,640,000***
Secondary B Pipeline Outlet Structure					
28	Cast in Place Concrete	110	m^3	$ 1,500	$ 165,000
29	1200 mm Concrete Pipe	130	m	$ 1,500	$ 195,000
30	Cast Iron Sluice Gate (1220 x 1220) c/w actuator	2	ea.	$ 100,000	$ 200,000
31	Electrical and Controls	1	LS	$ 75,000	$ 75,000
				Subtotal	***$ 635,000***
				GRAND TOTAL	**$ 14,683,750**

Reservoir A1
Scenario 2

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Requirements					
1	Mobilization and Demobilization	1	LS	$ 650,000	$ 650,000
2	Care of Water	1	LS	$ 50,000	$ 50,000
3	Access Road	2	km	$ 100,000	$ 200,000
4	Instrumentation	1	LS	$ 100,000	$ 100,000
5	Environmental Compensation	1	LS	$ 1,000,000	$ 1,000,000
				Subtotal	***$ 2,000,000***
East Dam					
6	Topsoil Stripping and Replacement	61,000	m^3	$ 6.00	$ 366,000
7	Cutoff Excavation	35,000	m^3	$ 3.50	$ 122,500
8	Random Fill	730,000	m^3	$ 3.00	$ 2,190,000
9	Impervious Fill	375,000	m^3	$ 4.00	$ 1,500,000
10	Road Gravel	1,000	m^3	$ 60.00	$ 60,000
11	Supply and Install Riprap	26,000	m^3	$ 160.00	$ 4,160,000
12	Supply and Install Bedding Gravel	10,800	m^3	$ 90.00	$ 972,000
13	Filter Drain	42,000	m^3	$ 70.00	$ 2,940,000
				Subtotal	***$ 12,310,500***
West Dam					
14	Topsoil Stripping and Replacement	7,500	m^3	$ 6.00	$ 45,000
15	Cutoff Excavation	10,000	m^3	$ 3.50	$ 35,000
16	Random Fill	56,000	m^3	$ 3.00	$ 168,000
17	Impervious Fill	30,500	m^3	$ 4.00	$ 122,000
18	Road Gravel	150	m^3	$ 60.00	$ 9,000
19	Supply and Install Riprap	4,600	m^3	$ 160.00	$ 736,000
20	Supply and Install Bedding Gravel	1,800	m^3	$ 90.00	$ 162,000
21	Filter Drain	7,600	m^3	$ 70.00	$ 532,000
22	Seepage Pumping Station	1	LS	$ 300,000.00	$ 300,000
				Subtotal	***$ 2,109,000***
Secondary A Canal Outlet Structure					
23	Cast in Place Concrete	925	m^3	$ 1,500	$ 1,387,500
24	Cast Iron Sluice Gate (2130 x 2130) c/w actuator	2	ea.	$ 150,000	$ 300,000
25	Control Building	1	LS	$ 250,000	$ 250,000
26	Electrical and Controls	1	LS	$ 125,000	$ 125,000
27	Power Supply	1	LS	$ 100,000	$ 100,000
				Subtotal	***$ 2,162,500***
Secondary B Pipeline Outlet Structure					
28	Cast in Place Concrete	130	m^3	$ 1,500	$ 195,000
29	1200 mm Concrete Pipe	140	m	$ 1,500	$ 210,000
30	Cast Iron Sluice Gate (1220 x 1220) c/w actuator	2	ea.	$ 100,000	$ 200,000
31	Electrical and Controls	1	LS	$ 75,000	$ 75,000
				Subtotal	***$ 680,000***
				GRAND TOTAL	**$ 19,262,000**

Reservoir A1
Scenario 3

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Requirements					
1	Mobilization and Demobilization	1	LS	$ 750,000	$ 750,000
2	Care of Water	1	LS	$ 50,000	$ 50,000
3	Access Road	2	km	$ 100,000	$ 200,000
4	Instrumentation	1	LS	$ 100,000	$ 100,000
5	Environmental Compensation	1	LS	$ 1,000,000	$ 1,000,000
				Subtotal	***$ 2,100,000***
East Dam					
6	Topsoil Stripping and Replacement	72,000	m^3	$ 6.00	$ 432,000
7	Cutoff Excavation	20,000	m^3	$ 3.50	$ 70,000
8	Random Fill	1,100,000	m^3	$ 2.50	$ 2,750,000
9	Impervious Fill	460,000	m^3	$ 3.50	$ 1,610,000
10	Road Gravel	1,200	m^3	$ 60.00	$ 72,000
11	Supply and Install Riprap	38,500	m^3	$ 150.00	$ 5,775,000
12	Supply and Install Bedding Gravel	15,500	m^3	$ 80.00	$ 1,240,000
13	Filter Drain	50,000	m^3	$ 70.00	$ 3,500,000
				Subtotal	***$ 15,449,000***
West Dam					
14	Topsoil Stripping and Replacement	10,000	m^3	$ 6.00	$ 60,000
15	Cutoff Excavation	12,500	m^3	$ 3.50	$ 43,750
16	Random Fill	84,000	m^3	$ 2.50	$ 210,000
17	Impervious Fill	46,000	m^3	$ 3.50	$ 161,000
18	Road Gravel	175	m^3	$ 60.00	$ 10,500
19	Supply and Install Riprap	9,000	m^3	$ 150.00	$ 1,350,000
20	Supply and Install Bedding Gravel	2,600	m^3	$ 80.00	$ 208,000
21	Filter Drain	10,300	m^3	$ 70.00	$ 721,000
22	Seepage Pumping Station	1	LS	$ 300,000.00	$ 300,000
				Subtotal	***$ 3,064,250***
Secondary A Canal Outlet Structure					
23	Cast in Place Concrete	1,100	m^3	$ 1,500	$ 1,650,000
24	Cast Iron Sluice Gate (2430 x 2130) c/w actuator	2	ea.	$ 175,000	$ 350,000
25	Control Building	1	LS	$ 25,000	$ 25,000
26	Electrical and Controls	1	LS	$ 125,000	$ 125,000
27	Power Supply	1	LS	$ 100,000	$ 100,000
				Subtotal	***$ 2,250,000***
Secondary B Pipeline Outlet Structure					
28	Cast in Place Concrete	145	m^3	$ 1,500	$ 217,500
29	1200 mm Concrete Pipe	150	m	$ 1,500	$ 225,000
30	Cast Iron Sluice Gate (1220 x 1220) c/w actuator	2	ea.	$ 100,000	$ 200,000
31	Electrical and Controls	1	LS	$ 75,000	$ 75,000
				Subtotal	***$ 717,500***
				GRAND TOTAL	**$ 23,580,750**

SECONDARY A CANAL
Scenario 1

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Requirements					
1	Mobilization and Demobilization	1	LS	$ 500,000	$ 500,000
2	Easement Costs	240	ha	$ 7,500	$ 1,800,000
3	Automation	1	LS	$ 300,000	$ 300,000
				Subtotal	**$ 2,600,000**
Secondary A Canal Reach 1 (0+000 to 13+700)					
1	Construct Lined Canal (Q = 4.3 m^3/s)	13700	LM	$ 400	$ 5,480,000
2	Check Structures	5	ea.	$ 250,000	$ 1,250,000
3	Turnouts	17	ea.	$ 40,000	$ 680,000
				Subtotal	**$ 7,410,000**
Secondary A Canal Reach 3 (Acadia Reservoir Feed)					
1	Construct Lined Canal (Q = 1.08 m^3/s)	4600	LM	$ 250	$ 1,150,000
2	Check/Drop Structures	6	ea.	$ 125,000	$ 750,000
3	Turnouts	7	ea.	$ 25,000	$ 175,000
4	Reservoir Inlet Structure	1	LS	$ 200,000	$ 200,000
				Subtotal	**$ 2,275,000**
				GRAND TOTAL	**$ 12,285,000**

SECONDARY A CANAL
Scenario 2

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Requirements					
1	Mobilization and Demobilization	1	LS	$ 750,000	$ 750,000
2	Easement Costs	390	ha	$ 7,500	$ 2,925,000
3	Automation	1	LS	$ 300,000	$ 300,000
				Subtotal	**$ 3,975,000**
Secondary A Canal Reach 1 (0+000 to 13+700)					
1	Construct Lined Canal (Q = 7.6 m^3/s)	13700	LM	$ 475	$ 6,507,500
2	Check Structures	5	ea.	$ 300,000	$ 1,500,000
3	Turnouts	17	ea.	$ 40,000	$ 680,000
				Subtotal	**$ 8,687,500**
Kennedy Coulee Syphon					
1	Supply and Install 1500 mm Pipe	3200	m	$ 950	$ 3,040,000
2	Inlet Structure	1	LS	$ 100,000	$ 100,000
3	Outlet Structure	1	LS	$ 100,000	$ 100,000
4	Drainout	1	LS	$ 25,000	$ 25,000
				Subtotal	**$ 3,265,000**
Secondary A Canal Reach 3 (Acadia Reservoir Feed)					
1	Construct Lined Canal (Q = 1.08 m^3/s)	4600	LM	$ 250	$ 1,150,000
2	Check/Drop Structures	6	ea.	$ 125,000	$ 750,000
3	Turnouts	7	ea.	$ 25,000	$ 175,000
4	Reservoir Inlet Structure	1	LS	$ 200,000	$ 200,000
				Subtotal	**$ 2,275,000**
Secondary A Canal Reach 4 (West of Kennedy Creek)					
1	Construct Lined Canal (Q = 3.54 m^3/s)	8000	LM	$ 350	$ 2,800,000
2	Check Structures	3	ea.	$ 200,000	$ 600,000
3	Turnouts	20	ea.	$ 40,000	$ 800,000
4	Open Channel Lateral (Q=0.40 m^3/s)	4000	LM	$ 200	$ 800,000
5	Return Flow Structure	1	LS	$ 50,000	$ 50,000
6	Return Flow Channel	4000	LM	$ 200	$ 800,000
				Subtotal	**$ 5,850,000**
				GRAND TOTAL	**$ 24,052,500**

MPE Engineering Ltd.

SECONDARY A CANAL
Scenario 3

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Requirements					
1	Mobilization and Demobilization	1	LS	$ 750,000	$ 750,000
2	Easement Costs	510	ha	$ 7,500	$ 3,825,000
3	Automation	1	LS	$ 300,000	$ 300,000
				Subtotal	**$ 4,875,000**
Secondary A Canal Reach 1 (0+000 to 13+700)					
1	Construct Lined Canal (Q = 9.6 m^3/s)	13700	LM	$ 525	$ 7,192,500
2	Check Structures	5	ea.	$ 400,000	$ 2,000,000
3	Turnouts	17	ea.	$ 40,000	$ 680,000
				Subtotal	**$ 9,872,500**
Kennedy Coulee Syphon					
1	Supply and Install 1200 mm and 1500 mm Pipe	3200	m	$ 1,575	$ 5,040,000
2	Inlet Structure	1	LS	$ 200,000	$ 200,000
3	Outlet Structure	1	LS	$ 200,000	$ 200,000
4	Drainout	1	LS	$ 40,000	$ 40,000
				Subtotal	**$ 5,480,000**
Secondary A Canal Reach 3 (Acadia Reservoir Feed)					
1	Construct Lined Canal (Q = 1.08 m^3/s)	4600	LM	$ 250	$ 1,150,000
2	Check/Drop Structures	6	ea.	$ 125,000	$ 750,000
3	Turnouts	7	ea.	$ 25,000	$ 175,000
4	Reservoir Inlet Structure	1	LS	$ 200,000	$ 200,000
				Subtotal	**$ 2,275,000**
Secondary A Canal Reach 4 (West of Kennedy Creek)					
1	Construct Lined Canal (Q = 3.54 m^3/s)	8000	LM	$ 350	$ 2,800,000
2	Check Structures	3	ea.	$ 200,000	$ 600,000
3	Turnouts	20	ea.	$ 40,000	$ 800,000
4	Open Channel Lateral (Q=0.40 m^3/s)	4000	LM	$ 200	$ 800,000
5	Return Flow Structure	1	LS	$ 50,000	$ 50,000
6	Return Flow Channel	4000	LM	$ 200	$ 800,000
				Subtotal	**$ 5,850,000**
				GRAND TOTAL	**$ 28,352,500**

Secondary A - Lateral A1 Cost Estimate

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Items					
1	Mobilization and Demobilization	1	LS	60,000.00	$ 60,000.00
2	Care of Water	1	LS	15,000.00	$ 15,000.00
				Subtotal	**$ 75,000.00**
Structures					
3	Precast Concrete Inlet Structure	1	LS	$50,000.00	$ 50,000.00
4	Automated Mechanical Screen	1	LS	$50,000.00	$ 50,000.00
				Subtotal	**$ 100,000.00**
Pipeline					
5	Supply PVC Pipe - DR 51 600mm dia. (includes 7% for all fittings)	700	m	$ 130.00	$ 91,000.00
6	Install PVC Pipe - DR 51 600mm dia.	700	m	$ 100.00	$ 70,000.00
7	Supply PVC Pipe - DR 51 450mm dia. (includes 7% for all fittings)	500	m	$ 75.00	$ 37,500.00
8	Install PVC Pipe - DR 51 450mm dia.	500	m	$ 80.00	$ 40,000.00
9	Supply PVC Pipe - DR 41 350 mm dia. (includes 7% for all fittings)	800	m	$ 50.00	$ 40,000.00
10	Install PVC Pipe - DR 41 350 mm dia.	800	m	$ 70.00	$ 56,000.00
11	Pipeline Turnouts	5	LS	$ 10,000.00	$ 50,000.00
12	Pipeline Drain Out	1	LS	$ 15,000.00	$ 15,000.00
				Subtotal	**$ 399,500.00**
				Total	**$ 574,500.00**

MPE Engineering Ltd.

Secondary A - Lateral A2 Cost Estimate

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Items					
1	Mobilization and Demobilization	1	LS	0.00	$ 100,000.00
2	Care of Water	1	LS	0.00	$ 25,000.00
				Subtotal	**$ 125,000.00**
Structures					
3	Precast Concrete Inlet Structure	1	LS	$50,000.00	$ 50,000.00
4	Automated Mechanical Screen	1	LS	$50,000.00	$ 50,000.00
				Subtotal	**$ 100,000.00**
Pipeline					
5	Supply PVC Pipe - DR 51 600mm dia. (includes 7% for all fittings)	1200	m	$ 130.00	$ 156,000.00
6	Install PVC Pipe - DR 51 600mm dia.	1200	m	$ 100.00	$ 120,000.00
7	Supply PVC Pipe - DR 51 500mm dia. (includes 7% for all fittings)	1600	m	$ 90.00	$ 144,000.00
8	Install PVC Pipe - DR 51 500mm dia.	1600	m	$ 90.00	$ 144,000.00
9	Supply PVC Pipe - DR 51 450mm dia. (includes 7% for all fittings)	800	m	$ 75.00	$ 60,000.00
10	Install PVC Pipe - DR 51 450mm dia.	800	m	$ 80.00	$ 64,000.00
11	Pipeline Turnouts	9	LS	$ 10,000.00	$ 90,000.00
12	Pipeline Drain Out	1	LS	$ 15,000.00	$ 15,000.00
				Subtotal	**$ 793,000.00**
				Total	**$ 1,018,000.00**

Secondary A - Lateral A3 Cost Estimate

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Items					
1	Mobilization and Demobilization	1	LS	80,000.00	$ 80,000.00
2	Care of Water	1	LS	20,000.00	$ 20,000.00
				Subtotal	**$ 100,000.00**
Structures					
3	Precast Concrete Inlet Structure	1	LS	$50,000.00	$ 50,000.00
4	Automated Mechanical Screen	1	LS	$50,000.00	$ 50,000.00
				Subtotal	**$ 100,000.00**
Pipeline					
5	Supply PVC Pipe - DR 51 500mm dia. (includes 7% for all fittings)	1900	m	$ 90.00	$ 171,000.00
6	Install PVC Pipe - DR 51 500mm dia.	1900	m	$ 90.00	$ 171,000.00
7	Supply PVC Pipe - DR 51 450mm dia. (includes 7% for all fittings)	800	m	$ 75.00	$ 60,000.00
8	Install PVC Pipe - DR 51 450mm dia.	800	m	$ 80.00	$ 64,000.00
9	Pipeline Turnouts	6	LS	$ 10,000.00	$ 60,000.00
10	Pipeline Drain Out	1	LS	$ 15,000.00	$ 15,000.00
				Subtotal	**$ 541,000.00**
				Total	**$ 741,000.00**

Secondary A - Lateral A4 Cost Estimate

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Items					
1	Mobilization and Demobilization	1	LS	80,000.00	$ 80,000.00
2	Care of Water	1	LS	20,000.00	$ 20,000.00
				Subtotal	**$ 100,000.00**
Structures					
3	Precast Concrete Inlet Structure	1	LS	$50,000.00	$ 50,000.00
4	Automated Mechanical Screen	1	LS	$50,000.00	$ 50,000.00
				Subtotal	**$ 100,000.00**
Pipeline					
5	Supply PVC Pipe - DR 51 500mm dia. (includes 7% for all fittings)	1000	m	$ 90.00	$ 90,000.00
6	Install PVC Pipe - DR 51 500mm dia.	1000	m	$ 90.00	$ 90,000.00
7	Supply PVC Pipe - DR 51 450mm dia. (includes 7% for all fittings)	1600	m	$ 75.00	$ 120,000.00
8	Install PVC Pipe - DR 51 450mm dia.	1600	m	$ 80.00	$ 128,000.00
9	Pipeline Turnouts	8	LS	$ 10,000.00	$ 80,000.00
10	Pipeline Drain Out	1	LS	$ 15,000.00	$ 15,000.00
				Subtotal	**$ 523,000.00**
				Total	**$ 723,000.00**

Secondary A - Lateral A5 Cost Estimate

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Items					
1	Mobilization and Demobilization	1	LS	30,000.00	$ 30,000.00
2	Care of Water	1	LS	7,500.00	$ 7,500.00
				Subtotal	**$ 37,500.00**
Structures					
3	Precast Concrete Inlet Structure	1	LS	$50,000.00	$ 50,000.00
4	Automated Mechanical Screen	1	LS	$50,000.00	$ 50,000.00
				Subtotal	**$ 100,000.00**
Pipeline					
5	Supply PVC Pipe - DR 51 400mm dia. (includes 7% for all fittings)	800	m	$ 60.00	$ 48,000.00
6	Install PVC Pipe - DR 51 400mm dia.	800	m	$ 70.00	$ 56,000.00
7	Pipeline Turnouts	4	LS	$ 10,000.00	$ 40,000.00
8	Pipeline Drain Out	1	LS	$ 15,000.00	$ 15,000.00
				Subtotal	**$ 159,000.00**
				Total	**$ 296,500.00**

Secondary A - Lateral A7 Cost Estimate

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Items					
1	Mobilization and Demobilization	1	LS	80,000.00	$ 80,000.00
2	Care of Water	1	LS	20,000.00	$ 20,000.00
				Subtotal	**$ 100,000.00**
Structures					
3	Precast Concrete Inlet Structure	1	LS	$60,000.00	$ 60,000.00
4	Automated Mechanical Screen	1	LS	$90,000.00	$ 90,000.00
				Subtotal	**$ 150,000.00**
Pipeline					
5	Supply PVC Pipe - DR 51 750mm dia. (includes 7% for all fittings)	100	m	$ 200.00	$ 20,000.00
6	Install PVC Pipe - DR 51 750mm dia.	100	m	$ 110.00	$ 11,000.00
7	Supply PVC Pipe - DR 51 600mm dia. (includes 7% for all fittings)	1400	m	$ 130.00	$ 182,000.00
8	Install PVC Pipe - DR 51 600mm dia.	1400	m	$ 100.00	$ 140,000.00
9	Supply PVC Pipe - DR 51 350mm dia. (includes 7% for all fittings)	425	m	$ 50.00	$ 21,250.00
10	Install PVC Pipe - DR 51 350mm dia.	425	m	$ 70.00	$ 29,750.00
11	Supply PVC Pipe - DR 51 250mm dia. (includes 7% for all fittings)	800	m	$ 25.00	$ 20,000.00
12	Install PVC Pipe - DR 51 250mm dia.	800	m	$ 70.00	$ 56,000.00
13	Pipeline Turnouts	9	LS	$ 10,000.00	$ 90,000.00
14	Pipeline Drain Out	2	LS	$ 15,000.00	$ 30,000.00
				Subtotal	**$ 600,000.00**
				Total	**$ 850,000.00**

MPE Engineering Ltd.

Secondary A - Lateral A8 Cost Estimate

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Items					
1	Mobilization and Demobilization	1	LS	100,000.00	$ 100,000.00
2	Care of Water	1	LS	25,000.00	$ 25,000.00
				Subtotal	**$ 125,000.00**
Structures					
3	Precast Concrete Inlet Structure	1	LS	$60,000.00	$ 60,000.00
4	Automated Mechanical Screen	1	LS	$90,000.00	$ 90,000.00
				Subtotal	**$ 150,000.00**
Pipeline					
5	Supply PVC Pipe - DR 51 750mm dia. (includes 7% for all fittings)	1300	m	$ 200.00	$ 260,000.00
6	Install PVC Pipe - DR 51 750mm dia.	1300	m	$ 110.00	$ 143,000.00
7	Supply PVC Pipe - DR 51 600mm dia. (includes 7% for all fittings)	800	m	$ 130.00	$ 104,000.00
8	Install PVC Pipe - DR 51 600mm dia.	800	m	$ 100.00	$ 80,000.00
9	Supply PVC Pipe - DR 51 400mm dia. (includes 7% for all fittings)	800	m	$ 60.00	$ 48,000.00
10	Install PVC Pipe - DR 51 400mm dia.	800	m	$ 80.00	$ 64,000.00
11	Supply PVC Pipe - DR 51 350mm dia. (includes 7% for all fittings)	800	m	$ 50.00	$ 40,000.00
12	Install PVC Pipe - DR 51 350mm dia.	800	m	$ 70.00	$ 56,000.00
13	Pipeline Turnouts	9	LS	$ 10,000.00	$ 90,000.00
14	Pipeline Drain Out	2	LS	$ 15,000.00	$ 30,000.00
				Subtotal	**$ 915,000.00**
				Total	**$ 1,190,000.00**

Secondary A - Lateral A9 Cost Estimate

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Items					
1	Mobilization and Demobilization	1	LS	160,000.00	$ 160,000.00
2	Care of Water	1	LS	40,000.00	$ 40,000.00
				Subtotal	**$ 200,000.00**
Structures					
3	Precast Concrete Inlet Structure	1	LS	$70,000.00	$ 70,000.00
4	Automated Mechanical Screen	1	LS	$100,000.00	$ 100,000.00
				Subtotal	**$ 170,000.00**
Pipeline					
5	Supply PVC Pipe - DR 51 1050mm dia. (includes 7% for all fittings)	950	m	$ 400.00	$ 380,000.00
6	Install PVC Pipe - DR 51 1050mm dia.	950	m	$ 130.00	$ 123,500.00
7	Supply PVC Pipe - DR 51 900mm dia. (includes 7% for all fittings)	400	m	$ 285.00	$ 114,000.00
8	Install PVC Pipe - DR 51 900mm dia.	400	m	$ 120.00	$ 48,000.00
9	Supply PVC Pipe - DR 51 600mm dia. (includes 7% for all fittings)	3150	m	$ 130.00	$ 409,500.00
10	Install PVC Pipe - DR 51 600mm dia.	3150	m	$ 100.00	$ 315,000.00
11	Supply PVC Pipe - DR 51 500mm dia. (includes 7% for all fittings)	800	m	$ 90.00	$ 72,000.00
12	Install PVC Pipe - DR 51 500mm dia.	800	m	$ 90.00	$ 72,000.00
13	Supply PVC Pipe - DR 51 450mm dia. (includes 7% for all fittings)	1300	m	$ 75.00	$ 97,500.00
14	Install PVC Pipe - DR 51 450mm dia.	1300	m	$ 80.00	$ 104,000.00
15	Supply PVC Pipe - DR 51 300mm dia. (includes 7% for all fittings)	400	m	$ 36.00	$ 14,400.00
16	Install PVC Pipe - DR 51 300mm dia.	400	m	$ 70.00	$ 28,000.00
17	Supply PVC Pipe - DR 51 250mm dia. (includes 7% for all fittings)	400	m	$ 25.00	$ 10,000.00
18	Install PVC Pipe - DR 51 250mm dia.	400	m	$ 70.00	$ 28,000.00
19	Pipeline Turnouts	18	LS	$ 10,000.00	$ 180,000.00
20	Pipeline Drain Out	4	LS	$ 15,000.00	$ 60,000.00
				Subtotal	**$ 2,055,900.00**
				Total	**$ 2,425,900.00**

Secondary B Pipeline Cost Estimate
Scenarios 1-3

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Items					
1	Mobilization and Demobilization	1	LS	$ 300,000.00	$ 300,000.00
2	Care of Water	1	LS	$ 75,000.00	$ 75,000.00
				Subtotal	**$ 375,000.00**
Pipeline					
5	Supply DR 51 PVC Pipe - 1200mm dia. (includes 7% for all fittings)	1,400	m	$ 520.00	$ 728,000.00
6	Install DR 51 PVC Pipe - 1200mm dia.	1,400	m	$ 140.00	$ 196,000.00
7	Supply DR 51 PVC Pipe - 900mm dia. (includes 7% for all fittings)	900	m	$ 285.00	$ 256,500.00
8	Install DR 51 PVC Pipe - 900mm dia.	900	m	$ 120.00	$ 108,000.00
9	Supply DR 51 PVC Pipe - 750mm dia. (includes 7% for all fittings)	900	m	$ 200.00	$ 180,000.00
10	Install DR 51 PVC Pipe - 750mm dia.	900	m	$ 110.00	$ 99,000.00
11	Supply DR 51 PVC Pipe - 600mm dia. (includes 7% for all fittings)	1,200	m	$ 130.00	$ 156,000.00
12	Install DR 51 PVC Pipe - 600mm dia.	1,200	m	$ 100.00	$ 120,000.00
13	Supply DR 51 PVC Pipe - 500 mm dia. (includes 7% for all fittings)	800	m	$ 90.00	$ 72,000.00
14	Install DR 51 PVC Pipe - 500 mm dia.	800	m	$ 90.00	$ 72,000.00
15	Supply DR 51 PVC Pipe - 450mm dia. (includes 7% for all fittings)	3,400	m	$ 75.00	$ 255,000.00
16	Install DR 51 PVC Pipe - 450mm dia.	3,400	m	$ 80.00	$ 272,000.00
17	Supply DR 41 PVC Pipe - 300mm dia. (includes 7% for all fittings)	400	m	$ 36.00	$ 14,400.00
18	Install DR 41 PVC Pipe - 300mm dia.	400	m	$ 70.00	$ 28,000.00
19	Pipeline Turnouts	26	LS	$ 10,000.00	$ 260,000.00
20	Pipeline Drain Out	5	LS	$ 15,000.00	$ 75,000.00
21	Air/Vac Structure	5	LS	$ 5,000.00	$ 25,000.00
				Subtotal	**$ 2,916,900.00**
				Total	**$ 3,291,900.00**

