Darrin F. Lahr
Supervisor, Siting and Land Rights

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February 27, 2012

Darrell Nitschke
Executive Secretary
North Dakota Public Service Commission
Department 408
600 East Boulevard Avenue
Bismarck, ND 58505-0480

Re: Northern States Power Company Fargo-Monticello MN 345 kV Cap-X Transmission Line Siting Application Case No. PU-07-759

Dear Mr. Nitschke:

Northern States Power Company, a Minnesota corporation, ("Xcel Energy" or the "Company"), applicant in the above referenced case provides the following late-filed exhibits to the North Dakota Public Service Commission (the "Commission") in this proceeding:

- Late-Filed Exhibit 29: A map showing landowner agreements for route location including, signed agreements, permission for access only, and those parcels with no signed agreements;

- Late-Filed Exhibit 30: A discussion of the proximity of the Fargo Project to future load-serving needs of the Fargo area, a copy of the study supporting this discussion, and the verification of Mr. Daniel P. Kline related to this material; and

- Late-Filed Exhibits 32 and 33: An affidavit of Mr. Darrin F. Lahr containing an assessment of mitigation options for the Kraft airstrips and a discussion related to routing options on the boundary of the City of Mapleton.

Please feel free to contact me at the phone number listed above with any questions or concerns.

Sincerely,

Darrin F. Lahr

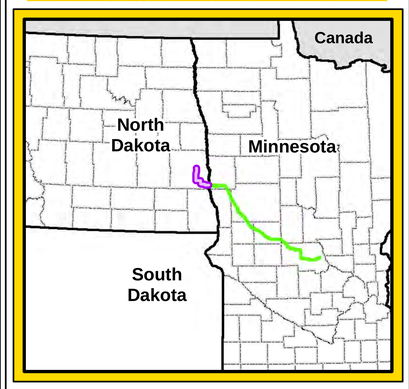
Supervisor, Siting and Land Rights,
Xcel Energy Services Inc., as agent for
Northern States Power Company,
a Minnesota corporation

4515527v1

Late-Filed Exhibit 29

CapX2020

Delivering electricity you can rely on



Legend

- Proposed Alignment
- Proposed Bison Switching Station Site
- Option Signed
- Access Only, No Option Signed
- Not Signed, No Access
- MN Permitted Route
- Substations

Existing Transmission Lines

Voltage (kV)

- 400
- 345
- 250
- 230
- 115
- 69

Roads

- Interstate
- US Highway
- State Highway
- County Road / Secondary Road
- Railroad
- River / Stream
- Lake
- State Boundary
- County Boundary
- Municipal Boundary
- Township Boundary

N W E S

0 0.5 1 2 3 Miles

Right-of-Entry Mileage Breakdown

Option Signed -19.0 Miles

Access Only, No Option Signed - 6.8 Miles

Not Signed, No Access - 6.9 Miles

*** There are 6.0 miles of landowners affected that have agreements reached with signatures pending.**

FARGO TO ST. CLOUD 345 kV TRANSMISSION LINE PROJECT

Right of Entry Status

Date: 02/24/12

Drawn by: MLTEICHERT

Late-Filed Exhibit 30

LATE FILED EXHIBIT 30

Benefit of Locating Fargo – St. Cloud Line Close to Fargo Load Center

The Fargo Line Optimization Study, attached as Schedule 1, was completed by the Fargo – St. Cloud project participants in 2009 to serve as a reference document for future Fargo area transmission development. The study was intended to ensure the Fargo – St. Cloud project provided three primary benefits:

1. Optimal local reliability benefits for loads in the greater Fargo area
2. Maximum delivery of generation from North Dakota to the rest of the upper Midwest
3. System efficiency and security in the form of protection against critical system contingencies and adverse weather conditions

Ultimately, the study laid out a three-phase plan for ensuring these three benefits were achieved. The first phase of the plan was the interconnection of the Fargo – St. Cloud line at Bison Substation.

The second phase of the plan was focused largely on ensuring the ongoing reliability of load as the Fargo area continues to grow. In this analysis, planners recognized the benefits of locating the Fargo – St. Cloud line sufficiently close to the Fargo load center to interconnect the line to existing 230 kV lines on the south side of the City. Having a new 345 kV source close to existing high voltage lines serving the Fargo presents the opportunity to either convert existing 230 kV facilities to 345 kV or double-circuit those lines with new 345 kV lines. The result would be a 345 kV "loop" that would provide extremely reliable service to the greater Fargo area.

The recommended plan spreads the power flowing through the Fargo area transmission system among new facilities to ensure the system is capable of withstanding the loss of facilities without causing interruption of service. By routing the Fargo-St. Cloud 345 kV 345 kV line close to the city, as contemplated in the plan, three main things are accomplished:

1. The potential for transmission facilities inside the city going out of service is reduced due to the facilities being located most closely to the load center.

2. The benefit of those facilities is maximized as the distance from the load center is reduced.
3. The proliferation of additional future facilities is minimized. If the lines are located too far south of the city, obtaining desired levels of voltage support may require additional transmission lines to reach into the city in the future. The proposed plan will allow NSP to simply tie existing facilities together when the time is right.

Locating the route along the Proposed Route realizes these objectives. The 345 kV line would be close to the Maple River – Frontier – Wahpeton 230 kV line, enabling potential interconnections at existing substations, e.g. Frontier Substation, while minimizing potential conflicts with the USACE Diversion Project.

A more southerly route, south of Oxbow would likely result in a degradation of those electrical benefits due to its distance from the 345 kV loop. In the end, the trade-offs between routing considerations and electrical considerations indicate a route near to the south of the Fargo load center to be the most advantageous.

To the west of the City, the Proposed Route for the 345 kV line is marginally more remote. However, it will terminate at a new substation that will provide additional sources of power to the City.

Schedule 1 to Late-Filed Exhibit 30

CapX 2020 Group 1 Fargo Line Optimization Study

Prepared for:
Xcel Energy

Prepared by:
Excel Engineering, Inc.

July 22, 2009

Principal Contributors:

Richard Gonzalez, PE
Michael Cronier, PE
Jeffrey Norman, PE
Ling Hua
Stephen Malek

Table of Contents

List of Tables and Figures

Dynamic Stability Analysis

Losses

Recommended Plan

Appendices

0.0 Certification

I hereby certify that this plan, specification, or report was prepared by me or under my direct supervision and that I am a duly Licensed Professional Engineer under the Laws of the State of Minnesota.

Richard Gonzalez
Registration Number 18938
July 22, 2009

I hereby certify that this report was prepared by me or under my direct supervision and that I am a duly registered Professional Engineer under the Laws of the State of North Dakota.

Richard Gonzalez
Registration Number PE-6138
July 22, 2009

1.0 Executive Summary

1.1 Background

This study was undertaken to identify the optimal transmission system configuration for the northern (Fargo) termination of the Twin Cities-Fargo CapX 2020 Group 1 345 kV line considering current and anticipated future needs. The study's objectives were to

- maximize generation output deliverability enabled by the Twin Cities-Fargo 345 kV line ("Fargo line");
- maximize local load serving capability in the Fargo area; and
- ensure system efficiency and security.

The initial (conceptual) plan for the Fargo line called for the 345 kV line to connect to Maple River Substation on the "north" end and Monticello Substation on the "south" end. At the time, the Maple River termination was presumed satisfactory. However, during the three years since the last transmission study work regarding the Twin Cities-Fargo line was completed, certain conditions have changed, necessitating a more detailed examination of whether the Maple River termination represents the optimal configuration.

Recent changes in this area include:

- Construction of a new 230 kV generation interconnection transmission line (Pillsbury-Maple River);
- Minnkota Power Cooperative's proposed construction of a new 345 kV line from Center, ND to Fargo or Grand Forks;
- Expansion of a residential housing development just north of Maple River Substation

These additional facilities and encroaching development have further limited the available right-of-way for new transmission line projects in the Maple River Substation vicinity. In addition, the concentration of high voltage facilities at Maple River Substation introduces long-term transmission reliability concerns.

To address these issues, the northern terminus of the Fargo project has been re-examined. As part of this analysis, a conceptual three-phased development plan for the Fargo area has been developed that includes projects to address both generation output deliverability and local load-serving needs. Phase I is expected to be in service in 2015. Decisions regarding implementation of the other phases described in this report will be made at a future date based on further review of electric power system needs.

1.2 Recommended Plan

1.2.1 Generation Output Deliverability

The Phase I Recommended Plan for the Fargo vicinity is to terminate the Twin Cities-Fargo 345 kV line at a new "Bison Substation" to be located along the existing Buffalo-Maple River 345 kV line northwest of Fargo. In addition to being the northern terminus for the new "Fargo" line, this substation will also contain 345/230 kV transformation to enable its connection to the existing Fargo 230 kV network by intercepting the recently-constructed Pillsbury Wind Farm-Maple River 230 kV line. In order to maintain flexibility with respect to future transmission developments in the area, it is suggested the new 345 kV line be routed around the south and west sides of Fargo. Termination at Maple River Substation is also an option, but that site is not recommended from the standpoint of future expansion, right-of-way access, system reliability, and flood vulnerability.

Results from the steady-state (powerflow) and dynamic stability analyses indicate the recommended initial configuration yields an incremental Fargo to Twin Cities (southward) power transfer capability of approximately 700 MW. Inadvertent ("loop flow") loading of the Winnipeg-Twin Cities 500 kV path becomes relevant at incremental transfers of over 360 MW; this can be addressed by either series compensation of the new Twin Cities-Fargo line or by installation of the second 345 kV circuit on this line.

Northward power transfer capability is improved to a somewhat higher degree, but its full utilization would require additional transmission development northward beyond Fargo.

The southward transfer capability is limited to approximately 700 MW by overload of the Sheyenne-Audubon 230 kV line following outage of the Fargo-Alexandria portion of the Twin Cities - Fargo (CapX Group 1) 345 kV line. Since failure of the new line (whether single or double circuit) is the limiting contingency, installing the second circuit does not increase N-1 transfer capability until the Sheyenne-Audubon 230 kV overload is addressed. The installation of the second circuit does, however, offer the "system intact" benefits of loss reduction and alleviation of inadvertent flow on the Winnipeg-Twin Cities 500 kV.

If further increments of power transfer capability are desired, a "Phase II" could be implemented, which would involve a rebuild of the Sheyenne-Audubon-Hubbard-Riverton-Benton Co 230 kV path to double-circuit 345/230 kV. This rebuild can yield another southward transfer capability increment of approximately 600 MW (1300 MW total). The new Flint substation site on the south side of Fargo would be an important part of this future upgrade, as it would provide the western 345 kV terminus for the rebuilt Sheyenne line, and interconnect the two 345 kV Twin Cities-Fargo lines (Fargo-Alexandria-Monticello and Fargo-Riverton-Benton Co). An additional 400 MW (total of 1700 MW) of transfer capability can then be achieved by installing the second 345kV circuit on the Flint-Twin Cities section of 345 kV line, or through addition of equivalent series compensation.

Another option for a "second stage" (Phase II) increase is the addition of a new 345 kV line southward from Fargo to the Brookings Co substation; this yields a total of 1100 MW (700 + 400) of incremental transfer capability, at which point the Audubon 230 kV line is again the limiter.

Ultimately, it may be desirable to undertake both the "Fargo-Brookings Co" and the "Sheyenne-Audubon-Hubbard-Riverton-Benton Co" improvements.

Dynamic stability analysis shows that with a new Twin Cities-Fargo 345 kV line, the presumed post-Big Stone II NDEX stability limit of 2450 MW is increased by at least 800 MW, provided the Jamestown-Buffalo-Maple River 345 kV fault clearing is improved from 5 cycles to 4 cycles. Since this 800 MW increment exceeds the 700 MW increment identified in the steady-state (thermal) analysis, dynamic stability is not expected to be the limiting consideration.

Routing the Fargo line around the east and north sides of Fargo/Moorhead is not recommended because of the additional circuit length required for airport avoidance, reduced usefulness for addressing both local load-serving and future transmission interconnection needs, and excessive reliance on the Maple River substation. Routing around the south and west has the additional advantage of coordinating better with possible future 500 and 345 kV developments.

Termination on the south side of Fargo without a connection to the Buffalo-Maple River 345 kV line is not recommended. Such a plan leads to a premature need to rebuild significant 230 kV line mileage in the Red River Valley area. Coordinated consideration of future needs (both transfer capability and Fargo area load serving) leads to the recommendation that the line be routed through the "Flint" or similar southern site and that such a site be acquired now to ensure its future availability for 345/230 kV development.

Direct connection of the new Twin Cities-Fargo 345 kV line to the WAPA Fargo substation does not appear to be necessary initially. However, it is suggested the new line be routed in the vicinity of the WAPA substation as it passes around the west side of Fargo, to enable its connection to the WAPA station at a future date.

The Sheyenne-Audubon 230kV line overload is a common limiter for all of the 345 kV line termination sites studied. Due to its considerable upgrade cost the incremental transfer capability associated with this limiter is considered the appropriate "stopping point" for the first-stage 345 kV development.

1.2.2 Fargo Area Load-Serving Needs

Examination of Fargo area local load-serving needs indicates a need for a new Maple River-Cass Co.-Sheyenne 230 kV line and a Cass Co 230/115 kV transformer addition. This new line could also be built at 345 kV, in which case a more practical configuration would be Maple River-Cass Co.-Flint (or Frontier). Either southern termination (Sheyenne or Flint) coordinates well with any long-range plan that includes rebuild of the Sheyenne-Audubon 230 kV line. Connecting to Flint provides a greater degree of load-serving capability in the south and west portions of the

Fargo area, the fastest growing parts of the region. Construction at 345 kV provides an additional loss reduction and facilitates future upgrades of the regional transmission system. An appropriate initial step is to construct the Maple River-Cass County 345 kV line segment and operate the line initially at 230 kV.

