Southern Alberta Transmission Reinforcement

Alternative Development and Screening

October 8, 2008

EXECUTIVE SUMMARY

As a part of its mandate, the Alberta Electric System Operator (AESO) is responsible for planning the transmission system within the province of Alberta as set out in the *Electric Utilities Act, SA 2003 c E-5.1*. As prescribed in the *Transmission Regulation* ("Regulation"), the AESO issued the 10-Year Transmission System Plan 2007-2016 in February 2007. In the context of the 10-Year Transmission System Plan, the AESO has engaged in the planning process to facilitate the preparation of a Needs Identification Document (NID) for the southern region of Alberta.

In the first stage of the Southern Alberta Planning Study, the AESO identified the transmission need from a bulk system and local area supply perspective. The results were presented in the Need Identification Results document. In the second stage, which is the subject of this document, potential transmission options have been identified to address the need in the Southern region. The broad range of new transmission options considered for the Southern region is as follows:

- 240 kV AC (Alternating Current)
- 500 kV AC
- 765 kV AC
- HVDC (High Voltage Direct Current) Classic
- HVDC Voltage Sourced Converter (VSC) Technology

Of these options, 765 kV AC and HVDC VSC are not being considered further for detailed evaluation for the reasons outlined in this document. There is a significant amount of existing 138 kV transmission in southern Alberta, however 138 kV was not considered to be an option for addressing the need because it does not provide sufficient capacity and because system losses are high.

Based on the remaining options, four transmission alternatives were formulated to address the need in the South. These alternatives are summarized as follows:

- 240 kV looped system
- 240 kV radial system
- 500 kV looped system
- HVDC Classic system

This document outlines the rationale for the final set of alternatives to the Southern Alberta transmission development that will be carried over to the detailed analysis stage for further technical, economic and social impact evaluation.

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1.0 INTRODUCTION

In the first stage of the Southern Alberta Planning Study, the AESO identified the transmission need in southern Alberta. This documented the planning criteria used to identify the need, load and generation assumptions, methodology followed to arrive at the conclusions, and the detailed results of the need analysis.

Most of the southern Alberta transmission system was originally designed to supply rural loads. Since then, there has been significant load growth in the southern region as well as significant interest in wind development.

The AESO has received applications for wind power development of approximately 7,500 MW in southern Alberta. Given technical and economic considerations, the AESO anticipates an additional wind generation capacity of approximately 2,700 MW will develop in the next 10 years.

The Need Identification Results for the South are summarized as follows:

- There is no incremental capability in the southern Alberta transmission system to deliver additional generation output on a firm basis to AESO load;
- Given the large numbers of system constraints, the southern Alberta transmission system will require substantial system improvements to accommodate the proposed wind generation regardless of the generation location;
- The AESO transmission system responds differently with system overloading depending upon the location of generation interconnections;
- In the High River area, there is insufficient load serving capability of the transmission system and voltage support under Category B[1] conditions;
- In the Strathmore area thermal overload will start to manifest by 2017; and
- In the Glenwood area, thermal overload and voltage issues are present under Category B conditions.

Load driven system improvements for the south east were addressed in a NID filed in 2007 and approved in 2008.

Figure 1-1 shows the existing transmission system of the South region. Figure 1-2 shows an overview of the need with respect to wind interest in the South.

[1] NERC/WECC Planning Standards Category B; event resulting in the loss of a single element