Block 3 Secondary C Pipeline Cost Estimate
Scenario 3

DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Items					
1	Mobilization and Demobilization	1	LS	750,000.00	$ 750,000.00
2	Care of Water	1	LS	100,000.00	$ 100,000.00
				Subtotal	**$ 850,000.00**
Structures					
3	Pump Supply (1 - 400 HP with VFD, 3 - 350 HP w/ Soft Starts)	1	LS	$451,000.00	$ 451,000.00
4	Pump Installation	1	LS	$60,000.00	$ 60,000.00
5	Cast-In- Place Structure	1	LS	$100,000.00	$ 100,000.00
6	Pumphouse Structure	1	LS	$200,000.00	$ 200,000.00
7	Automated Mechanical Screen	1	LS	$150,000.00	$ 150,000.00
8	Intake Header and Piping	1	LS	$100,000.00	$ 100,000.00
8	Header including Piping and Valves	1	LS	$100,000.00	$ 100,000.00
9	Electrical and Controls	1	LS	$100,000.00	$ 100,000.00
				Subtotal	**$ 1,261,000.00**
Pipeline					
10	Supply DR 41 PVC Pipe - 1050mm dia. (includes 7% for all fittings)	600	m	$ 555.00	$ 333,000.00
11	Install DR 41 PVC Pipe - 1050mm dia.	600	m	$ 130.00	$ 78,000.00
12	Supply DR 51 PVC Pipe - 1050mm dia. (includes 7% for all fittings)	800	m	$ 400.00	$ 320,000.00
13	Install DR 51 PVC Pipe - 1050mm dia.	800	m	$ 130.00	$ 104,000.00
14	Supply DR 51 PVC Pipe - 900mm dia. (includes 7% for all fittings)	580	m	$ 285.00	$ 165,300.00
15	Install DR 51 PVC Pipe - 900mm dia.	580	m	$ 120.00	$ 69,600.00
16	Supply DR 51 PVC Pipe - 750mm dia. (includes 7% for all fittings)	4650	m	$ 200.00	$ 930,000.00
17	Install DR 51 PVC Pipe - 750mm dia.	4650	m	$ 110.00	$ 511,500.00
18	Supply DR 51 PVC Pipe - 600mm dia. (includes 7% for all fittings)	1630	m	$ 130.00	$ 211,900.00
19	Install DR 51 PVC Pipe - 600mm dia.	1630	m	$ 100.00	$ 163,000.00
20	Supply DR 51 PVC Pipe - 500 mm dia. (includes 7% for all fittings)	3260	m	$ 90.00	$ 293,400.00
21	Install DR 51 PVC Pipe - 500 mm dia.	3260	m	$ 90.00	$ 293,400.00
22	Supply DR 51 PVC Pipe - 450mm dia. (includes 7% for all fittings)	4070	m	$ 75.00	$ 305,250.00
23	Install DR 51 PVC Pipe - 450mm dia.	4070	m	$ 80.00	$ 325,600.00
24	Supply DR 51 PVC Pipe - 400mm dia. (includes 7% for all fittings)	1605	m	$ 60.00	$ 96,300.00
25	Install DR 51 PVC Pipe - 400mm dia.	1605	m	$ 80.00	$ 128,400.00
26	Supply DR 41 PVC Pipe - 350mm dia. (includes 7% for all fittings)	825	m	$ 50.00	$ 41,250.00
27	Install DR 41 PVC Pipe - 350mm dia.	825	m	$ 70.00	$ 57,750.00
26	Supply DR 41 PVC Pipe - 300mm dia. (includes 7% for all fittings)	2475	m	$ 36.00	$ 89,100.00
27	Install DR 41 PVC Pipe - 300mm dia.	2475	m	$ 70.00	$ 173,250.00
28	Supply DR 41 PVC Pipe - 250mm dia. (includes 7% for all fittings)	6265	m	$ 25.00	$ 156,625.00
29	Install DR 41 PVC Pipe - 250mm dia.	6265	m	$ 70.00	$ 438,550.00
30	Pipeline Turnouts	31	LS	$ 10,000.00	$ 310,000.00
31	Pipeline Drain Out	10	LS	$ 15,000.00	$ 150,000.00
32	Air/Vac Structure	10	LS	$ 5,000.00	$ 50,000.00
				Subtotal	**$ 5,795,175.00**
				Total	**$ 7,906,175.00**

Block 4 Pipeline Cost Estimate
Scenario 1, 2, and 3

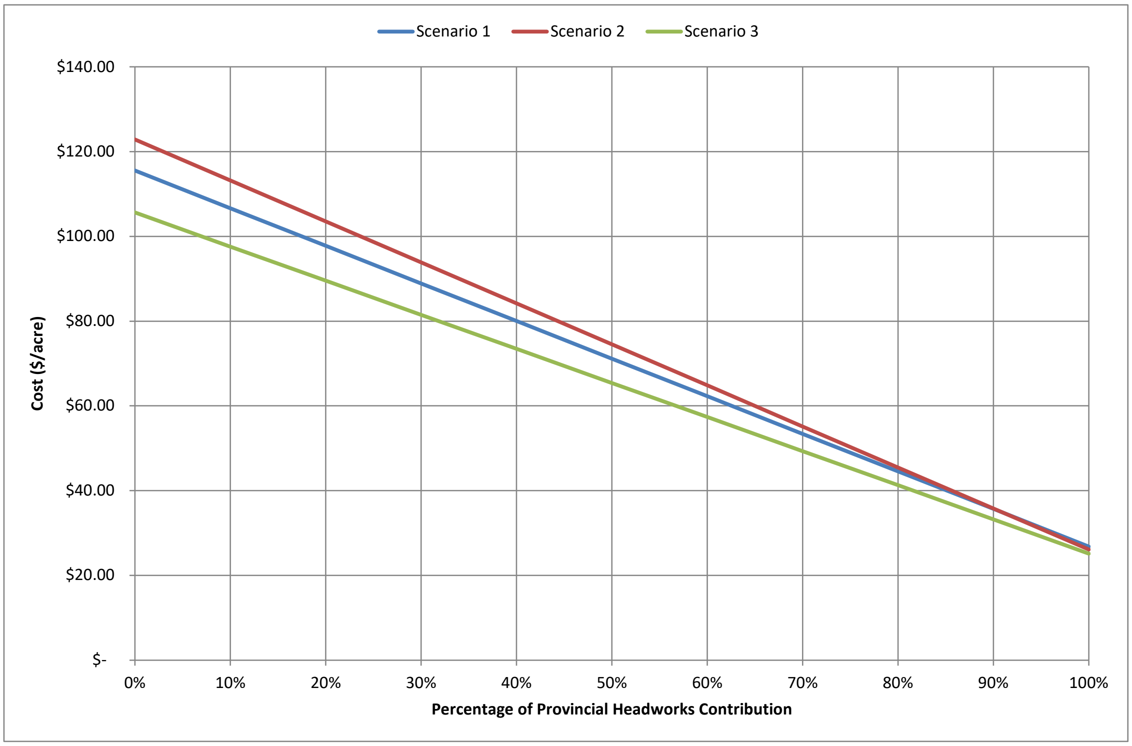
DESCRIPTION		QUANTITY	UNIT	UNIT PRICE	COST
General Items					
1	Mobilization and Demobilization	1	LS	300,000.00	$ 300,000.00
2	Care of Water	1	LS	75,000.00	$ 75,000.00
				Subtotal	**$ 375,000.00**
Structures					
3	Pump Supply (2 - 350 HP w/ Soft Start and VFD, 1 - 300 HP w/ Soft Start)	1	LS	$304,000.00	$ 304,000.00
4	Pump Installation	1	LS	$40,000.00	$ 40,000.00
5	Cast-In- Place Structure	1	LS	$150,000.00	$ 150,000.00
6	Pumphouse Structure	1	LS	$150,000.00	$ 150,000.00
7	Automated Mechanical Screen	1	LS	$100,000.00	$ 100,000.00
8	Header including Piping and Valves	1	LS	$75,000.00	$ 75,000.00
9	Electrical and Controls	1	LS	$75,000.00	$ 75,000.00
				Subtotal	**$ 894,000.00**
Pipeline					
10	Supply DR 51 PVC Pipe - 900mm dia. (includes 7% for all fittings)	620	m	$ 285.00	$ 176,700.00
11	Install DR 51 PVC Pipe - 900mm dia.	620	m	$ 130.00	$ 80,600.00
12	Supply DR 51 PVC Pipe - 750mm dia. (includes 7% for all fittings)	1305	m	$ 200.00	$ 261,000.00
13	Install DR 51 PVC Pipe - 750mm dia.	1305	m	$ 120.00	$ 156,600.00
14	Supply DR 51 PVC Pipe - 600mm dia. (includes 7% for all fittings)	3775	m	$ 130.00	$ 490,750.00
15	Install DR 51 PVC Pipe - 600mm dia.	3775	m	$ 100.00	$ 377,500.00
16	Supply DR 51 PVC Pipe - 500 mm dia. (includes 7% for all fittings)	2230	m	$ 90.00	$ 200,700.00
17	Install DR 51 PVC Pipe - 500 mm dia.	2230	m	$ 90.00	$ 200,700.00
18	Supply DR 51 PVC Pipe - 450mm dia. (includes 7% for all fittings)	870	m	$ 75.00	$ 65,250.00
19	Install DR 51 PVC Pipe - 450mm dia.	870	m	$ 80.00	$ 69,600.00
20	Supply DR 51 PVC Pipe - 400mm dia. (includes 7% for all fittings)	3080	m	$ 60.00	$ 184,800.00
21	Install DR 51 PVC Pipe - 400mm dia.	3080	m	$ 80.00	$ 246,400.00
22	Supply DR 41 PVC Pipe - 300mm dia. (includes 7% for all fittings)	3400	m	$ 36.00	$ 122,400.00
23	Install DR 41 PVC Pipe - 300mm dia.	3400	m	$ 70.00	$ 238,000.00
24	Supply DR 41 PVC Pipe - 250mm dia. (includes 7% for all fittings)	1140	m	$ 25.00	$ 28,500.00
25	Install DR 41 PVC Pipe - 250mm dia.	1140	m	$ 70.00	$ 79,800.00
26	Pipeline Turnouts	19	LS	$ 10,000.00	$ 190,000.00
27	Pipeline Drain Out	5	LS	$ 15,000.00	$ 75,000.00
28	Air/Vac Structure	5	LS	$ 5,000.00	$ 25,000.00
				Subtotal	**$ 3,269,300.00**
				Total	**$ 4,538,300.00**

Irrigation Delivery Infrastructure
Operation and Maintenance Cost Estimate Summary

	DESCRIPTION	SCENARIO 1	SCENARIO 2	SCENARIO 3
	Total Acres Irrigated	**13,500**	**22,000**	**27,000**
	Pumpstation Energy Charges			
	Red Deer River Pumpstation	$ 909,503	$ 1,769,506	$ 1,813,913
	Block 3 Pumpstation	$ -	$ -	$ 255,316
	Block 4 Pumpstation	$ 161,769	$ 161,769	$ 161,769
	Subtotal	***$ 1,071,272***	***$ 1,931,275***	***$ 2,230,997***
	Operation and Maintenance			
	Percentage of Red Deer River Pumpstation Capital Costs (3.0%)	$ 288,375	$ 359,400	$ 359,400
	O&M Costs $ 25.00 Per Acre	$ 337,500	$ 550,000	$ 675,000
	Subtotal	***$ 625,875***	***$ 909,400***	***$ 1,034,400***
	TOTAL ANNUAL OPERATION AND MAINTENANCE	**$ 1,697,000**	**$ 2,841,000**	**$ 3,265,000**
	TOTAL ANNUAL OPERATION AND MAINTENANCE/ACRE	**$ 125.70**	**$ 129.14**	**$ 120.93**
	Pressure Surcharges			
	Pressure Surcharge $ 55.00/acre	$ 137,500	$ 137,500	$ 412,500
	Remaining O&M Costs	$ 1,559,500	$ 2,703,500	$ 2,852,500
	O&M Cost Per Acre (Incl. Pressure Surcharge)	**$ 115.52**	**$ 122.89**	**$ 105.65**
	Provincial Contribution to Headworks			
	Provincial Headworks Contribution (percentage)	70%	100%	100%
	Provincial Headworks Contribution	$ 838,514	$ 2,128,906	$ 2,173,313
	Net O&M Costs for Irrigators	$ 720,986	$ 574,594	$ 679,187
	O&M Cost Per Acre (Excl. Pressure Surcharge)	**$ 53.41**	**$ 26.12**	**$ 25.16**

Effect of Provincial Contribution to Operation and Maintenance of Headworks System

	O&M Cost Per Acre		
	Scenario 1	Scenario 2	Scenario 3
0%	**$ 115.52**	**$ 122.89**	**$ 105.65**
10%	**$ 106.65**	**$ 113.21**	**$ 97.60**
20%	**$ 97.77**	**$ 103.53**	**$ 89.55**
30%	**$ 88.90**	**$ 93.86**	**$ 81.50**
40%	**$ 80.03**	**$ 84.18**	**$ 73.45**
50%	**$ 71.15**	**$ 74.50**	**$ 65.40**
60%	**$ 62.28**	**$ 64.83**	**$ 57.35**
70%	**$ 53.41**	**$ 55.15**	**$ 49.30**
80%	**$ 44.53**	**$ 45.47**	**$ 41.25**
90%	**$ 35.66**	**$ 35.79**	**$ 33.20**
100%	**$ 26.79**	**$ 26.12**	**$ 25.16**



APPENDIX C

ECONOMIC ANALYSIS TABLES

Table C-1. Economic Crop Budgets for Existing Dryland Crop Production in Acadia Valley $2019

ITEM	All Wheat	Canola	Barley	Peas	Lentils	WEIGHTED AVEAGE	
						per Acre	per Hectare
WEIGHTS (Crop Mix)	**47%**	**30%**	**9%**	**11%**	**3%**		
REVENUE/Acre:							
Yield/Acre (bu or lb.)	40	32	55	36	1232		
Product Price	6.20	10.50	4.75	7.00	0.19		
GROSS REVENUE (A)	**248**	**336**	**261.25**	**252**	**234.08**	**275.61**	**680.77**
VARIABLE COSTS/Acre:							
Seed	25.67	53.00	21.25	41.55	36.00		
Fertilizer	44.50	63.00	55.25	19.00	15.00		
Chemical	46.86	31.35	32.98	40.15	65.35		
Hail/Crop Insurance	16.76	22.78	14.98	21.77	28.27		
Trucking/Marketing	13.84	8.96	15.26	15.83	9.11		
Fuel/Oil/Lube	14.56	16.49	13.94	14.81	12.27		
Machinery Repairs	13.19	8.33	8.59	11.20	8.33		
Building Repairs	1.82	1.56	1.04	2.34	2.86		
Custom Work	3.06	6.12	3.32	2.04	2.04		
Paid Labour*	7.07	6.90	4.35	1.54	1.28		
Utilities & Misc.	9.88	8.96	8.96	8.96	6.71		
Operating Interest	5.91	5.09	5.53	5.09	5.88		
TOTAL VARIABLE COSTS (B)	**203.12**	**232.54**	**185.45**	**184.28**	**193.10**	**207.98**	**513.72**
FIXED COSTS/Acre:							
Land Taxes, Licenses, Insurance	10.00	10.00	10.00	10.00	10.00		
TOTAL FIXED COSTS [C]	**10.00**	**10.00**	**10.00**	**10.00**	**10.00**	**10.00**	**24.70**
GROSS MARGIN (A-B-C)**	**34.88**	**93.46**	**65.80**	**57.72**	**30.98**	**57.63**	**142.35**

* Adjusted to exclude unpaid labour/acre = $12.

** Payment to land, labour, capital, and management. Value-added.

Area and yields based on AFSC insured acreage, Risk Area 9, 2018. Source: Yield Alberta 2019; **Alberta Farmer Express**, February 2019.

Product prices and costs-of-production for Brown Soils taken directly from 2019 Cropping Alternatives Report, **AgriProfit$ Business Analysis**, AAF, 2019.

Table C-2. Economic Crop Budgets for Projected Irrigated Crop Production in Acadia Valley **$2019**

ITEM	All Wheat*	Barley/Other Cereals	Alfalfa/Other Hay	Cereal Silage	Canola	Canola/Alfalfa Seed	Dry Beans/Peas	Hemp Seed	Lentil/Chickpea	Potato/Other	WEIGHTED AVEAGE	
											per Acre	per Hectare
WEIGHTS (Crop Mix)	**26.3%**	**4.9%**	**14.8%**	**7.3%**	**14.3%**	**4.4%**	**13.1%**	**3.1%**	**2.3%**	**9.6%**		
REVENUE/Acre:												
Yield/Acre (bu, t, lb, or cwt)	104	125	4.00	11.38	58	58	2459	1678	2000	298		
Product Price	6.09	4.73	100.00	50.00	10.50	15.75	0.35	0.74	0.28	11.66		
GROSS REVENUE (A)	**633**	**591**	**400**	**569**	**609**	**914**	**861**	**1242**	**560**	**3475**	**919.44**	**2271.02**
VARIABLE COSTS/Acre:												
Seed	26.75	26.57	18.38	21.25	72.88	72.88	49.51	65.32	45.36	385.20		
Fertilizer	88.50	81.00	27.00	85.00	108.50	108.50	83.50	57.19	15.23	292.71		
Chemical	52.97	38.83	2.10	14.83	37.60	37.60	43.70	32.52	59.36	259.51		
Hail/Crop Insurance	15.52	13.88			21.63	21.63	45.58	56.49	32.06	114.01		
Trucking/Marketing	36.51	35.99	97.29	36.4	17.32	17.32	26.17	13.80	26.17	190.75		
Fuel/Oil/Lube	26.62	30.32	45.34	33.61	30.46	30.46	45.88	32.62	18.35	56.77		
Machinery Repairs	28.71	29.51	35.42	19.27	30.21	30.21	65.10	17.88	10.81	448.42		
Building Repairs	2.08	2.08	1.04	1.04	2.08	2.08	4.43	7.17	4.43			
Irrigation: Pumping	44.94	40.82	54.40	41.83	41.48	41.48	40.59	49.92	43.40	78.27	48.00	
Custom Work	8.68	12.51	8.17	33.68	7.15	7.15	30.11	33.46		144.00		
Paid Labour**	19.48	22.73	22.73	23.75	19.67	19.67	57.98	13.34		400.00		
Utilities & Misc.	13.46	13.46	28.73	17.91	13.46	13.46	17.91	26.64	9.20	213.52		
Operating Interest	8.50	6.92	2.40	6.11	11.06	11.06	8.92	10.58	4.91	64.03		
TOTAL VARIABLE COSTS (B)	**372.72**	**354.62**	**343.00**	**334.68**	**413.50**	**413.5**	**519.38**	**416.93**	**269.28**	**2647.19**	**607.88**	**1501.48**
FIXED COSTS/Acre:												
Land Taxes, Licenses, Insurance	51.91	51.91	35.44	35.44	51.91	54.32	54.32	54.32	54.32	54.32		
TOTAL FIXED COSTS [C]	**51.91**	**51.91**	**35.44**	**35.44**	**51.91**	**54.32**	**54.32**	**54.32**	**54.32**	**54.32**	**49.06**	**121.18**
GROSS MARGIN (A-B-C)* **	**208.73**	**184.72**	**21.56**	**198.88**	**143.59**	**445.68**	**286.95**	**770.47**	**236.40**	**773.17**	**262.50**	**648.37**

* HRS. durum, soft, and winter wheat.

** Wheat thru canola: Alberta data less unpaid = $12.

*** Payment to land, labour, capital, and management. Value-added.

Sources: Crop Mix: Data for the SMRID, 2017. See: **Alberta Irrigation Information**, AAF/GOA, 2018.

Product prices and costs-of-production for Irrigated Soils taken directly from 2019 Cropping Alternatives Report, **AgriProfit$ Business Analysis,** AAF, 2019.

Basic data for hemp is taken directly from **Industrial Hemp Seed Production Costs and Returns in Alberta, 2015**, AAF, November 2016.

Data for Red Lentil drawn from **Irrigation Economics and Agronomics, 2017**, Irrigation Crop Diversification Corporation (ICDC), Saskatchewan, 2017.

Data for Potatoes drawn from **Irrigated Processing Potato Cost of Production, 2018**, Ministry of Agriculture, Manitoba, 2018.

Table C-3. Discounted Cash Flow Analysis, MD Acadia Irrigation Development Scenario 1 (13,500 acres)

$ Thousands 2019

Project Year	INCREMENTAL COSTS Project Capital+Engineering	Pumps, Pipeline, Dist. & Reservoirs O&M	Main Pump Energy Costs	Block 4 Incre. Pump Energy Costs (2500 acres)*	On-Farm Irrigation Equip. Capital	Add. On-Farm Capital (excl	On-Farm Irrigation Energy+O&M	Add.Farm Production Costs-Crops	Add.Farm Production Costs-Livestock	Other Incre. Costs	TOTAL INCRE-MENTAL COSTS	INCREMENTAL BENEFITS Gross Incr. Farm Crop Income	Gross Incr. Farm Livestock Income	Stock Water	Recreat-ion	Drought Mitigation	TOTAL INCRE-MENTAL BENEFITS	NET CASH FLOW	Area Irrigation Acres	Irrig. Dev. Rate
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	26252	0	0	0	0	0	0	0	0	0	26252	0	0	0	0	0	0	-26252		
2	26252	0	0	0	0	0	0	0	0	0	26252	0	0	0	0	0	0	-26252		
3	26252	0	0	0	0	0	0	0	0	0	26252	0	0	0	0	0	0	-26252		
4	0	153	222.3	10.2	3283.5	1742.4	158.4	1131.8	128.9	0	6830	2124.6	171.9	16.3	11.6	22.0	2346	-4484	3300	3300
5	0	306	444.6	20.4	3283.5	1742.4	316.8	2263.5	257.8	0	8635	4249.3	343.7	32.5	23.6	44.0	4693	-3942	6600	3300
6	0	459	667.0	30.6	3283.5	1742.4	475.2	3395.3	386.7	0	10440	6373.9	515.6	48.8	35.9	66.0	7040	-3399	9900	3300
7	0	612	889.3	40.8	3283.5	1742.4	633.6	4527.1	515.6	0	12244	8498.6	687.5	65.1	48.6	88.0	9388	-2857	13200	3300
8	0	626	909.5	41.8	298.5	158.4	648.0	4630.0	527.3	0	7839	8691.7	703.1	66.6	50.4	90.0	9602	1762	13500	300
9	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	51.1	90.0	9602	2220	13500	
10	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	51.8	90.0	9603	2221	13500	
11	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	52.5	90.0	9604	2221	13500	
12	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	53.3	90.0	9605	2222	13500	
13	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	54.0	90.0	9605	2223	13500	
14	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	54.8	90.0	9606	2224	13500	
15	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	55.5	90.0	9607	2224	13500	
16	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	56.3	90.0	9608	2225	13500	
17	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	57.1	90.0	9608	2226	13500	
18	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	57.9	90.0	9609	2227	13500	
19	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	58.7	90.0	9610	2228	13500	
20	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	59.5	90.0	9611	2228	13500	
21	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	60.4	90.0	9612	2229	13500	
22	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	61.2	90.0	9613	2230	13500	
23	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	62.1	90.0	9613	2231	13500	
24	0	626	909.5	41.8	0	1742.4	648.0	4630.0	527.3	0	9125	8691.7	703.1	66.6	62.9	90.0	9614	489	13500	
25	0	626	909.5	41.8	0	1742.4	648.0	4630.0	527.3	0	9125	8691.7	703.1	66.6	63.8	90.0	9615	490	13500	
26	0	626	909.5	41.8	0	1742.4	648.0	4630.0	527.3	0	9125	8691.7	703.1	66.6	64.7	90.0	9616	491	13500	
27	0	626	909.5	41.8	0	1742.4	648.0	4630.0	527.3	0	9125	8691.7	703.1	66.6	65.6	90.0	9617	492	13500	
28	0	626	909.5	41.8	0	158.4	648.0	4630.0	527.3	0	7541	8691.7	703.1	66.6	66.5	90.0	9618	2077	13500	
29	0	626	909.5	41.8	3283.5	0	648.0	4630.0	527.3	0	10666	8691.7	703.1	66.6	67.5	90.0	9619	-1047	13500	
30	0	626	909.5	41.8	3283.5	0	648.0	4630.0	527.3	0	10666	8691.7	703.1	66.6	68.4	90.0	9620	-1046	13500	
31	0	626	909.5	41.8	3283.5	0	648.0	4630.0	527.3	0	10666	8691.7	703.1	66.6	69.4	90.0	9621	-1045	13500	
32	0	626	909.5	41.8	3283.5	0	648.0	4630.0	527.3	0	10666	8691.7	703.1	66.6	70.3	90.0	9622	-1044	13500	
33	0	626	909.5	41.8	298.5	0	648.0	4630.0	527.3	0	7681	8691.7	703.1	66.6	71.3	90.0	9623	1942	13500	
34	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	72.3	90.0	9624	2241	13500	
35	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	73.3	90.0	9625	2242	13500	
36	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	74.4	90.0	9626	2243	13500	
37	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	75.4	90.0	9627	2244	13500	
38	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	76.5	90.0	9628	2245	13500	
39	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	77.5	90.0	9629	2246	13500	
40	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	78.6	90.0	9630	2248	13500	
41	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	79.7	90.0	9631	2249	13500	
42	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	80.8	90.0	9632	2250	13500	
43	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	82.0	90.0	9633	2251	13500	
44	0	626	909.5	41.8	0	1742.4	648.0	4630.0	527.3	0	9125	8691.7	703.1	66.6	83.1	90.0	9634	510	13500	
45	0	626	909.5	41.8	0	1742.4	648.0	4630.0	527.3	0	9125	8691.7	703.1	66.6	84.3	90.0	9636	511	13500	
46	0	626	909.5	41.8	0	1742.4	648.0	4630.0	527.3	0	9125	8691.7	703.1	66.6	85.4	90.0	9637	512	13500	
47	0	626	909.5	41.8	0	1742.4	648.0	4630.0	527.3	0	9125	8691.7	703.1	66.6	86.6	90.0	9638	513	13500	
48	0	626	909.5	41.8	0	158.4	648.0	4630.0	527.3	0	7541	8691.7	703.1	66.6	87.9	90.0	9639	2098	13500	
49	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	89.1	90.0	9640	2258	13500	
50	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	90.3	90.0	9642	2259	13500	
51	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	91.6	90.0	9643	2261	13500	
52	0	626	909.5	41.8	0	0	648.0	4630.0	527.3	0	7382	8691.7	703.1	66.6	92.9	90.0	9644	2262	13500	
53	-39377.5	626	909.5	41.8	-585.1	-4474.8	648.0	4630.0	527.3	0	-37055	8691.7	703.1	66.6	94.2	90.0	9646	46700	13500	
PV 0%	39378	30321	44060	2024	26280	16909	31392	224296	25545	0	440205	421065	34060	3224	3343	4362	466054	25849		
PV:																				
2%	$61,921	$17,647	$25,643	$1,178	$19,168	$12,011	$18,270	$130,537	$14,867	$0	$301,241	$245,055	$19,823	$1,876	$1,844	$2,539	$271,136	($30,105)		
4%	$67,925	$11,144	$16,193	$744	$14,797	$8,993	$11,537	$82,432	$9,388	$0	$223,152	$154,747	$12,518	$1,185	$1,108	$1,603	$171,161	($51,991)		
6%	$68,376	$7,543	$10,960	$503	$11,983	$7,079	$7,809	$55,795	$6,355	$0	$176,402	$104,742	$8,473	$802	$718	$1,085	$115,820	($60,582)		

Discount Rate	B/C Ratio	NPV ($,000)	IRR
2%	0.90	($30,105)	
4%	0.77	($51,991)	0.70%
6%	0.66	($60,582)	
0%	1.06	$25,849	

* Pressurized system cost of $64.71/acre less irrigated crop budget est. of $48/acre = $16.71/acre/year.