1.3 System Efficiency and Security

Considering both Summer and Winter conditions, transmission system losses are minimized by connecting the new Twin Cities-Fargo 345 kV line at one of the southern sites (Flint, Frontier, or WAPA Fargo) and extending the new 345 kV line all the way to the existing Jamestown-Buffalo-Maple River 345 kV line. From the standpoint of losses it essentially does not matter where this final connection is made (Bison, NW Angle, or Maple River).

The Flint and WAPA Fargo sites are located at an elevation approximately 914 ft. above sea level. This is 2 ft above the record flood elevations, and approximately 5 – 10 feet higher than the other substation sites examined, which are all below flood elevation. Consequently, development of a 345/230 kV substation at the Flint site is likely to improve bulk power system reliability during flood conditions, when other area substations may be impaired. Development of the Flint site also improves power system reliability by minimizing the number of 230 and 345 kV line crossings required, and reducing or eliminating the reliability impact of the remaining new crossings.

1.4 General Conclusions

The recommended plan for Phase I (345 kV line terminus at Bison Substation) most effectively meets all the needs for which Phase I is intended.

- The Fargo-Monticello 345 kV line's contribution to generation output deliverability is maximized;
- Local load-serving needs are met under both initial and possible future configurations;
- System efficiency is highest (losses are minimized)

In addition, as the possibility of regional high-voltage rebuilds or overlays is explored, such plans would need interconnection points to the Fargo area bulk transmission system. Developing Bison Substation and making provisions for a future Flint Substation, both help ensure practical connection locations for such regional developments are available when needed.

2.0 Background

Excel Engineering, Inc. performed an optimization study for the CapX 2020 Group 1 Twin Cities-Fargo 345 kV line with regard to its northern (Fargo, ND) termination. This Report documents the various sites and configurations studied, and identifies the Recommended Plan for the Fargo termination.

Project Description

Potential sites for the Fargo vicinity termination of the Twin Cities-Fargo 345kV line were selected taking into consideration the following:

- Resultant generation outlet capability (Twin Cities - Fargo power transfer capability, both southward and northward)
- Fargo area load-serving needs and the transmission options' resultant capabilities;
- Existing transmission line and substation capabilities;
- Avoidance, if feasible, of additional Red River or Sheyenne River crossings;
- Existing land use patterns in Fargo/Moorhead area surrounding existing substations;
- Avoidance, if feasible, of the new Twin Cities - Fargo line having to cross the existing Sheyenne-Audubon, Maple River-Wahpeton, or Fargo-Morris 230 kV lines;
- Red River Valley load serving bulk transmission needs;
- Anticipated Winnipeg-Fargo 500 kV line;
- Flexibility with respect to Minnkota's planned 2nd Center-Red River Valley 345 kV line, which may terminate in Fargo;
- Avoidance of excessive reliance on any one Fargo area transmission station;
- Flexibility with respect to future series and shunt compensation installations;
- Avoidance of flood-prone sites for new substation locations;
- Interface with WAPA and other non-MISO systems.

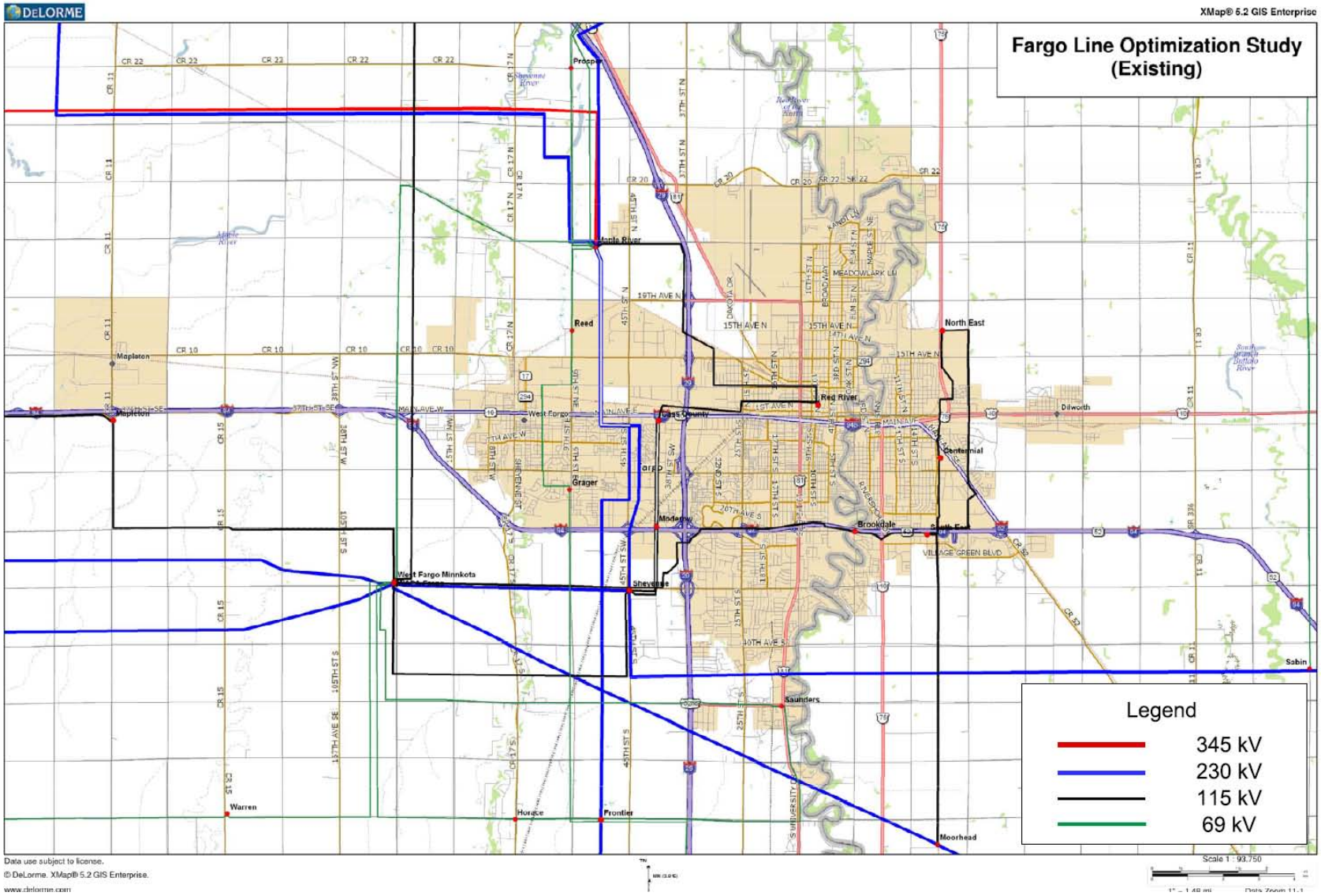
Initially, five sites in the Fargo, North Dakota vicinity were considered for the Fargo terminus of the 345kV line. The sites are shown in Table 2.1.

Table 2.1
Sites Studied

Number	Name	Description
1	Flint	Approx. 2 Miles South of Sheyenne
2	Frontier	Existing Minnkota Substation
3	WAPA Fargo	Existing WAPA Substation
4	Bison	South of City of Prosper
5	NW Angle	3.5 Miles West of Maple River

Each site has two or more transmission system configurations and sub-configurations that were studied. The configurations studied for each site are shown in Tables 2.2 through 2.6. In all cases it is presumed the new substation bus and breaker configurations would be established so as to ensure no new bus fault or breaker failure contingencies would become the limiting condition for power transfer or load-serving capabilities.

Figure 2.1
Existing Transmission, Fargo Vicinity



The study also quantifies the value of double circuiting the Twin Cities-Fargo 345kV line.

The steady-state Summer and Winter analyses were performed on models derived, respectively, from the "CorridorBaseOffP" case developed by Xcel Energy for the "Granite Falls-Southwest Twin Cities" study effort to represent Year 2016 Summer off-peak load conditions, and the "wp08aa" case from the Northern MAPP Operating Review Working Group (NMORWG) 2008 package which represents Year 2008 Winter on-peak conditions.

Power system performance was evaluated with respect to meeting steady-state performance criteria of the NERC Reliability Standards' Categories A-C. This corresponds with the generally recognized utility practice of ensuring satisfactory performance (ability to reliably serve all firm load) during system intact and first-contingency ("N-1") conditions, with some localized planned loss of load or generation re-dispatch being acceptable for subsequent disturbances (second contingency ("N-2") or "breaker failure" type occurrences. NERC Category C allows for some dropping of load but this was not invoked for this study.

The dynamic stability analysis was performed using the 2008 NMORWG stability study package (pkg2008-05-05-2008).

Transmission system demand (MW) losses were tabulated and compared for the various network configurations studied. This was performed to identify whether significant increases or decreases in electrical losses might arise from any of the system configurations under evaluation.

Detailed design of reactive compensation was beyond the scope of this study. The load-serving capabilities described in this report were tested without addition of series compensation to the new 345 kV line. Similarly, the transfer capability performance of the Twin Cities-Fargo 345 kV line was initially tested without series compensation. However, "inadvertent flow" issues were identified which may require series compensation in order to achieve significant increments of southward power transfer capability; this is addressed in Section 3.5.5.

No additional shunt capacitors were found necessary for satisfactory dynamic stability performance. More-detailed examination of steady-state performance may show that some shunt capacitor additions may be necessary or advantageous to support voltage levels during high power transfer levels, or future required high levels of load-serving capability. The amounts and locations of such shunt capacitor additions will be sensitive to the locations at which future generation additions are installed, and therefore cannot be accurately predicted at this time.

Consideration of "light-load" conditions will require installation of new shunt reactors; this is need is determined by the lengths of the new 345 kV line additions, and is essentially independent of the exact Fargo area termination selected for the Twin Cities-Fargo 345 kV development.

Finally this study provides a geographic assessment of the different sites under evaluation.

3.0 Thermal Analysis

3.1 Analysis Methods and Models

The following sections summarize the two principal portions to this study:

- Section 3.1.1 describes the Fargo area load serving analysis;
- Sections 3.1.2 describes the Power Transfer Capability analysis (Southward);
- Section 3.1.3 describes the Power Transfer Capability analysis (Northward).

Steady state thermal performance was evaluated using the Siemens Power Technologies Inc. PSS/E digital computer power flow program. The MUST automated contingency analysis activity "FCITC" (First Contingency Incremental Transfer Capability; similar to the activity "TLTG") was used to develop the tabulation of limiting transmission facilities encountered under system intact and single contingency conditions. These results are summarized and explained in corresponding portions of Section 3.5.

3.1.1 Fargo Area Load Serving Capability

Models Employed:
The source model for the load serving studies is the "CorridorBaseOffP" case which had been derived by Xcel Energy from Northern MAPP Operating Review Working Group (NMORWG) 2008 package.

The existing interface flow levels in this model were maintained:
MHEX = 2175 MW,
NDEX = 2080 MW,
MWEX = 1525 MW.

These represent high transfer ("maximum simultaneous") levels.

The new Pillsbury-Maple River 230 kV line and 400 MW of Pillsbury generation were added to the model. The recently-completed Frontier 230/69 kV substation (on the Maple River-Wahpeton 230 kV line) was added and Minnkota Fargo area 69 kV load was re-distributed.

Five Configurations were developed for the load serving analysis:

- Configuration 0 is the Existing System, before the Twin Cities-Fargo 345 kV line is in place.
- Configuration A is the base configuration (Configuration 0), plus the Twin Cities-Fargo line terminated directly at Maple River.
- Configuration B includes the Twin Cities-Fargo line from Configuration A, with the normally open 115 kV tie at WAPA Fargo (to the Mapleton-Sheyenne line) closed. To avoid creation of a 3-terminal line, this would actually be a "loop-in" at WAPA Fargo and would involve addition of 115 kV breakers and line relaying at the WAPA Fargo substation.

- Configuration C includes the additions from Configuration B, plus a new Maple River-Fargo 115 kV line.
- Configuration D includes the additions from Configuration C, plus a Maple River-Cass County-Sheyenne 230 kV line, with a 336 MVA 230/115 kV transformer at Cass County.

The "generation-to-load" method of power transfer simulation was employed in this study.

Analyses for this "load serving" analysis were conducted by incrementally increasing generation at the "source" group of generators from 0 to 600 MW while proportionately scaling up the Fargo area loads.

Source:
For all configurations, the "source" for the load-serving analysis was simulated by scaling up generation at Sherco, Fargo, and Maple River to represent future regional generation resources to meet the load growth. The generation sites and associated participation factors used were:

Table 3.1
Load Serving: Source and participation factors

Plant Name	Bus No.	Participation factor
Sherco	60001	50%
Fargo	66435	25%
Maple River	66792	25%
Total		**100%**

These hypothetical generation "sources" are generic and do not represent any particular existing or proposed generation additions.

Sink:
For all configurations, the "sink" consists of scaled increase of loads at the following buses in the Fargo vicinity:

Table 3.2
Load Serving: Sink Load Busses

Bus Name	kV	Bus No.	Initial (off-pk Base Case) Load, MW
Fargo	69	66203	23.1
Maple River	115	60136	2.8
Maple River	69	67000	71.3
Red River	115	60137	85.3
Cass Co	115	60135	54.3
Moderow	115	66761	19.0
Frontier	230	66750	37.1
Brookdale	115	67467	9.5
South East	115	67466	14.6
Centennial	115	67459	21.6
North East	115	67460	17.7

3.1.2 Summer Off-Peak (Southward) Transfer Capability

Model Employed:
"CorridorBaseOffP" case was used as the source case. The existing interface flow levels in this model were maintained: MHEX = 2175 MW, NDEX = 2080 MW, MWEX = 1525 MW. These represent high transfer ("maximum simultaneous") levels. The new Pillsbury-Maple River 230 kV line and 400 MW Pillsbury generation were added to the model. The Frontier substation and re-distributed Minnkota 69 kV load were added to the model.