Figure 1-1: Existing Southern Alberta Region Transmission System

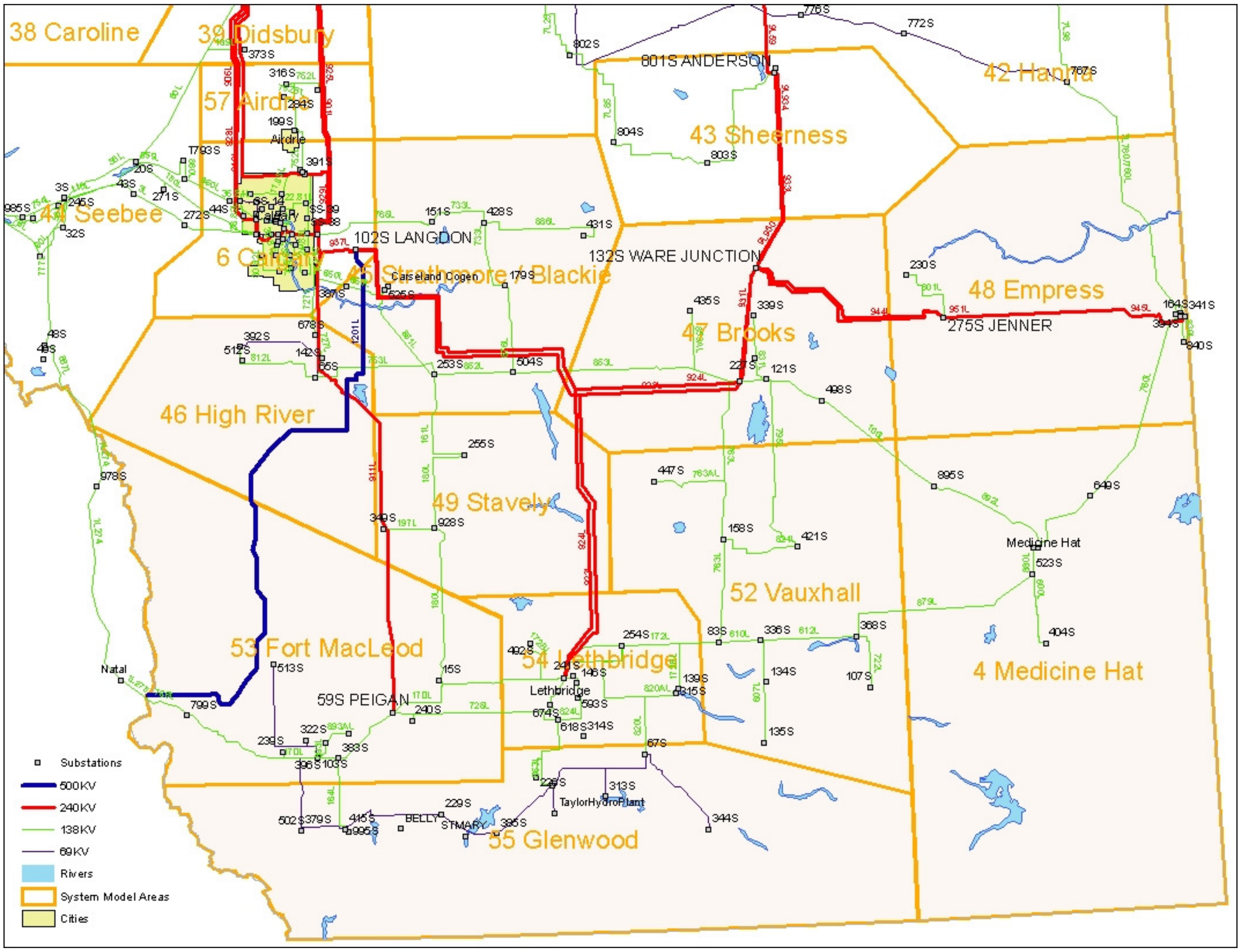
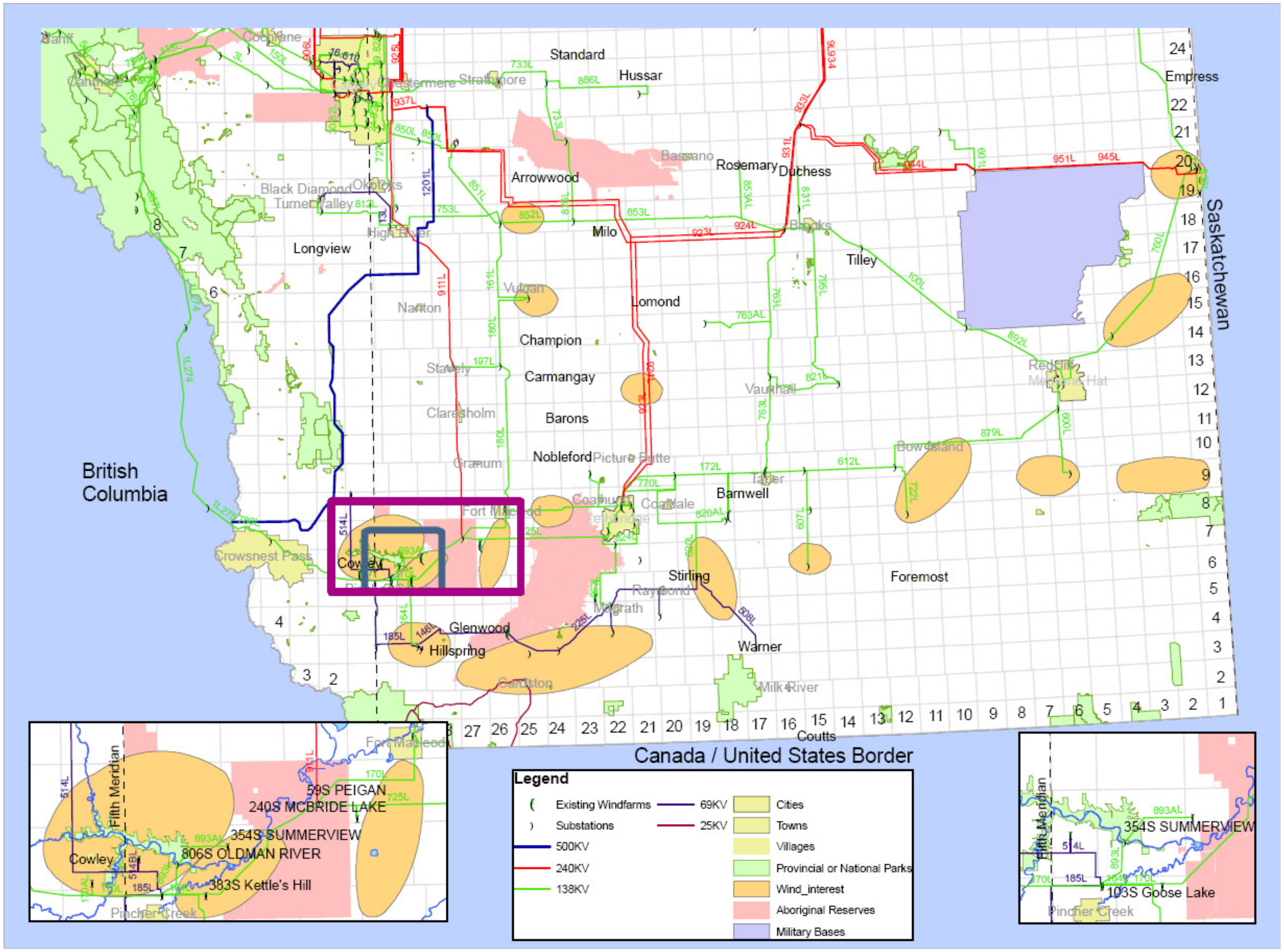