2019 COST ESTIMATES:

Col.1.	Project Construction ($,000)	78755	
Col.2	O&M/year ($,000) + $25/acre	288.4	
Col.3	Diversion Pumping-Energy $,000/yr.	909.5	
Col. 4	Block 4 Pumping-Incre. Energy $,000/yr.	41.8	
Col. 5	Irrigation Equip. $/acre	995	
Col. 6	Other Farm Equip. $/acre	528	
Col.7	Irrigation O&M $/acre/year	48	
Col.8	Annual Incr. Crop. Prod. Costs/acre	390.96	net of Col. (7)
Col.9	Annual Incre. Livestock Prod. Costs/acre	39.06	
Col.10	Other	0	

2019 BENEFIT ESTIMATES:

Col. 12	Annual Incre. Crop Revenue/acre	643.83
Col. 13	Annual Incre. Live.Revenue/acre	52.08
Col. 14	Stockwater/acre	4.93
Col. 15	Recreation/acre (+1.4%/yr.)	3.53
Col. 16	Drought Mitigation/acre	6.67

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MD Acadia B-C Simulatiions, October 2019

Table C-4. Discounted Cash Flow Analysis, MD Acadia Irrigation Development Scenario 2 (22,000 acres)

$ Thousands 2019

Project Year	INCREMENTAL COSTS											INCREMENTAL BENEFITS						NET CASH FLOW	Area Irrigation Acres	Irrig. Dev. Rate
	Project Capital+Eng-ineering	Pumps, Pipeline, Dist. & Reservoirs O&M	Main Pump Energy Costs	Block 4 Incre. Pump Energy Costs (2500 acres)*	On-Farm Irrigation Equip.	Add. On-Farm Capital	On-Farm Irrigation Energy+O&M	Add.Farm Production Costs-Crops	Add.Farm Production Costs-Livestock	Other Incre. Costs	TOTAL INCRE-MENTAL COSTS	Gross Incr. Farm Crop Income	Gross Incr. Farm Livestock Income	Stock Water	Recreat-ion	Drought Mitigation	TOTAL INCRE-MENTAL BENEFITS			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	37953	0	0	0	0	0	0	0	0	0	**37953**	0	0	0	0	0	**0**	**-37953**		
2	37953	0	0	0	0	0	0	0	0	0	**37953**	0	0	0	0	0	**0**	**-37953**		
3	37953	0	0	0	0	0	0	0	0	0	**37953**	0	0	0	0	0	**0**	**-37953**		
4	0	136	265.4	6.3	3283.5	1742.4	158.4	1131.8	128.9	0	**6853**	2124.6	171.9	16.3	11.6	22.0	**2346**	**-4507**	3300	3300
5	0	273	530.9	12.5	3283.5	1742.4	316.8	2263.5	257.8	0	**8680**	4249.3	343.7	32.5	23.6	44.0	**4693**	**-3987**	6600	3300
6	0	409	796.3	18.8	3283.5	1742.4	475.2	3395.3	386.7	0	**10507**	6373.9	515.6	48.8	35.9	66.0	**7040**	**-3467**	9900	3300
7	0	546	1061.7	25.1	3283.5	1742.4	633.6	4527.1	515.6	0	**12335**	8498.6	687.5	65.1	48.6	88.0	**9388**	**-2947**	13200	3300
8	0	682	1327.1	31.4	3283.5	1742.4	792.0	5658.8	644.5	0	**14162**	10623.2	859.3	81.3	61.6	110.1	**11735**	**-2426**	16500	3300
9	0	818	1592.6	37.6	3283.5	1742.4	950.4	6790.6	773.4	0	**15989**	12747.8	1031.2	97.6	74.9	132.1	**14084**	**-1905**	19800	3300
10	0	909	1769.5	41.8	2189.0	1161.6	1056.0	7545.1	859.3	0	**15532**	14164.3	1145.8	108.5	84.4	146.7	**15650**	**118**	22000	2200
11	0	909	1769.5	41.8	0.0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	85.6	146.7	**15651**	**3470**	22000	
12	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	86.8	146.7	**15652**	**3471**	22000	
13	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	88.0	146.7	**15653**	**3472**	22000	
14	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	89.2	146.7	**15654**	**3473**	22000	
15	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	90.5	146.7	**15656**	**3475**	22000	
16	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	91.8	146.7	**15657**	**3476**	22000	
17	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	93.0	146.7	**15658**	**3477**	22000	
18	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	94.3	146.7	**15660**	**3478**	22000	
19	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	95.7	146.7	**15661**	**3480**	22000	
20	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	97.0	146.7	**15662**	**3481**	22000	
21	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	98.4	146.7	**15664**	**3482**	22000	
22	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	99.7	146.7	**15665**	**3484**	22000	
23	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	101.1	146.7	**15666**	**3485**	22000	
24	0	909	1769.5	41.8	0	1742.4	1056.0	7545.1	859.3	0	**13924**	14164.3	1145.8	108.5	102.6	146.7	**15668**	**1744**	22000	
25	0	909	1769.5	41.8	0	1742.4	1056.0	7545.1	859.3	0	**13924**	14164.3	1145.8	108.5	104.0	146.7	**15669**	**1746**	22000	
26	0	909	1769.5	41.8	0	1742.4	1056.0	7545.1	859.3	0	**13924**	14164.3	1145.8	108.5	105.4	146.7	**15671**	**1747**	22000	
27	0	909	1769.5	41.8	0	1742.4	1056.0	7545.1	859.3	0	**13924**	14164.3	1145.8	108.5	106.9	146.7	**15672**	**1749**	22000	
28	0	909	1769.5	41.8	0	1742.4	1056.0	7545.1	859.3	0	**13924**	14164.3	1145.8	108.5	108.4	146.7	**15674**	**1750**	22000	
29	0	909	1769.5	41.8	3283.5	1742.4	1056.0	7545.1	859.3	0	**17207**	14164.3	1145.8	108.5	109.9	146.7	**15675**	**-1532**	22000	
30	0	909	1769.5	41.8	3283.5	1161.6	1056.0	7545.1	859.3	0	**16626**	14164.3	1145.8	108.5	111.5	146.7	**15677**	**-950**	22000	
31	0	909	1769.5	41.8	3283.5	0	1056.0	7545.1	859.3	0	**15465**	14164.3	1145.8	108.5	113.0	146.7	**15678**	**214**	22000	
32	0	909	1769.5	41.8	3283.5	0	1056.0	7545.1	859.3	0	**15465**	14164.3	1145.8	108.5	114.6	146.7	**15680**	**215**	22000	
33	0	909	1769.5	41.8	3283.5	0	1056.0	7545.1	859.3	0	**15465**	14164.3	1145.8	108.5	116.2	146.7	**15681**	**217**	22000	
34	0	909	1769.5	41.8	3283.5	0	1056.0	7545.1	859.3	0	**15465**	14164.3	1145.8	108.5	117.9	146.7	**15683**	**218**	22000	
35	0	909	1769.5	41.8	2189.0	0	1056.0	7545.1	859.3	0	**14370**	14164.3	1145.8	108.5	119.5	146.7	**15685**	**1315**	22000	
36	0	909	1769.5	41.8	0.0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	121.2	146.7	**15686**	**3505**	22000	
37	0	909	1769.5	41.8	0.0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	122.9	146.7	**15688**	**3507**	22000	
38	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	124.6	146.7	**15690**	**3509**	22000	
39	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	126.3	146.7	**15692**	**3510**	22000	
40	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	128.1	146.7	**15693**	**3512**	22000	
41	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	129.9	146.7	**15695**	**3514**	22000	
42	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	131.7	146.7	**15697**	**3516**	22000	
43	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	133.6	146.7	**15699**	**3518**	22000	
44	0	909	1769.5	41.8	0	1742.4	1056.0	7545.1	859.3	0	**13924**	14164.3	1145.8	108.5	135.4	146.7	**15701**	**1777**	22000	
45	0	909	1769.5	41.8	0	1742.4	1056.0	7545.1	859.3	0	**13924**	14164.3	1145.8	108.5	137.3	146.7	**15703**	**1779**	22000	
46	0	909	1769.5	41.8	0	1742.4	1056.0	7545.1	859.3	0	**13924**	14164.3	1145.8	108.5	139.2	146.7	**15704**	**1781**	22000	
47	0	909	1769.5	41.8	0	1742.4	1056.0	7545.1	859.3	0	**13924**	14164.3	1145.8	108.5	141.2	146.7	**15706**	**1783**	22000	
48	0	909	1769.5	41.8	0	1742.4	1056.0	7545.1	859.3	0	**13924**	14164.3	1145.8	108.5	143.2	146.7	**15708**	**1785**	22000	
49	0	909	1769.5	41.8	0	1742.4	1056.0	7545.1	859.3	0	**13924**	14164.3	1145.8	108.5	145.2	146.7	**15710**	**1787**	22000	
50	0	909	1769.5	41.8	0	1162	1056.0	7545.1	859.3	0	**13343**	14164.3	1145.8	108.5	147.2	146.7	**15712**	**2370**	22000	
51	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	149.3	146.7	**15714**	**3533**	22000	
52	0	909	1769.5	41.8	0	0	1056.0	7545.1	859.3	0	**12181**	14164.3	1145.8	108.5	151.4	146.7	**15717**	**3535**	22000	
53	-56930	909	1769.5	41.8	-2583.02	-8044.08	1056.0	7545.1	859.3	0	**-55376**	14164.3	1145.8	108.5	153.5	146.7	**15719**	**71095**	22000	
PV 0%	56930	42878	83432	1971	41197	26804	49790	355752	40517	0	**699272**	667845	54023	5114	5343	6919	**739243**	**39972**		
PV:																				
2%	$89,522	$24,607	$47,880	$1,131	$29,882	$18,761	$28,573	$204,158	$23,252	$0	**$467,765**	$383,260	$31,002	$2,935	$2,913	$3,971	**$424,080**	**($43,684)**		
4%	$98,202	$15,282	$29,735	$702	$22,752	$13,817	$17,745	$126,789	$14,440	$0	**$339,465**	$238,017	$19,253	$1,823	$1,725	$2,466	**$263,284**	**($76,181)**		
6%	$98,855	$10,156	$19,761	$467	$18,105	$10,684	$11,793	$84,262	$9,597	$0	**$263,680**	$158,184	$12,796	$1,211	$1,099	$1,639	**$174,929**	**($88,751)**		

Discount Rate	B/C Ratio	NPV ($,000)	IRR
2%	0.91	($43,684)	
4%	0.78	($76,181)	0.73%
6%	0.66	($88,751)	
0%	1.06	$39,972	

* Pressurized system cost of $64.71/acre less irrigated crop budget est. of $48/acre = $16.71/acre/year.

2019 COST ESTIMATES:

Col.1.	Project Construction ($,000)	113860	
Col.2	O&M/year ($,000) + $25/acre	359.4	
Col.3	Diversion Pumping-Energy $,000/yr.	1769.5	
Col. 4	Block 4 Pumping-Incre. Energy $,000/yr.	41.8	
Col. 5	Irrigation Equip. $/acre	995	
Col. 6	Other Farm Equip. $/acre	528	
Col.7	Irrigation O&M $/acre/year	48	
Col.8	Annual Crop. Prod. Costs/acre	390.96	(net of Col. (7)
Col.9	Annual Livestock Prod. Costs/acre	39.06	
Col.10	Other	0	

2019 BENEFIT ESTIMATES:

Col. 12	re. Crop Revenue/acre	643.83
Col. 13	re. Live.Revenue/acre	52.08
Col. 14	ckwater/acre	4.93
Col. 15	on/acre (+1.4%/yr.)	3.53
Col. 16	t Mitigation/acre	6.67

Marv Anderson & Associates Ltd.
MD Acadia B-C Simulatiions, October 2019

Table C-5. Discounted Cash Flow Analysis, MD Acadia Irrigation Development Scenario 3 (27,000 acres)

$ Thousands 2019

Project Year	INCREMENTAL COSTS											INCREMENTAL BENEFITS						NET CASH FLOW	Area Irrigation Acres	Irrig. Dev. Rate
	Project Capital+Eng-ineering	Pumps, Pipeline, Dist. & Reservoirs O&M	Main Pump Energy Costs	Block 4 & Block 3 Incre. Pump Energy Costs *	On-Farm Irrigation Equip. Capital	Add. On-Farm Capital (excl. irrig. equip.)	On-Farm Irrigation Energy+O&M	Add.Farm Production Costs-Crops	Add.Farm Production Costs-Livestock	Other Incre. Costs	TOTAL INCRE-MENTAL COSTS	Gross Incr. Farm Crop Income	Gross Incr. Farm Livestock Income	Stock Water	Recreat-ion	Drought Mitigation	TOTAL INCRE-MENTAL BENEFITS			
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
1	45872	0	0	0	0	0	0	0	0	0	**45872**	0	0	0	0	0	**0**	**-45872**		
2	45872	0	0	0	0	0	0	0	0	0	**45872**	0	0	0	0	0	**0**	**-45872**		
3	45872	0	0	0	0	0	0	0	0	0	**45872**	0	0	0	0	0	**0**	**-45872**		
4	0	126	221.7	7.0	3283.5	1742.4	158.4	1131.8	128.9	0	**6800**	2124.6	171.9	16.3	11.6	22.0	**2346**	**-4454**	3300	3300
5	0	253	443.4	14.0	3283.5	1742.4	316.8	2263.5	257.8	0	**8574**	4249.3	343.7	32.5	23.6	44.0	**4693**	**-3881**	6600	3300
6	0	379	665.1	20.9	3283.5	1742.4	475.2	3395.3	386.7	0	**10348**	6373.9	515.6	48.8	35.9	66.0	**7040**	**-3308**	9900	3300
7	0	506	886.8	27.9	3283.5	1742.4	633.6	4527.1	515.6	0	**12123**	8498.6	687.5	65.1	48.6	88.0	**9388**	**-2735**	13200	3300
8	0	632	1108.5	34.9	3283.5	1742.4	792.0	5658.8	644.5	0	**13897**	10623.2	859.3	81.3	61.6	110.1	**11735**	**-2161**	16500	3300
9	0	759	1330.2	41.9	3283.5	1742.4	950.4	6790.6	773.4	0	**15671**	12747.8	1031.2	97.6	74.9	132.1	**14084**	**-1587**	19800	3300
10	0	885	1551.9	48.9	3283.5	1742.4	1108.8	7922.4	902.3	0	**17445**	14872.5	1203.0	113.9	88.6	154.1	**16432**	**-1013**	23100	3300
11	0	1011	1773.6	55.8	3283.5	1742.4	1267.2	9054.1	1031.2	0	**19219**	16997.1	1374.9	130.2	102.7	176.1	**18781**	**-438**	26400	3300
12	0	1034	1813.9	57.1	597.0	316.8	1296.0	9259.9	1054.6	0	**15430**	17383.4	1406.2	133.1	106.5	180.1	**19209**	**3780**	27000	600
13	0	1034	1813.9	57.1	0	0	1176.0	9259.9	1054.6	0	**14396**	17383.4	1406.2	133.1	108.0	180.1	**19211**	**4815**	27000	
14	0	1034	1813.9	57.1	0	0	1176.0	9259.9	1054.6	0	**14396**	17383.4	1406.2	133.1	109.5	180.1	**19212**	**4816**	27000	
15	0	1034	1813.9	57.1	0	0	1176.0	9259.9	1054.6	0	**14396**	17383.4	1406.2	133.1	111.1	180.1	**19214**	**4818**	27000	
16	0	1034	1813.9	57.1	0	0	1176.0	9259.9	1054.6	0	**14396**	17383.4	1406.2	133.1	112.6	180.1	**19215**	**4819**	27000	
17	0	1034	1813.9	57.1	0	0	1176.0	9259.9	1054.6	0	**14396**	17383.4	1406.2	133.1	114.2	180.1	**19217**	**4821**	27000	
18	0	1034	1813.9	57.1	0	0	1176.0	9259.9	1054.6	0	**14396**	17383.4	1406.2	133.1	115.8	180.1	**19219**	**4823**	27000	
19	0	1034	1813.9	57.1	0	0	1176.0	9259.9	1054.6	0	**14396**	17383.4	1406.2	133.1	117.4	180.1	**19220**	**4824**	27000	
20	0	1034	1813.9	57.1	0	0	1176.0	9259.9	1054.6	0	**14396**	17383.4	1406.2	133.1	119.1	180.1	**19222**	**4826**	27000	
21	0	1034	1813.9	57.1	0	0	1176.0	9259.9	1054.6	0	**14396**	17383.4	1406.2	133.1	120.7	180.1	**19223**	**4828**	27000	
22	0	1034	1813.9	57.1	0	0	1176.0	9259.9	1054.6	0	**14396**	17383.4	1406.2	133.1	122.4	180.1	**19225**	**4829**	27000	
23	0	1034	1813.9	57.1	0	0	1176.0	9259.9	1054.6	0	**14396**	17383.4	1406.2	133.1	124.1	180.1	**19227**	**4831**	27000	
24	0	1034	1813.9	57.1	0	1742.4	1176.0	9259.9	1054.6	0	**16138**	17383.4	1406.2	133.1	125.9	180.1	**19229**	**3090**	27000	
25	0	1034	1813.9	57.1	0	1742.4	1176.0	9259.9	1054.6	0	**16138**	17383.4	1406.2	133.1	127.6	180.1	**19230**	**3092**	27000	
26	0	1034	1813.9	57.1	0	1742.4	1176.0	9259.9	1054.6	0	**16138**	17383.4	1406.2	133.1	129.4	180.1	**19232**	**3094**	27000	
27	0	1034	1813.9	57.1	0	1742.4	1176.0	9259.9	1054.6	0	**16138**	17383.4	1406.2	133.1	131.2	180.1	**19234**	**3096**	27000	
28	0	1034	1813.9	57.1	0	1742.4	1176.0	9259.9	1054.6	0	**16138**	17383.4	1406.2	133.1	133.1	180.1	**19236**	**3097**	27000	
29	0	1034	1813.9	57.1	3283.5	1742.4	1176.0	9259.9	1054.6	0	**19422**	17383.4	1406.2	133.1	134.9	180.1	**19238**	**-184**	27000	
30	0	1034	1813.9	57.1	3283.5	1742.4	1176.0	9259.9	1054.6	0	**19422**	17383.4	1406.2	133.1	136.8	180.1	**19240**	**-182**	27000	
31	0	1034	1813.9	57.1	3283.5	1742.4	1176.0	9259.9	1054.6	0	**19422**	17383.4	1406.2	133.1	138.7	180.1	**19241**	**-180**	27000	
32	0	1034	1813.9	57.1	3283.5	316.8	1176.0	9259.9	1054.6	0	**17996**	17383.4	1406.2	133.1	140.7	180.1	**19243**	**1247**	27000	
33	0	1034	1813.9	57.1	3283.5	0	1176.0	9259.9	1054.6	0	**17679**	17383.4	1406.2	133.1	142.6	180.1	**19245**	**1566**	27000	
34	0	1034	1813.9	57.1	3283.5	0	1176.0	9259.9	1054.6	0	**17679**	17383.4	1406.2	133.1	144.6	180.1	**19247**	**1568**	27000	
35	0	1034	1813.9	57.1	3283.5	0	1176.0	9259.9	1054.6	0	**17679**	17383.4	1406.2	133.1	146.7	180.1	**19249**	**1570**	27000	
36	0	1034	1813.9	57.1	3283.5	0	1176.0	9259.9	1054.6	0	**17679**	17383.4	1406.2	133.1	148.7	180.1	**19251**	**1572**	27000	
37	0	1034	1813.9	57.1	597.0	0	1176.0	9259.9	1054.6	0	**14993**	17383.4	1406.2	133.1	150.8	180.1	**19254**	**4261**	27000	
38	0	1034	1813.9	57.1	0.0	0	1176.0	9259.9	1054.6	0	**14396**	17383.4	1406.2	133.1	152.9	180.1	**19256**	**4860**	27000	
39	0	1034	1813.9	57.1	0	0	1176.0	9259.9	1054.6	0	**14396**	17383.4	1406.2	133.1	155.0	180.1	**19258**	**4862**	27000	
40	0	1034	1813.9	57.1	0	0	1176.0	9259.9	1054.6	0	**14396**	17383.4	1406.2	133.1	157.2	180.1	**19260**	**4864**	27000	
41	0	1034	1813.9	57.1	0	0	1176.0	9259.9	1054.6	0	**14396**	17383.4	1406.2	133.1	159.4	180.1	**19262**	**4866**	27000	
42	0	1034	1813.9	57.1	0	0	1176.0	9259.9	1054.6	0	**14396**	17383.4	1406.2	133.1	161.7	180.1	**19264**	**4868**	27000	
43	0	1034	1813.9	57.1	0	0	1176.0	9259.9	1054.6	0	**14396**	17383.4	1406.2	133.1	163.9	180.1	**19267**	**4871**	27000	
44	0	1034	1813.9	57.1	0	1742.4	1176.0	9259.9	1054.6	0	**16138**	17383.4	1406.2	133.1	166.2	180.1	**19269**	**3131**	27000	
45	0	1034	1813.9	57.1	0	1742.4	1176.0	9259.9	1054.6	0	**16138**	17383.4	1406.2	133.1	168.5	180.1	**19271**	**3133**	27000	
46	0	1034	1813.9	57.1	0	1742.4	1176.0	9259.9	1054.6	0	**16138**	17383.4	1406.2	133.1	170.9	180.1	**19274**	**3135**	27000	
47	0	1034	1813.9	57.1	0	1742.4	1176.0	9259.9	1054.6	0	**16138**	17383.4	1406.2	133.1	173.3	180.1	**19276**	**3138**	27000	
48	0	1034	1813.9	57.1	0	1742.4	1176.0	9259.9	1054.6	0	**16138**	17383.4	1406.2	133.1	175.7	180.1	**19278**	**3140**	27000	
49	0	1034	1813.9	57.1	0	1742.4	1176.0	9259.9	1054.6	0	**16138**	17383.4	1406.2	133.1	178.2	180.1	**19281**	**3143**	27000	
50	0	1034	1813.9	57.1	0	1742.4	1176.0	9259.9	1054.6	0	**16138**	17383.4	1406.2	133.1	180.7	180.1	**19283**	**3145**	27000	
51	0	1034	1813.9	57.1	0	1742.4	1176.0	9259.9	1054.6	0	**16138**	17383.4	1406.2	133.1	183.2	180.1	**19286**	**3148**	27000	
52	0	1034	1813.9	57.1	0	316.8	1176.0	9259.9	1054.6	0	**14713**	17383.4	1406.2	133.1	185.8	180.1	**19289**	**4576**	27000	
53	-68807.5138	1034	1813.9	57.1	-4155.12	-10406.88	1176.0	9259.9	1054.6	0	**-68974**	17383.4	1406.2	133.1	188.4	180.1	**19291**	**88265**	27000	
PV 0%	68808	47996	84165	2649	49575	32361	55214	429660	48934	0	**819363**	806590	65246	6176	6482	8356	**892850**	**73487**		
PV:																				
2%	$108,199	$27,326	$47,918	$1,508	$35,784	$22,457	$31,606	$244,621	$27,860	$0	**$547,280**	$459,220	$37,147	$3,516	$3,511	$4,757	**$508,152**	**($39,128)**		
4%	$118,691	$16,813	$29,483	$928	$27,018	$16,388	$19,566	$150,509	$17,142	$0	**$396,538**	$282,546	$22,855	$2,164	$2,061	$2,927	**$312,554**	**($83,984)**		
6%	$119,479	$11,061	$19,397	$611	$21,285	$12,548	$12,956	$99,021	$11,278	$0	**$307,636**	$185,889	$15,037	$1,423	$1,302	$1,926	**$205,577**	**($102,058)**		

Discount Rate	B/C Ratio	NPV ($,000)	IRR
2%	0.93	($39,128)	
4%	0.79	($83,984)	1.08%
6%	0.67	($102,058)	
0%	1.09	$73,487	

* Block 4 pressurized system cost of $64.71/acre less irrigated crop budget est. of $48/acre = $16.71/acre/year.
Block 3 pressurized system cost of $51.06/acre less irrigated crop budget est. of $48/acre = $3.06/acre/year.

2019 COST ESTIMATES:

Col.1.	Project Construction ($,000)	137615	
Col.2	O&M/year ($,000) + $25/acre	359.4	
Col.3	Diversion Pumping-Energy $,000/yr.	1813.9	
Col. 4	Blocks 4 & 3 Pumping-Incre. Energy $,000/yr.	57.1	
Col. 5	Irrigation Equip. $/acre	995	
Col. 6	Other Farm Equip. $/acre	528	
Col.7	Irrigation O&M $/acre/year	48	
Col.8	Annual Crop. Prod. Costs/acre	390.96	net of Col. (7)
Col.9	Annual Livestock Prod. Costs/acre	39.06	
Col.10	Other	0	

2019 BENEFIT ESTIMATES:

Col. 12	Annual Incre. Crop Revenue/acre	643.83
Col. 13	Annual Incre. Live.Revenue/acre	52.08
Col. 14	Stockwater/acre	4.93
Col. 15	Recreation/acre (+1.4%/yr.)	3.53
Col. 16	Drought Mitigation/acre	6.67

Marv Anderson & Associates Ltd.
MD Acadia B-C Simulatiions, October 2019

Table C-6. Supplemental Farm Financial Data to Assess Irrigation System Cost Sharing Capacity

ITEM	All Wheat	Barley/Other Cereals	Alfalfa/Other Hay	Cereal Silage	Canola	Canola/Alfalfa Seed	Dry Beans/Peas	Hemp Seed	Lentil/Chickpea	Potato/Other	WEIGHTED AVERAGE
GROSS MARGIN = VALUE-ADDED*	208.73	184.72	21.56	198.88	143.59	445.68	286.95	770.47	236.4	773.17	**262.50**
CAPITAL COSTS											
Equipment & Bldg. Interest	38.95	38.95	38.95	38.95	38.95	38.95	38.95	38.95	38.95	38.95	**38.95**
Building & Equipment Depreciation	95.70	95.70	95.70	95.70	95.70	95.70	95.70	95.70	95.70	95.70	**95.70**
TOTAL CAPITAL COSTS	134.65	134.65	134.65	134.65	134.65	134.65	134.65	134.65	134.65	134.65	**134.65**
UNPAID FAMILY LABOUR (non-cash)*****	33.50	44.75	62.40	58.50	38.00	38.00	39.50	32.50	39.50	100.00	**48.23**
BACKGROUND DATA:											
INVESTMENT per ACRE:											
Land	2000	2000	2000	2000	2000	2000	2000	2000	2000	2000	**2000.00**
Buildings	200	200	200	200	200	200	200	200	200	200	**200.00**
Machinery	523	523	523	523	523	523	523	523	523	523	**523.00**
Livestock											
Irrigation Equipment	995	995	995	995	995	995	995	995	995	995	**995.00**
TOTAL	3718	3718	3718	3718	3718	3718	3718	3718	3718	3718	**3718.00**
LABOUR per ACRE:											
Hired Labour	1.62	1.89	1.89	1.98	1.64	1.64	4.83	1.1	4.83	16	**3.56**
Unpaid Labour	1.34	1.79	2.496	2.34	1.52	1.52	1.58	1.3	1.58	4	**1.93**
Total Labour (hrs./acre/yr.)	2.96	3.68	4.386	4.32	3.16	3.16	6.41	2.4	6.41	20	**5.49**
$ Rate/Hour	25	25	25	25	25	25	25	25	25	25	**25**

* Taken directly from Annex Table A-2.