The models for the Fargo vicinity termination sites and associated sub-configurations were created from this base configuration. Descriptions and maps of the five sites evaluated are as follows (see Appendix A for maps of all configurations for each site):

Table 3.3
Configurations Studied for Site 1 "Flint"

Configuration	Description
1	Add loop-in of Sheyenne-Audubon 230kV at Flint Add 2 x 336 MVA 345/230 kV tx at Flint
1.1	Configuration 1 improvements Add Sheyenne-Flint 230 kV (double circuit with Sheyenne-Fargo 115 kV)
1.2	Configuration 1.1 improvements Add loop-in of Maple River-Frontier 230kV at Flint
1.3	Configuration 1.2 improvements Add loop-in of WAPA Fargo-Moorhead 230kV at Flint
2	Add loop-in of Sheyenne-Audubon 230kV at Flint Add 2 x 336MVA 345/230kV tx at Flint Add 345 kV extended to Maple River (West Route)
2.1	Configuration 2 improvements Add Sheyenne-Flint 230kV (double circuit with Sheyenne-Fargo 115 kV)
2.2	Configuration 2 improvements Add 345 kV extended to Maple River (East Route)

Figure 3.1
Termination at Flint

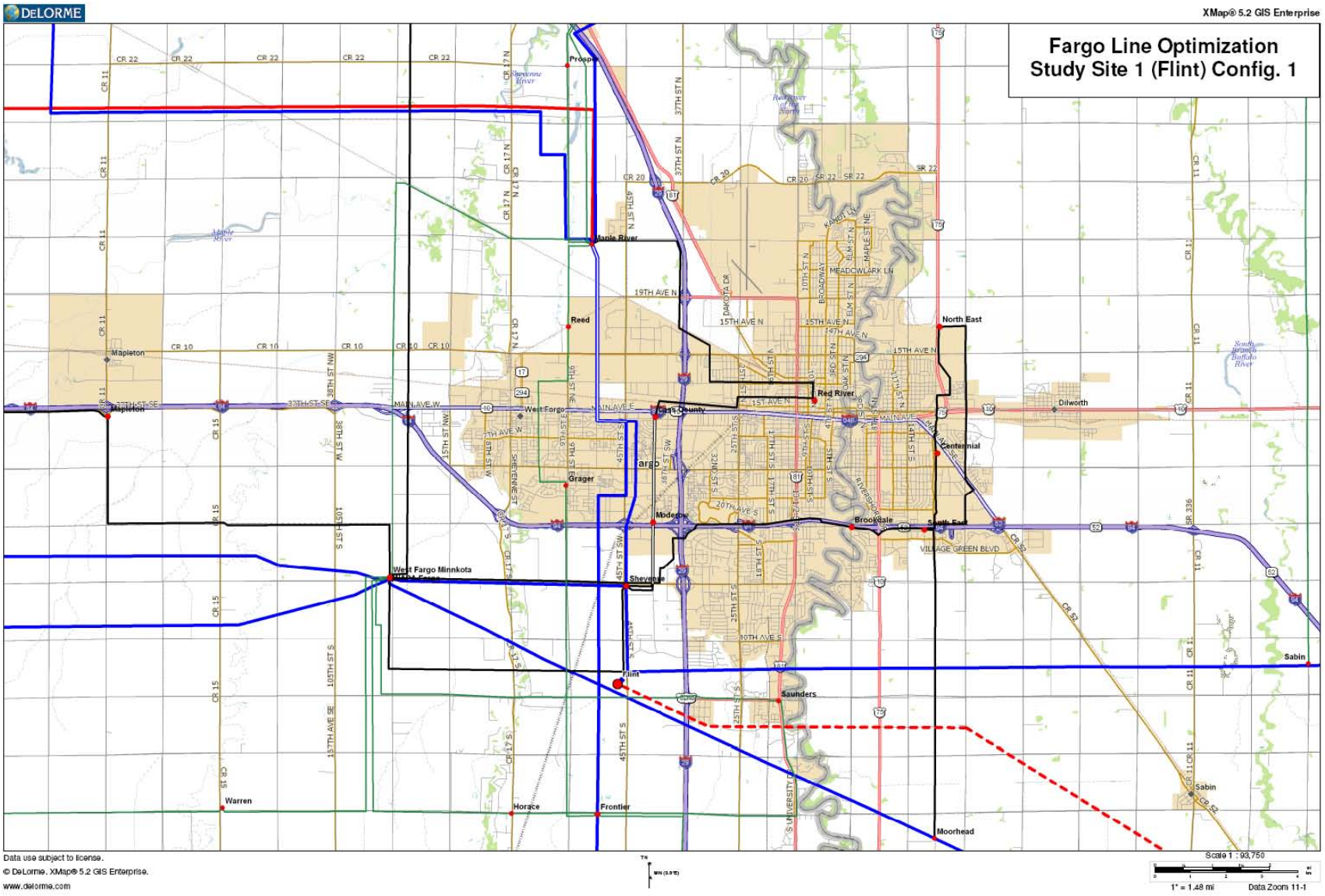


Table 3.4
Configurations Studied for Site 2 "Frontier"

Configuration	Description
1	Add 2 x 336MVA 345/230kV tx at Frontier
1.1	Configuration 1 improvements Add loop-in of Sheyenne-Audubon 230kV at Frontier Sheyenne 230 kV
1.2	Configuration 1.1 improvements Add 2nd Frontier-Sheyenne 230 kV
2	Configuration 1 improvements Add 345kV extended to Maple River (West Route)
2.1	Configuration 2 improvements Add 2nd Frontier-Sheyenne 230 kV

Figure 3.2
Termination at Frontier

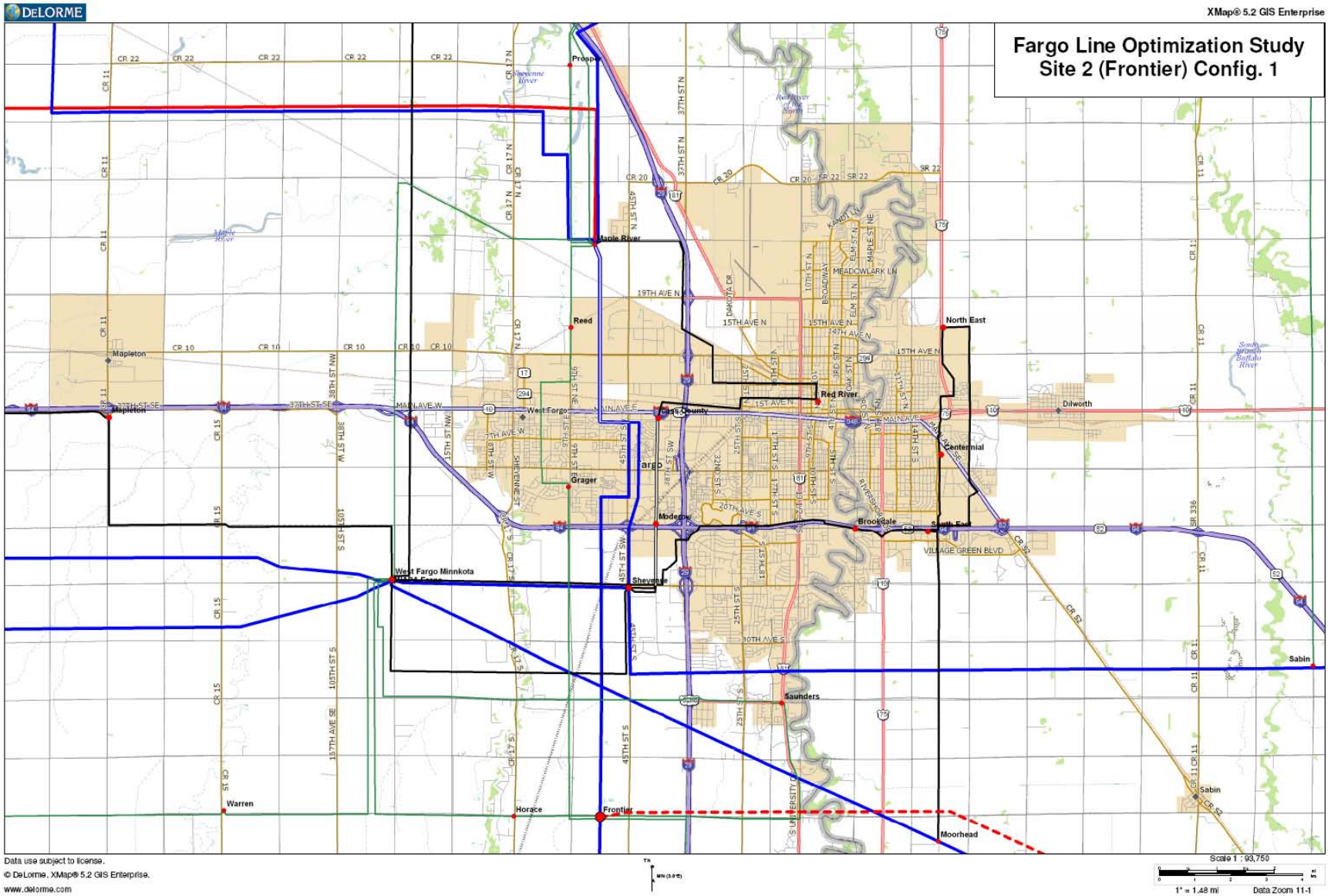


Table 3.5
Configurations Studied for Site 3 "WAPA Fargo"

Configuration	Description
1	Add 2 x 336 MVA 345/230 kV tx at WAPA Fargo
2	Add 2 x 336 MVA 345/230 kV tx at WAPA Fargo Add 345 kV extended to Maple River

Figure 3.3
Termination at WAPA Fargo

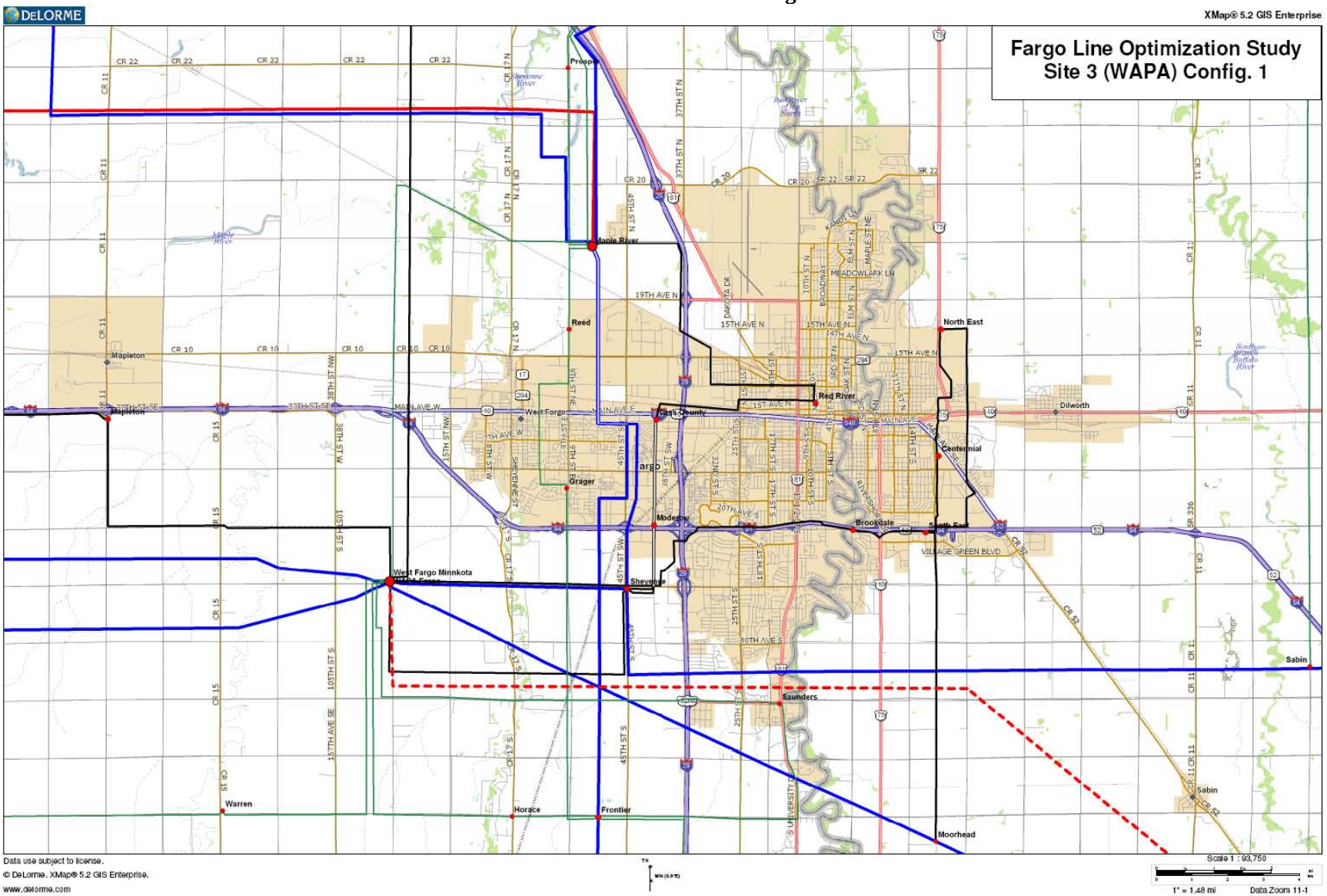


Table 3.6
Configurations Studied for Site 4 "Bison"