Figure 1-2: Overview of Southern Alberta Need – Wind Interest



In this stage of study, the potential options to address the need are presented and discussed. Utilizing these options, a number of transmission alternatives have been formulated to address the need in the South region. The alternatives have been filtered from the larger set to arrive at a final set of alternatives that will undergo detailed evaluation (social, technical and economic impact) in the next stage of study.

2.0 OPTIONS SCREENING

The broad range of new transmission options considered for the South region includes:

- 240 kV AC
- 500 kV AC
- 765 kV AC
- HVDC Classic
- HVDC VSC

Although there is a significant amount of existing 138 kV transmission system in southern Alberta, 138 kV was not considered an option for addressing the need as it does not provide enough capacity and system losses are high.

Of the options outlined above, 765 kV AC and HVDC VSC are also not being considered further in the detailed evaluation stage.

As shown in Figure 1-2, future interest in wind development in southern Alberta is spread across the region (i.e. the need is not in a concentrated area of the South region). The southern Alberta bulk system also needs to be reinforced to move supply from Alberta’s generation sites to southern load centres. Using 765 kV AC technology would have been suitable from the perspective of providing high capacity in the region; however this option has now been excluded. The rationale for excluding 765 kV AC from further detailed analysis is as follows:

- Not a suitable option as the wind interest is spread across the region; may have been suitable if the generation was concentrated in a single area of the South;
- The distances are less that 300 km and 765 kV is more appropriate to use for longer distances; and
- 765 kV AC is a new voltage being introduced to the Alberta system which adds to the complexity and cost of integration into the system.

Underground alternatives for this project as a whole are not recommended. HVDC VSC underground is favourable from a visual perspective; however the newer HVDC VSC Underground technology has limited application at this time and has yet to be commercially or technically proven in applications similar to the requirements of this project (i.e. length and capacity). In regards to 500 kV AC or HVDC Classic in underground applications, the technical limitations with 300 km distances and cost (5 to 10 times) also removes this as a recommended option.

3.0 OPTIONS CONSIDERED

The remaining options from which the alternatives for South transmission development have been formulated include 240 kV AC, 500 kV AC and HVDC Classic. These options not only provide the transmission system for generation interconnection but also provide additional reliable bulk system capacity for transferring power from Alberta's generation sites to the southern load centres.

The rationale for including these options in further detailed analysis is outlined in the sections that follow.

3.1 240 kV AC Option

The existing South transmission system consists of a 240 kV transmission system with an underlying 138 kV system. As such, 240 kV forms a natural choice to be considered for new transmission lines in the region.

There are a number of advantages associated with 240 kV AC technology in the South. It is suitable for interconnecting the approximate 2,700 MW of anticipated wind generation in the southern region as well as reinforcing the bulk system to transfer power into the region to supply loads when required. It is an economical solution relative to the other options being considered and it is an existing voltage in the system which minimizes the complexities associated with system integration. Also, 240 kV transmission lines typically require smaller right-of-way widths than the higher voltage options creating a smaller construction footprint through new corridors.

The disadvantages of 240 kV AC technology in the South are that it is an option that will be at its limits in terms of the distances required to meet the need in the South and it is a less efficient option with respect to system losses relative to the other options being considered. Although 240 kV typically requires smaller right-of-way widths, more distance of new 240 kV lines may be required due to that fact that more circuits will be needed to provide a similar capability as that of a higher voltage.

3.2 500 kV AC Option

500 kV AC options were also considered for addressing the South Alberta need. The planned backbone network voltage of the future system throughout Alberta is 500 kV, with a few new 500 kV lines currently at various stages of planning in Alberta. As such, 500 kV is an appropriate option to consider for transmission development in the South.