** Linked to investment levels @2.5%/annum.

*** Linked to investment levels: 5%/yr. for buildings; 10%/yr. for farm equipment; and 4%/yr. for irrigation equipment.

**** Assumes interest and depreciation = actual principal and interest payments.

***** Hours/yr. X $25/hr. Not included in variable costs-of-production,

Table C-7. Trust Requirement to Fully Fund System Energy Requirement for 50 Years

YEAR	TRUST BALANCE	plus Annual Trust Growth (+4%/yr)	TRUST GROWTH	less Annual Energy O&M (+1.5%/yr.)	TRUST RESIDUAL
	53,000,000	0			
1	51,182	2,047	53,229	1,818	51,410
2	51,410	2,056	53,467	1,846	51,621
3	51,621	2,065	53,686	1,873	51,812
4	51,812	2,072	53,885	1,902	51,983
5	51,983	2,079	54,063	1,930	52,132
6	52,132	2,085	54,218	1,959	52,259
7	52,259	2,090	54,349	1,988	52,361
8	52,361	2,094	54,455	2,018	52,437
9	52,437	2,097	54,534	2,049	52,486
10	52,486	2,099	54,585	2,079	52,506
11	52,506	2,100	54,606	2,110	52,496
12	52,496	2,100	54,596	2,142	52,453
13	52,453	2,098	54,552	2,174	52,377
14	52,377	2,095	54,472	2,207	52,266
15	52,266	2,091	54,356	2,240	52,116
16	52,116	2,085	54,201	2,274	51,927
17	51,927	2,077	54,004	2,308	51,697
18	51,697	2,068	53,765	2,342	51,422
19	51,422	2,057	53,479	2,377	51,102
20	51,102	2,044	53,146	2,413	50,733
21	50,733	2,029	52,762	2,449	50,313
22	50,313	2,013	52,326	2,486	49,840
23	49,840	1,994	51,833	2,523	49,310
24	49,310	1,972	51,282	2,561	48,721
25	48,721	1,949	50,670	2,600	48,070
26	48,070	1,923	49,993	2,639	47,355
27	47,355	1,894	49,249	2,678	46,571
28	46,571	1,863	48,434	2,718	45,715
29	45,715	1,829	47,544	2,759	44,785
30	44,785	1,791	46,576	2,800	43,776
31	43,776	1,751	45,527	2,842	42,684
32	42,684	1,707	44,392	2,885	41,507
33	41,507	1,660	43,167	2,928	40,239
34	40,239	1,610	41,848	2,972	38,876
35	38,876	1,555	40,431	3,017	37,414
36	37,414	1,497	38,911	3,062	35,848
37	35,848	1,434	37,282	3,108	34,174
38	34,174	1,367	35,541	3,155	32,387
39	32,387	1,295	33,682	3,202	30,480
40	30,480	1,219	31,699	3,250	28,449
41	28,449	1,138	29,587	3,299	26,288
42	26,288	1,052	27,340	3,348	23,992
43	23,992	960	24,951	3,398	21,553
44	21,553	862	22,415	3,449	18,965
45	18,965	759	19,724	3,501	16,223
46	16,223	649	16,872	3,554	13,318
47	13,318	533	13,851	3,607	10,244
48	10,244	410	10,653	3,661	6,992
49	6,992	280	7,272	3,716	3,556
50	3,556	142	3,698	3,772	- 74

APPENDIX D

DESKTOP ENVIRONMENTAL AND HISTORICAL IMPACTS REPORT

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DESKTOP ENVIRONMENTAL AND HISTORICAL IMPACTS

Municipal District of Acadia No. 34 Irrigation Development

Prepared for:
Mike Breunig
MPE Engineering Ltd.

November 6, 2019

Project No.: 5178

Ghostpine Rev: 0

EFFECTIVE PLANNING, REAL SOLUTIONS

Executive Summary

The Municipal District of Acadia No. 34 (M.D. of Acadia) wishes to examine the feasibility of constructing a water supply system to provide irrigation water to irrigable lands within the southern portion of the municipality (Study Area). The M.D. of Acadia retained MPE Engineering Ltd. (MPE) to update the original 2005 feasibility study (MPE 2005). Ghostpine Environmental Services Ltd. (Ghostpine) was contracted by MPE to provide an updated overview of potential environmental and historical issues associated with the proposed project which may have changed, or become available, since the 2005 report. This section provides a brief summary of the information in the main report. Refer to Section 2.4 for further information.

The objectives of this study were to:

- Identify and update any ecological issues that may influence the proposed development;
- Outline any changes in regulations since the 2005 report was prepared;
- Identify and discuss approaches for environmental impact assessment mitigation and monitoring that may be required;
- Determine critical path items that could impact the schedule/budget on the project;
- Outline what mitigation strategies could be implemented to manage environmental/historical issues; and,
- Suggest routing changes for irrigation canals and pipelines, if needed, to avoid or minimize impacts to areas with environmental/historical sensitivities.

Land Use /Vegetation Cover

The Study Area is within the White Zone of Alberta (Figure 1). Although the majority of land ownership is private, there is also provincial Crown-owned and municipal land lease land in the Study Area. All of Reservoir A1, the Main Supply Pipeline, Intake and Pump House, siphon, and small portions of the irrigation blocks and pipelines traverse Crown-owned Land.

The Study Area is located within the Dry Mixedgrass (Grassland) Subregion and is characterized by level to gently undulating terrain, broken by coulees and badlands. The warm, dry climate supports grasses, shrubs and herbs that are adapted to summer droughts (Natural Regions Committee 2006).

Dominant land use within the Study Area is annual cropland, with the remaining land use predominantly native prairie grassland with scarce wetlands, shrubland and improved pasture. Reservoir A1, the Main Supply Pipeline, and the Intake and Pump House traverse native prairie grassland. Most of the remaining grassland occurs within the coulee systems to the Red Deer River. All of the proposed irrigation blocks and the proposed canal and pipeline systems primarily traverse annual cropland (Figure 2).

The project area is largely undulating low-relief land bisected by coulee systems of varying sizes. Slopes range from 0 to 30%, with higher relief areas subject to slope failure. Well-drained prairie soils (Chernozemic) with a small amount of poorly developed soils (Regosols) are found within the project area (Figure 5; Ministry of Agriculture and Forestry 2019).

Critical Path Items:

All of Reservoir A1, the Main Supply Pipeline, Intake and Pump House, siphon, and small portions of the Irrigation Blocks and pipelines traverse native prairie, of which, portions are also Crown land. Crown land applications and assessments may be required, including: conservation assessments on native prairie, disposition supplements, targeted wildlife and vegetation surveys according to the *Sensitive Species Inventory Guidelines*, and pre-construction wildlife sweeps (Government of Alberta [GOA] 2013a and 2018a).

The proposed project will require an Environmental Impact Assessment (EIA) under the *Environmental Protection and Enhancement Act* (EPEA [GOA 2000a; AEP 2019]). It will also require the submission of a Project Description as it has been designated a *Physical Activity* under the Canadian Environmental Assessment Agency (CEAA 2012 [Pers. Comm. Wallsmith 2019). Additional work, such as multiple years of targeted wildlife and rare plant surveys may be required to supplement the EIA and CEAA applications.

Specific recommended mitigation actions for Land Use /Vegetation Cover are located in Section 2.4.1.

Vegetation and Wildlife (Species of Concern)

Much of the vegetation within the Study Area has been altered from its original state and is currently used for agricultural practices such as cropland. According to the Grassland Vegetation Inventory Index (2016), approximately 41% of the total project remains in primarily native condition. This generally coincides with the coulee which bisects the Study Area and the grassland, coulees/drainages associated with the Red Deer River Valley (Figure 3).

There is a high potential for rare plants and rare plant communities to occur within the Study Area within the native vegetation areas. Areas of particular potential include dry eroded valley and ravine slopes; alkaline flats and blowouts; wetlands; sandy soils/sand dunes; poplar, and Manitoba maple woodland along river valleys.

The Dry Mixedgrass Subregion contains the greatest diversity of wildlife of all the grassland subregions. The study area traverses several Wildlife Sensitivity Ranges including: Burrowing Owl, Sharp-tailed Grouse, Sensitive Amphibian, Sensitive Raptor Range: ferruginous hawk and prairie falcon, Other Sensitive and Endangered Species (Grassland), as well as Sensitive Snake Range (Alberta Environment and Parks [AEP] 2016).

Critical Path Items:

The Study Area has potential for vegetation and wildlife species of concern, especially in native prairie grasslands, coulees, riparian areas and wetlands. Clearing/construction of the project, especially during the high-risk period for migratory birds and other species of concern, could lead to project delays and/or potential contravention of wildlife legislation (i.e., the *Alberta Wildlife Act* [GOA 2000b], *Migratory Birds Convention Act* [Government of Canada {GC} 1994] and *Species at Risk Act* [GC 2002] if wildlife is disturbed or killed. As with the federal *Migratory Birds Convention Act* and *Species at Risk Act*, the proponent must show due diligence under the provincial *Wildlife Act* that wildlife is not harmed as a result of the project.

There are development setback standards on Crown-owned land for wildlife species of concern site-specific habitats (i.e., nest and dens) and rare plants which are listed under the *Alberta Wildlife Act* (GOA 2000b; GOA 2018a). The proponent must provide justification for development within setbacks of a wildlife species of concern site-specific habitat or listed rare plant according to the *Master Schedule of Standards and Conditions* (GOA 2018a). The *Recommended Land Use Guidelines for Protection of Selected Wildlife Species and Habitat within Grassland and Parkland Natural Regions of Alberta* (Alberta Sustainable Resource Development 2011) also provide guidance for development setbacks and timing constraints from site-specific habitats of species of concern. Although rare plant species which only are tracked or watched by Alberta Conservation Information Management System ([ACIMS] 2017) have no government protection, best management practices would be to avoid or mitigate disturbance of rare plants where feasible.

Specific recommended mitigation actions for Vegetation and Wildlife (Species of Concern) are located in Section 2.4.2.

Fisheries

The proposed project potentially effects the Acadia Valley Municipal Reservoir, the Red Deer River, an unnamed tributary to Kennedy's Coulee; as well as numerous potential watercourses traversed by the proposed canal/pipeline system (Figure 8).

The Acadia Valley Municipal Reservoir (bordered by Irrigation Block 4) does not have a natural population of fish, but it is stocked by the GOA annually with rainbow trout; thus, meeting the definition of a recreational sport-fishery. The input of diverted water to and installing an outfall on the Acadia Valley Municipal Reservoir may affect aquatic resources.

Based on historical data, sportfish within Red Deer River system include: burbot, goldeye, lake sturgeon, lake whitefish, mooneye, mountain whitefish, northern pike, quillback, sauger, walleye, and yellow perch. It should be noted that lake sturgeon and sauger are provincially listed as *At Risk* and *Sensitive*, respectively (AEP 2019). The installation of a water intake structure in, and the withdrawal of water from, the Red Deer River may affect aquatic resources.

There is a lack of existing fisheries data for the unnamed tributary to Kennedy's Coulee, which will be dammed off for the proposed Reservoir A1. The unnamed tributary appears to be ephemeral or intermittent in nature and is unlikely to support fish; however, upon completion of construction works, fish could potentially colonize Reservoir A1. Alternatively, the GOA may be interested in stocking this artificial waterbody.

Several watercourses may potentially be crossed by the proposed canal/pipeline system. In general, there is a lack of existing fisheries data for these crossing locations. Based on desktop imagery, there is a low likelihood for these watercourses to provide fish habitat; thus, local populations of fish are not anticipated. The crossing of an irrigation canal over a watercourse may require specialist construction techniques and engineering designs.

Critical Path Items:

Information deficiencies and data gaps pertaining to fish and aquatic resources should be identified and subject to a desktop assessment, a field assessment, or both. In addition, fish and fish habitat assessments should be completed wherever project infrastructure overlaps with potential watercourses and fisheries resources.

Water diversions (i.e., withdrawal, storage and release), and the construction of associated infrastructure (i.e., intakes, dams, pipeline crossings, irrigation canals, and discharge structures), have the potential to adversely affect fish and fish habitat. As such, the project is required to adhere to the requirements of the *Water Act* (GOA 2000c), the *Fisheries Act* (GC 1985a) and the *Canadian Navigable Waters Act* (Transport Canada 2019). Outfalls and watercourse crossings (i.e., pipeline and temporary construction access) should also adhere to the *Code of Practice for Outfall Structures on Waterbodies*, the *Code of Practice for Watercourse Crossings* (GOA 2013b and 2013c), and the *Guide to the Code of Practice for Watercourse Crossings, Including Guidelines for Complying with the Code of Practice* (Alberta Environment 2000a). In the event that the requirements listed in these Codes of Practices and the Fisheries and Oceans Canada's (DFO)
Measure to Avoid Causing Harm to Fish and Fish Habitat (DFO 2018) cannot be met, and effects to fish and fish habitat are anticipated, the project will be subject to approval(s) under the *Water Act*, and *Fisheries Act.*

Request-for-Review(s) or Authorization(s) including, but not limited to, DFO offsetting requirements and associated monitoring. These regulatory processes will require written specifications and recommendations of a Qualified Aquatic Environmental Specialist.

Specific recommended mitigation actions for Fisheries are located in Section 2.4.3.

Wetlands/Ephemeral Waterbodies

According to the Alberta Merged Wetland Inventory topographical mapping and aerial photography, marsh, shallow open water wetlands and ephemeral drainages occur throughout the Study Area (AEP 2017a; Figure 8). Two known springs also occur in the Study Area: one along Secondary Canal A and the other on the boarder of Block 4. Wetlands are also traversed by all Irrigation Blocks, pipelines and canals according to the desktop review.

Critical Path Items:

A *Water Act* Application including Wetland Assessment and Impact Report, or a Wetland Assessment and Impact Form may be required for any permanent impacts to wetlands, depending on the type of proposed development. A review under the *Public Lands Act* (GOA 2000e) may also be required for any potentially permanent wetlands. AEP requires proof of effort put into the project design to avoid and minimize impacts to wetlands.

The wetland assessments for the WAIR must be completed within the growing season (approximately May to September) to align with the *Alberta Wetland Policy* (Alberta Environment and Sustainable Resource Development 2013). Current review times by AEP are in the range of 6 months to two years (or more), depending on regulator workload, the number of impacted features and the complexity of the system.

Government consultation is recommended on application requirements for flooding wetlands due to irrigation as the scope of approval for this type of activity is not clear in the regulatory documentation.

Specific recommended mitigation actions for Wetlands/Ephemeral Waterbodies are located in Section 2.4.4.

Archaeological/Palaeontological Resources

To obtain *Historical Resources Act* (GOA 2000d) clearance for the proposed project, a Historical Resources Application must be submitted to Alberta Ministry of Culture, Multiculturalism and Status of Women (CMSW). This application will be accompanied by a Statement of Justification (SoJ) which will provide CMSW with the various project components, proposed ground disturbance activities, and a summary of the potential impacts to cultural resources. The evaluation of the project within this document will closely resemble the important content within the SoJ.

The overall project area contains notations for archaeology within the Listing of Historic Resources (CMSW 2019). These notations indicate that the project traverses lands with previously recorded archaeological sites as well as lands with high potential for the discovery of new archaeological sites (Figure 9).

The proposed reservoir, pumphouse, intake, main supply line, canals, and Irrigation Blocks 1A, 1B and 2 traverse lands that are listed as containing archaeological resources and also having potential for discovery of new archaeological sites. The potential to discover additional archaeological resources along the margins of the coulee, the valley upland, within the Red Deer River valley, or native prairie portions of the regional upland is also very high.

Proposed Irrigation Block 3 is composed of lands that do not contain archaeological resources and are also not listed as having potential for discovery of new archaeological resource sites.

Proposed Irrigation Block 4 is composed of lands that do not contain archaeological resources but are listed as having potential for discovery of new archaeological resource sites, specifically where the proposed block impacts native prairie along the edge of the creek channel.

There are no previously discovered historic resource sites (artifacts, site features, or standing structures related to the Historic Period in Alberta) within the overall project area or within individual component areas related to the project.

The overall project area contains notations for palaeontology within the *Listing of Historic Resources* (CMSW 2019). These notations indicate that the project traverses lands with high potential for the discovery of new palaeontological sites, particularly along the Red Deer River, along Kennedy's Coulee and along the proposed reservoir site. There are no previously discovered cultural resource sites (usually a designation assigned to First Nations and Métis traditional use or sacred sites) within the overall project area or within individual component areas related to the project.

Critical Path Items:

A Historical Resources Application is required for all components of this project, as per the *Historical Resources Act* of Alberta.

The Reservoir, Main Supply Pipeline, Intake, Pump House, siphon, and small portions of the Irrigation Blocks and pipelines traverse native prairie and erosional slopes. The potential for undiscovered archaeological and palaeontological resources in these areas is extremely high. Several previously recorded archaeological resource sites are in conflict with key components of the project. A Historical Resources Impact Assessment will be required in order to compile a complete inventory of historical resources within the project disturbance footprint, evaluate the potential impacts to these resources, and to develop mitigation strategies for each project component.

Wherever archaeological or palaeontological resources exist within the proposed disturbance footprint, archaeological or palaeontological mitigative excavation and/or sampling may be required. The probability of at least some level of mitigative excavation being required is very high. This type of mitigation can sometimes extend for many months and may require additional phases of excavation based on initial findings.

With cultural resources such as archaeology or palaeontology, stakeholder/First Nations interest or concerns may create unforeseen pressures on the project timeline or budget.

Specific recommended mitigation actions for Archaeological/Palaeontological Resources are located in Section 3.

Limitation of Liability

Methods and results in this report are based on Ghostpine Environmental Services Ltd.'s (Ghostpine) adherence to municipal, provincial and federal regulations in place on the date issued. Inter and intra-regulatory agency interpretation of rules and regulations have been accounted for as much as reasonably possible.

During the preparation of this report and associated services, Ghostpine relied upon the full disclosure and accuracy of all applicable information by MPE Engineering Ltd. (MPE) on the past, present and proposed conditions of this site. This report is based upon the information provided by MPE, information collected during desktop and/or field investigations, information gathered from regulatory bodies and agencies. The information provided by parties other than Ghostpine is believed to be accurate but cannot be guaranteed. The work was conducted by Ghostpine in accordance with the scope of work prepared for this project, including verbal or written requests from MPE. No other warranty, expressed or implied, is made.

Ghostpine has exercised reasonable care and due diligence in the preparation of this report and the services have been performed in a manner consistent with other professionals currently practicing under similar conditions in the jurisdiction in which the services were provided.

It must be noted that the environmental assessment, as per the established scope of work of any site, is based on observations made at a specific moment in time; therefore, the conclusions and recommendations set out in this report are time sensitive. The report is based solely on the conditions that existed at the time of the investigation. The conclusions and recommendations set out in this report are based on the specific observations and testing at the subject site. Conditions across the site may vary which would affect the conclusions and recommendations made in the report. No detailed assessment on a given property or site can wholly eliminate the uncertainty regarding the potential for unrecognized conditions in connection with that particular property or site.

This report and the assessments and recommendations described within are intended for the sole use of MPE and their agents. Other representations or warranties regarding surface, subsurface, biotic, abiotic, and documentation of said condition in the form of report, or regulatory submission not referenced, are not provided. Any unauthorized use of this report is at the sole risk of the user. The document may not be manipulated, edited or amended without the expressed written consent and understanding of Ghostpine.

MPE may rely on this completed report for specific application to this project, based on project area discussed and conditions present at the time of the field assessment.

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Appendix

1 INTRODUCTION

1.1 Background

The Municipal District of Acadia No. 34 (M.D. of Acadia) wishes to examine the feasibility of constructing a water supply system to provide irrigation water to irrigable lands within the southern portion of the municipality (Study Area; Figure 1). The M.D. of Acadia retained MPE Engineering Ltd. (MPE) to update the original 2005 feasibility study (MPE 2005). Ghostpine Environmental Services Ltd. (Ghostpine) was contracted by MPE to provide an updated overview of potential environmental and historical issues associated with the proposed project which may have changed or become available since the 2005 report.

1.2 Objectives

The objectives of this study were to:

- Identify and update any environmental/historical issues that may influence the proposed development including:
  - Outline any changes in regulations since the 2005 report was prepared;
  - Identify and discuss approaches and costs for an Environmental Impact Assessment (EIA) mitigation and monitoring that may be required;
  - Determine critical path items that could impact schedule/budget on the project;
  - Outline what mitigation strategies could be implemented to manage environmental/historical issues with a range of costs; and
  - Suggest routing changes for irrigation canals and pipelines, if needed, to avoid or minimize impacts to areas with environmental/historical sensitivities.

To service the proposed irrigation blocks, the M.D. of Acadia is proposing to construct an off-stream storage reservoir (Reservoir A1), within an unnamed tributary to Kennedy Coulee. Irrigation Blocks 1A, 1B, and 2 will be gravity fed from the storage reservoir via a lined canal (Secondary A) and a closed pipeline (Secondary B). Irrigation Blocks 3 and 4 will be gravity fed via Secondary A Canal to the existing Acadia Recreational Reservoir and then pumped via a pressurized delivery system. All delivery laterals will be pipelines. Gravity delivery systems will run to the irrigation parcel, while pressurized systems (Blocks 3 and 4) will supply water to the center of the pivot with adequate pressure to negate on-farm pumping.

Additional infrastructure requirements for the proposed project include in-take pipes and two-chamber wet wells for high sediment loads; drum screen for debris and aquatic weeds; river pump station; supply pipeline (1,067 mm for Scenario 1; 1,220 mm for Scenarios 2 and 3); storage reservoir (Reservoir A1) and 2 dams for containing the reservoir; spillway channel at the southeast end of the reservoir; 2 outlet structures for Secondary A canal and Secondary B pipeline; and a pump station for the Acadia Recreational Reservoir.

1.3 Methods

1.3.1 Landscape Mapping

The primary information sources used in the background review update of the Study Area is provided in Table 1. The regional location of the Study Area is shown in Figure 1.

Table 1 Background Information Sources Used in the Review of the Study Area

Criteria	Background Information to Map Variables/Features
Land Use	• Toporama (Topographical map) layer (Government of Canada [GC] 2012) • Natural Resources Land Cover (GC 2009) • Abacus Datagraphics (2019) • Geographic Land Information Management and Planning System (2019). • Provincial Park, Protected Area, Natural Area, Ecological Reserve, or Heritage Rangeland (Alberta Tourism, Parks, and Recreation [ATPR] 2013) • Environmentally Significant Areas (ESAs) (ATPR 2014) • Red Deer River Corridor Integrated Management Plan (Alberta Environment 2000b)
Sensitive Soils/Unique Landforms	• Toporama (topographical map) layer (GC 2012) • Agricultural Region of Alberta Soil Inventory Database (AGRASID [Ministry of Agriculture and Forestry 2019])
Wetlands/Watercourses/ Drainages/Springs	• Toporama (topographical map) layer (GC 2012) • Alberta Merged Wetland Inventory (Alberta Environment and Parks [AEP] 2017a) • 2016 Acadia Valley Aerial Image, Provided by MPE on May 15, 2019, Date of Photography: 2016 • *Code of Practice* (COP) watercourse maps (GOA 2006) • Fish and Wildlife Internet Mapping Tool (AEP 2019) • Springs (Borneuf 1983)
Native Prairie/ Vegetation/ Rare Plant Species	• Grassland Vegetation Inventory (GVI [2016]) • Alberta Conservation Information Management System database (ACIMS [2017]) • Crown Reservation Database to determine Protected Notations (Geographic Land Information Management and Planning System 2019) • AEP Wildlife Sensitivity Datasets – Endangered and Threatened Plant Layer (AEP 2016) • Critical Habitat areas designated by Environment Canada (none traversed by Study Area)
Wildlife Species of Concern and their habitats	• Fish and Wildlife Management Information System (FWMIS [AEP 2019]) database (Stevens, pers. comm.). • Crown Reservation Database to determine Protected Notations (Geographic Land Information Management and Planning System 2018) • Birdlife International - Important Bird and Biodiversity Areas Birdlife International (2019) • AEP Wildlife Sensitivity Datasets (AEP 2016) • Critical Habitat areas designated by Environment and Climate Change Canada (2018) (none traversed by Study Area)
Archaeological Resources	• Alberta Ministry of Culture, Multiculturalism and Status of Women (CMSW) *Listing of Historic Resources* (2019) • CMSW Archaeological Site Inventory Data
Palaeontological Resources	• CMSW *Listing of Historic Resources* (2019) • Alberta Geological Survey (2013) Bedrock Geology of Alberta maps • Alberta Geological Survey (2013) Surficial Geology of Alberta maps • Royal Tyrrell Museum Palaeontological Site Inventory Data

2 OVERVIEW OF ECOLOGICAL SETTING AND POTENTIAL ISSUES

2.1 Land Use

The Study Area is within the White Zone of Alberta. Figure 1 shows the Study Area, proposed irrigation area options, Reservoir A1 as well as the current pipeline and canal routing.

Although the majority of land ownership is private, there is also provincial Crown-owned and municipal land lease land in the Study Area. All of Reservoir A1, the Main Supply Pipeline, Intake and Pump House and small portions of the Irrigation Blocks and pipelines traverse Crown-owned Land. Additionally, if Reservoir A1 is flooded to maximum capacity, it could potentially extend outside of the M.D. of Acadia and into Special Areas Number 3 (Figure 1).

Dominant land use within the Study Area is annual cropland (58%), with the remaining land use predominantly native prairie grassland (38%) with scarce wetlands and shrubland (2%) as well as improved pasture (2%) (Figures 2 and 3). Reservoir A1, the Main Supply Pipeline, Intake and Pump House traverse native prairie grassland. Most of the remaining grassland occurs within the general area of interest in coulee systems to the Red Deer River. Irrigation Blocks 1A, 1B, 2, 3, and the proposed canal and pipeline systems primarily traverse annual cropland.

The southern portion of the Study Area surrounding the Red Deer River is within the Red Deer River Corridor Integrated Management Plan (Figure 1). The Red Deer River Corridor Integrated Management Plan provides objectives, guidelines and best management practices for several resource management areas which are enforceable on Crown land (Alberta Environment 2000b).

Additionally, if Reservoir A1 is flooded to maximum capacity, it could potentially extend outside of the M.D. of Acadia and into Special Areas Number 3 which could trigger additional consultation and approvals.

The proposed Study Area is not located within or adjacent to a Provincial Park, Protected Area, Natural Area, Ecological Reserve, or Heritage Rangeland (ATPR 2013).

Much of the grassland portion of the Study Area occurs within ESA including Reservoir A1, intake, pumphouse and portions of the Main Supply Intake and Secondary B pipeline (Figure 4). The criteria for ESA selection is as follows: areas that contribute to focal species, species groups or habitats; areas which contribute to a unique focal habitat; areas with ecological integrity and areas which contribute to water quality and quantity. There are no standards or regulations in Alberta which legislate the avoidance of ESAs; however, this information can be considered when routing/siting projects. The ESAs in the Study Area include a diversity of upland, wetland and river valley sites (MPE 2005).

2.2 Regional Ecological Conditions

The Study Area traverses the Dry Mixedgrass Subregion, which is the largest of the four grassland subregions, and is characterized by level to gently undulating terrain, broken by coulees and badlands (Natural Regions Committee 2006). The warm, dry climate supports grasses, shrubs and herbs that are adapted to summer droughts although approximately 40% of the land area is cleared (Natural Regions Committee 2006). Permanent streams and waterbodies are relatively rare but are well-defined. Brown Chernozems and Brown Solonetzic soils are common (Natural Regions Committee 2006).

2.3 Study Area Ecological Conditions

2.3.1 Ecodistricts, Landforms and Soils

2.3.1.1 Landforms

The project area is largely undulating low-relief land bisected by coulee systems of varying sizes. Slopes range from 0 to 30%, with higher relief areas subject to slope failure. This risk of slope failure is highest along the proposed Reservoir A1 area, within the area of Bingville soils (Figure 5). The project will increase the amount of cultivation which could lead to changes in localized landform stability. Other long-term landform impacts are not anticipated (Ministry of Agriculture and Forestry 2019).