Configuration	Description
1	Add 2 x 336 MVA 345/230 kV tx at Bison
1.1	Configuration 1 improvements Add Maple River-Cass Co-Sheyenne 230 kV Add 230/115kV 336 MVA tx at Cass Co
1.2	Configuration 1.1 improvements Add loop in of Alex SS- Bison 345 kV at Flint Add loop in of Sheyenne-Audubon 230 kV at Flint Add 2 x 336 MVA 345/230 kV tx at Flint Add 2nd Sheyenne-Flint 230 kV
1.3	Configuration 1.2 improvements Rebuild Flint-Riverton-Benton Co as double circuit, operating at 230 kV and 345 kV
1.4	Configuration 1.3 improvements Add 3rd Maple River 345/230 kV transformer Add 75% Series Compensation on Flint-Quarry and Flint-Benton Co 345 kV
1.5	Configuration 1.3 improvements Add 3rd Maple River 345/230 kV transformer Add 2nd circuit Flint-Monticello 345 kV
1.6	Configuration 1 improvements Add loop in of Alex SS- Bison 345 kV at Flint Add loop in of Sheyenne-Audubon 230 kV at Flint Add 2 x 336MVA 345/230 kV tx at Flint Rebuild Flint-Riverton-Benton Co as double circuit, operating at 230 kV and 345kV Add Maple River-Cass Co-Flint 345 kV Add 345/115kV 336MVA tx at Cass Co Add 3rd Maple River 345/230 kV transformer Add 75% Series Compensation on Flint-Quarry and Flint-Benton Co 345 kV
2	Configuration 1 improvements Add 2nd Bison-Maple River 345 kV
3	Configuration 1.2 improvements Add Flint-Hankinson-Big Stone-Brookings Co 345 kV
3.1	Configuration 3 improvements Add 2nd circuit Flint-Monticello 345 kV

Figure 3.4
Termination at Bison

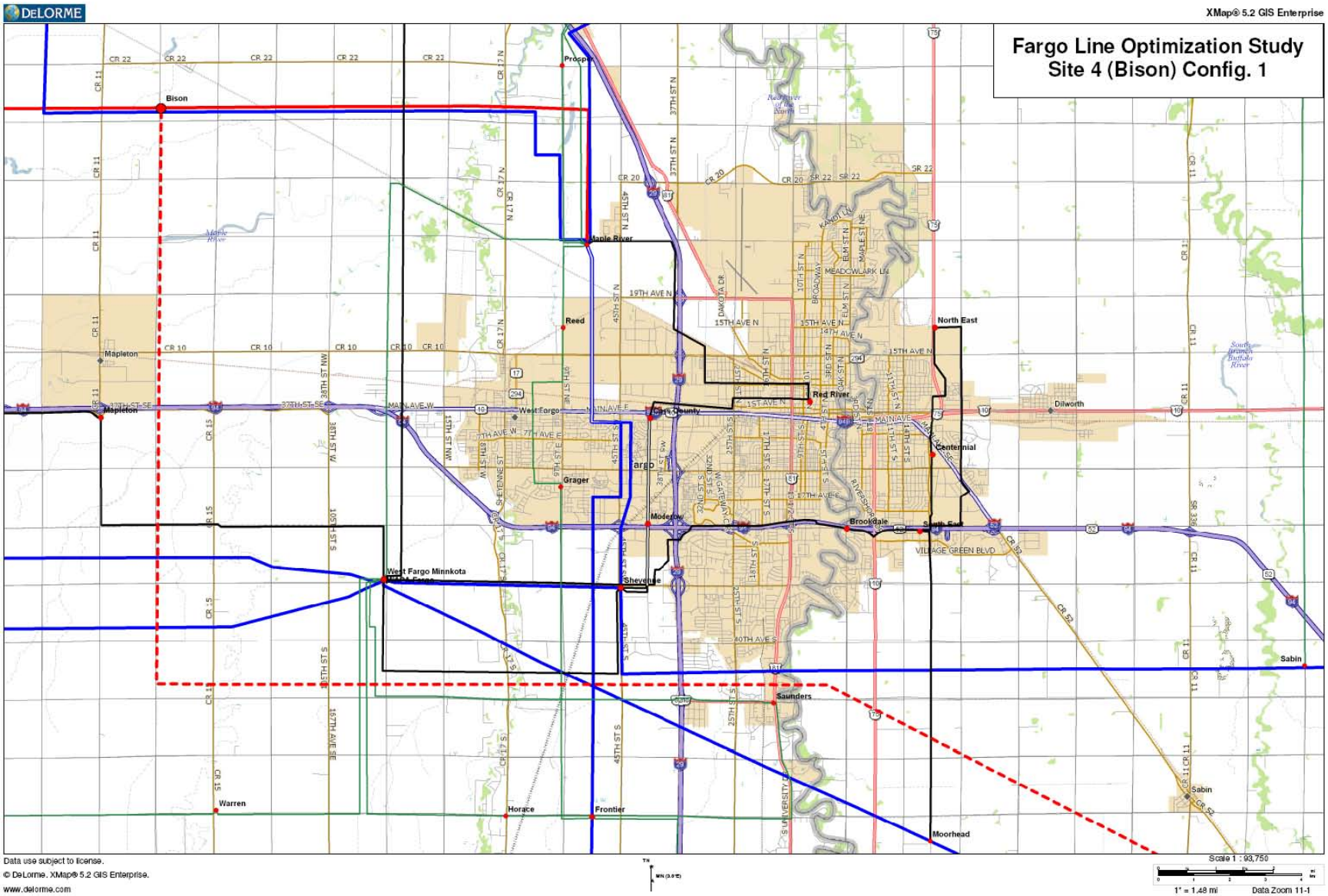
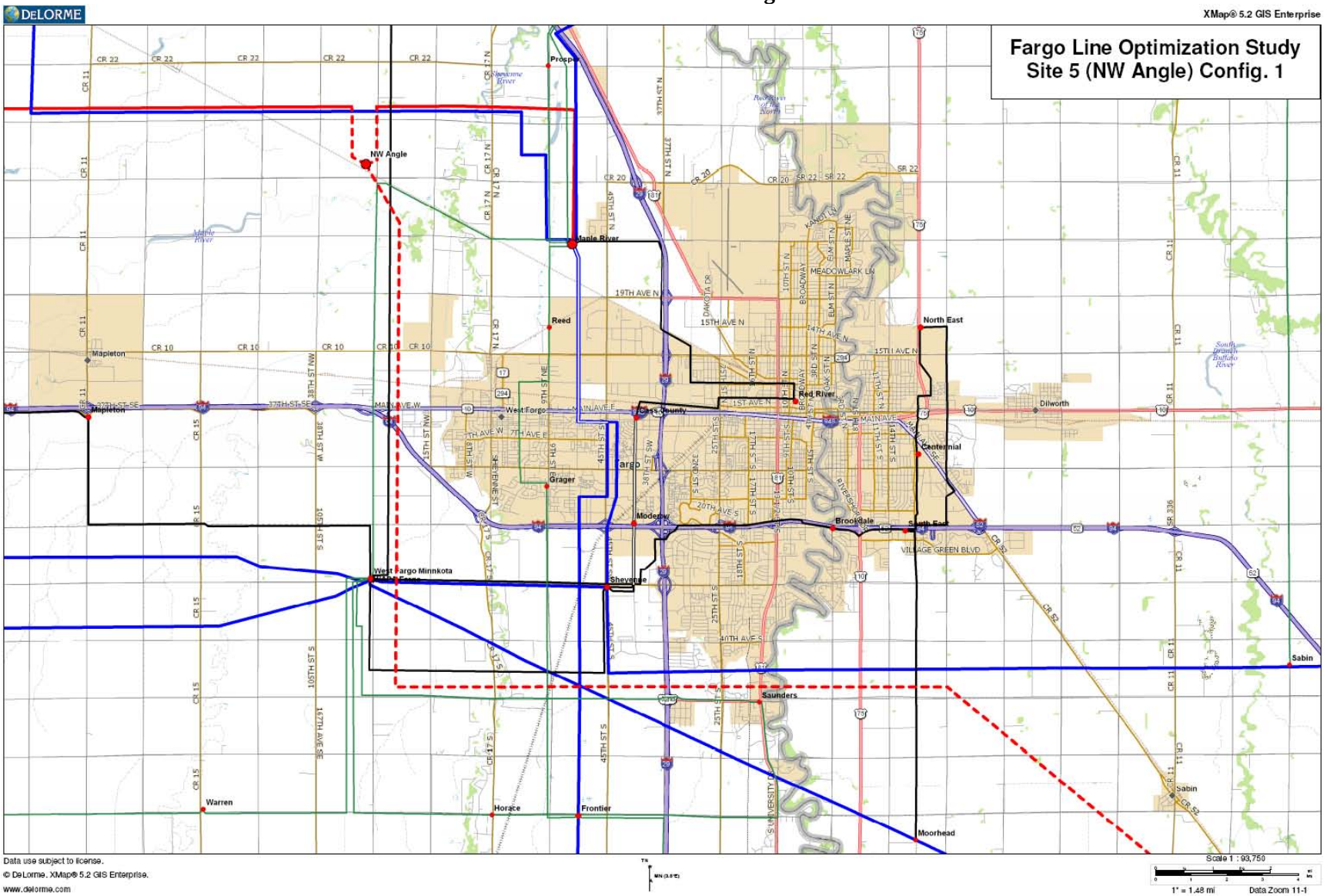


Table 3.7
Configurations Studied for Site 5 "NW Angle"

Configuration	Description
1	Add loop in of Maple River Buffalo 345 kV at NW Angle
2	Configuration 1 Add 2nd NW Angle-Maple River 345 kV #2

Figure 3.5
Termination at NW Angle



The "generation-to-generation" method of power transfer simulation was employed in this transfer capability analysis.

Source:
For all sites and configurations, the "source" consists of added generation at Maple River 345 kV (75%) and WAPA Fargo 230 kV (25%). These two generation output injections are proxies for indeterminate future generation resources in North Dakota or Manitoba. Total generation output was incrementally increased from 0-1000 MW. Generation was further increased beyond 1000 MW for configurations that address the Sheyenne-Audubon 230 kV line limitation.

Sink:
For all sites and configurations, the "sink" was simulated by scaling down generation at Sherco, King, Edgewater, and Pleasant Prairie to represent presumed deliveries to the Xcel Energy/NSP and Eastern Wisconsin areas. The generators scaled down and participation factors used were:

Table 3.8
Summer Off-Peak: Sinks and participation factors

Plant Name	Bus No.	Participation factor
Sherco	60001	60%
King	60006	20%
Edgewater	39208	10%
Pleasant Prairie	39430	10%
Total		**100%**

3.1.3 Winter Peak (Northward) Transfer Capability

Model Employed:
The source model for the winter peak transfer capability analysis is the "wp08aa" case from Northern MAPP Operating Review Working Group (NMORWG) 2008 package. The MHEX is at -700 MW level (700 MW northward).

The "generation-to-generation" method of power transfer simulation was employed in this transfer capability analysis.

FCITC analyses were conducted by incrementally increasing generation at the "source" group of generators from 0 to 1000 MW.

Source:
For all sites and configurations, the "source" was simulated by scaling up generation at Sherco, King, Edgewater, and Pleasant Prairie to represent presumed deliveries from the Xcel Energy/NSP and Eastern Wisconsin areas. Generators scaled up and associated participation factors used were:

Table 3.9
Winter Peak: Sources and participation factors

Plant Name	Bus No.	Participation factor
Sherco	60001	60%
King	60006	20%
Edgewater	39208	10%
Pleasant Prairie	39430	10%
Total		**100%**

Sink:
For all sites and configurations, the "sink" consists of Maple River 345 kV (75%) and WAPA Fargo 230 kV (25%).

3.2 Contingencies and Monitored Facilities

Contingencies:

- N-1 Contingences were simulated in the following areas:

Table 3.10
N-1 Contingencies

Transmission Owner	Voltage	Area
Xcel/NSP	115 kV & above	600
GRE	115 kV & above	618
MH	115 kV & above	667
OTP	115 kV & above	626
MP	115 kV & above	608
WAPA	115 kV & above	652

- Northern MAPP multi-contingencies are included in the analysis.
- N-2 Contingencies were simulated within in a Fargo-centered study zone defined by the following tie lines:

From	To	Voltage (kV)
Hankinson	Forman	230
Hankinson	Browns Valley	230
Wahpeton	Tyler	115
Moorhead	Morris	230
Grant Co.	Morris	115
(Fargo)	Alex SS	345
Inman	Wing River	230
Inman	Elmo	115
Audubon	Hubbard	230
Audubon	Ulrich	115
Maple River	Winger	230
Prairie	Winger	230
Grand Forks	Falconer	115
Prairie	Ramsey	230
Prairie	Drayton	230
Jamestown OTP	Buffalo	345
Jamestown	Carrington	115
Jamestown	Garrison	230
Jamestown	Bismarck	230
Jamestown	Weber	230
Jamestown	Edgeley	115
Valley City	Forman	115
Gwinner	Forman OTP	115

Monitored Areas:

Table 3.11
Monitored facilities

Transmission Owner	Voltage	Area
Xcel/NSP	115 kV & above	600
GRE	115 kV & above	618
MH	115 kV & above	667
OTP	115 kV & above	626
MP	115 kV & above	608
WAPA	115 kV & above	652

3.3 Performance Criteria

Power system performance for steady-state was evaluated against the MAPP/NERC Planning Standards, with respect to meeting system thermal performance standards of contingency Categories A, B, and C. A brief explanation of the different types of NERC contingencies is:

- Category A relates to "system intact" conditions
- Category B relates to first contingency ("n-1") conditions
- Category C was used to the extent that it relates to loss of two separate components within the study area at least 115 kV or above. This represents either two unrelated (but overlapping in time) line, transformer, or generator outages, or loss of two components due to common breaker or bus.

Thermal performance was judged to be acceptable if:

1. System intact loadings were within the continuous ratings, and
2. Post-contingent loadings were within the applicable emergency ratings given there were operating procedures available to adequately unload a facility to its continuous rating within 30 minutes.

Overloads were flagged and discussed within this report if facilities were loaded beyond these criteria.