One advantage of using 500 kV in the South is that it is a long-term, expandable option in anticipation of southern system growth exceeding the 240 kV network capabilities. It is also a more efficient option with respect to system losses and it has the capability to deliver future wind generation in southern Alberta without constructing as many kilometers of transmission lines compared to the 240 kV options.

In contrast, the disadvantages include the requirement of larger right-of-way widths relative to 240 kV as well as a higher initial capital cost. Although some of the new 500 kV transmission lines would be initially operated at 240 kV until the higher capacity of 500 kV was required, this option could be perceived as an overbuild. Finally, Category C[2] contingencies on the 500 kV system could be an issue (e.g. the loss of two 500 kV lines at one time could have a significant impact on the system if the precontingency loadings are high).

3.3 HVDC Classic Option

HVDC lines are typically constructed when bulk power has to be transmitted over long distances. HVDC would be capable of transferring significant amounts of power to the South when required as well as move wind generation throughout and out of the southern region when it is operating. The need to reinforce the bulk southern system over relatively long distances makes HVDC technology an appropriate option to consider.

Similar to 500 kV AC, HVDC has the capability to deliver future wind generation in southern Alberta without constructing as many kilometers of transmission lines as compared to 240 kV. HVDC maximizes the use of right-of-ways and also creates a smaller tower footprint relative to other options.

Although HVDC transmission lines have fewer losses than other options for transmitting energy over long distances, the distances across southern Alberta are much shorter and would result in limited efficiency gains considering the additional energy losses consumed by the converter stations. HVDC is also limited in its flexibility as it cannot be segmented, or tapped, without construction of expensive additional converter stations. As such, little flexibility would exist to expand a HVDC system and significant 240 kV AC transmission would be required to collect wind energy into a HVDC converter station. Finally, HVDC also has a higher initial capital cost and may be perceived as an overbuild.

4.0 FORMULATION OF PLANNING ALTERNATIVES

Planning alternatives are formed when one or more transmission options are combined to form a transmission scheme that satisfies the system needs of a region while meeting or exceeding the system reliability criteria. The following sections describe the planning alternatives formulated to address the transmission need in the South.

4.1 240 kV AC Looped Alternative

A 240 kV looped alternative was considered which would create new 240 kV transmission lines across southern Alberta. The new 240 kV lines would be looped into the existing 240 kV substations such as Peigan, Lethbridge and West Brooks. A few new 240 kV switching stations would tie the 240 kV transmission lines together such that the 240 kV transmission lines would be

[2] NERC/WECC Planning Standards Category C; event(s) resulting in the loss of two or more (multiple) elements

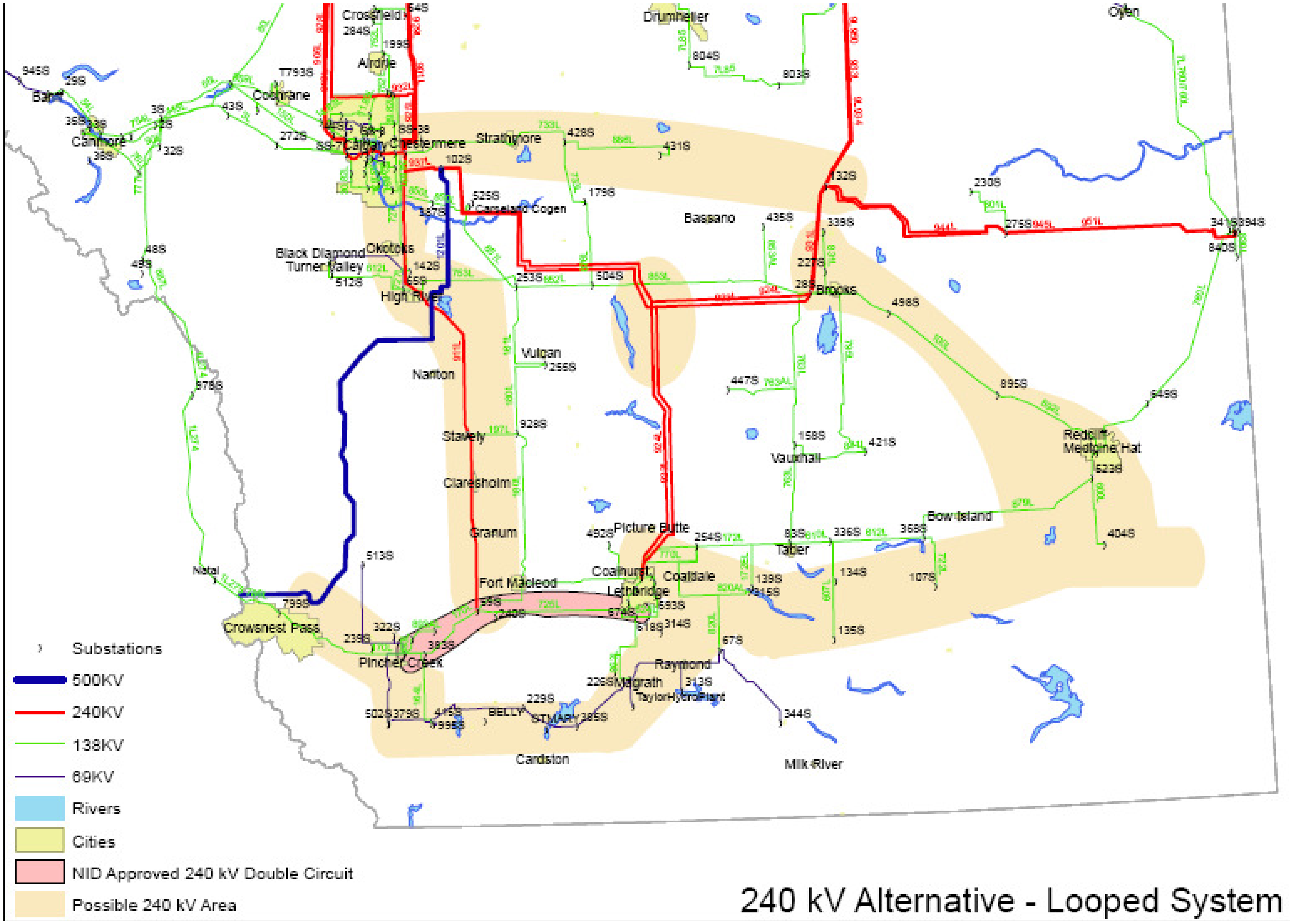
fully looped to provide a high level of reliability. The new 240 kV lines in southern Alberta would be utilized primarily for transferring wind energy onto the bulk 240 kV system, where it can then be delivered to central Alberta load centers.