Table 2 lists the Protective Notations (PNTs) in the area (Figure 6). PNTs require consultation with AEP to ensure appropriate mitigations are employed during design and construction. PNT 700256 and 753559 are for rough banks of the Red Deer River and deeply incised slopes. PNT 780792 is for rough topography and poor soils. Care should be taken if these lands are traversed as they will pose increased construction and reclamation risk.

Table 2 List of the Protective Notations in the area.

Location	PNT No.	Alberta Government Referral Location	PNT Description
NE 20-23-2 W4M	PNT050217	Medicine Hat Office - Fish and Wildlife Department of Sustainable Resource Development	0470: Rare and Endangered Species Habitat Protection Area 4: No Surface Disposition 110: Unimproved Grazing Kennedy Coulee Rattlesnake Hibernaculum. Snake Winter Den. *Amendment Comments* Surface Assess for Existing Dispositions Will Be Honored and Renewed Subject to Site Specific Restrictions as Required to Protect Endangered Species Habitat.
NE 29-23-2 W4M			
SE 29-23-2 W4M			
NE 5-23-3 W4M	PNT700256	Medicine Hat NW Office - Rangeland District-Lands Division Department. of Sustainable Resource Development	0110: Erosion Hazard 3: No Agricultural Disposition 100: Grazing Haying 710: See Comments Rough Banks of Red Deer River
NE 7-23-3 W4M			
SW 17-23-3 W4M			
NE 18-23-3 W4M			
NW 18-23-3 W4M			
SE 18-23-3 W4M			
SW 18-23-3 W4M			

Location	PNT No.	Alberta Government Referral Location	PNT Description
SE 25-23-3 W4M	PNT753559	Medicine Hat NW Office - Rangeland District-Lands Division Department of Sustainable Resource Development	0120: Fragile Slope Hazard 3: No Agricultural Disposition 100: Grazing Haying 710: See Comments Incised by Steep Coulee
SE 27-23-3 W4M	PNT780792	Medicine Hat NW Office - Rangeland District-Lands Division Department of Sustainable Resource Development	0140: General Topographic Constraints 3: No Agricultural Disposition 100: Grazing Haying 710: See Comments Rough Topography, Poor Soils
1-11-24-3 W4M	PNT340001	Environment and Water, Department of Regional Services	0150: Water Resource Management Area 2: No Agricultural Sale Disposition 730: Consent Required
2-11-24-3 W4M			
7-11-24-3 W4M			

2.3.1.2 Soils

Well-drained prairie soils (Chernozemic) with a small amount of poorly developed soils (Regosols) are found within the project area. AGRASID (Ministry of Agriculture and Forestry 2019) identifies more than 50 different soil polygons (Figure 5) within the project area. Details of these soil types can be found in the June 2005 report (MPE 2005). Most of the soils are not anticipated to pose any significant concerns for the proposed development; however, a few could cause issues during construction. Table 3 and Figure 6 outline the problematic soils. A small amount of solonetzic (salty) soils are found in the northern part of the project area which are avoided by the current design. If future design changes require impacts to these soils, additional mitigations will be required.

Table 3 Problem Soils in the Project Area and Construction Implications

Soil type	Issue	Project impacts
BVL (Bingville)	High Wind Erosion Risk on slopes over 15%; Unstable Slopes	• Unvegetated soils and spoil piles will be subject to wind erosion if erosion and sediment controls (ESC) measures are not employed. • Unvegetated soils are subject to slumping and slope failure.
CVD (Cavendish)		
RAM (Ramilles)		
PUN (Pemukun)	High Wind Erosion Risk on slopes over 15%; Unstable Slopes; gravel	• Unvegetated soils and spoil piles will be subject to wind erosion if ESC measures are not employed. • Unvegetated soils are subject to slumping and slope failure. • Gravel lenses in soil can be an issue for pipeline construction.

Soil type	Issue	Project impacts
CHZ (CHINZ)	Lower soils are saline	- Lower soils must not be mixed with topsoil during construction to preserve agriculture capability. - Soils are sensitive to salt movement and difficulty in reclamation. - Saline soils can contribute to higher levels of salt in water used for irrigation.
RMR (Rosemary)	Lower soils are saline and high pH	
ROL (Ronalaine)	Lower soils are solonetzic	

2.3.2 Vegetation Cover

Much of the vegetation within the Study Area has been altered from its original state and is currently used for agricultural practices such as cropland. According to the GVI Index, approximately 41% of the overall project remains in primarily native condition (Figure 3). This generally coincides with the coulee, which bisects the Study Area, and coulees/drainages associated with the Red Deer River Valley.

The typical vegetation community of the Dry Mixedgrass Subregion is low-growing drought-tolerant species, such as needle and thread grass, blue grama, June grass speargrass and western wheatgrass. Northern wheatgrass and western porcupine grass are common in the hummocky moraine areas. Shrubs such as buckbrush (western snowberry), sagebrush and prickly rose are common in areas of adequate moisture, such as coulees, but trees are generally absent, excluding large river valleys. Permanent streams and waterbodies are relatively rare (Natural Regions Committee 2006, Cottonwood Consultants 1991a and b). The active floodplains of the Red Deer River Valley include sandbar willow, rose, buckbrush with balsam poplar stands (MPE 2005).

2.3.3 Rare Plants and Communities

There is a high potential for rare plants and rare plant communities to occur within the Study Area within the native vegetation areas (MPE 2005). Areas of particular potential include the following: dry eroded valley and ravine slopes; alkaline flats and blowouts; wetlands, sandy soils/sand dunes, poplar and Manitoba maple woodland along river valleys. Rare plant communities have potential to occur in all habitat types; floodplain, landforms, wetlands and dunes/blowouts (MPE 2005).

The southern portion of the project area is within an *Endangered/Threatened* Plant Layer for Tiny Cryptanthe and the *Endangered/Threatened* Plant Layer for Slender Mouse-Eared Cress is south of the Study Area Boundary along the Red Deer River (ACIMS 2017; Figure 7a). These species are both considered *Threatened* - Schedule 1 under the *Species at Risk Act* (GC 2002) and *Endangered* under the Alberta *Wildlife Act* GOA (2000b) and ranked under Committee on the Status of Endangered Wildlife in Canada (COSEWIC [2018]), Canadian Endangered Species Conservation Council (CESCC [2016]) and ACIMS (2017). The Tiny Cryptanthe inhabits dry upland habitats adjacent to river systems and the Slender Mouse-Eared Cress's habitat is sandy or sandy alkaline grassland, perhaps occasionally on gravelly sands.

There are occurrences of three other rare plant species within the Study Area boundaries: few flowered aster, smooth sweet cicely and common beggarticks. Other rare plants have been reported near the Study Area: shrubby evening primrose, hairy pepperwort, chaffweed and short-stalk mouse-eared chickweed (Figure 7a). These species are ranked under ACIMS but are not listed or protected by provincial or federal legislation (ACIMS 2017; GC 2002; GOA 2000b).

FWMIS and ACMIS only provides previously recorded observations from various sources and does not replace data obtained from field surveys. Targeted rare plant surveys according to the Alberta Government *Sensitive Species Inventory Guidelines* and Alberta Native Plant Council (ANPC) *Guidelines for Rare Vascular Plant Surveys* (ANPC 2012) are recommended on high quality habitat on privately-owned land and required on any Crown-owned land traversed to adequately identify *Endangered* and *Threatened* plants within the project area so mitigation/avoidance measures can be recommended. Refer to Section 2.4 for Critical Path and Mitigation Options.

2.3.4 Wildlife Species at Risk

The Dry Mixedgrass Subregion contains the greatest diversity of wildlife of all the grassland subregions (Natural Regions Committee 2006). The study area traverses several Wildlife Sensitivity Ranges: burrowing owl, sharp-tailed grouse, sensitive amphibian, sensitive raptor range ferruginous hawk and prairie falcon, Other Sensitive and Endangered Species, and Sensitive Snake range (Figures 7a and 7b).

The general locations of site-specific habitats (such as nests, den and breeding areas), based upon previous records of wildlife observations from FWMIS (AEP 2019) and ACIMS (2017) are shown (Figures 7a and 7b). Exact locations are not provided due to data sharing agreements with the AEP. A PNT for rattlesnake hibernacula also occurs in Kennedy Coulee in NE 20, NE 29 and SE 29-23-2 W4M with restrictions for development in place (Geographic Land Information Management and Planning System 2019) (Figure 6; Section 2.3.1, Table 2).

Nests, dens and/or breeding areas of species of concern previously recorded within the study area are:

- northern leopard frog (breeding sites);
- prairie rattlesnake, bull snake, wandering garter snake (hibernacula),
- burrowing owl (den sites),
- sharp-tailed grouse (leks),
- ferruginous hawk (nest sites),
- loggerhead shrike (nest sites).

Most of these species are listed as Schedule 1 under the *Species at Risk Act*: northern leopard frog (*Special Concern*), prairie rattlesnake (*Special Concern*), burrowing owl (*Endangered*), ferruginous hawk (*Special Concern*), and loggerhead shrike (*Threatened*) (GC 2002). Northern leopard frog, burrowing owl and ferruginous hawk are also listed as *Endangered* or *Threatened* under the Alberta *Wildlife Act* (GOA 2000b). All of these species are also ranked by COSEWIC, CESCC, the *Alberta Wild Species General Status Listing – 2015*, and/or ACIMS (ACIMS 2017; COSEWIC 2018; CESCC 2016; AEP 2017b).

Other species of concern observations in and within and near the Study Area previously recorded in FWMIS are:

Invertebrates: Delaware skipper

Amphibians: Canadian toad, great plains toad(1) plains spadefoot toad

Reptiles: western hog-nosed snake

Birds: American kestrel, bald eagle, Baird's sparrow(1), barn swallow(2), chestnut-collared longspur(2), common nighthawk(2), grasshopper sparrow, lark bunting, long-billed curlew(1), northern goshawk, prairie falcon, sage thrasher(3), short-eared owl(1), Sprague's pipit(2), upland sandpiper

Mammals: American badger(1), Ord's kangaroo rat(3,4) (observed outside of the Study Area to the west and south); olive-backed pocket mouse, pronghorn

Notes:

(1) Schedule 1 - *Special Concern* (GC 2002)
(2) Schedule 1 - *Threatened* (GC 2002)
(3) Endangered - *Species at Risk Act* (GC 2002)
(4) Endangered GOA (2000b)

Many of these species are also listed under the *Species at Risk Act* (GC 2002) and all are ranked under by COSEWIC, CESCC, the *Alberta Wild Species General Status Listing – 2015*, and/or ACIMS (COSEWIC 2018; CESCC 2016; AEP 2017b; ACIMS 2017).

Although species of concern can breed/forage in modified habitat such as improved pasture, shelterbelts and cultivated areas, there are several wildlife habitat types within the study area of higher value to species of concern. Most site-specific habitats found within the study area are associated with native prairie or native vegetation habitats. Open native prairie grassland with few trees are inhabited by burrowing owl, ferruginous hawk and sharp-tailed grouse and are also foraging areas for snake species of concern (GOA 2013a). Snake hibernacula are most often found in south, southeast or east facing slopes of coulees/drainages and river valleys, often in proximity to water as well as rock outcrops and fissures (Russell and Bauer 2000). Amphibians, such as the northern leopard frog also disperse/migrate along drainages and watercourses (Russell and Bauer 2000). Wetlands and the diverse riparian area of the Red Deer River Valley provides breeding habitat for amphibian and bird species of concern and foraging habitat for a variety of species (MPE 2005). The northern leopard frog breeds in shallow water associated with semi-permanent and permanent wetlands and also requires deep well-oxygenated wetlands for hibernation (GOA 2013a; Russell and Bauer 2000). These habitats are also essential foraging breeding and travel corridor habitat for other species of human and economic importance such as ungulates (white-tailed and mule deer and pronghorn antelope) and waterfowl (MPE 2005). The loggerhead shrike nests in shrubs such as thorny buffaloberry bush and is associated with native prairie/improved pasture but may also occur in modified habitat such as shelterbelts (Semenchuk 1992).

FWMIS/ACMIS only provides previously recorded observations from various sources and does not replace data obtained from field surveys. Targeted wildlife surveys according to the Alberta *Sensitive Species Inventory Guidelines* (GOA 2013a) are recommended on private land and are required on Crown land with wildlife habitat in order to re-confirm previously recorded site-specific habitats and identify previously unknown sites for routing, siting recommendations of avoidance and mitigation measures (GOA 2018a). Targeted surveys recommended/required in the study area include: Sharp-tailed Grouse, Burrowing Owl, Grassland Bird, Common Nighthawk, Short-eared Owl, Prairie Raptor, Amphibian and Snake (GOA 2013a). Additional targeted surveys may be recommended based on the habitat that is traversed by the project. Survey focus would be on native habitats such as the Main Supply Pipeline and Reservoir A1 and other areas of native prairie, shrubland, wetland and riparian area. The proposed project will require an EIA and the Canadian Environmental Assessment Act (CEAA) Review which could trigger further requirements for targeted surveys.

Most wildlife species in Alberta are protected under government legislation (*Migratory Birds Convention Act* [GC 1994] and/or the Alberta *Wildlife Act* [GOA 2000b]. Species which are listed under the federal *Species at Risk Act* [GC 2002]) have further protection under this Act under various circumstances (i.e., on federal lands and on all jurisdictions for migratory birds and aquatic species) (GC 2002). There are setback distances and timing constraints for site-specific habitats such as nests, dens and breeding areas of species of concern and listed plant species (GOA 2013a; Alberta Sustainable Resource Development [ASRD] 2011). The proponent must show due diligence under these Acts that protected wildlife will not be harmed as a result of this project. Refer to Section 2.4 for Critical Path and Mitigation Options.

2.3.5 Fisheries

The proposed project potentially affects the Acadia Valley Municipal Reservoir, the Red Deer River, an unnamed tributary to Kennedy's Coulee; as well as numerous ephemeral drainages traversed by the proposed canal/pipeline system (Figure 8).

The Acadia Valley Municipal Reservoir (bordered by Irrigation Block 4) does not have a natural population of fish; however, it is stocked by the GOA annually with rainbow trout (Cooper, pers. comm.). From 3,000 to 8,000 natural reproductive (2N) rainbow trout were stocked each year from 1985 to 2016. In 2017 and 2018, a total of 9,360 all-female non-reproductive (AF3N) rainbow trout were stocked. The fishery was diversified with brook trout in the fall of 2017 and again in 2019 (Cooper, pers. comm.). The reservoir does occasionally exhibit winter kills (likely as a result of low dissolved oxygen [DO]) in 2013 and 2016, and summer kills (likely as a result of low DO and elevated water temperature) in 1993, 2010 (June), 2015 (July) and 2016 (August) (Cooper, pers. comm.).

Based on historical data (AEP 2019), sportfish documented within the Red Deer River system include: northern pike, walleye, sauger, mooneye, lake whitefish, yellow perch, burbot, lake sturgeon, mountain whitefish, goldeye and quillback. Lake sturgeon and sauger are provincially listed as *At Risk* and *Sensitive*, respectively; however, it should be noted that the existing fisheries data within the Lower Red Deer River is outdated (i.e., greater than 10 years old). Ursus Ecosystem (Ursus) conducted a fisheries inventory in 2004 as part of MPE's feasibility study for this project (MPE 2005). As per the Ursus report, the last set of fisheries data was collected on the Red Deer River area in the vicinity of the proposed project in the summer of 2004. Fish species detected in 2004 included: walleye, sauger, burbot, goldeye and quillback, as well as shorthead redhorse, longnose sucker, and flathead chub. This was the only data collected along theRed Deer River in the vicinity of the project at that time. The Alberta government's fisheries biologists did some work in 1990 and 1991 but did not sample downstream of Buffalo crossing. Since the Ursus report in 2005, AEP's fisheries management conducted a fisheries inventory in July 2011 mimicking the locations conducted by Ursus. The 2011 inventory resulted in 13 fish species captured through electrofishing efforts including 6 sportfish species (i.e., goldeye, sauger, mooneye, quillback, walleye and burbot) and 7 non-sportfish species (i.e., shorthead redhorse, white sucker, longnose sucker, silver redhorse, flathead chub, river shiner, and emerald shiner). As historically shown, goldeye was the most numerous sportfish captured in the 2011 inventory. Fish habitat data was not available for this area of the Red Deer River.

There is no existing fisheries data for the unnamed tributary to Kennedy's Coulee, which will be impounded for the proposed Reservoir A1. The unnamed tributary appears to be ephemeral or intermittent in nature and is unlikely to support fish; however, a field assessment is required to confirm.

The proposed project potentially effects the fisheries associated to the Acadia Valley Municipal Reservoir and the Red Deer River through water intake and outfall operations, and the unnamed tributary through damming activities. The Acadia Valley Municipal Reservoir is bounded on the west and east shorelines by the proposed Irrigation Block 4. A water intake and pumphouse for the proposed Secondary C pipeline (within Irrigation Block 4) is proposed for the reservoir. A water intake is also proposed for the Red Deer River to extract water to fill Reservoir A1.

Water diversions (i.e., withdrawal, storage and release), and the construction of associated infrastructure (i.e., intakes, dams, pipeline crossings, irrigation canals and discharge structures), have the potential to adversely affect fish and fish habitat. More specifically, in the absence of mitigation measures, the diversion of water could result in direct fish mortality (e.g., fish stranding, fish entrainment or impingement, etc.) or adverse effect on fish habitat (e.g., inadequate stream flow, excessive water temperatures, low DO concentrations, reduction or blockage to fish passage, etc.). Similarly, the construction of associated water diversion infrastructure (i.e., intakes, dams, pipeline crossings, irrigation canals and discharge structures) could result in direct fish mortality (e.g., fish stranding, impingement and death resulting from physical contact with construction machinery, etc.) or adverse effect to fish habitat (e.g., permanent change or loss of habitat, elevated suspended sediment, increased sediment deposition and embeddedness of the streambed, etc.).

2.3.6 Wetlands, Waterbodies, and Watercourses

An overview of water resources within the Study Area is shown (Figure 8). According to the Alberta Merged Wetland Inventory (AEP 2017a) topographical mapping and aerial photography, marsh, shallow open water wetlands and ephemeral drainages occur throughout the Study Area. Two known springs also occur in the Study Area: one along Secondary Canal A and the other on the boarder of Block 4 (Figure 8). Wetlands are also traversed by all Blocks, pipelines and canals according to the desktop review.

The current *Alberta Wetland Policy* in the White Zone of Alberta came into effect in June 2015 (Alberta Environment and Sustainable Resource Development [AESRD] 2013). The primary and preferred action according to the Policy is to avoid impacts to wetlands, where possible. If avoidance is not possible, minimization of impacts is required. As a final resort, where avoidance is not possible and where minimization efforts are not possible or prove to be ineffective, wetland replacement is required. The AEP requires proof of effort put into the project design to avoid and minimize impacts to wetlands (GOA 2017).

The proposed project borders the west and east shorelines of the Acadia Valley Municipal Reservoir (FWMIS ID 6900). The reservoir is located on Kennedy's Coulee (FWMIS ID 22029) which transitions from a mapped Class D watercourse at the reservoir to a mapped Class C watercourse in SW 5-24-2 W5M, with a Restricted Activity Period (RAP) from April 16 to July 15. The study area is also bordered along its south boundary by the Red Deer River (FWMIS ID 2193), which is a large permanent watercourse with a designation of a mapped Class C watercourse with a RAP from April 16 to August 15 (GOA 2006). An unnamed tributary to Kennedy's Coulee (FWMIS ID 114209) will be permanently altered with the construction of Reservoir A1. The unnamed tributary to Kennedy's Coulee is an unmapped intermittent Class C watercourse with a RAP from April 16 to July 15. Tributaries to this watercourse will carry the same RAP.

An application or notification under the *Water Act* is required for all permanent impacts to waterbodies (including wetlands) and drainages/watercourses. Additionally, a Wetland Assessment and Impact Report (WAIR) or a Wetland Assessment and Impact Form (WAIF) (GOA 2018b) will be required for any permanent impacts to wetlands, depending on the type of proposed development. WAIRs are generally required for "higher risk" activities and include a field assessment to identify wetlands, including: wetland classification, description (AESRD 2015), and an Alberta Wetland Rapid Evaluation Tool-Actual (ABWRET-A) assessment, as well as a review of historical aerial photographs to determine existing and historical land use surrounding the wetland (GOA 2017).

WAIFs are used to support “lower risk activities” such as pipeline construction. They can be completed by desktop assessment and include an Alberta Wetland Rapid Evaluation Tool-Desktop (ABWRET-D) assessment, as well as a review of historic aerial photographs to determine existing and historical land use surrounding the wetland. Fieldwork may also be used to supplement the background information in WAIFs. Risk rankings, and therefore which stream (WAIR vs. WAIF) is required for an activity is determined by the AEP (GOA 2019).

Under the *Alberta Wetland Policy*, compensation is required for any net wetland loss. Compensation for wetland loss is determined using the ABWRET assessments. Field or desktop data for each wetland is collected and is submitted to AEP for review. AEP reviews the submitted data, and provides a Relative Wetland Value, which is used to determine compensation for wetland losses (AEP 2014; AEP 2018a; GOA 2015). Costs for wetland replacement are payable directly to the GOA (2019). An estimate for costs in not possible until field survey has occurred.

A COP notification is required for wetland or watercourse crossings and outfalls (GOA 2013b and 2013c). COP notifications must be submitted to AEP a minimum of 14 days prior to commencement of construction (GOA 2013c). *Water Act* Approvals can take from 6 months up to 2 years to approve.

Consultation is recommended regarding potential requirements for regulatory applications for flooding of wetlands on the irrigation blocks.

2.3.7 Applicable Regulations

Canadian Environmental Assessment Act (2012)

CEAA 2012 regulates projects that have Federal impact. Based on the current information regarding the the project, it appears to meet the definition of a designated project pursuant to item 6 of the Regulations Designating Physical Activities (the Regulations) under the CEAA (2012). The project, as presented, is a designated physical activity under CEAA 2012 and the preparation of a formal Project Description is required.

Environmental Protection and Enhancement Act

The *Environmental Protection and Enhancement Act* (EPEA [GOA 2000a]) and its accompanying regulations set out the activities which require approval, registration or notice and the key aspects of the process for obtaining an approval. Alberta Environment’s review of registration applications helps ensure proposed activities do not cause an adverse impact on the environment. After review of the application for registration of a proposed activity, the Director makes a decision as to whether a registration should be issued or refused. If a registration is issued, the activity must be conducted in accordance with specified requirements such as a COP and EIA, in addition to the applicable provisions of EPEA and the regulations, and any other applicable legislation.

Ghostpine on behalf of the M.D. of Acadia has submitted a project summary to AEP to determine if an EIA will be required for the project because it triggers the following activities under the EPEA Environmental Assessment - Mandatory and Exempted Activities Regulation (GOA 2000a):

- Schedule 1 Mandatory Activities:
    - A dam greater than 15 metres in height when measured to the top of the dam from the natural bed of the watercourse at the downstream toe of the dam, in the case of a dam across a watercourse; and,
    - The proposed dam heights associated with Reservoir A1 are currently up to 30.5 m tall.

  A response from AEP (2019) indicated an EIA is required.

Public Lands Act

Wetlands are administered under the *Water Act* (GOA 2000c) and, in certain situations for permanent naturally occurring water bodies, under the *Public Lands Act* (GOA 2000e). Activities or water diversions that may impact wetlands may require approval, authorization, a licence and/or a disposition under both Acts. In addition, compliance with other legislation, both provincial and federal (e.g., *Species at Risk Act*), may be required before proceeding.

The *Public Lands Act*: Section 3 provides the GOA with ownership to the beds and shores of most permanent and naturally occurring waterbodies. The Department is responsible for administration of public land under provisions of the *Public Lands Act*, including wetlands. The criteria which must be met for ownership (public land) of a wetland are:

- A body of water;
- Permanent; and,
- Naturally occurring.

Some exceptions exist, and these are outlined in Section 3(2) of the *Public Lands Act*. Under section 3(3) of the *Public Lands Act,* the GOA ownership of bed and shore is retained even if a waterbody is drained or altered without authorization.

The GOA's ownership of bed and shore under Section 3 of the *Public Lands Act* is a reservation against the original land grant (Section 61(1)a of the *Land Titles Act*: Implied conditions) and applies even if the current land title is silent regarding ownership of a body of water. Consequently, even if the landowner has title to the land – unless the bed and shore is specifically mentioned on the title - the landowner may not own the wetland.

In order to impact any permanent wetland that is public land, one must have ownership or obtain a disposition. A permanent impact for private use, such as draining or infilling a wetland, is a conversion of a Public Land asset. The *Public Lands Act* authorizes the Minister to exchange public land for other land where it is in the public interest to do so.

For access, occupation and work on public land, AEP issues written authorizations, or 'dispositions', that specify the Province's requirements for these activities. The most common dispositions for work in the bed and shore are Temporary Field Authorizations (TFA) and Department Licence of Occupation (DLO).

A TFA is a short-term disposition issued for a year or less. They can be issued quickly, and authorize access, occupation or work on public land for a temporary time period. A TFA is typically issued for quick one-off projects where there is no long-term or permanent occupation of public land (e.g. permanent structures).

A DLO is a long-term disposition typically issued for multi-year projects, or the long-term or permanent occupation of public land. A DLO is often required for projects such as erosion protection, river training structures and channel realignments. DLOs have a separate application process from TFAs, which includes a letter from the applicant describing the need for the project, a completed DLO disposition application form, a detailed sketch plan and application fees. Much like a tenancy agreement, a DLO disposition may also be subject to rental fees and damage deposits.

Water Act

The *Water Act* (GOA 2000c) provides the GOA ownership of water and AEP is responsible for the administration of water management under provisions of the *Water Act*, including water in wetlands.

Any activity that affects or has the potential to affect (including cumulative effects) a waterbody and/or the aquatic environment (*Water Act*: Section 36) requires a *Water Act* approval. Additionally, before initiating any activity on "public land" (water bed or shore line) (*Public Lands Act*: Sections 20 and 47*)* an approval under the *Public Lands Act* is required.

A COP notification under the *Water Act* may also be required for wetland or watercourse crossings and outfalls (GOA 2013b). COP notifications must be submitted to AEP a minimum of 14 days prior to commencement of construction (GOA 2013b). *Water Act* Approvals can take from 6 months up to 2 years to approve.

Water Ministerial Regulation

The *Water (Ministerial) Regulation* (GOA 1998) is the secondary statute that provides information on the administration of the *Water Act*. It includes definitions of important terms, identifies the basis for *Water Act* approvals and outlines regulatory requirements, including the regulations for dam and canal safety.

The M.D. of Acadia will need to initiate a *Water Act* application for construction of the dam for Reservoir A1 if it meets certain criteria. Dam activities are those considered to include all activities related to a dam as specified in the *Water (Ministerial) Regulation*. That requires that the dam both provides a storage capacity of 30,000 cubic metres or more and is 2.5 metres or more in height.

In accordance with the Alberta Dam and Canal Safety Regulatory Framework (*Alberta Dam and Canal Safety Directive*, AEP 2018b), a dam and canal owner is responsible and accountable for the safety of their structures and must comply with all regulatory requirements that cover the life cycle of their structures, including requirements for:

- Design
- Construction
- Operation
- Decommissioning/closure

The regulatory requirements are based on the consequence classification or risk posed by the structures. To monitor compliance, the requirements and the performance of the structures are tracked by the regulators. An owner may face penalties for non-compliance with the regulatory requirements.

Alberta Wetland Policy

The *Alberta Wetland Policy* (AESRD 2013) provides a "strategic framework for conserving, restoring and protecting Alberta's wetlands." The purpose of this Directive is to inform decision making to avoid and minimize negative impacts to wetlands and, where necessary, replace lost wetland area and value. Proponents must adhere to the Wetland Mitigation Hierarchy through all stages of a proposed activity, from initial planning considerations, through operations and reclamation.