3.4 Thermal Case Naming Convention

Cases for the potential Fargo vicinity termination sites studied are named by the site number and configuration number. For example, the case for the Flint site, configuration 2.1 is named "OP_Site 1 Configuration 2_1.sav"

Cases for the load serving study are named with an abbreviated description of the element added in the configuration. For example, the case adding the Fargo-Maple River 115kV line with the Pillsbury facilities in place is named "opPillsbury_FargoMPR115_FTF.sav"

3.5 Results

Tables in this section provide summary results for the load serving and transfer capability scenarios studied. Detailed raw data outputs are presented in Appendices B-D. These tables show the limiting facilities sequentially encountered while progressively incrementing power transfer between "source" and "sink". The "Incremental MW" column represents the incremental MW levels of "source" generation at which the indicated limiters are first encountered.

Facilities identified in the FCITC outputs are considered valid limiters if they:

- have an PTDF of 2.0% or greater (system intact), or
- have an OTDF of 2.0% or greater (outage condition).

This 2.0% criterion was selected in coordination with the *MAPP Design Review Subcommittee (DRS) Policies and Procedures*' use of 5.0% (PTDF) and 3.0% (OTDF) cutoff levels for system impact analyses' determination of "Significantly Affected Facilities" and the MISO use of similar distribution factor criteria for System Impact Studies. By screening at a 2.0% level it is ensured that all relevant limiters are identified, considering that the PTDFs and OTDFs are sensitive to several modeling assumptions and "sink" selection practices. Furthermore, it is recognized that at PTDFs or OTDFs lower than 2%, very large reductions in generation (over 50:1) are required in order to achieve a perceptible amount of load relief. Consequently, PTDFs/OTDFs lower than 2% strongly indicate that other power system adjustments are likely to be more effective in producing the desired ameliorative effect than would generation adjustments in the study area.

100% of Rate A is used as the continuous rating. Emergency ratings are different according to facility ownership:

Owner	Line Emergency Rating	Transformer Rating
Xcel Energy/NSP	110% of Rate A	115% of Rate A (beginning in 2010)
WAPA	110% of Rate A	125% of Rate A
GRE	100% of Rate A	125% of Rate A
MP	110% of Rate A	125% of Rate A
OTP	110% of Rate A	125% of Rate A

3.5.1 Load Serving Study Thermal Analysis

The Fargo/Moorhead area electrical loads are served from three subsystems.

I. All Minnkota loads except for Moderow are served from a Minnkota 69 kV system whose power sources are the 115/69 kV transformations at Maple River and WAPA Fargo, and the 230/69 kV transformer at Frontier.

   As loads grow on this 69 kV system, the 69 kV lines and supply transformations must be upgraded, or load must be converted to 115 kV supply.

II. The Xcel Energy/NSP loads are served from the Red River and Cass County 115-23.9 kV substations. These two substations and Minnkota's Moderow distribution substation are supplied from a 115 kV system whose sources are the Maple River and Sheyenne 230/115 kV transformations.

   The most severe contingency on this 115 kV system is outage of the Sheyenne-Moderow portion of the Sheyenne-Moderow-Cass Co double-circuit 115 kV line. During this condition, all loads on this 115 kV subsystem must be supplied from the Maple River 230/115 kV transformation, via the Maple River-Red River 115 kV line.

III. The Moorhead Public Service (MPS) loads are supplied from four distribution substations: Brookdale, Centennial, Northeast, and Southeast. These substations are supplied from a 115 kV system whose sources are the WAPA Fargo 230/115 kV transformation and the "Moorhead" 230/115 kV station located south of Moorhead on the WAPA Fargo-Morris 230 kV line.

   Load-serving limitations on the MPS 115 kV system arise from loss of either the Fargo or the "Moorhead Municipal" 115 kV sources; in this condition, the remaining source must supply the entire MPS 115 kV system. Eventually, the 230/115 transformers at Fargo and Moorhead substations must be upgraded and the corresponding 115 kV outlet lines reconductored to higher capacity, or one or more new 115 kV sources must be established on the MPS 115 kV system. However, these load-serving limitations are not reached until load levels significantly beyond the "Year 2014" levels.

There are no interconnections between the Xcel Energy/NSP 115 kV system and the MPS 115 kV system. Consequently, load growth-related deficiencies that arise on the two systems are independent of each other, and can be addressed separately. However, long-term planning should consider whether there may be electrical and strategic advantages to establishing interconnections between the two 115 kV systems.

Since the total load on the Xcel Energy/NSP 115 kV system is substantially larger than the load on the MPS 115 kV system, it is difficult for new interconnections between the NSP and the lower-capacity MPS 115 kV system to provide significant long-term load-serving assistance to the NSP system.

This study identifies several upcoming load-serving limitations on the Moorhead Public Service 115 kV system. From this analysis, it is evident that long-range planning should consider several interconnection options that are readily apparent:

- Establish a Maple River-Northeast 115 kV tie
- Establish a Red River-Centennial tie
- Loop in the Fargo-Brookdale 115 kV line at Sheyenne

Establishing one or more of these interconnections would significantly increase the MPS 115 kV system's load-serving capability. Any new interconnection will roughly double the MPS 115 kV system's N-1 capability, as it increases the number of 115 kV sources from 2 to 3. Comparison of these MPS load-serving options' effectiveness and costs is beyond the scope of the present study.

The balance of this load-serving analysis is focused on the Xcel Energy/NSP 115 kV system.

An incremental load serving analysis was performed to

- identify upcoming load-serving limitations;
- identify whether the various Fargo Line termination options yield significantly different load-serving capabilities;
- identify recommended short- and long-term load-serving plans as they relate to the development proposed with the Twin Cities – Fargo 345 kV line.

The load-serving analysis was performed by uniformly scaling up all the Fargo area loads and identifying the incremental load levels at which various first-contingency load-serving limits are encountered. Tables 3.14-3.18 are summaries of the contingency analyses; Appendix B provides the "raw" output from the PSS/E "MUST" simulations. The post-contingent line overloads for this load-serving analysis are flagged at 100% of the continuous rating (rather than 110%) because there is no local generation re-dispatch available with which to reduce post-contingent line loadings to within the lines' continuous ratings within 30 minutes. In contrast, the post-contingent transformer overloads are flagged at the transformer emergency ratings (115 to 125% of continuous) because the transformer emergency ratings are developed in consideration of daily and seasonal load shapes; there is no need for generation re-dispatch to achieve transformer loading relief because the daily load pattern provides the necessary relief.

The MW levels at which the various limiters are encountered are relative to the off-peak load levels represented in the base case. Appendix B provides a tabulation of the Fargo area loads. The important point is that the base case has the various load-serving entities' Fargo area loads represented at approximately 50-70% of annual peak. Consequently, when focusing on the Xcel Energy/NSP 115 kV system, which has base case NSP loads of only 49% of the forecast Year 2014 peak load, the Year 2014 peak load level corresponds to an incremental load level of approximately 300 MW in the summary tables. The load-serving analyses were all run an additional 300 MW, to an incremental load level of 600 MW, which corresponds to a NSP Fargo Area load level approximately 50% higher than the Year 2014 forecast level.

Table 3.12
Fargo Load-Serving Analysis, Configuration 0

"Existing System" (Year 2014)
Prior to Maple River-Alex SS-Quarry-Monticello 345 kV
Fargo-Fargo Tap 115 Open
Fargo-Maple River 69 Open

Incremental Load MW	Limiting Facility	Outage	DF %	Remedy
-1260	Maple Riv-Sheyenne 230 kV at 100% of 320 MVA	Wahpeton-Fergus Falls 230 kV	4.3	Equip limit
-445	Buffalo 345/115 tx at 100% of 112	Buffalo-Maple River 345	4.1	* (invalid contingency)
-20	Mapleton-Fargo Tp 115 at 100% of 96	Buffalo-Maple River 345	4.1	* (invalid contingency)
-20	Fargo-MPS Brook 115 at 100% of 130	Fargo-Moorhead 230	7.7	**(invalid contingency)
180	MPS SE-MPS Brook 115 at 100% of 130	Fargo-Moorhead 230	4.5	**(invalid contingency)
265	Fargo 230/115 tx 1 & 2 at 125% of 100	Fargo-Moorhead 230	13.2	**(invalid contingency)
290	Maple River 115/69 tx at 100% of 112	(System Intact)	19.2	MPC 69 kV load sect.
290	**Maple River 230/115 tx 5 & 6 at 115% of 187**	**Sheyenne-Moderow/Sheyenne-Cass Co 115**	**37.2**	
295	**Maple River-Red River 115 at 100% of 318**	**Sheyenne-Moderow/Sheyenne-Cass Co 115**	**54.2**	
300	**--(Approx. Year 2014 peak load level)--**			
320	**Maple River-Sheyenne 230 kV at 100% of 388**	**Wahpeton-Fergus Falls 230 kV**	**4.3**	Reconductor
390	**Cass Co-Red River 115 at 100% of 199**	**Maple River-Red River 115**	**29.2**	
390	Moorhead-MPS NE 115 at 100% of 119	Fargo-MPS Brook 115	14.3	
390	Fargo-Moorhead 230 at 100% of 240	Fargo-MPS Brook 115	7.5	Equip limit
395	**Sheyenne-Cass Co 115 at 100% of 223**	**Sheyenne-Moderow 115**	**36.4**	
400	Maple River-Sheyenne 230 at 100% of 320	(System Intact)	5.7	
465	Fargo-MPS Brook 115 at 100% of 130	Moorhead-MPS NE 115	14.3	
550	**Fargo 230/115 tx 1 & 2 at 125% of 100**	**Moorhead-MPS NE 115**	**13.2**	
590	**Sheyenne 230/115 tx 5 & 6 at 115% of 187**	**Maple River-Red River 115**		
600	(no further limiters encountered to this level)			

* There are no 345 kV breakers at Buffalo; the Buffalo-Maple River 345 kV outage normally is associated with outage of Jamestown-Buffalo 345 kV, which eliminates the 345 kV source at Buffalo.

** Outage of Fargo-Moorhead 230 kV also trips both Moorhead 230/115 kV transformers.

Referring to Table 3.12, it is seen that for the "existing system" configuration ("Configuration 0") the first load-serving limitations encountered (at 290-295 MW) are overload of the Maple River 230/115 kV transformers and overload of the Maple River-Red River 115 kV line, following outage of the Sheyenne-Moderow double-circuit 115 kV line. This 290-295 MW incremental load level corresponds approximately to the Year 2014 forecast peak load. Consequently, it is evident that some type of improvement is needed soon for the Xcel Energy/NSP Fargo 115 kV system.

During the next 100 MW of Fargo Area load increase, the Sheyenne-Cass Co and Cass Co-Red River 115 kV lines become overloaded, as does the Maple River-Sheyenne 230 kV line, although this 230 kV overload is primarily due to causes other than Fargo area load serving, as demonstrated by the low distribution factor (4.3%) that incremental load has on this facility.

Of all these "existing system" limiters, the Maple River-Red River 115 kV line overload is the most problematic, because this line has already been reconductored to high capacity (310 MVA; 795 kcm ACSS). Consequently, achieving yet-higher capacity on this path would likely require rebuilding, either with bundled conductor, or to a double-circuit configuration.

Configuration A represents the power system configuration immediately following addition of a Maple River-Quarry-Alexandria-Monticello 345 kV line. This is meant to generically represent installation of a Twin Cities-Fargo line; later Configurations test different Fargo termination options for the 345 kV line.

Configuration A's results (Table 3.13) show that addition of the 345 kV line in this "express" configuration does not affect the load-serving limiters identified from Configuration 0. Between 290 and 295 MW of load growth, the Maple River 230/115 kV transformer and Maple River-Red River 115 kV line overloads are still encountered.

Table 3.13
Fargo Load-Serving Analysis, Configuration A

"Existing System" (Year 2014)
with Maple River-Alex SS-Quarry-Monticello 345 kV addition
Fargo-Fargo Tap 115 Open
Fargo-Maple River 69 Open

Incremental Load MW	Limiting Facility	Outage	DF %	Remedy
-815	Buffalo 345/115 kV tx at 100% of 112 MVA	Buffalo-Maple River 345 kV	3.6	* (invalid contingency)
-330	Mapleton-Fargo Tp 115 at 100% of 96	Buffalo-Maple River 345	3.6	* (invalid contingency)
-20	Mapleton-Fargo Tp 115 at 100% of 96	Buffalo-Maple River 345	4.1	* (invalid contingency)
-20	Fargo-MPS Brook 115 at 100% of 130	Fargo-Moorhead 230	7.7	**(invalid contingency)
180	MPS SE-MPS Brook 115 at 100% of 130	Fargo-Moorhead 230	4.5	**(invalid contingency)
290	Maple River 115/69 tx at 100% of 112	(System Intact)	19.2	MPC 69 kV load sect.
290	**Maple River 230/115 tx 5 & 6 at 115% of 187**	**Sheyenne-Moderow/Sheyenne-Cass Co 115**	**37.2**	
295	**Maple River-Red River 115 at 100% of 318**	**Sheyenne-Moderow/Sheyenne-Cass Co 115**	**54.2**	
300	**--(Approx. Year 2014 peak load level)--**			
365	**Sheyenne-Cass Co 115 at 100% of 223**	**Sheyenne-Moderow 115**	**36.0**	
375	Maple River-Sheyenne 230 at 100% of 320	Sheyenne-Fargo 230	23.2	Equip limit
390	Moorhead-MPS NE 115 at 100% of 119	Fargo-MPS Brook 115	14.3	
390	**Cass Co-Red River 115 at 100% of 199**	**Maple River-Red River 115**	**29.2**	
465	Fargo-MPS Brook 115 at 100% of 130	Moorhead-MPS NE 115	14.3	
510	Fargo 230/115 tx 1 & 2 at 125% of 100	Fargo-Moorhead 230	9.4	
600	(no further limiters encountered to this level)			

* There are no 345 kV breakers at Buffalo; the Buffalo-Maple River 345 kV outage normally is associated with outage of Jamestown-Buffalo 345 kV, which eliminates the 345 kV source at Buffalo.