An advantage of this looped alternative is that 240 kV is the backbone network voltage of the existing system in the South. Consistency with the existing 240 kV eliminates the need for costly transformers. Also, 240 kV has the capability to deliver future wind generation in the South when multiple transmission circuits are constructed to share the loading. This 240 kV alternative meets the Reliability Criteria of the Alberta Electric System Operator and the Western Electricity Coordinating Council (WECC).

Some of the new 240 kV transmission lines would initially be built as single circuits; however the transmission structures would be constructed to accommodate a second circuit to expand the system capacity when required. The looping of the new 240 kV transmission lines will help to avoid the transfer limitations caused by longer lines.

Figure 4-1 illustrates the concept of the 240 kV looped alternative. Other variations of this looped system are also being considered. The transmission line routes, location of the proposed substations as well as the decision to build underground cable instead of overhead lines for some parts of the system has not been considered in this Need stage but will be visited at the facilities application stage.

Figure 4-1: 240 kV AC Looped Alternative



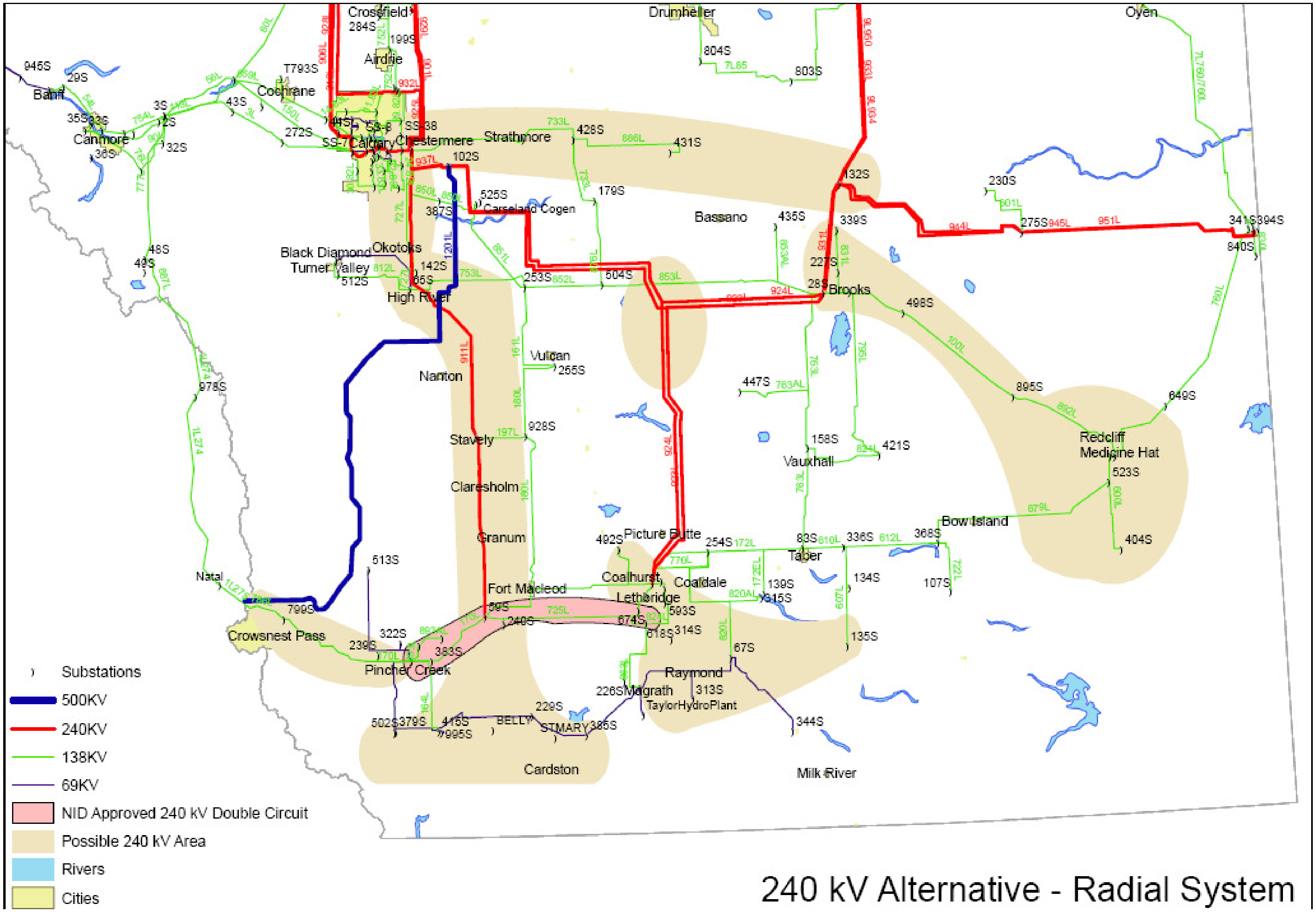
4.2 240 kV AC Radial Alternative

A 240 kV radial alternative was considered which would also create new 240 kV transmission lines across southern Alberta. The rationale for developing this alternative is to arrive at a lower capital cost alternative so that the impact on rate payers is lower compared to the other alternatives. The new 240 kV lines would extend as radial circuits from the existing 240 kV substations such as Peigan, Lethbridge and West Brooks. The radial 240 kV circuits would terminate at new 240 kV switching stations where future wind generators would connect. The radial 240 kV transmission lines would be constructed as double circuits to provide a high level of reliability. The new 240 kV lines in southern Alberta would be utilized for transferring wind energy onto the bulk 240 kV system, where it could then be delivered to the load centers.

Similar to the looped alternative, an advantage of the 240 kV radial alternative is that 240 kV is the backbone network voltage of the existing system in southern Alberta eliminating the need for costly voltage transformers. It also has the capability to deliver future wind generation when multiple transmission circuits are constructed to share the loading. This alternative would also meet the planning criteria of the AESO and the Western Electricity Coordinating Council (WECC).

A significant disadvantage of the 240 kV radial alternative is that there will be less flexibility for future expansion. Future expansion would require either additional 240 kV lines or looping the existing 240 kV system resulting in proliferation of transmission lines to connect wind farms to hubs. The new 240 kV radial transmission lines will be of substantial length which would place limitations on the maximum amount of power that can be delivered from the remote southern Alberta region. Figure 4-2 illustrates the 240 kV radial alternative.