The *Alberta Wetland Assessment and Impact Report Directive* (GOA 2017) specifies that for the majority of activities that may impact a wetland, a qualified professional or team must prepare a WAIR. The report must be signed by an authenticating professional and submitted as part of the regulatory application(s). The WAIF (GOA 2018b) is used to support low risk activities regulated by AEP. For eligible activities, the form is to be used in place of the WAIR and must be authenticated by a qualified professional and submitted with a regulatory application(s) or notification and all other required plans.

Wildlife Act

The GOA has the responsibility and authority under the *Wildlife Act* (GOA 2000b) and Wildlife Regulation for the protection and management of wildlife on all land in Alberta, irrespective of whether these lands are owned by the Crown or by private interests.

There are development setback standards for Crown land for wildlife species of concern site-specific habitats (i.e., nests, dens) and rare plants which are listed under the Alberta *Wildlife Act* (GOA 2000b; GOA 2018a). The proponent must provide justification for development within setbacks of a wildlife species of concern site-specific habitat or listed rare plant according to the *Master Schedule of Standards and Conditions* (GOA 2018a).

The Fish and Wildlife Division of Alberta has developed setback distance guidelines (i.e., *Recommended Land Use Guidelines for Protection of Selected Wildlife Species and Habitat within Grassland and Parkland Natural Regions of Alberta* [ASRD 2011]) to provide effective management for selected wildlife species within the Grassland and Parkland natural regions of Alberta. With the exception of a few minor changes, these timing and setback guidelines have been used as the basis for Fish and Wildlife Division input to the Public Lands Division land use referral system since 1996.

The guidelines focus on species within the prairie and parkland natural regions in Alberta that have been identified as:

- at risk of extirpation
- may be at risk of extirpation
- sensitive and requiring special attention

These classifications are based on the *General Status of Species in Alberta*. The guidelines were developed to identify general setback distances and timing restrictions that should apply to various land use/surface disturbance activities, including resource exploration and development.

The *General Status of Alberta Wild Species 2015* (CESCC 2016) uses a system for evaluating the general status of all wild vertebrate species in Alberta. General status determination is the first step in a continuing process of evaluating and reporting on the biological status of Alberta's wild species. Those species that *May Be at Risk* receive a detailed status assessment and will go on to receive much more detailed evaluation.

With the release of the 2015 wild species status information, the Fish and Wildlife Policy Branch of AEP is reporting the status of vertebrates (amphibians, birds, fish, mammals and reptiles) using the same methodology and terms used in 2000, 2005, 2010 and will no longer be including plant or invertebrate information in the database. This allows comparison of general status information from one reporting period to another.

Migratory Birds Convention Act

The purpose of the *Migratory Birds Convention Act* (GC 1994) is to implement the convention by protecting and conserving migratory birds, as populations and individual birds, and their nests.

Clearing of brush, trees, grasses or aquatic vegetation from an area that may contain a nesting migratory bird is prohibited by the regulations. The mitigation recommended by Environment Canada and provincial agencies is to avoid clearing during the breeding season (generally between mid April to September 1 in southern Alberta) (Environment Canada 2018). If clearing is unavoidable, they recommend that proponents undertake a nesting site survey to identify nest sites within the area to be disturbed and to protect those sites until the young birds have fledged and are able to leave the nest.

Species at Risk Act

The purpose of the *Species at Risk Act* (GC 2002) is threefold: to prevent wildlife species from being extirpated or becoming extinct; to provide for the recovery of wildlife species that are extirpated, endangered or threatened as a result of human activity; and to manage species of special concern to prevent them from becoming endangered or threatened. *Species at Risk Act* complements provincial and territorial laws as well as existing federal legislation (e.g. the *Canada Wildlife Act*, the *Fisheries Act*, the *Migratory Birds Convention Act*).

The *Species at Risk Act* establishes Schedule 1, as the official list of wildlife species at risk. It classifies those species as being either extirpated, endangered, threatened, or a special concern. Once listed, the measures to protect and recover a listed wildlife species are implemented.

Weed Control Act

Weeds listed in the Alberta *Weed Control Act* (GOA 2008) are a threat to Alberta's environment, economy and society. They have the potential to degrade habitats, reduce biodiversity, increase erosion, cause wildfires, reduce property value, create obstacles to international trade and cause reduction in productivity of agricultural land.

Under the Alberta *Weed Control Act*, *Prohibited Noxious* weeds need to be destroyed and *Noxious* weeds need to be controlled. The *Weed Control Regulation* (GOA 2010) provides the list of *Prohibited Noxious* weeds and *Noxious* weeds in Alberta. Landowners and occupiers are responsible for controlling *Noxious* weeds and destroying *Prohibited Noxious* weeds under the Act. A pre-construction weed survey of the project footprint and weed control plan generally need to be completed as a component of regulatory submissions. Post-construction weed surveys and reporting may also be required as a component of regulatory approval.

Fisheries Act

Under the provisions of the *Fisheries Act* (GC 1985a), no work may be carried out that will cause serious harm to fish that is a part of a commercial, recreational, or aboriginal fishery unless authorized by the Fisheries and Oceans Canada (DFO).

RAPs for fish species in the ten (10) fish management zones of Alberta provide periods during which activities in or along fish-bearing waters in each of the ten fish management zones are considered high risk for causing harm to specified fish populations. RAPs protect fish, their eggs and juveniles and habitats from harm through avoidance or full mitigation of any potentially harmful activities during high-risk periods.

Historical Resources Act

The *Historical Resources Act* (GOA 2000d) is the act which defines the duty of proponents to obtain clearance from Alberta CMSW for most ground disturbance activities in Alberta. Although several procedural changes have occurred within the cultural resource management framework, the overall regulatory systems have not changed in a substantive way over time.

Canadian Navigable Waters Act

Approvals from Transport Canada will not be required for this project, as the Red Deer River is not listed as waterways under the *Canadian Navigable Waters Act* (Transport Canada 2019); however, the Common Law Right of Navigation must be maintained, meaning warning signs should be used if obstructing a navigable waterway and assistance provided for those who wish to navigate past the project (Transport Canada 2014).

2.4 Critical Path Items and Mitigation Options

2.4.1 Land Use/Vegetation Cover

Critical Path Item:

All of Reservoir A1, the Main Supply Pipeline, Intake and Pump House and small portions of the Blocks and pipelines traverse native prairie, of which portions are also Crown land. Crown land applications and assessments may be required on Crown-owned land, including: conservation assessments on native prairie, disposition supplements, and targeted wildlife and vegetation surveys according to the Alberta Government *Sensitive Species Inventory Guidelines*, and pre-construction wildlife sweeps (GOA 2013a; GOA 2018a).

The proposed project will require an EIA under the *Environmental Protection and Enhancement Act* (EPEA [GOA 2000a; AEP 2019]). It will also require the submission of a Project Description as it has been designated a *Physical Activity* under the CEAA [Pers. Comm. Wallsmith 2019). Additional work, such as multiple years of targeted wildlife and rare plant surveys may be required to supplement the EIA and CEAA applications.

Mitigation Strategies:

- Government consultation is recommended in order to determine the required applications and scope of assessments required for the proposed project.
- One of the most effective strategies to minimize environmental impacts on flora and fauna in the Study Area would be to route and site the project to avoid native prairie grasslands, coulees and riparian areas and other sensitive areas such as wetlands as much as feasible. Much of the project has already been sited within cultivated lands; however, further routing could serve to avoid more sensitive habitats. Avoidance of Crown-owned land will also reduce the overall application costs and potential project delays.
- Construction techniques such as boring pipelines through sensitive areas instead of trenched construction would serve to minimize disturbance to native prairie, coulee and wetlands habitats.
- The site for Reservoir A1 is a native prairie coulee and there are no current alternatives for this site. A no-net loss compensation strategy for the native prairie habitat coulee such as the purchase of native prairie for wildlife habitat use near the Study Area would be a potential option to preserve the native prairie grassland. Government consultation is recommended regarding potential compensation options for native prairie.
- Due diligence is required to ensure that weeds are not introduced into the site or spread throughout the Study Area under the *Weed Control Act* and *Weed Control Regulations* (GOA 2008 and 2010). It is recommended that all construction equipment arrive in the Study Area in a clean condition to minimize the risk of weed introduction. Any equipment, which arrives in a dirty condition, be cleaned at a suitable off-site location. Post reclamation monitoring is also recommended to ensure weeds have not been introduced into the project area.

2.4.2 Vegetation and Wildlife (Species of Concern)

Critical Path Item:

The Study Area has potential for vegetation and wildlife species of concern, especially in native prairie grasslands, coulees, riparian areas and wetlands. Clearing/construction of the project especially during the high-risk period for migratory birds and other species of concern could lead to project delays and/or potential contravention of wildlife legislation (i.e., the *Alberta Wildlife Act* (GOA 2000b), *Migratory Birds Convention*

Act (GC 1994) and *Species at Risk Act* (GC 2002) if wildlife is disturbed or killed. As with the federal *Migratory Birds Convention Act* and *Species at Risk Act*, the proponent must show due diligence under the provincial *Wildlife Act* that wildlife is not harmed as a result of the project.

There are development setback standards for Crown land for wildlife species of concern site-specific habitats (i.e., nests, dens) and rare plants which are listed under the Alberta *Wildlife Act* (GOA 2000b; GOA 2018a). The proponent must provide justification for development within setbacks of a wildlife species of concern site-specific habitat or listed rare plant according to the *Master Schedule of Standards and Conditions* (GOA 2018a). The *Recommended Land Use Guidelines for Protection of Selected Wildlife Species and Habitat within Grassland and Parkland Natural Regions of Alberta* (ASRD 2011) also provide guidance for development setbacks and timing constraints from site-specific habitats of species of concern.

Although rare plant species which only are tracked or watched by ACIMS (2017) have no government protection, best management practices would be to avoid or mitigate disturbance of rare plants where feasible.

Mitigation Strategies:

Wildlife:

- See Land Use/Vegetation cover for avoidance/mitigation options for wildlife habitat and sensitive habitat for rare plant species;
- In order to reduce/avoid disturbance and mortality of wildlife species as much as possible, it is recommended that clearing and construction of the project and the flooding of the reservoir occur outside of high-risk periods for wildlife, including breeding period (March 15 to September 1);
- Targeted Surveys according to Alberta Government *Sensitive Species Inventory Guidelines* (GOA 2013a) are recommended where wildlife and rare plant habitat is traversed by the project, regardless of ownership. Surveys for wildlife and listed rare plants are required on any traversed Crown-owned land. Surveys must be conducted during specific times over the spring and summer and multiple trips are required for certain surveys (GOA 2013a).
- Targeted surveys recommended/required in the study area include: sharp-tailed grouse, burrowing owl, grassland bird, common nighthawk, short-eared owl, prairie raptor, amphibian, snake and rare plant. Additional targeted surveys may be recommended based on the habitat which is traversed by the project.
- There are setback distances and timing constraints for site-specific habitats such as nests, dens and breeding areas of species of concern and listed plant species (GOA 2013a; ASRD 2011). Taking the recommended setbacks and timing constraints in to consideration for site-specific habitats will reduce disturbance/mortality of species of concern.
- A pre-construction wildlife sweep prior to construction is also recommended for due diligence purposes, if the work is during the high-risk period, in order to identify potential issues and undertake mitigation/avoidance measures. Pre-construction wildlife sweeps are required on Crown-owned land regardless of the time of year and as a condition for WAIFs and WAIRs.
- If wildlife protected under the federal *Migratory Birds Convention Act* (GC 1994), species protected under the Alberta *Wildlife Act* (GOA 2000b) or federal *Species at Risk Act* (GC 2002) are found, suspected or observed during clearing, construction and/or clean up, work should be postponed. Ghostpine should be contacted and a mitigation plan to minimize disturbance should be undertaken.
- During pipeline construction and excavation, check the trench at least twice daily for trapped wildlife. Provide 5 m wide pipe, spoil pile, or trench breaks (2:1 sloped plugs) every 300 m to allow wildlife to escape from the trench as well as providing for greater wildlife movement across the right of way (ROW). Remove all trapped wildlife from the trench. Note that removal of wildlife should be conducted by a qualified wildlife professional and reported to the local AEP Fish and Wildlife (F&W) office.

- The proposed project is within the range of the prairie rattlesnake. Workers should be informed that prairie rattlesnakes are protected by the Alberta *Wildlife Act* and it is illegal to kill this species (GOA 2000b). This species is "venomous and dangerous, but rarely fatal" (Russell and Bauer 2000). As a precaution, and to avoid conflicts with snakes, workers should check excavations prior to backfilling and worksites prior to construction (for the presence of all snake species) and be vigilant of their surroundings (i.e., entering and exiting vehicles and equipment). If a prairie rattlesnake is found on the development, removal of wildlife should be conducted by a qualified wildlife professional and reported to the local F&W office. Workers should be aware of first aid procedures for snake bites.
- In an effort to reduce mortality and disturbance to wildlife during the construction program, speed limits of project traffic should be strictly enforced. It should be noted that there are many rattlesnake observations recorded in FWMIS along roads in the project area as this and other snake species bask on roads for their heat. Workers should be informed to respect speed limits and watch for and avoid all wildlife on roads at all times.
- Workers found harassing or feeding wildlife or littering should be removed from the project.
- Other mitigation/compensation measures may include: construction of hibernacula/den sites if any hibernaculum are lost due to flooding; alterative nesting platforms, artificial burrow construction for burrowing owls, wetland or riparian habitat restoration.
- During pipeline construction, best management techniques options include: narrowing down the ROW, use of padding and fencing to avoid root damage, and proper soil salvage techniques to maintain the seed bed. If rare plants cannot be avoided, transfer of plants to adjacent similar habitats with a watering/monitoring program may be a potential option. Consultation regarding transfer of listed Rare and Endangered Species is recommended.

2.4.3 Fisheries

Critical Path Item:

Information deficiencies and data gaps pertaining to fish and aquatic resources should be identified and subject to a desktop assessment, a field assessment, or both. In addition, fish and fish habitat assessments should be completed wherever project infrastructure overlaps with potential watercourses and fisheries resources.

Water diversions (i.e., withdrawal, storage and release), and the construction of associated infrastructure (i.e., intakes, dams, pipeline crossings, irrigation canals, and discharge structures), have the potential to adversely affect fish and fish habitat. As such, the project is required to adhere to the requirements of the *Water Act* (GOA 2000c), the *Fisheries Act* (GC 1985a) and the *Navigation Protection Act* (GC 1985b). Outfalls and watercourse crossings (i.e., pipeline and temporary construction access) should also adhere to the *Code of Practice for Outfall Structures on Waterbodies*, the *Code of Practice for Watercourse Crossings* (GOA 2013b and 2013c), and the *Guide to the Code of Practice for Watercourse Crossings, Including Guidelines for Complying with the Code of Practice* (Alberta Environment 2000a). In the event that the requirements listed in these codes of practices of the DFO's *Measure to Avoid Causing Harm to Fish and Fish Habitat* cannot be met, and effects to fish and fish habitat are anticipated, the project will be subject to approvals under the W*ater Act*, and *Fisheries Act* Request-for-Review(s) or Authorization(s), including, but not limited to, DFO offsetting requirements and associated monitoring. These regulatory processes will require written specifications and recommendations of a Qualified Aquatic Environmental Specialist (QAES).

Mitigation Strategies:

- A comprehensive fish and fish habitat assessment should be conducted at proposed intake and outfall locations and at the proposed Reservoir A1 location to document existing fisheries resources that would require protection strategies as well as provide habitat limitations where mitigation may not be required. Due to regulatory approval timelines, it is recommended a fish assessment be conducted as soon as possible so that the results of the assessment could accompany any regulatory applications.
- Identify data gaps, areas of overlap between the project footprint and aquatic resources and other aquatic habitats that might be indirectly affected (e.g., decreased instream flows below the intake on the Red Deer River).
- Physically avoid overlaps and potential interactions (e.g., locate intakes and outfalls on the banks as opposed to the bed of the waterbodies, route pipeline and canal alignment in a manner that minimizes the number of watercourse crossings, etc.).
- Construction should occur in a manner that avoids the watercourse specific RAPs, water withdrawals and diversion shall occur at a time that does not adversely affect critical fish spawning and overwintering.
- During construction, fish rescue activities should be conducted in areas where fish could be stranded within an isolated work site (i.e. at water intakes or outfalls). All fish present (if any) within the proposed Reservoir A1 location will require relocation during construction.
- A water quality monitoring program should be implemented for all construction work below the high water mark on the Acadia Valley Municipal Reservoir, Red Deer River and the unnamed tributary to Kennedy's Coulee (at Reservoir A1).

2.4.4 Wetlands/Ephemeral Waterbodies

Critical Path Item:

A *Water Act* Application including WAIR or a WAIF will be required for any permanent impacts to wetlands, depending on the type of proposed development. A review under the *Public Lands Act* may also be required for any potentially permanent wetlands. The AEP requires proof of effort put into the project design to avoid and minimize impacts to wetlands.

The wetland assessments for the WAIR must be completed within the growing season (approximately May to September) to align with the *Alberta Wetland Policy*. Current review times by AEP are in the range of 6 months to two years (or more), depending on regulator workload, the number of impacted features and the complexity of the system.

Government consultation is recommended on application requirements for flooding wetlands due to the irrigation project.

Mitigation Strategies:

- Potentially permanent wetlands should be avoided where possible; if not, a wetland permanency review may be required.
- It is recommended to bore under wetlands where possible during pipeline construction;
- If avoidance of wetlands is not possible, minimization of impacts is required. As a final resort, where avoidance is not possible and where minimization efforts are not possible or prove to be ineffective, wetland replacement is required. Offset costs will be calculated after field assessment is complete.

3 HISTORICAL RESOURCES OVERVIEW

To obtain *Historical Resources Act* (GOA 2000d) clearance for the proposed project, a Historic Resources Application must be submitted to CMSW. This application will be accompanied by a Statement of Justification (SoJ) which will provide CMSW with the various project components, proposed ground disturbance activities and a summary of the potential impacts to cultural resources. The evaluation of the project within this document will closely resemble the important content within the SoJ.

CMSW will base their recommendations for a Historical Resources Impact Assessment (HRIA) on specific ground disturbance activities. This would include flooding, earthworks, temporary and permanent access road construction and/or utilization, pipeline trenching, ROW and temporary workspace stripping and grading, pumphouse site excavation, canal excavation, and potentially project related expansion of cultivated areas. Other ground disturbance activities may also require evaluation. As such, the various project components will be discussed in relation to specific cultural resources.

3.1 Archaeological Resources

3.1.1 Area of Interest

The overall project area contains notations for archaeology and palaeontology within the *Listing of Historic Resources* (CMSW 2019). These notations indicate that the project traverses lands with previously recorded archaeological sites as well as lands with high potential for the discovery of new archaeological and palaeontological sites (Figure 9).

Previously recorded archaeological resources are primarily concentrated along the Red Deer River, Kennedy's Coulee, the proposed Reservoir site, and to a lesser extent within native prairie portions of the valley upland. Several resources are also located on cultivated lands, though it is assumed that these resource sites have been negatively impacted by cultivation since their discovery.

3.1.2 Reservoir

The proposed reservoir traverses lands that are listed as containing archaeological resources and also having potential for discovery of new archaeological resource sites. Specifically, five (5) previously recorded archaeological resource sites overlap the proposed reservoir boundary. As such, the potential to negatively impact these archaeological resources through either flooding or the construction of related earthworks is certain.

The potential to discover additional archaeological resources along the margins of the coulee or within the coulee channel is also very high. The existing archaeological sites are comprised of tipi rings and stone cairns that were discovered through a broad survey of the Red Deer River Valley in 1975. As such, systematic shovel testing may uncover additional archaeological material, and a more detailed ground survey could result in the discovery of additional stone feature sites. Backhoe testing of the coulee channel will likely be required to properly evaluate the archaeological potential due to the increased sedimentation.

Archaeological excavation of the known archaeological resource sites, as well as any newly discovered resource sites will be the recommended mitigation, due to the ground disturbance impact of the proposed reservoir.

3.1.3 Pumphouse, Intake and Main Supply Line

The proposed pumphouse, intake, and main supply line traverses lands that are listed as containing archaeological resources and also having potential for discovery of new archaeological resource sites. Specifically, three (3) previously recorded archaeological resource sites exist in close proximity to the proposed project components. The potential to negatively impact these archaeological resources through construction activities is relatively low, but access to these components may require avoidance of these sites.

The potential to discover additional archaeological resources along the margins of the coulee, the valley upland or within the Red Deer River valley is also very high. The existing archaeological sites are comprised of tipi rings and stone cairns that were discovered through a broad survey of the Red Deer River Valley in 1975 and again in 2016. As such, systematic shovel testing may uncover additional archaeological material and a more detailed ground survey could result in the discovery of additional stone feature sites. Backhoe testing of the floodplain of the Red Deer River valley will likely be required to properly evaluate the archaeological potential due to the increased sedimentation.

Avoidance of the known archaeological resource sites, as well as any newly discovered resource sites will be the recommended mitigation wherever possible. If avoidance is not possible, archaeological excavation of the resource will be recommended.

3.1.4 Canals and Irrigation Conveyance Network

The proposed irrigation canals traverse lands that are listed as containing archaeological resources and also having potential for discovery of new archaeological resource sites. Specifically, three previously recorded archaeological resource sites exist in close proximity to the proposed canals in the vicinity of the proposed reservoir. One previously recorded site also exists along the proposed Secondary B Pipeline, although it is located on cultivated lands and is almost certainly destroyed. Finally, one previously recorded site exists along the proposed Siphon Line. The potential to negatively impact these archaeological resources through construction activities is moderate to high.

The potential to discover additional archaeological resources within native prairie portions of the regional upland is also very high. The existing archaeological sites are comprised of tipi rings and stone cairns that were discovered through a broad survey of the Red Deer River Valley in 1975 and again in 2007. As such, systematic shovel testing may uncover additional archaeological material and a more detailed ground survey could result in the discovery of additional stone feature sites.

Avoidance of the known archaeological resource sites, as well as any newly discovered resource sites will be the recommended mitigation wherever possible. If avoidance is not possible, archaeological excavation of the resource will be recommended. A revisit of the previously recorded archaeological site located within cultivated lands should be conducted so that the condition of this site can be updated in the provincial database.

3.1.5 Irrigation Block 1A

Proposed Irrigation Block 1A is composed of lands that contain archaeological resources and are also listed as having potential for discovery of new archaeological resource sites. Specifically, one previously recorded archaeological resource sites exists within the proposed irrigation block footprint. Two previously recorded sites also exists within close proximity to the proposed block. The potential to negatively impact these archaeological resources through agricultural activities is moderate to high, especially where the proposed block expands into native prairie. One previously recorded archaeological site will be negatively impacted if cultivation is expanded within the proposed block footprint.

The potential to discover additional archaeological resources within native prairie portions of the regional upland is also very high. The existing archaeological sites are comprised of tipi rings and stone cairns that were discovered through a HRIA survey in 1977. Systematic shovel testing may uncover additional archaeological material and a more detailed ground survey could result in the discovery of additional stone feature sites.

Avoidance of the known archaeological resource sites, as well as any newly discovered resource sites will be the recommended mitigation wherever possible. If avoidance is not possible, archaeological excavation of the resource will be recommended.

3.1.6 Irrigation Block 1B

Proposed Irrigation Block 1B is composed of lands that contain archaeological resources and are also listed as having potential for discovery of new archaeological resource sites. Specifically, eight previously recorded archaeological resource sites exist within the proposed irrigation block footprint. Of these sites, one is located within cultivated land and is almost certainly destroyed. The remaining seven sites are located within native prairie. The potential to negatively impact these archaeological resources through agricultural activities is moderate to high, especially where the proposed block expands into native prairie. Seven previously recorded archaeological sites will be negatively impacted if cultivation is expanded within the proposed block footprint.

The potential to discover additional archaeological resources within native prairie portions of the regional upland is also very high. The existing archaeological sites are comprised of tipi rings and stone cairns that were discovered through a broad survey of the Red Deer River Valley in 1975. As such, systematic shovel testing may uncover additional archaeological material and a more detailed ground survey could result in the discovery of additional stone feature sites.

Avoidance of the known archaeological resource sites, as well as any newly discovered resource sites will be the recommended mitigation wherever possible. If avoidance is not possible, archaeological excavation of the resource will be recommended. A revisit of the previously recorded archaeological site located within cultivated lands should be conducted so that the condition of this site can be updated in the provincial database.

3.1.7 Irrigation Block 2

Proposed Irrigation Block 2 is composed of lands that contain archaeological resources and are also listed as having potential for discovery of new archaeological resource sites. Specifically, five previously recorded archaeological resource sites exist within the proposed irrigation block footprint. Of these sites, one or two are located within cultivated land and are likely destroyed. The remaining three sites are located within native prairie. The potential to negatively impact these archaeological resources through agricultural activities is moderate to high, especially where the proposed block expands into native prairie. Three previously recorded archaeological sites will be negatively impacted if cultivation is expanded within the proposed block footprint.

The potential to discover additional archaeological resources within native prairie portions of the regional upland is also very high. The existing archaeological sites are comprised of tipi rings, stone cairns, and an artifact scatter that were discovered through a broad survey of the Red Deer River Valley in 1975 as well as a HRIA in 1999. Systematic shovel testing may uncover additional archaeological material and a more detailed ground survey could result in the discovery of additional stone feature sites.

Avoidance of the known archaeological resource sites, as well as any newly discovered resource sites will be the recommended mitigation wherever possible. If avoidance is not possible, archaeological excavation of the resource will be recommended. A revisit of previously recorded archaeological sites located within cultivated lands should be conducted so that the condition of these sites can be updated in the provincial database.

3.1.8 Irrigation Block 3

Proposed Irrigation Block 3 is composed of lands that do not contain archaeological resources and are also not listed as having potential for discovery of new archaeological resource sites. This is due, in part, to the fact that the proposed irrigation block is made up of predominately cultivated lands, and no cultural resources have been previously reported on those lands.

The potential to discover archaeological resources within the native prairie found in the northeast corner of the block is considered moderate due to the preponderance of archaeological sites associated with native prairie throughout the region. Systematic shovel testing and a detailed ground survey could result in the discovery of additional buried artifact scatters or stone feature sites.

Avoidance of any newly discovered resource sites will be the recommended mitigation wherever possible. If avoidance is not possible, archaeological excavation of the resource will be recommended.

3.1.9 Irrigation Block 4

Proposed Irrigation Block 4 is composed of lands that do not contain archaeological resources but are listed as having potential for discovery of new archaeological resource sites, specifically where the proposed block impacts native prairie along the edge of the creek channel. The proposed irrigation block is made up of predominately cultivated lands, and no cultural resources have been previously reported on those lands.

The potential to discover archaeological resources within the native prairie found along the southwest edge of the block is considered moderate. Systematic shovel testing and a detailed ground survey could result in the discovery of additional buried artifact scatters or stone feature sites.

Avoidance of any newly discovered resource sites will be the recommended mitigation wherever possible. If avoidance is not possible, archaeological excavation of the resource will be recommended.

3.2 Historic Resources

There are no previously discovered historic resource sites (artifacts, site features, or standing structures related to the Historic Period in Alberta) within the overall project area or within individual component areas related to the project.

A HRIA may result in the discovery of new historic resource sites. These may consist of standing structures, surface artifacts, surface features, or buried materials. Any newly discovered sites would be detailed within the final report of the HRIA, including site significance and recommendations regarding site avoidance or site mitigations.