** Outage of Fargo-Moorhead 230 kV also trips both Moorhead 230/115 kV transformers.

Table 3.14
Fargo Load-Serving Analysis, Configuration B

(Year 2014)
with Maple River-Alex SS-Quarry-Monticello 345 kV
Fargo-Fargo Tap 115 Closed
Fargo-Maple River 69 Open

Incremental Load MW	Limiting Facility	Outage	DF %	Remedy
-1180	Buffalo 345/115 kV tx at 100% of 112 MVA	Buffalo-Maple River 345 kV	3.1	* (invalid contingency)
-595	Mapleton-Fargo Tp 115 at 100% of 96	Buffalo-Maple River 345	3.1	* (invalid contingency)
285	**Fargo 230/115 tx 1 & 2 at 125% of 100**	**Sheyenne-Fargo 230**	**16.2**	
290	**Maple River 230/115 tx 5 & 6 at 115% of 187**	**Sheyenne-Moderow/Sheyenne-Cass Co 115**	**37.2**	
290	Maple River 115/69 tx at 100% of 112	(System Intact)	19.2	MPC 69 kV load sect.
295	**Maple River-Red River 115 at 100% of 318**	**Sheyenne-Moderow/Sheyenne-Cass Co 115**	**54.2**	
300	**--(Approx. Year 2014 peak load level)--**			
305	Fargo-MPS Brook 115 at 100% of 130	Fargo-Moorhead 230	8.0	**(invalid contingency)
310	Maple River-Sheyenne 230 at 100% of 320	Maple River-Alex SS	7.1	Equip limit
345	**Sheyenne-Cass Co 115 at 100% of 223**	**Sheyenne-Moderow 115**	**36.9**	
390	Moorhead-MPS NE 115 at 100% of 119	Fargo-MPS Brook 115	14.3	
390	**Cass Co-Red River 115 at 100% of 199**	**Maple River-Red River 115**	**29.2**	
465	Fargo-MPS Brook 115 at 100% of 130	Moorhead-MPS NE 115	14.3	
475	Fargo 230/115 tx 1 & 2 at 100% of 100	(System Intact)	11.6	
480	**Maple River 230/115 tx 5 & 6 at 115% of 187**	**Sheyenne-Moderow/Sheyenne-Cass Co 115**	**28.2**	
495	Moorhead 230/115 tx 1 & 2 at 100% of 67	Fargo-MPS Brook 115	7.1	
510	Cass Co-Moderow 115 at 100% of 239	Sheyenne-Cass Co 115	31.2	
530	Sheyenne-Fargo Tp 115 at 100% of 144	Sheyenne-Fargo 230	14.3	
560	Sheyenne-Moderow 115 at 100% of 310	Sheyenne-Cass Co 115	37.7	
600	(no further limiters encountered to this level)			

Configuration B tests closing the normally-open 115 kV connection at the WAPA Fargo substation. Closing this connection makes the WAPA Fargo 230/115 kV transformation available to the Xcel Energy/NSP 115 kV system. However, the results for Configuration B (Table 3.14) show that this does not delay the Maple River 230/115 kV transformer overloads, or the Maple River-Red River 115 kV overloads. This occurs because the critical outage (Sheyenne-Moderow 115 kV double circuit) still causes Maple River to be the only supply available to the loads on the Xcel Energy/NSP 115 kV system. A further limitation is that the WAPA Fargo 230/115 kV transformers are subject to overload at the 285 MW incremental load level, just prior to the Maple River transformer overloads. WAPA does have plans for replacement of the Fargo 230/115 kV transformers within the next 5 years; however, the schedule is tentative and subject to revision due to budgetary constraints and unanticipated failures of other transformers that could occur in the next few years.

Configuration C tests the addition of a Maple River-Fargo 115 kV line. The results of Configuration C (Table 3.15) show that the Maple River 230/115 kV transformer overload is postponed by approximately 200 MW of load growth, but this configuration does nothing to address the Maple River-Red River 115 kV overload, nor the later Sheyenne-Cass Co and Cass Co-Red River 115 kV overloads.

Table 3.15
Fargo Load-Serving Analysis, Configuration C

(Year 2014)
with Maple River-Alex SS-Quarry-Monticello 345 kV
Add Maple River-Fargo 115 kV
Fargo-Fargo Tap 115 Closed
Fargo-Maple River 69 Open

Incremental Load MW	Limiting Facility	Outage	DF %	Remedy
-1185	Buffalo 345/115 kV tx at 100% of 112 MVA	Buffalo-Maple River 345 kV	3.1	* (invalid contingency)
-625	Mapleton-Fargo Tp 115 at 100% of 96	Buffalo-Maple River 345	3.1	* (invalid contingency)
290	Maple River 115/69 tx at 100% of 112	(System Intact)	19.2	MPC 69 kV load sect.
295	**Maple River-Red River 115 at 100% of 318**	**Sheyenne-Moderow/Sheyenne-Cass Co 115**	**54.2**	
300	Fargo-MPS Brook 115 at 100% of 130	Moorhead-MPS NE 115	7.8	
300	Fargo 230/115 tx 1 & 2 at 125% of 100	Sheyenne-Fargo 230	17.0	
300	**--(Approx. Year 2014 peak load level)--**			
365	**Sheyenne-Cass Co 115 at 100% of 223**	**Sheyenne-Moderow 115**	**35.2**	
390	Moorhead-MPS NE 115 at 100% of 119	Fargo-MPS Brook 115	14.3	
390	**Cass Co-Red River 115 at 100% of 199**	**Maple River-Red River 115**	**29.2**	
445	Fargo 230/115 tx 1 & 2 at 100% of 100	(System Intact)	12.5	
450	**Maple River 230/115 tx 5 & 6 at 115% of 187**	**Sheyenne-Moderow/Sheyenne-Cass Co 115**	**28.2**	
495	Moorhead 230/115 tx 1 & 2 at 100% of 67	Fargo-MPS Brook 115	7.1	
495	**Maple River 230/115 tx 5 or 6 at 100% of 187**	**Maple River 230/115 tx 6 or 5**	**24.2**	
545	Cass Co-Moderow 115 at 100% of 239	Sheyenne-Cass Co 115	30.0	
590	Sheyenne-Moderow 115 at 100% of 310	Sheyenne-Cass Co 115	36.1	
600	(no further limiters encountered to this level)			

Table 3.16
Fargo Load-Serving Analysis, Configuration D

(Year 2014)
Add Fargo-Maple River 115 kV
& Maple River-Cass Co-Sheyenne 230 kV w Cass Co 230/115 tx
with Maple River-Alex SS-Quarry-Monticello 345 kV
Fargo-Fargo Tap 115 Closed
Fargo-Maple River 69 Open

Incremental Load MW	Limiting Facility	Outage	DF %	Remedy
-1280	Buffalo 345/115 kV tx at 100% of 112 MVA	Buffalo-Maple River 345 kV	2.8	* (invalid contingency)
-670	Mapleton-Fargo Tp 115 at 100% of 96	Buffalo-Maple River 345	3.1	* (invalid contingency)
280	**Fargo 230/115 tx 1 & 2 at 125% of 100**	**Sheyenne-Fargo 230**	**16.3**	
300	**--(Approx. Year 2014 peak load level)--**			
290	Maple River 115/69 tx at 100% of 112	(System Intact)	19.2	MPC 69 kV load sect.
375	Cass Co 230/115 tx at 100% of 187	Sheyenne-Moderow/Sheyenne-Cass Co 115	28.6	Install larger tx (new tx)
390	**Cass Co-Red River 115 at 100% of 199**	**Maple River-Red River 115**	**29.2**	
465	Fargo-MPS Brook 115 at 100% of 130	Moorhead-MPS NE 115	14.3	
495	Moorhead 230/115 tx 1 & 2 at 100% of 67	Fargo-MPS Brook 115	7.1	
510	Fargo 230/115 tx 1 & 2 at 100% of 100	(System intact)	11.1	
600	(no further limiters encountered to this level)			

The new Cass Co-Sheyenne 230 kV segment was assumed to be double circuit south of Cass Co with a portion of the existing Maple River-Sheyenne 230 kV. Accordingly, this new double-circuit outage was tested to confirm it does not pose a new limiting condition.

Configuration D adds a new Maple River-Cass Co-Sheyenne 230 kV line, and a 230/115 kV transformer at Cass Co. As expected, the results (Table 3.16) show this is very effective at addressing both the Maple River 230/115 kV transformer loadings, and the Maple River-Red River 115 kV line overload. The only remaining Xcel Energy/NSP load-serving limiter is the Cass Co-Red River 115 kV line overload; this can be addressed by reconductoring if necessary. However, it is not certain when or if this overload will actually be encountered because it only occurs when the Red River Substation load exceeds 199 MW. It is likely that as the urban Fargo loads grow, some of the incremental load growth will eventually be served from new 115/23 kV transformations at Maple River and Sheyenne, rather than exclusively from the Red River and Cass Co substations.

The WAPA Fargo transformer overloads will eventually be addressed by their planned replacement. In the interim, the 115 kV Fargo tie can remain open to prevent this overload, as there will be ample 230/115 kV transformer capability on the Xcel Energy/NSP system following the Cass Co transformer addition.

Load Serving Analysis Summary

In the near term, the Maple River 230/115 kV transformer overloads and the Maple River-Red River 115 kV overload need to be addressed. The Maple River-Sheyenne 230 kV line also is a limiter, but its overloading is primarily due to causes other than Fargo area load.

Due to the nature of the most-limiting contingency, other options tested, such as a WAPA Fargo-Maple River 115 kV line, are not effective at addressing both of the near-term load-serving limiters. However, the Fargo-Maple River 115 kV connection will likely eventually be desirable because it establishes a Fargo 115 kV loop and provides opportunities for serving more of the future Fargo area load at 115 kV rather than 69 kV. It can also be inferred that tapping the new 345 kV line at any location surrounding Fargo (e.g., WAPA Fargo, Frontier, Sheyenne, or Flint) will not be effective in addressing the early-year load-serving limiters identified on the Xcel Energy/NSP 115 kV system. In order to be effective for these near-term limiters, any new source to the Xcel Energy/NSP 115 kV system must be connected directly to either Cass Co. or Red River Substation.

Addition of a Maple River-Cass Co-Sheyenne 230 kV line and a Cass Co. 230/115 kV transformer is very effective at addressing the identified load-serving limiters; the only additional improvement, which may be required later due to continued load growth, is a reconductor of the Cass Co-Red River 115 kV line.

3.5.2 Summer Off-Peak Transfer Capability Analysis

This study identifies the southward power transfer capability limitations for each of the five potential sites selected for study. Each site studied has two base configurations, one with the Twin Cities-Fargo 345 kV line terminated at the site, and one with the 345 kV line extended to Maple River. Additional sub-configurations that address limiters identified in the base configuration were also tested. Line overloads are flagged based on their short-term emergency ratings (generally 110% of continuous rating) because in a transfer capability study generation re-dispatch is presumed to be available for post-contingent loading relief.

The results of the transfer capability analysis are tabulated in Tables 3.19 through 3.44. The MW levels at which the various limiters are encountered represent the additional southward power transfer capability obtained with the configuration tested. Limitations that can be addressed by fixes that are considered to be minor, such as eliminating equipment limitations and increasing conductor ground clearance, are normal text in the tables. Limitations that can be addressed by fixes that are considered moderately significant, such as transformer replacement or reconductoring of relatively short lines, are blue text. Limitations that appear again after the line has been reconductored are red text. These latter limitations are considered to be significant, as they would require addressing the same overload twice before the Sheyenne-Audubon "stopping point" were reached.

The Sheyenne-Audubon 230kV line overload is a notable limitation common to all sites tested, since it is due to the outage of the new Twin Cities-Fargo line. This will be a limitation regardless of the Fargo termination site for the Twin Cities-Fargo 345 kV line. Due to the significant cost of addressing this limitation, it is considered to be the natural initial "stopping point" and is **bold font** in the tabulations. Subsequent stopping points encountered in configurations addressing this limitation are also shown in bold.