Figure 4-2: 240 kV AC Radial Alternative



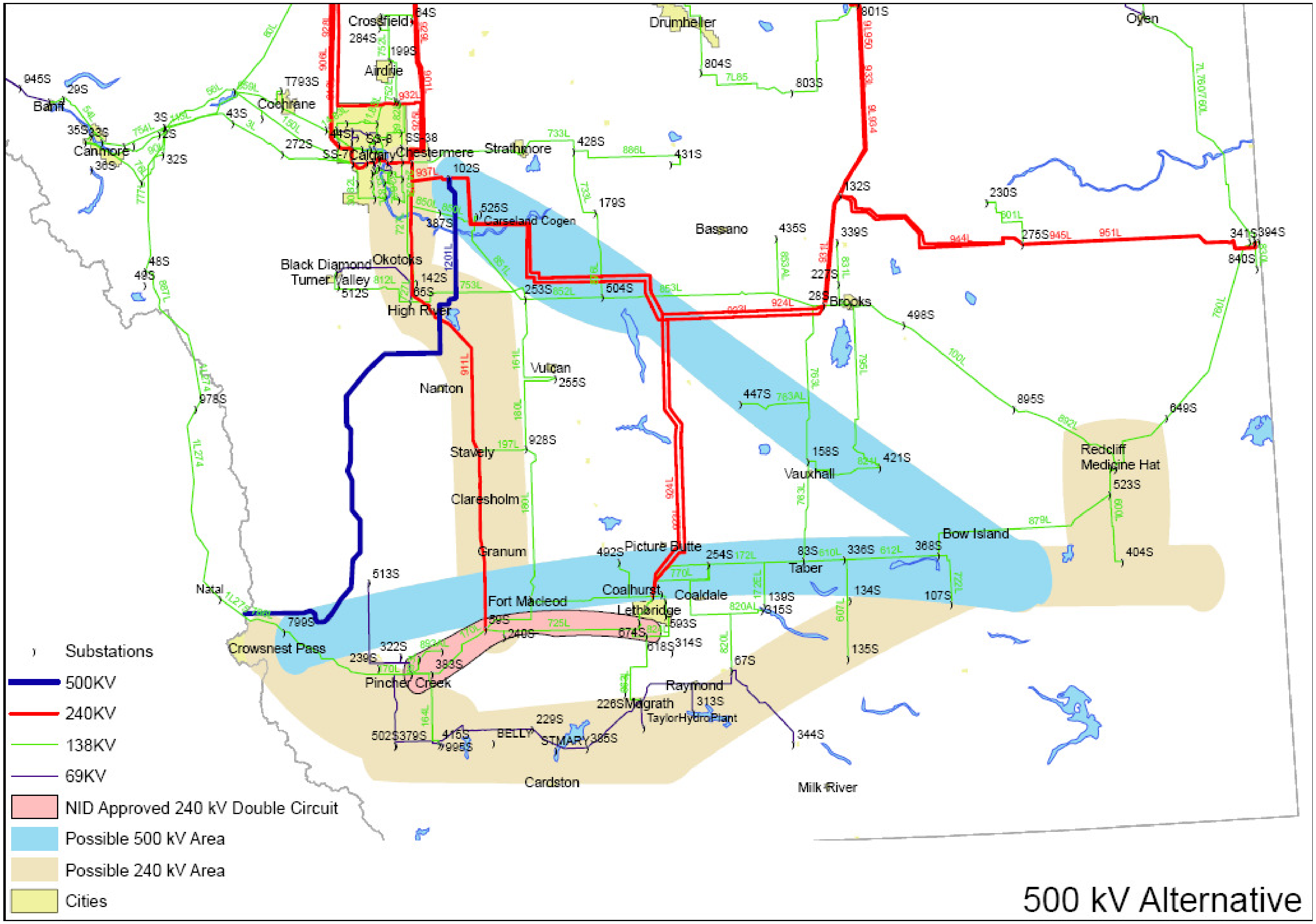
4.3 500 kV AC Looped Alternative

The 500 kV AC looped alternative would create a new 500 kV transmission backbone loop in southern Alberta. The existing 500 kV line which connects Alberta to British Columbia would be utilized as part of the new 500 kV loop. The new 500 kV loop would be more efficient than 240 kV for transmitting wind energy significant distances across Alberta.

Wind generators would be connected through existing and new 240 kV transmission lines to avoid constructing multiple 500 kV loops throughout the South and a couple of new 500/240 kV substations would provide points where the collected wind energy could be transformed to the more efficient 500 kV system. Where possible, the 240 kV transmission lines collecting the wind generation would be looped to provide a high level of reliability. The 240 kV systems in southern Alberta would be utilized primarily for transferring the wind energy to the new bulk 500 kV system. This 500 kV alternative would also meet the planning criteria of the AESO and the WECC. The looped configuration of the 500 kV transmission lines would provide uninterrupted service during any single outage event on the network.

The 500 kV alternative would have a higher capital cost than the 240 kV alternatives. This high initial capital investment will be difficult to justify if less than anticipated wind development takes place in the next ten years or if wind development is more pronounced in some areas than the others. Category C (double outages) events on the 500 kV transmission system may also be more severe than in the case of a 240 kV build out. Figure 4-3 illustrates the 500 kV looped alternative.