3.3 Palaeontological Resources

3.3.1 Area of Interest

The overall project area contains notations for palaeontology within the *Listing of Historic Resources* (CMSW 2019). These notations indicate that the project traverses lands with high potential for the discovery of new palaeontological resource sites, particularly along the Red Deer River, along Kennedy's Coulee and along the coulee proposed for the reservoir.

3.4 Cultural Resources

There are no previously discovered cultural resource sites (usually a designation assigned to First Nations and Métis traditional use or sacred sites) within the overall project area or within individual component areas related to the project.

A HRIA will not likely result in the discovery of new cultural resource sites. Any newly discovered sites of cultural significance to First Nations would be detailed in an appendix within the final report of the HRIA, including perceived site significance and recommendations regarding site avoidance or stakeholder consultation.

3.5 Critical Path Items and Mitigation Options

3.5.1 Archaeological/Palaeontological Resources

Critical Path Item:

A Historic Resources Application is required for all components of this project, as per the *Historical Resources Act* of Alberta.

The Reservoir, Main Supply Pipeline, Intake, Pump House and small portions of the Blocks and pipelines traverse native prairie and erosional slopes. The potential for undiscovered archaeological and palaeontological resources in these areas is extremely high. Several previously recorded archaeological resource sites are in conflict with key components of the project. A HRIA will be required in order to compile a complete inventory of historical resources within the project disturbance footprint, evaluate the potential impacts to these resources, and to develop mitigation strategies for each project component.

Wherever archaeological or palaeontological resources exist within the proposed disturbance footprint, archaeological or palaeontological mitigative excavation and/or sampling may be required. The probability of at least some level of mitigative excavation being required is very high. This type of mitigation can sometimes extend for many months and may require additional phases of excavation based on initial findings.

With cultural resources such as archaeology or palaeontology, stakeholder/First Nations interest or concerns may create unforeseen pressures on the project timeline or budget. These are very dynamic situations that may require a customized mitigative approach.

Mitigation Strategies:

- A comprehensive HRIA should be conducted as soon possible to establish a full understanding of the historical resources that will require mitigation. This assessment would be based on the requirements set out by CMSW, using methodology reviewed by a provincial Regional Archaeologist.
- The preferred form of mitigation for historical resources is avoidance. Performing a HRIA in the early phases of project planning can increase the feasibility of routing infrastructure away from historical resource impact areas.
- Mitigative excavation may be required wherever a negative impact to known historical resources cannot be avoided.
- Historical resources monitoring during construction may be a preferred mitigation strategy for palaeontological resources, which are sometimes difficult to identify and avoid prior to construction due to their deeply buried nature.
- Throughout all phases of construction, operation, and maintenance, the proponent must comply with the *Standard Requirements Under the Historical Resources Act: Reporting the Discovery of Historic Resources* document. Under Section 31 of the *Historical Resources Act* (GOA 2000d), if the proponent and/or their agents become aware of historic resources within the project footprint, they are required to report their discoveries to the Heritage Division of CMSW.

4 SERVICES AND ASSOCIATED COSTS

4.1 Land use/Vegetation Cover/Wildlife

Services that could be completed in the near future to help address any critical path items include:

- Targeted surveys recommended/required in the study area include: Sharp-tailed Grouse, Burrowing Owl, Grassland Bird, Common Nighthawk, Short-eared Owl, Prairie Raptor, Amphibian, Snake and Rare Plant. Additional targeted surveys may be recommended based on the habitat which is traversed by the project. If surveys are conducted early in the process, a repeat of the surveys would likely be warranted within the season prior to construction to re-confirm site-specific habitats.

Range of costs for wildlife, rare plant and wetland surveys would be approximately $150,000 to $200,000. Costs include one season of surveys for the reservoir and pipelines only. Costs of surveys can be refined with additional government consultation regarding the amount and type of targeted surveys and applications required.

4.2 Fisheries

Services that could be completed in the near future to help address any critical path items include:

- Complete field assessments; and,
- Data collected during the fisheries field surveys, would be compiled such that Ghostpine's QAES can provide some input during the design phase to incorporate restoration techniques and mitigation strategies that could potentially minimize regulatory approval requirements and/or expedite the approval process.

Range of costs for the fish and fish habitat assessment are approximately $30,000 to $50,000.

4.3 Wetlands/Ephemeral Waterbodies

Services that could be completed in the near future to help address any critical path items include:

- Wetland surveys, vegetation surveys and targeted wildlife surveys. Surveys would be combined where appropriate in order to be cost efficient as possible.

Costs for wetland surveys have been included in the wildlife surveys.

4.4 Historic Resources

Services that could be completed in the near future to help address any critical path items include:

- A Historic Resources Application could be sent as soon as possible, in order to facilitate moving forward with a HRIA and getting further guidance on palaeontological resource management concerns from the Royal Tyrrell Museum.
- A HRIA should be conducted as soon as possible, in order to identify the historic resource critical path items at the earliest possible stage of project planning. This will provide the greatest potential for impact avoidance through project design, as well as allow ample time to plan and conduct mitigative excavations. Excavations can be a source of project stress if left late in the schedule and the budget allocation.

Range of costs for a HRIA are $30,000 to $50,000 (this includes archaeological fieldwork and reporting only). Palaeontological requirements are possible but may take a variety of forms.

Range of costs for Mitigative Excavation per site are $37,000 to $55,000 (this includes one phase of excavation consisting of 10 to 20 square metres with moderate artifact yields).

4.5 Regulatory Applications and Consultation

Regulatory applications (supplements, permanence assessments, WAIFs/WAIRs, COPs, etc.) are not included in the above cost estimates as it's unknown how many will be needed until after consultation with the government.

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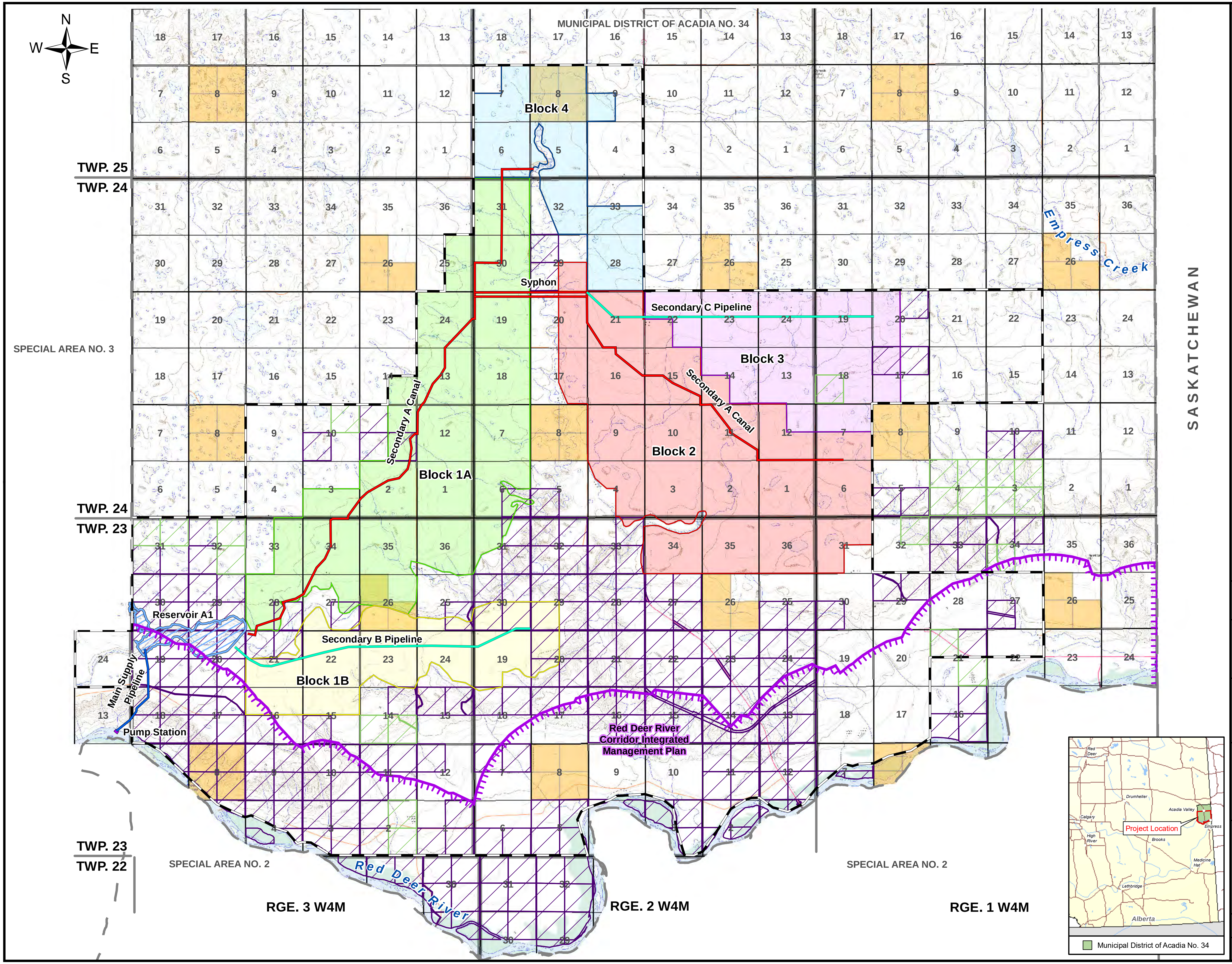
FIGURES



Legend

- ⬛ Area of Interest
- 🟩 Block 1A
- 🟨 Block 1B
- 🟥 Block 2
- 🟪 Block 3
- 🟦 Block 4
- ▨ Reservoir A1*
- Main Supply Pipeline, Intake
- Secondary B Pipeline, Secondary C Pipeline
- Secondary Canal A, Syphon
- ▣ Pump Station

Administrative Boundaries:

- Integrated Resource Management Plans - Subregional
- 🟧 Hudson's Bay Company Lands

Entire Mapped Area:

White Area

Crown Land:

- ▨ Crown Land (Provincial)
- ▨ MD Lease Land (Municipal)

** Note: If Reservoir A1 is filled to Scenario 3 at 728.5 m elevation, a portion of the reservoir will flow into 8-25-23-4 W4M, within Special Areas No. 3.*

SCALE: 1:100,000

1 0 1 km

Drafted:	MGW	*Date:*	*Revision:*
QA/QC:	SF		
Approved:	JG	Nov. 5, 2019	1
Development Source:		*Date:*	*Revision:*
CAD File		Oct. 28, 2019	n/a

Ghostpine Environmental Services Ltd.

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ATS Grid: AltaLIS 2007.
Crown Land: Received from MPE as DWG May 17, 2019.
Please see report or contact Ghostpine Environmental Services Ltd.
for additional source information.

Although we have no reason to doubt the accuracy and completeness of the data used to generate this product, users should be aware that errors in the data may be present.

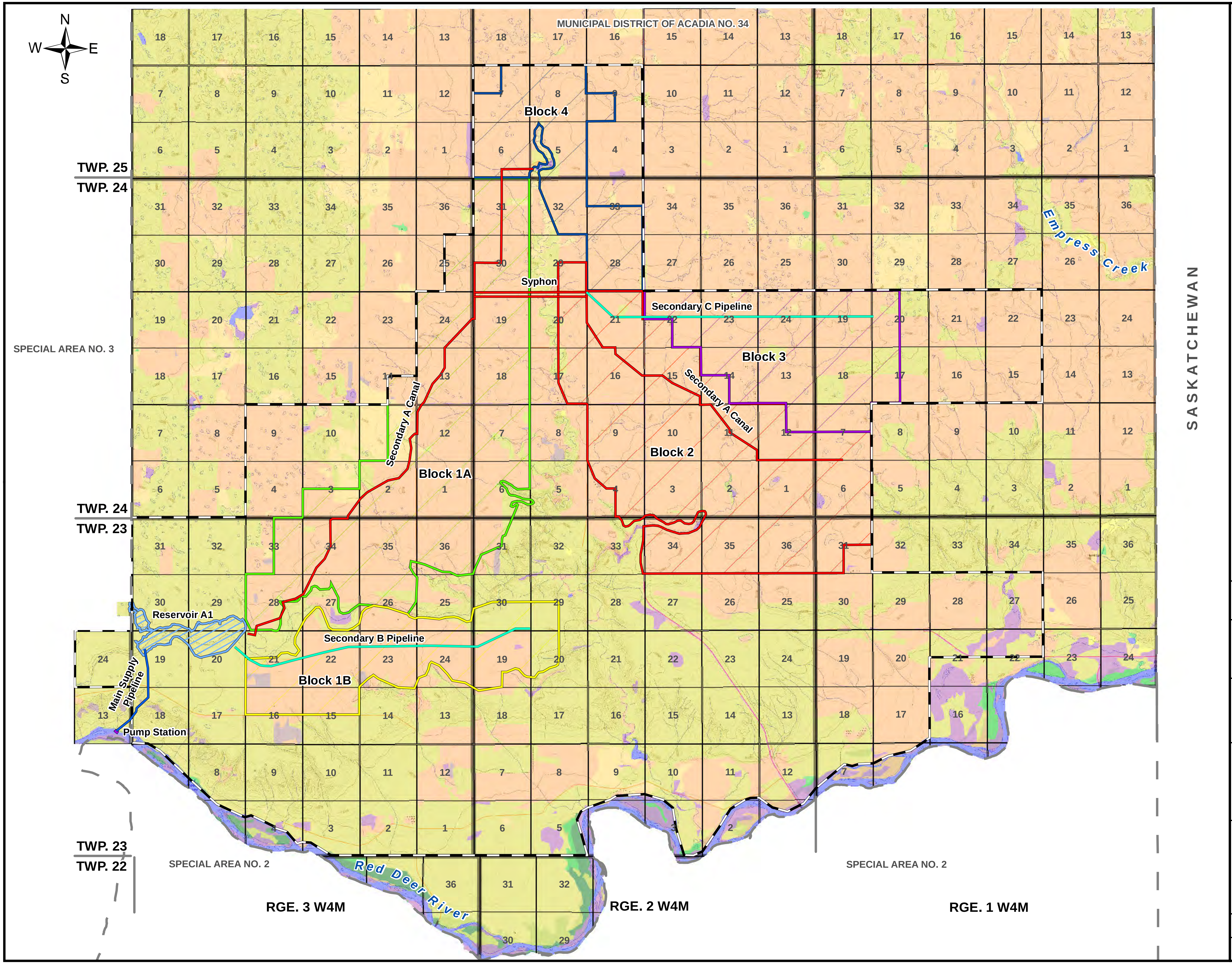
MPE Engineering Ltd.

Regional Location of the Municipal District of Acadia No. 34 Irrigation Development Study

November 2019

REF.: 5178-06-600
(Desktop Assessment)

Figure 1



Legend

- ▣ Area of Interest
- ▨ Block 1A
- ▨ Block 1B
- ▨ Block 2
- ▨ Block 3
- ▨ Block 4
- ▨ Reservoir A1*
- — Main Supply Pipeline, Intake
- — Secondary B Pipeline, Secondary C Pipeline
- — Secondary Canal A, Syphon
- ☐ Pump Station

Natural Resources Canada Land Cover:

- ■ 20-Water
- ■ 30-Barren/Non-vegetated
- ■ 34-Developed
- ■ 50-Shrubland
- ■ 80-Wetland
- ■ 110-Grassland
- ■ 121-Annual Cropland
- ■ 122-Perennial Cropland and Pasture
- ■ 210-Coniferous Forest
- ■ 220-Deciduous Forest

** Note: If Reservoir A1 is filled to Scenario 3 at 728.5 m elevation, a portion of the reservoir will flow into 8-25-23-4 W4M, within Special Areas No. 3.*

SCALE: 1:100,000

1 0 1 km

Drafted:	MGW	*Date:*	*Revision:*
QA/QC:	SF		
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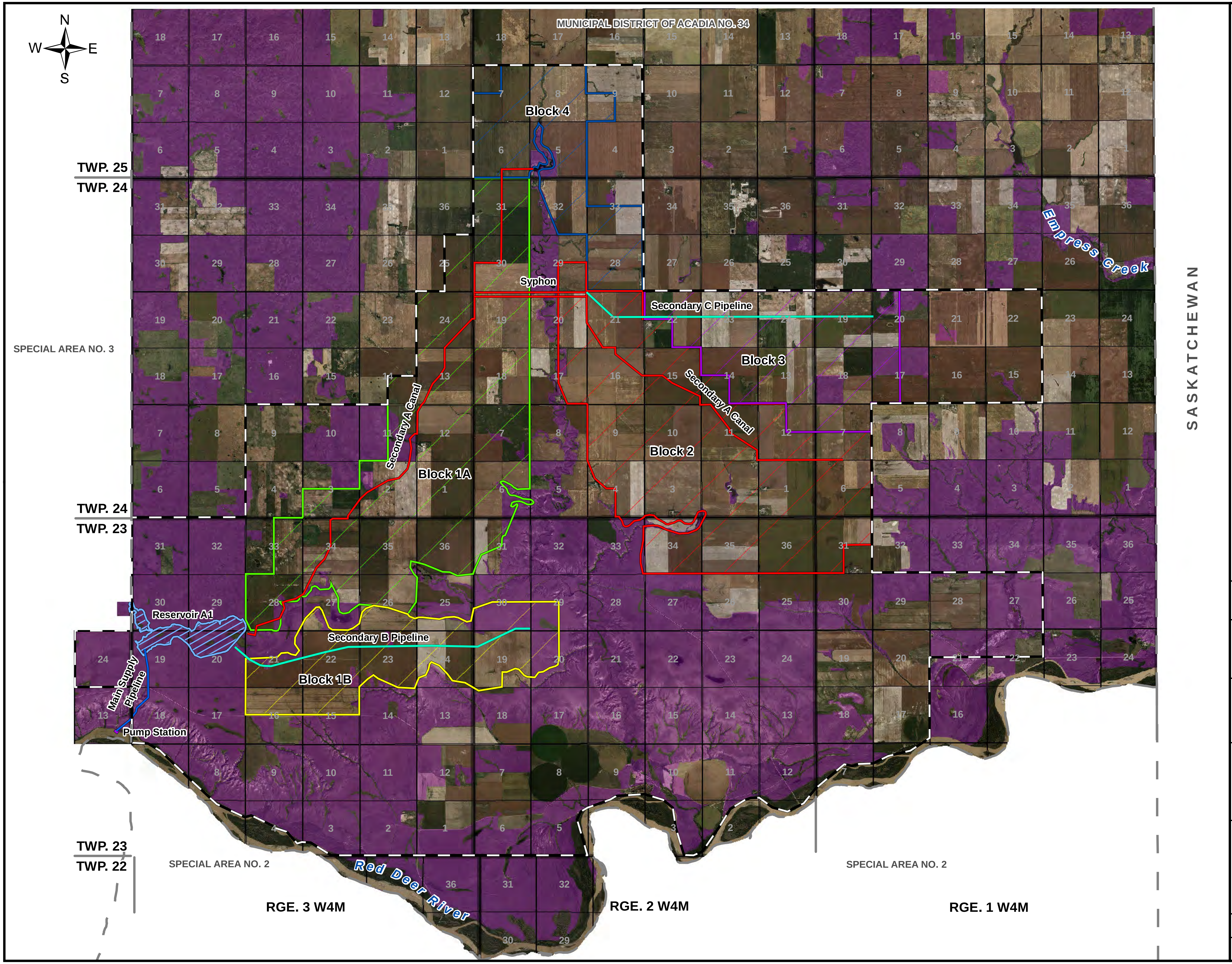
MPE Engineering Ltd.

Land Use of the Municipal District of Acadia No. 34 Irrigation Development Study

November 2019

REF.: 5178-06-600
(Desktop Assessment)

Figure 2



Legend

- Area of Interest
- Block 1A
- Block 1B
- Block 2
- Block 3
- Block 4
- Reservoir A1*
- Main Supply Pipeline, Intake
- Secondary B Pipeline, Secondary C Pipeline
- Secondary Canal A, Syphon
- Pump Station

Grassland Vegetation Inventory (GVI):

- 30-100% Native Prairie

** Note: If Reservoir A1 is filled to Scenario 3 at 728.5 m elevation, a portion of the reservoir will flow into 8-25-23-4 W4M, within Special Areas No. 3.*

SCALE: 1:100,000

1 0 1 km

Drafted:	MGW	*Date:*	*Revision:*
QA/QC:	SF		
Approved:	JG	Nov. 5, 2019	1
Development Source:		*Date:*	*Revision:*
CAD File		Oct. 28, 2019	n/a

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Imagery: Recieved from MPE. Date of Photography: 2016.
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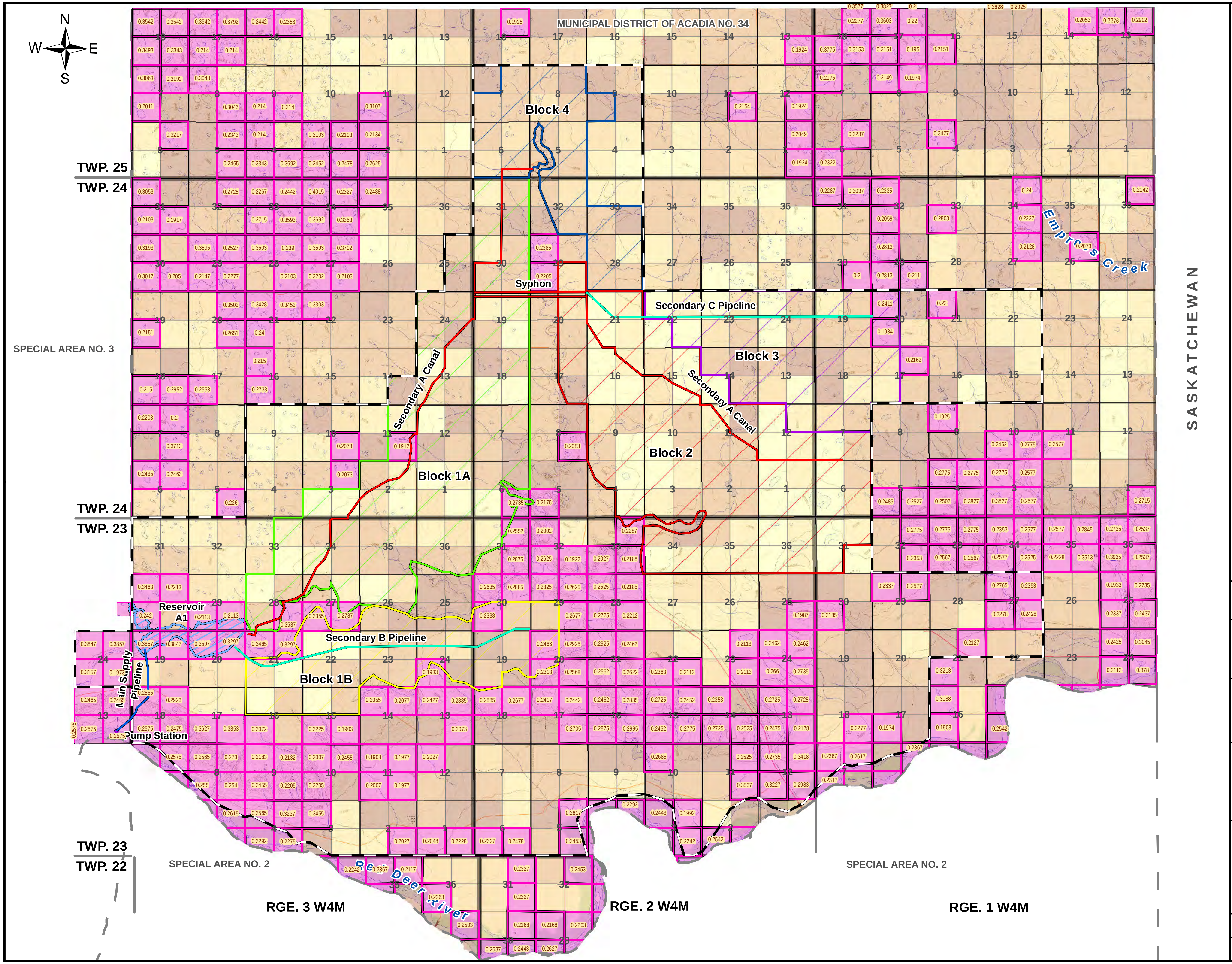
GVI Native Prairie of the Municipal District of Acadia No. 34 Irrigation Development Study

November 2019

REF.: 5178-06-600
(Desktop Assessment)

Figure 3



Legend

- ⬛ Area of Interest
- 🟩 Block 1A
- 🟨 Block 1B
- 🟥 Block 2
- 🟪 Block 3
- 🟦 Block 4
- ▨ Reservoir A1*
- Main Supply Pipeline, Intake
- Secondary B Pipeline, Secondary C Pipeline
- Secondary Canal A, Syphon
- □ Pump Station

Environmentally Significant Areas (ESAs):

- ■ >0.189 = ESA
- ■ 0.147 - 0.189
- ■ 0.108 - 0.147
- ■ 0.074 - 0.108
- ■ 0.041 - 0.074
- ■ 0.001 - 0.041

** Note: If Reservoir A1 is filled to Scenario 3 at 728.5 m elevation, a portion of the reservoir will flow into 8-25-23-4 W4M, within Special Areas No. 3.*

SCALE: 1:100,000

1 0 1 km

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Approved:	JG	Nov. 5, 2019	1
Development Source:		*Date:*	*Revision:*
CAD File		Oct. 28, 2019	n/a

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Environmentally Significant Areas of the Municipal District of Acadia No. 34 Irrigation Development Study

November 2019

REF.: 5178-06-600
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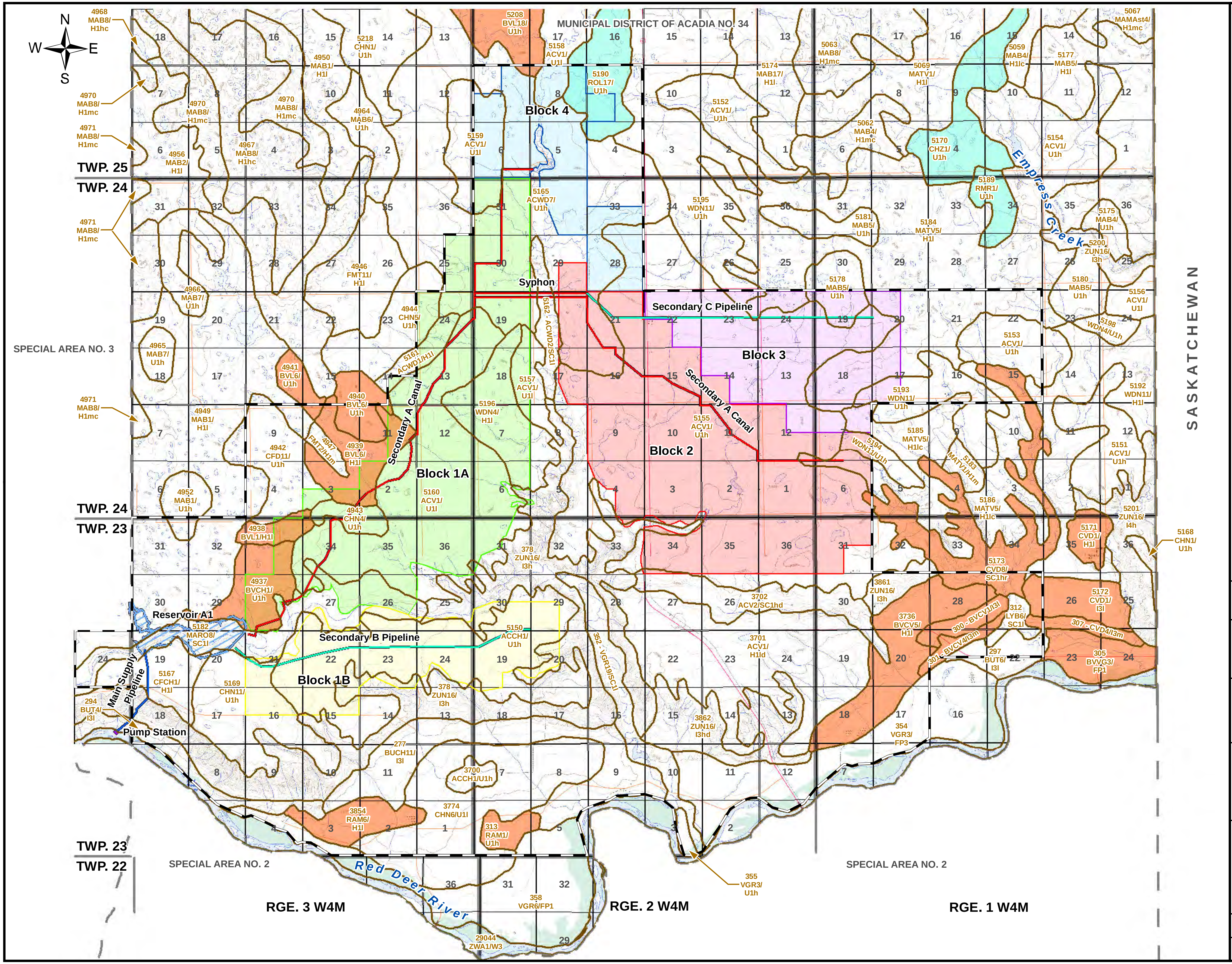
Figure 4



Legend

Area of Interest

🟩 Block 1A	Block 3
Block 1B	Block 4
🟥 Block 2	▨ Reservoir A1*

Main Supply Pipeline, Intake

Secondary B Pipeline, Secondary C Pipeline

Secondary Canal A, Syphon

Pump Station

AGRASID Polygons:

AGRASID Polygon

5177 MAB5/H1l - AGRASID Polygon Number - Details

Soil Concerns:

Saline or Solonetzic Soils
1. Moderate Wind Erosion Risk;
2. Solonetzic Tendancies; Saline C Layer - CHZ..
3. Subsoils are Weakly Saline and Sodic - RMR.
4. Subsoil is Slightly Solonetzic - ROL.