Table 3.17
Southward Power Transfer Capability
Site 1 "Flint" Configuration 1

(345 kV ends at Flint, loop-in only Sheyenne-Audubon 230 kV)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
-270	Sheyenne-Flint 230 kV at 110% of 388 MVA	Wahpeton-Fergus Falls 230	38.7	Reconductor
-240	Sheyenne-Flint 230 at 100% of 388	(System Intact)	35.9	
-385	Maple River-Sheyenne 230 at 110% of 320	Sheyenne-Fargo 230	31.4	Equip limit
-235	Maple River-Sheyenne 230 at 100% of 320	(System Intact)	29.9	Equip limit
-145	Maple River-Sheyenne 230 at 110% of 388	Sheyenne-Fargo 230	31.4	Reconductor
-10	Maple River-Sheyenne 230 at 100% of 388	(System Intact)	29.9	
90	Maple River-Frontier 230 at 110% of 265	Sheyenne-Flint 230	23.5	Increase ground clearance
165	Cass Co-Red River 115 at 110% of 199	Maple R-Sheyenne/Maple R-Frontier 230	17.7	Reconductor
200	Maple River 230/115 tx 5 & 6 at 115% of 187	Maple R-Sheyenne/Maple R-Frontier 230	11.5	Replace txs
215	Maple River 345/230 tx 1 or 2 at 125% of 336	Maple River 345/230 tx 2 or 1	55.7	Replace txs
255	Wahpeton-Frontier 230 at 110% of 265	Sheyenne-Flint 230	23.6	Increase ground clearance
265	Whitlock-Glenham 230 at 110% of 240	Leland Olds- Ft Thompson 345	4.2	Equip limit
300	Blackberry-Boswell 230 ckt 2 at 110% of 399	Fault of South 500 w/xtrip of north 500	3.3	(reconductor or revise xtrip)
390	Bismarck-Glenham 230 at 110% of 240	Leland Olds- Ft Thompson 345	4.2	Equip limit
390	Sheyenne-Flint 230 kV at 110% of 620	Wahpeton-Fergus Falls 230	38.7	(already reconductored)
405	Sheyenne-Flint 230 at 100% of 620	(System Intact)	35.9	(already reconductored)
420	Maple River-Red River 115 at 110% of 318	Maple R-Sheyenne/Maple R-Frontier 230	17.7	(already ACSS)
470	Flint 345/230 tx 1 or 2 at 115% of 336	Flint 345/230 tx 2 or 1	22.3	Install larger txs
470	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds- Ft Thompson 345	4.2	Equip limit
595	Maple River 345/230 tx 1 & 2 at 100% of 336	(System Intact)	29.7	
640	Wahpeton-Fergus Falls 230 at 110% of 320	Sheyenne-Flint 230	15.2	
665	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	7.0	Addressed by CapX 2020
665	Maple River-Frontier 230 at 110% of 388	Sheyenne-Flint 230	23.5	Reconductor
670	Alexandria-Alex SS at 100% of 160	Quarry-Alex 345	6.1	Increase ground clearance
670	Maple River-Sheyenne 230 at 110% of 620	Sheyenne-Fargo 230	31.4	(already reconductored)
670	Mahnomen-Winger 115 at 110% of 96	Sheyenne-Flint 230	3.4	
715	Oahe-Sully Butte 230 at 110% of 240	Leland Olds- Ft Thompson 345	4.2	Equip limit

735	Sheyenne-Fargo 230 at 110% of 388	Jamestown-Buffalo-Maple River 345	18.1	
745	**Flint-Audubon 230 at 110% of 318**	**Alex SS-Flint 345**	**16.5**	**Reconductor or rebuild**
750	Fargo-Moorhead 230 at 110% of 240	Sheyenne-Flint 230	15.0	Equip limit
765	Granite Falls-Morris 230 at 110% of 239	Canby-Granite Falls 230	7.2	Equip limit
790	Moorhead-Morris 230 at 110% of 239	Sheyenne-Flint 230	15.9	Equip limit
795	Wilton-Bemidji 115 at 110% of 143	Sheyenne-Flint 230	3.0	
805	Maple River-Frontier 230 at 110% of 265	(System Intact)	14.4	
830	Wahpeton-Frontier 230 at 110% of 388	Sheyenne-Flint 230	23.6	Reconductor
845	Mahnomen-Ulrich 115 at 110% of 96	Sheyenne-Flint 230	3.4	
855	Cass Co-Red River 115 at 110% of 310	Maple R-Sheyenne/Maple R-Frontier 230	17.7	(already reconductored)
880	Chisago Co 500 kV series cap at 110% of 1732	Arrowhead-Stone Lk 345	17.9	
910	Maple River-Winger 230 at 110% of 342	Sheyenne-Frontier/Sheyenne-Maple R	23.5	
930	Roseau Co 500 kV Series Caps at 100% of 1732	(System Intact)	9.4	
1000	(no further limiters encountered to this level)			

Observations:

The Sheyenne-Flint 230 kV line immediately needs to be reconductored, or a second circuit added. Reconductoring only achieves ~390 MW of transfer capability (provided Maple River-Sheyenne 230 and Red River-Cass Co 115 have been reconductored, and additional 345/230 and 230/115 kV transformer capacity has been provided at Maple River), at which point Sheyenne-Flint 230 needs relief again. Addition of a second Sheyenne-Flint 230 kV circuit would also prevent several other overloads at higher MW levels. The addition of a second Sheyenne-Flint circuit is tested in Configuration 1.1 (see next table).

Transfer capability is severely constrained by the Maple River double circuit 230 kV outage, which causes several line and transformer overloads, and by the overload of those two circuits.

Flint-Audubon 230 kV is a limiter at 745 MW; it will be so at approximately this level regardless of Fargo termination configuration.

The Roseau Co 500 kV series capacitors exceed their continuous rating at the 930 MW incremental transfer level, system intact. The outage of the Fargo line (or any other line in the study area) does not cause the capacitor emergency rating to be exceeded before the system intact overload is encountered. The base case employed in this study has the Dorsey-Roseau Co-Forbes 500 kV "system intact" loading at approximately 87 MW below the capacitor rating (1732 – 87 = 1645 MW). Use of a different base case with slightly higher pre-continent flow on the Dorsey-Roseau Co-Forbes 500 kV would result in the Roseau Co series capacitors being a limiter at significantly lower southward power transfer levels. For example, if the pre-contingent 500 kV loading were 50 MW higher, the "930 MW" limiter would be encountered at 50/.094 = 532 MW lower, or approximately 400 MW. For this reason, further study is recommended to address this issue; it may be necessary to provide series compensation on the new Twin Cities - Fargo line in order to achieve the thermal limits suggested by this transfer capability analysis.

Table 3.18
Southward Power Transfer Capability
Site 1 "Flint" Configuration 1.1

(345 kV ends at Flint, loop-in Sheyenne-Audubon 230 kV)
(Add Sheyenne-Flint 230 kV #2)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
-390	Maple River-Sheyenne 230 at 110% of 320 MVA	Sheyenne-Fargo 230	31.6	Equip limit
-245	Maple River-Sheyenne 230 at 100% of 320	(System Intact)	30.1	
-140	Maple River-Sheyenne 230 at 110% of 388	Sheyenne-Fargo 230	32.0	Reconductor
-135	Sheyenne-Flint #1 or 2 at 110% of 388	Sheyenne-Flint #2 or 1	35.9	Reconductor
-15	Maple River-Sheyenne 230 at 100% of 388	(System Intact)	30.1	
160	Cass Co-Red River 115 at 110% of 199	Maple R-Sheyenne/Maple R-Frontier 230	17.7	Reconductor
195	Maple River 230/115 tx #5 & #6 at 115% of 187	Maple R-Sheyenne/Maple R-Frontier 230	11.6	Replace with larger units
215	Maple River 345/230 tx 1 or 2 at 125% of 336	Maple River 345/230 tx 2 or 1	55.8	Replace with larger units
295	Whitlock-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.2	CT Limitation
295	Blackberry-Boswell 230 ckt 2 at 110% of 399	Fault of South 500 w/xtrip of north 500	3.3	(reconductor or revise xtrip)
325	Maple River-Frontier 230 at 110% of 265	Maple River-Sheyenne230	20.2	Increase ground clearance
415	Maple River-Red River 115 at 110% of 318	Maple R-Sheyenne/Maple R-Frontier 230	17.7	?? (already ACSS)
420	Bismarck-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.2	CT Limitation
455	Flint 345/230 tx 1 or 2 at 115% of 336	Flint 345/230 tx 2 or 1	22.4	Install larger txs
500	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.1	CT Limitations
515	Wahpeton-Frontier 230 at 110% of 265	Maple River-Sheyenne 230	20.8	Increase ground clearance
575	Sheyenne-Flint #1 or 2 at 110% of 620	Sheyenne-Flint #2 or 1	35.9	(already reconductored)
595	Maple River 345/230 tx 1 & 2 at 125% of 336	(System Intact)	29.7	Replace with larger units
650	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	7.1	Addressed by CapX 2020
655	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345	6.2	Increase ground clearance
660	Maple River-Sheyenne 230 at 110% of 620	Sheyenne-Fargo 230	32.0	(already reconductored)
720	Sheyenne-Fargo 230 at 110% of 388	Jamestown-Buffalo-Maple River 345	18.1	Reconductor
730	**Flint-Audubon 230 at 110% of 318**	**Alex SS-Flint 345**	**16.6**	**Reconductor or rebuild**
740	Oahe-Sully Butte 230 at 110% of 240	Leland Olds- Ft Thompson 345	4.2	Equip limit
775	Granite Falls-Morris 230 at 110% of 239	Canby-Granite Falls 230	7.3	Equip limit
815	Sheyenne-Flint 230 #1 & 2 at 100% of 388	(System Intact)	18.1	

815	Maple River-Frontier 230 at 110% of 265	(System Intact)	20.2	Increase ground clearance
850	Cass Co-Red River 115 at 110% of 310	Maple R-Sheyenne/Maple R-Frontier 230	17.7	(already reconductored)
880	Chisago Co 500 kV series cap at 110% of 1732	Arrowhead-Stone Lk 345	17.9	
910	Maple River-Winger 230 at 110% of 342	Sheyenne-Frontier/Sheyenne-Maple R	23.5	
930	Roseau Co 500 kV Series Caps at 100% of 1732	(System Intact)	9.0	
1000	(No further limiters encountered to this level)			

Observations:

Adding the Flint-Sheyenne 230 kV second circuit helps, but performance is still severely constrained by the Maple River double circuit 230 kV outage (limiter at 415 MW, if Maple River transformers have all been replaced), and by the overload of those two circuits.

Table 3.19
Southward Power Transfer Capability
Site 1 "Flint" Configuration 1.2

(345 kV ends at Flint, loop-in Sheyenne-Audubon 230 kV)
(Add Sheyenne-Flint 230 kV #2, loop-in Maple River-Frontier 230 kV)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
-500	Maple River-Flint 230 at 110% of 265 MVA	Maple River-Sheyenne 230	40.1	Increase ground clearance
-155	Maple River-Flint 230 at 110% of 388	Maple River-Sheyenne 230	40.1	Reconductor
-380	Maple River-Sheyenne 230 at 110% of 320	Maple River-Flint 230	41.7	Equip limit
-200	Maple River-Sheyenne 230 at 110% of 388	Maple River-Flint 230	41.7	Reconductor
30	Maple River-Flint 230 at 100% of 265	(System Intact)	21.2	Increase ground clearance
95	Maple River-Sheyenne 230 at 100% of 320	(System Intact)	24.2	Equip limit
110	Cass Co-Red River 115 at 110% of 199	Maple Riv-Flint/Maple Riv-Sheyenne 230	18.6	Reconductor
145	Maple River 230/115 tx 5 & 6 at 115% of 187	Maple Riv-Flint/Maple Riv-Sheyenne 230	12.1	Replace with larger units
280	Sheyenne-Flint 230 # 1 or 2 at 110% of 388	Sheyenne-Flint # 2 or 1	27.8	Reconductor
205	Maple River 345/230 tx 1 or 2 at 125% of 336	Maple River 345/230 tx 2 or 1	56.0	Replace with larger units
295	Whitlock-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.2	CT Limitation
305	Blackberry-Boswell 230 ckt 2 at 110% of 399	Fault of South 500 w/xtrip of north 500	3.3	(reconductor or revise xtrip)
355	Maple River-Red River 115 at 110% of 318	Maple Riv-Flint/Maple Riv-Sheyenne 230	17.7	?? (already ACSS)
420	Bismarck-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.2	CT Limitation
425	Flint 345/230 tx 1 or 2 at 115% of 336	Flint 345/230 tx 2 or 1	22.8	Install larger txs
425	Frontier-Flint 230 at 110% of 265	Alex SS-Flint 345	19.4	Increase ground clearance
425	Frontier-Wahpeton 230 at 110% of 265	Alex SS-Flint 345	19.4	Increase ground clearance
480	Maple River-Flint 230 at 110% of 620	Maple River-Sheyenne 230	40.1	(already reconductored)
500	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.2	CT Limitations
585	Maple River 345/230 tx 1 & 2 at 125% of 336	(System Intact)	29.8	Replace with larger units
615	Maple River-Flint 230 at 100% of 388	(System Intact)	21.2	
630	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345	6.2	Increase ground clearance
650	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	7.1	Addressed by CapX 2020
730	**Flint-Audubon 230 at 110% of 318**	**Alex SS-Flint 345**	**16.4**	**Reconductor or rebuild**
735	Sheyenne-Fargo 230 at 110% of 388	Jamestown-Buffalo-Maple River 345	18.4	
740	Oahe-Sully Butte 230 at 110% of 240	Ft Thompson-Leland Olds 345	4.2	

770	Granite Falls-Morris 230 at 110% of 239	Canby-Granite Falls 230	7.2	Equip limit
780	Cass Co-Red River 115 at 110% of 310	Maple Riv-Flint/Maple Riv-Sheyenne 230	17.7	(already reconductored)
885	Chisago Co 500 kV series cap at 110% of 1732	Arrowhead-Stone Lk 345	17.9	
935	Roseau Co 500 kV Series Caps at 100% of 1732	(System Intact)	9.0	
955	Maple River-Winger 230 at 110% of 342	Maple Riv-Flint/Maple Riv-Sheyenne 230	22.9	
1000	(No further limiters encountered to this level)			

Observations:

Looping in the Maple River-Frontier 230 kV helps slightly, but performance is still severely constrained by the Maple River double circuit 230 kV outage, and by the overload of those two circuits.