Figure 4-3: 500 kV AC Looped Alternative



4.4 HVDC Classic Alternative

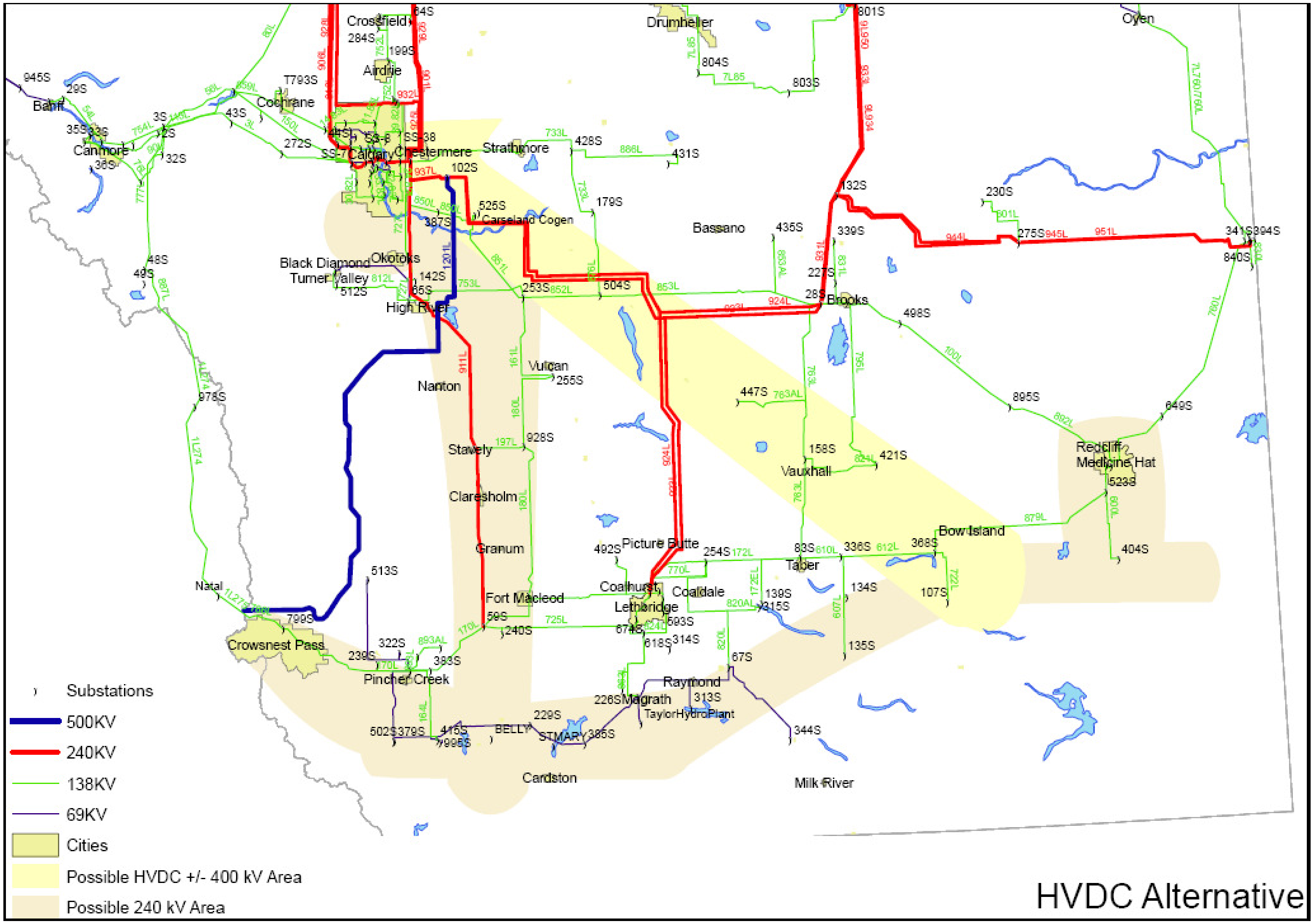
A HVDC alternative was also considered which would create a new HVDC transmission line across southern Alberta. New converter/inverter substations would be needed at each end of the new HVDC line to convert the electricity between direct current (DC) and alternating current (AC). The new converter/inverter substation at the north end of the new HVDC line would be connected to the existing Langdon substation. The new converter/inverter substation at the south end of the new HVDC line would be located in remote southeastern Alberta.

Similar to the 500 kV AC looped alternative, wind generators would be connected to the south converter station through new 240 kV transmission lines. The new HVDC line would be utilized for transferring wind energy to central Alberta, where it would be delivered to the load centers by the existing AC transmission system.

As in the case of the 500 kV alternative, the HVDC alternative would also require high capital investment. Due to relatively shorter distances in southern Alberta, the HVDC system may not result in lower losses compared to the other alternatives. Expansion by the addition of terminals would be very expensive and technically challenging.

The HVDC alternative would also meet the planning criteria of the AESO and the WECC. Figure 4-4 illustrates the HVDC alternative.

Figure 4-4: HVDC Alternative



5.0 NEXT STAGE

The next stage of study will be the Alternative Assessment and Recommendation. This will include a detailed technical, economic and social impact analysis for the alternatives being considered:

- Technical evaluation will include power flow and contingency analysis to ensure that the alternatives are robust and address the need; voltage stability, short circuit and transient stability studies will also be performed to test the alternatives in greater detail;
- Capital costs at the NID +/-30% level derived in coordination with the incumbent Transmission Facility Owner (TFO), AltaLink, will be included and losses will be obtained from power flow studies for the economic analysis; and
- Social impact analysis and consultation outcomes will be documented and compared across the alternatives as per Alberta Utilities Commission (AUC) Rule 007: Rules Respecting Applications for Power Plants, Substations, Transmission Lines, and Industrial System Designations.

Following the documentation and communication of the Alternative Assessment and Recommendation for the South, a NID filing to the Alberta Utilities Commission (AUC) is targeted for Q4 of 2008. The targeted in-service date (ISD) for the first stages of the South transmission development is 2011/12.

6.0 REFERENCE LIST

10-Year Transmission System Plan:

http://www.aeso.ca/downloads/FINAL10YearFEB2807.pdf

20 Year Outlook

http://www.aeso.ca/downloads/AESO_20-YearOutlookDocument_2005_Final.pdf

AESO Reliability Criteria:

http://www.aeso.ca/rulesprocedures/8677.html

Electric Utilities Act SA 2003 c E-5.1:

http://www.auc.ab.ca/aucdocs/requirements/actsregs/eu_act.pdf

Transmission Development Policy:

http://www.energy.alberta.ca/Electricity/687.asp

Transmission Regulation:

http://www.energy.alberta.ca/Electricity/687.asp