Problem Soil - Slope >15%
1. High Wind Erosion Risk; Unstable Exposed Faces BVL, CVD, RAM.
2. High Wind Erosion Risk; Gravel Seam at 30 cm; Unstable Exposed Faces PUN.

** Note: If Reservoir A1 is filled to Scenario 3 at 728.5 m elevation, a portion of the reservoir will flow into 8-25-23-4 W4M, within Special Areas No. 3.*

SCALE: 1:100,000

1 0 1 km

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Soils of the Municipal District of Acadia No. 34 Irrigation Development Study

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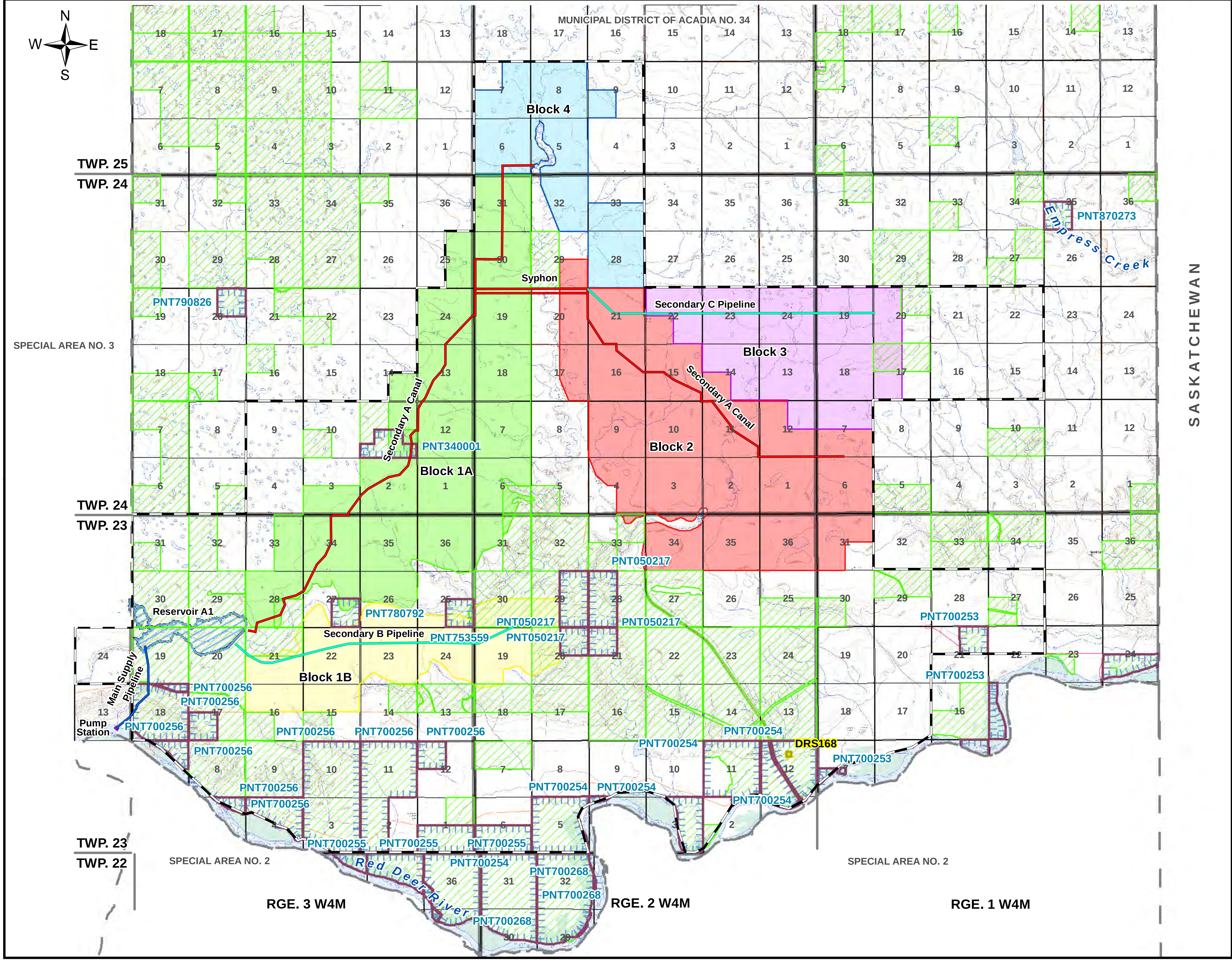
Figure 5



Legend

- ⬜ Area of Interest
- 🟩 Block 1A
- 🟨 Block 1B
- 🟥 Block 2
- 🟪 Block 3
- 🟦 Block 4
- ▨ Reservoir A1*
- — Main Supply Pipeline, Intake
- — Secondary B Pipeline, Secondary C Pipeline
- — Secondary Canal A, Syphon
- ☐ Pump Station

Digital Dispositions:

- ▦ Disposition Reservation (DRS)
- ▨ Grazing Lease (GRL)
- ▦ Protective Notation (PNT)

** Note: If Reservoir A1 is filled to Scenario 3 at 728.5 m elevation, a portion of the reservoir will flow into 8-25-23-4 W4M, within Special Areas No. 3.*

SCALE: 1:100,000

1 0 1 km

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Crown Land: Received from MPE as DWG May 17, 2019.
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Digital Dispositions within the Municipal District of Acadia No. 34 Irrigation Development Study

November 2019

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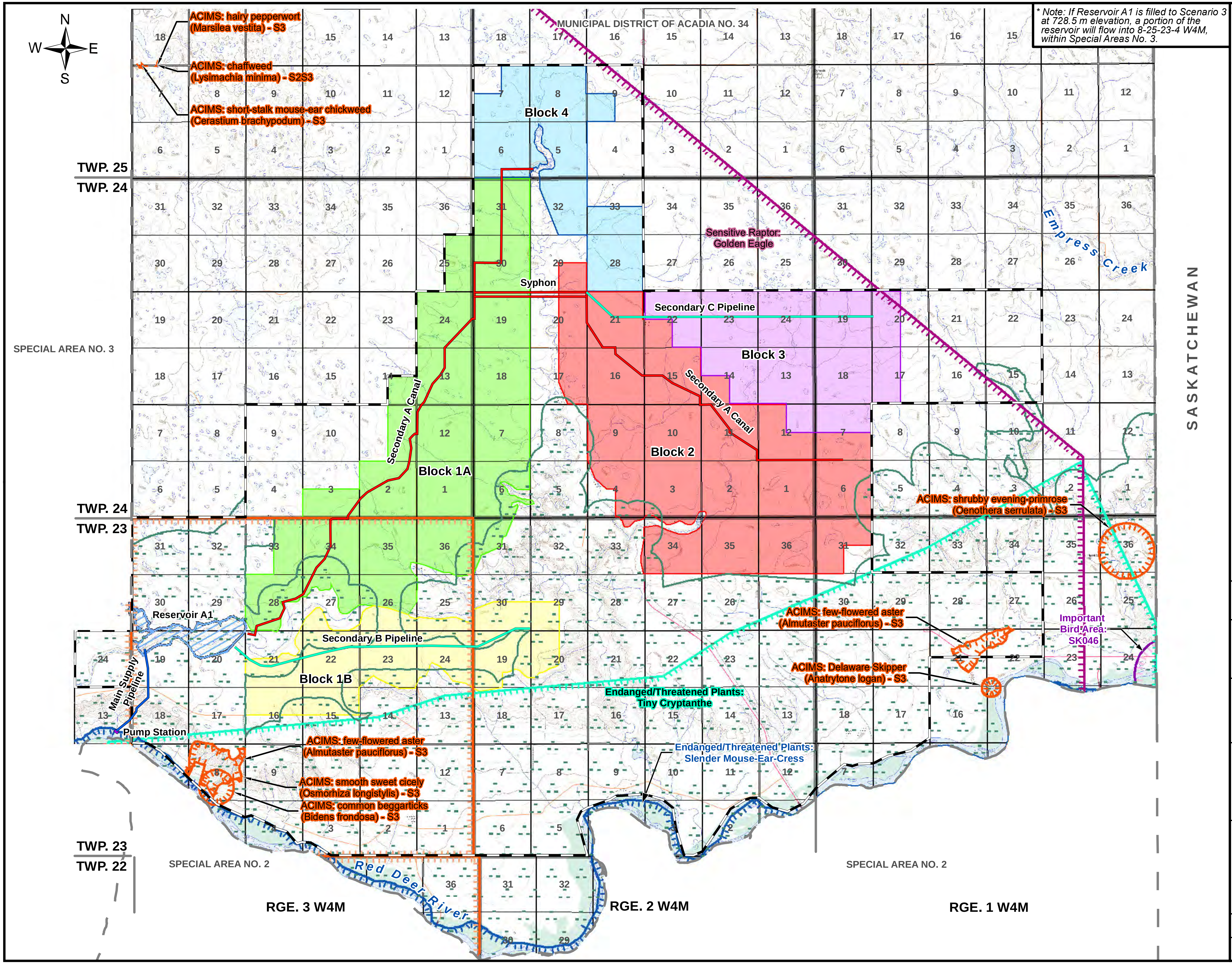
Figure 6



Legend

- ▢ Area of Interest
- 🟩 Block 1A
- 🟨 Block 1B
- 🟥 Block 2
- 🟪 Block 3
- 🟦 Block 4
- ▨ Reservoir A1*
- — Main Supply Pipeline, Intake
- — Secondary B Pipeline, Secondary C Pipeline
- — Secondary Canal A, Syphon
- ▫ Pump Station

Vegetation and Wildlife Sensitivities:

- ▢ Sensitive Snake Species Range
- ▢ Important Bird Areas

Sensitive Raptor Ranges:

- ▢ Golden Eagle

Alberta Conservation Information Management System (ACIMS):

- ▢ Nonsensitive Element Occurrences
- ▢ Sensitive Element Occurrences by Township

Endangered and Threatened Plants Range:

- ▢ Slender Mouse-Ear-Cress
- ▢ Tiny Cryptanthe

Enitre Mapped Area:

Natural Subregion: Dry Mixedgrass (Grassland)

Wildlife Sensitivity Range: Burrowing Owl; Sharp-tailed Grouse Survey; Sensitive Amphibian; Sensitive Raptor Range - Ferruginous Hawk, Prairie Falcon.

Other Sensitive and Endangered Species: Grassland.

SCALE: 1:100,000

1 0 1 km

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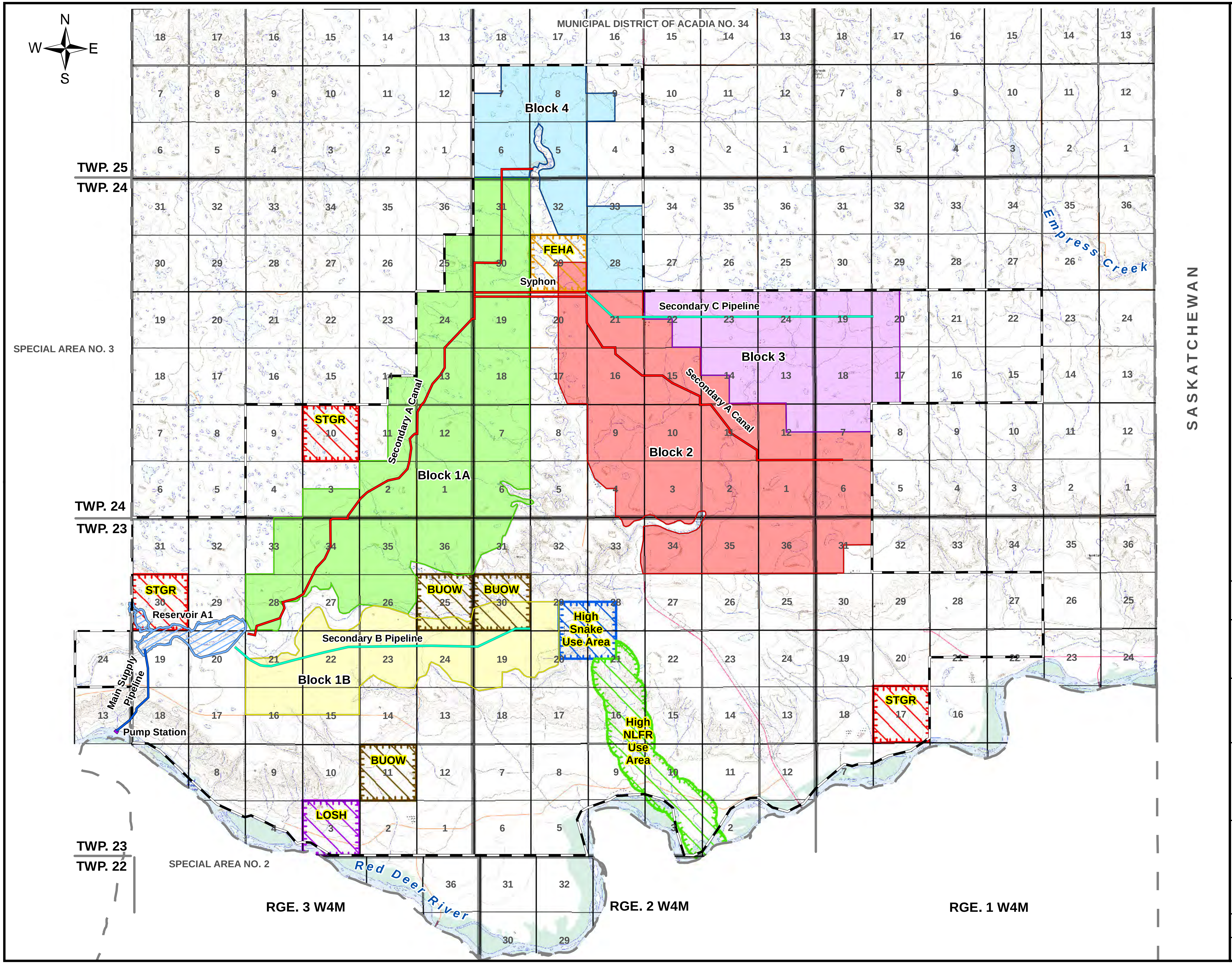
Vegetation and Wildlife Sensitivities of the Municipal District of Acadia No. 34 Irrigation Development Study

November 2019

REF.: 5178-06-600
(Desktop Assessment)

Figure 7a



Legend

- ▢ Area of Interest
- 🟩 Block 1A
- 🟨 Block 1B
- 🟥 Block 2
- 🟪 Block 3
- 🟦 Block 4
- ▨ Reservoir A1*
- — Main Supply Pipeline, Intake
- — Secondary B Pipeline, Secondary C Pipeline
- — Secondary Canal A, Syphon
- ▫ Pump Station

Generalized FWMIS Nest/Niche Sites:**

- ▨ BUOW = Burrowing Owl
- ▨ FEHA = Ferruginous Hawk
- ▨ High NLFR Use Area = Northern Leopard Frog
- ▨ LOSH = Loggerhead Shrike
- ▨ STGR = Sharp-tailed Grouse
- ▨ Snake Hibernaculum Area

*** Generalized FWMIS (Fisheries and Wildlife Management Information System) results indicate the existence of a nest, niche site, or lek within the section highlighted.*

** Note: If Reservoir A1 is filled to Scenario 3 at 728.5 m elevation, a portion of the reservoir will flow into 8-25-23-4 W4M, within Special Areas No. 3.*

SCALE: 1:100,000

1 0 1 km

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Listed Species within the vicinity of the Municipal District of Acadia No. 34 Irrigation Development Study

November 2019

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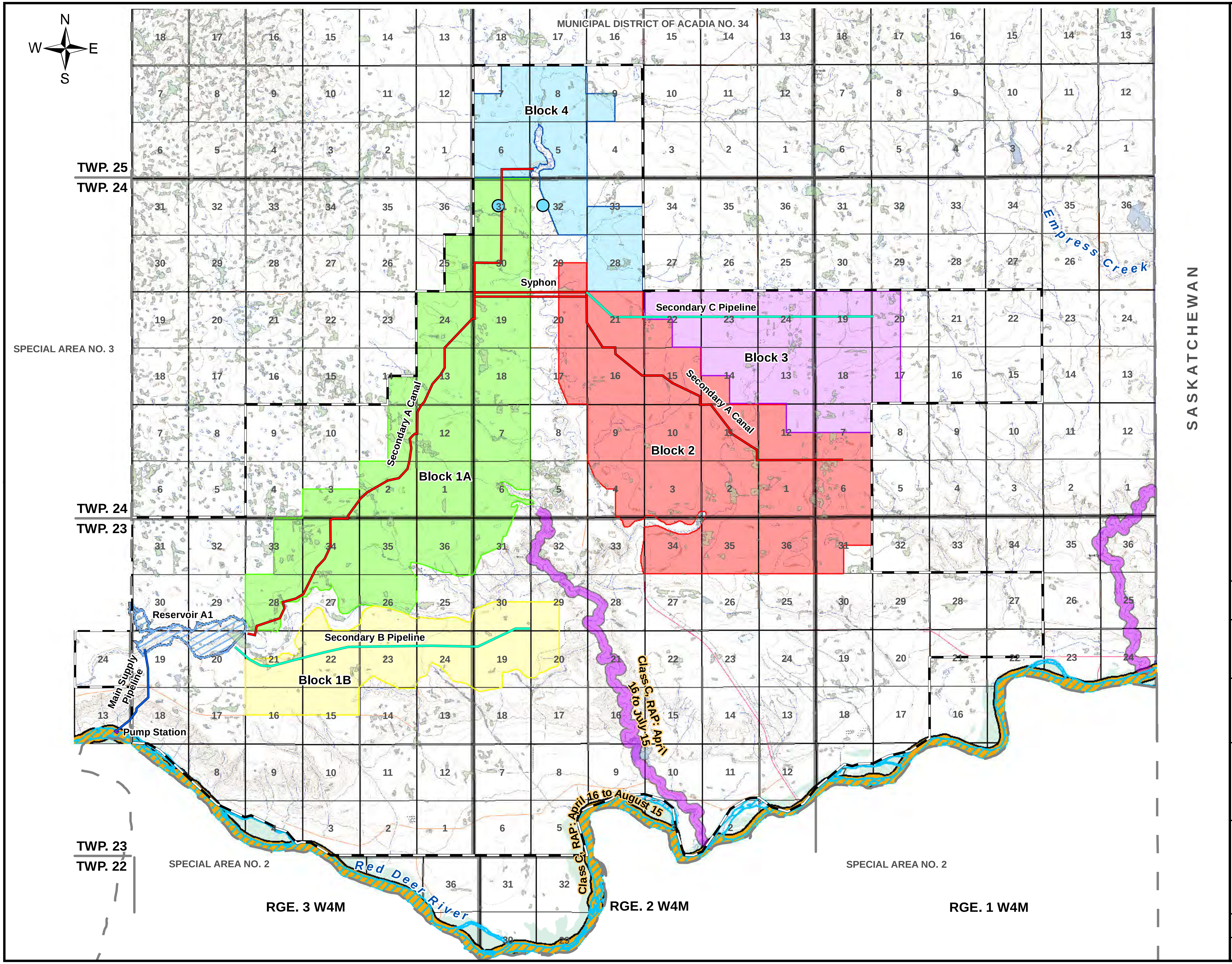
(Desktop Assessment)

Figure 7B



Legend

- ⬛ Area of Interest
- 🟩 Block 1A
- 🟪 Block 3
- 🟨 Block 1B
- 🟦 Block 4
- 🟥 Block 2
- ▨ Reservoir A1*
- — Main Supply Pipeline, Intake
- — Secondary B Pipeline, Secondary C Pipeline
- — Secondary Canal A, Syphon
- ◻ Pump Station

Water Resources:

- ● Springs of Alberta

Provincial Sensitive Fish Areas:

- ▨ Lake Sturgeon

Code of Practice Watercourse (Class, Restricted Activity Period [RAP]):

- 🟧 Class C, April 16 to August 15
- 🟪 Class C, April 16 to July 15

Alberta Merged Wetland Inventory:

- 🟩 Marsh
- 🟦 Open Water

Enitre Mapped Area:

Whirling Disease Layers:
WD - White Zone: Low Risk
HUC6: Lower Red Deer River
- Alkau Creek

** Note: If Reservoir A1 is filled to Scenario 3 at 728.5 m elevation, a portion of the reservoir will flow into 8-25-23-4 W4M, within Special Areas No. 3.*

SCALE: 1:100,000

1 0 1 km

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QA/QC:	SF		
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Water Resources of the Municipal District of Acadia No. 34 Irrigation Development Study

November 2019

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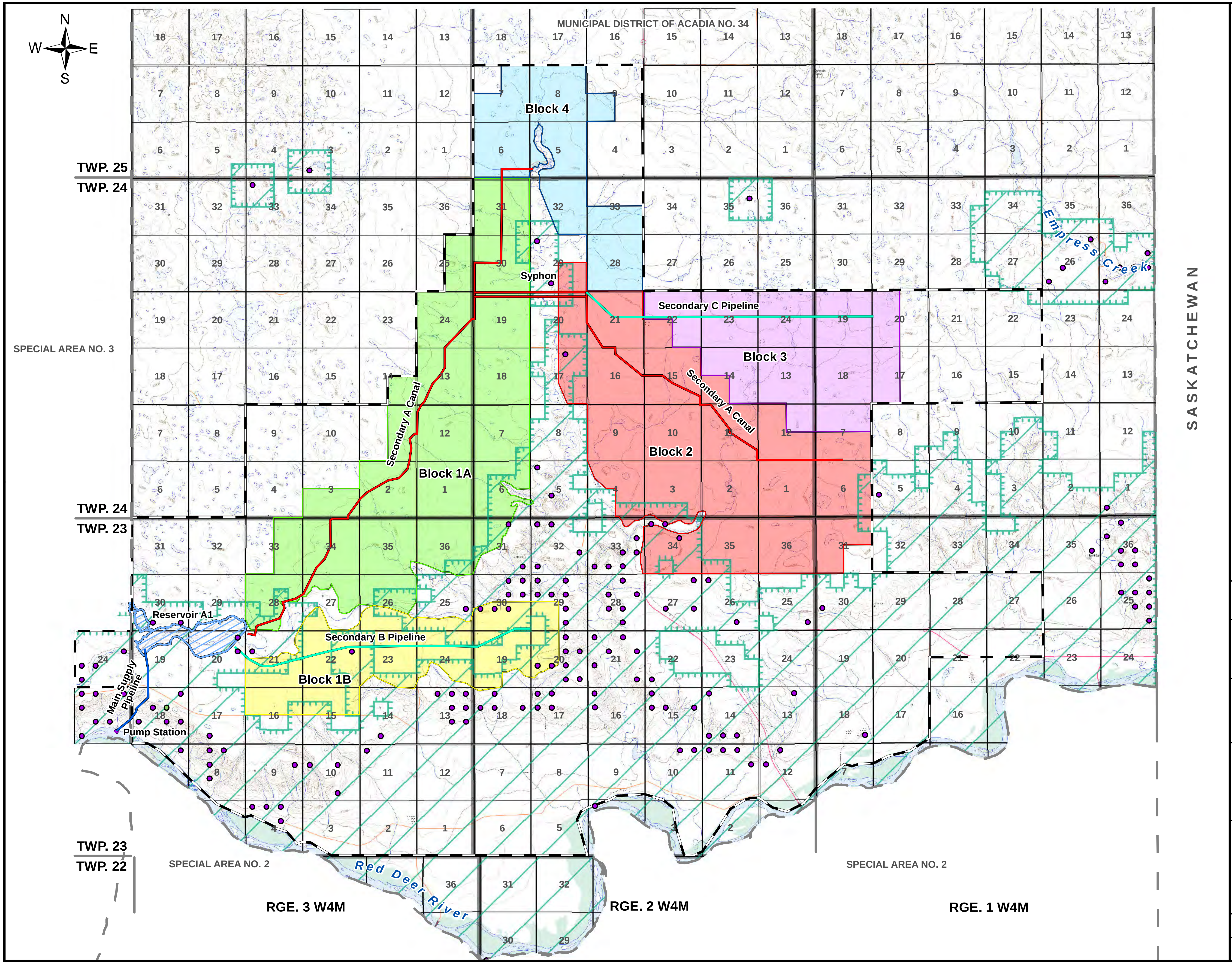
Figure 8



Legend

- ⬚ Area of Interest
- 🟩 Block 1A
- 🟨 Block 1B
- 🟥 Block 2
- 🟪 Block 3
- 🟦 Block 4
- ▨ Reservoir A1*
- — Main Supply Pipeline, Intake
- — Secondary B Pipeline, Secondary C Pipeline
- — Secondary Canal A, Syphon
- ☐ Pump Station

Historical Resources:**

- ▨ Area with Historical Resource Value
- ● Historical Resource Site (HRV-4)
- ● Historical Resource Site (HRV-3)

*** Historical Resource Site point locations are approximate.*

** Note: If Reservoir A1 is filled to Scenario 3 at 728.5 m elevation, a portion of the reservoir will flow into 8-25-23-4 W4M, within Special Areas No. 3.*

SCALE: 1:100,000

1 0 1 km

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ATS Grid: AltaLIS 2007.
Historical Sites and Areas: Alberta Culture and Tourism 2019.
Listing of Historic Resources (Public Version) May 2019.
Please see report or contact Ghostpine Environmental Services Ltd. for additional source information.
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Historic Resources of the Municipal District of Acadia No. 34 Irrigation Development Study

November 2019

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Figure 9