Table 3.20
Southward Power Transfer Capability
Site 1 "Flint" Configuration 1.3

(345 kV ends at Flint, loop-in Sheyenne-Audubon 230 kV)
(Add Sheyenne-Flint 230 kV #2, loop-in Maple River-Frontier 230 kV & WAPA Fargo-Moorhead 230 kV)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
-495	Maple River-Flint 230 at 110% of 265 MVA	Maple River-Sheyenne 230	40.2	Increase ground clearance
-380	Maple River-Sheyenne 230 at 110% of 320	Maple River-Flint 230	41.7	Equip limit
-200	Maple River-Sheyenne 230 at 110% of 388	Maple River-Flint 230	41.7	Reconductor
-160	Maple River-Flint 230 at 110% of 388	Maple River-Sheyenne 230	40.2	Reconductor
40	Maple River-Flint at 100% of 265	(System Intact)	21.3	Increase ground clearance
85	Maple River-Sheyenne 230 at 100% of 320	(System Intact)	24.2	Equip limit
130	Cass Co-Red River 115 at 110% of 199	Maple Riv-Flint/Maple Riv-Sheyenne 230	18.6	Reconductor
150	Maple River 230/115 tx 5 & 6 at 115% of 187	Maple Riv-Flint/Maple Riv-Sheyenne 230	12.1	Replace with larger units
205	Maple River 345/230 tx 1 or 2 at 125% of 336	Maple River 345/230 tx 2 or 1	56.0	Replace with larger units
300	Whitlock-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.2	CT Limitation
305	Blackberry-Boswell 230 ckt 2 at 110% of 399	Fault of South 500 w/xtrip of north 500	3.3	(reconductor or revise xtrip)
365	Maple River-Sheyenne 230 at 100% of 388	(System Intact)	24.2	Reconductor
375	Maple River-Red River 115 at 110% of 318	Maple Riv-Flint/Maple Riv-Sheyenne 230	18.5	(already ACSS)
415	Maple River-Sheyenne 230 at 110% of 620	Maple River-Flint 230	41.7	(already reconductored)
425	Flint 345/230 tx 1 or 2 at 115% of 336	Flint 345/230 tx 2 or 1	22.8	Install larger txs
425	Bismarck-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.2	CT Limitation
430	Frontier-Flint 230 at 110% of 265	Alex SS-Flint 345	19.4	Increase ground clearance
475	Maple River-Flint 230 at 110% of 620	Maple River-Sheyenne 230	40.2	(already reconductored)
465	Fargo-Flint 230 at 110% of 240	Maple Riv-Flint/Maple Riv-Sheyenne 230	13.7	Equip limit
500	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.2	CT Limitation
535	Sheyenne-Flint 230 # 1 or 2 at 110% of 388	Sheyenne-Flint # 2 or 1	27.8	Reconductor
585	Maple River 345/230 tx 1 & 2 at 125% of 336	(System Intact)	29.8	Replace with larger units
625	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	7.1	Addressed by CapX 2020
630	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345	6.2	Increase ground clearance
630	Frontier-Wahpeton 230 at 110% of 265	Alex SS-Flint 345	19.4	Increase ground clearance

640	Maple River-Sheyenne 230 at 100% of 620	(System Intact)	41.7	(already reconductored)
740	**Flint-Audubon 230 at 110% of 318**	**Alex SS-Flint 345**	**16.4**	**Reconductor or rebuild**
745	Oahe-Sully Butte 230 at 110% of 240	Ft Thompson-Leland Olds 345	4.2	Equip limit
780	Granite Falls-Morris 230 at 110% of 239	Canby-Granite Falls 230	7.3	Equip limit
885	Chisago Co 500 kV series cap at 110% of 1732	Arrowhead-Stone Lk 345	17.9	
940	Roseau Co 500 kV Series Caps at 100% of 1732	(System Intact)	9.0	
950	Maple River-Winger 230 at 110% of 342	Maple Riv-Flint/Maple Riv-Sheyenne 230	22.9	
970	Frontier-Flint 230 at 100% of 265	(System Intact)	13.4	Increase ground clearance
1000	(No further limiters encountered to this level)			

Observations:

Looping in the WAPA Fargo-Moorhead 230 kV helps slightly, but performance is still severely constrained by the Maple River double circuit 230kV outage, and by the overload of those two circuits.

Based on the results from configurations 1 through 1.3, the transfer capability for termination at the Flint site is limited to less than 400 MW even with several lines reconductored. The transfer limit is near 400 MW regardless of which existing lines are looped into the Flint substation. Continuation of the new 345 kV line to Maple River (or equivalent north-side location) would help address the limiters. This scenario is tested in Configuration 2.

Table 3.21
Southward Power Transfer Capability
Site 1 "Flint" Configuration 2

(Add Flint-Maple River 345 kV, loop-in Sheyenne-Audubon 230 kV at Flint)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
-120	Sheyenne-Flint 230 at 110% of 388 MVA	Maple River-Flint 345	35.9	Reconductor, or 2nd ckt
-125	Maple River-Sheyenne-230 kV at 110% of 320	Maple River-Flint 345	29.9	Equip limit
125	Maple River-Sheyenne-230 kV at 110% of 388	Maple River-Flint 345	29.9	Reconductor
380	Whitlock-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.9	CT Limitation
400	Blackberry-Boswell 230 ckt 2 at 110% of 399	Fault of South 500 w/xtrip of north 500	3.0	(reconductor or revise xtrip)
420	Minn Valley Tap-Granite Falls 230 110% of 387	Hazel-Granite Falls 230	9.1	
440	Maple River-Frontier at 110% of 265	Alex SS-Flint 345	18.8	Increase ground clearance
460	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	7.1	Addressed by CapX 2020
465	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345	7.2	Increase ground clearance
525	Bismarck-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.9	CT Limitation
590	Sheyenne-Flint 230 at 110% of 620 MVA	Maple River-Flint 345	35.9	(already reconductored)
600	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.9	CT Limitation
640	Frontier-Wahpeton 230 at 110% of 265	Alex SS-Flint 345	18.8	Increase ground clearance
670	**Flint-Audubon 230 at 110% of 318**	**Alex SS-Flint 345**	**16.4**	**Reconductor or rebuild**
780	Granite Falls-Morris 230 at 110% of 239	Canby-Granite Falls 230	7.1	Equip limit
860	Oahe-Sully Butte 230 at 110% of 240	Ft Thompson-Leland Olds 345	3.9	
875	Maple River 345/230 tx 1 & 2 at 125% of 336	Maple River-Flint 345	29.7	Replace with larger units
960	Chisago Co 500 kV series cap at 110% of 1732	Arrowhead-Stone Lk 345	17.1	
980	Maple River-Sheyenne-230 kV at 110% of 620	Maple River-Flint 345	29.9	(already reconductored)
1000	(No more limitations encountered to this level)			

Observations:

The Flint-Audubon 230 kV limitation is reached earlier (670 vs 730-740 MW) due to direct connection to Maple River 345 kV, but now the Maple River 345/230 kV transformer limits are not encountered until after Flint-Audubon 230 kV limit is reached.
The Sheyenne-Flint 230 kV line reconductored to 795 ACSS will still be limiting before Flint-Audubon 230 kV (590 vs 670 MW). It would need to be reconductored to at least 954 kcm ACSS in order to have the Flint-Audubon line be the "stopping point".

Table 3.22
Southward Power Transfer Capability
Site 1 "Flint" Configuration 2.1

(Flint-Maple River 345 kV, loop-in Sheyenne-Audubon 230 kV)
(Add Sheyenne-Flint 230 kV #2)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
-130	Maple Riv-Sheyenne 230 kV at 110% of 320 MVA	Maple River-Flint 345	30.1	Equip limit
120	Maple River-Sheyenne 230 kV at 110% of 388	Maple River-Flint 345	30.1	Reconductor
385	Whitlock-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.9	CT Limitation
400	Blackberry-Boswell 230 ckt 2 at 110% of 399	Fault of South 500 w/xtrip of north	3.0	(reconductor or revise xtrip)
420	Minn Valley Tap-Granite Falls 230 110% of 387	Hazel-Granite Falls 230	9.1	
440	Maple River-Frontier 230 at 110% of 265	Maple River-Sheyenne 230	18.8	Increase ground clearance
460	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	8.1	Addressed by CapX 2020
465	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345	7.2	Increase ground clearance
525	Bismarck-Glenham 230 at 110% of 240 (600 amp)	Leland Olds-Fort Thompson 345	4.1	CT Limitation
600	Sully Buttes-Whitlock 230 at 110% of 240 (600 amp)	Leland Olds-Fort Thompson 345	3.9	CT Limitations
645	Wahpeton-Frontier 230 at 110% of 265	Sheyenne-Maple River 230	20.8	Increase ground clearance
670	**Flint-Audubon 230 at 110% of 318**	**Alex SS-Flint 345**	**17.3**	**Reconductor or rebuild**
780	Granite Falls-Morris 230 at 110% of 239 (600 amp)	Canby-Granite Falls 230	7.1	CT Limitations
865	Oahe-Sully Buttes 230 at 110% of 240 (600 amp)	Leland Olds-Fort Thompson 345	3.9	CT Limitation
875	Maple River 345/230 tx #1 & 2 at 125% of 336	Maple River-Flint 345	29.7	Replace with larger units
965	Chisago Co 500 series cap at 110% of 1732	Arrowhead-Stone Lk 345	17.1	
970	Maple Riv-Sheyenne 230 kV at 110% of 620	Maple River-Flint 345	30.1	(already reconductored)
1000	(No more limitations encountered to this level)			

Observations:

This configuration works well because Maple River-Sheyenne 230 kV is the only reconductor needed in order to reach the generation level at which Flint-Audubon 230 kV is limitation. No Maple River transformer upgrades are required to reach the Flint-Audubon limitation. This also suggests the addition of a Maple River-Cass Co-Sheyenne 230 kV line (or equivalent) as suggested from the load-serving analysis would address most of the limiters up to the 670 MW level at which Flint-Audubon becomes the limiter. To confirm this hypothesis, the following configuration was tested.

Table 3.23
Southward Power Transfer Capability
Site 1 "Flint" Configuration 2.2

(Flint-Maple River 345 kV, loop-in Sheyenne-Audubon 230 kV)
(Add Sheyenne-Flint 230 kV #2, Flint-Maple River 345 kV "east")

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
390	Whitlock-Glenham 230 at 110% of 240 MVA	Leland Olds-Fort Thompson 345	3.8	CT Limitation
425	Blackberry-Boswell 230 ckt 2 at 110% of 399	Fault of South 500 w/xtrip of north	3.0	(reconductor or revise xtrip)
430	Minn Valley Tap-Granite Falls 230 110% of 387	Hazel-Granite Falls 230	9.1	
430	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	8.3	Addressed by CapX 2020
430	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345	7.2	Increase ground clearance
445	Maple River-Frontier 230 at 110% of 265	Maple River-Sheyenne 230	18.7	Increase ground clearance
525	Bismarck-Glenham 230 at 110% of 240 (600 amp)	Leland Olds-Fort Thompson 345	3.8	CT Limitation
615	Sully Buttes-Whitlock 230 at 110% of 240 (600 amp)	Leland Olds-Fort Thompson 345	3.8	CT Limitations
645	Wahpeton-Frontier 230 at 110% of 265	Alex SS-Flint 345	18.7	Increase ground clearance
660	**Flint-Audubon 230 at 110% of 318**	**Alex SS-Flint 345**	**17.4**	**Reconductor or rebuild**
790	Granite Falls-Morris 230 at 110% of 239 (600 amp)	Canby-Granite Falls 230	7.1	CT Limitation
880	Oahe-Sully Buttes 230 at 110% of 240 (600 amp)	Leland Olds-Fort Thompson 345	3.8	CT Limitation
980	Forbes-Chisago Co 500 at 110% of 1732	Arrowhead-Stone Lk 345	16.9	
1000	(No more limitations encountered to this level)			

Observations:

This configuration works well because no reconductors or transformer upgrades required to reach the Flint-Audubon 230 kV transfer limit. The transfer limit due to the Flint-Audubon 230kV line in this configuration dropped slightly, to 660 MW. Although this configuration would be expensive if transfer capability were the only consideration, the identified load-serving needs call for an "east-side" development of at least a 230 kV circuit on this north-south path in order to establish a new 115 kV source at Cass Co Sub.

The indicated power transfer limit of 660 MW could be increased to approximately 700 MW by reducing the amount of new 345/230 kV transformer capacity installed at Flint; the powerflow model used assumed the presence of two 336 MVA transformers, but only one should be necessary if this "east-side" 345 kV development is installed.

Table 3.24
Southward Power Transfer Capability
Site 2 "Frontier" Configuration 1
(345 kV ends at Frontier)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
-540	Maple River-Frontier 230 at 110% of 265 MVA	Hankinson-Wahpeton 230 Hankinson 230/115 Wahpeton 230/115	32.5	Increase ground clearance
-415	Maple River-Frontier 230 at 100% of 265	(System Intact)	35.0	
-105	Sheyenne-Maple River 230 at 110% of 320	Maple River-Frontier 230	31.4	Equipment Limitation
145	Sheyenne-Maple River 230 at 110% of 391	Maple River-Frontier 230	31.4	Reconductor
205	Maple River 345/230 tx 1 or 2 at 125% of 336	Maple River 345/230 tx 2 or 1	56.1	Replace with larger units
245	Whitlock-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.3	CT Limitation
250	Blackberry-Boswell 230 ckt 2 at 110% of 399	Fault of South 500 w/xtrip of north	3.4	(reconductor or revise xtrip)
335	**Sheyenne-Audubon 230 at 110% of 318**	**Maple River-Frontier 230**	**21.0**	**Reconductor or rebuild**
365	Bismarck-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.3	CT Limitation
440	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.3	CT Limitations
450	Minn Valley Tap-Granite Falls at 110% of 387	Watertown-White 345/ Watertown-Brookings 115 (double ckt) Arlington-Watertown 115 Arlington-Brookings 115	8.8	(xtrip no longer needed)
480	Cass Co.-Red River 115 at 110% of 199	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	14.5	Reconductor
490	Maple River 230/115 tx #5 & #6 at 115% of 187	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	9.7	Replace with larger units
555	Frontier 345/230 tx 1 or 2 at 115% of 336	Frontier 345/230 tx 2 or 1	21.1	Replace with larger units
580	Maple River 345/230 tx #1 or 2 at 100% of 336	(System Intact)	29.8	Replace with larger units
595	Maple River-Frontier 230 at 100% of 620	(System Intact)	35.0	(Already reconductored)
620	Wahpeton-Frontier 230 at 110% of 265	Alex SS-Frontier 345	19.3	Increase ground clearance
660	Maple River-Frontier 230 at 110% of 620	Hankinson-Wahpeton 230 Hankinson 230/115 Wahpeton 230/115	32.5	(Already reconductored)
675	Fargo-Moorhead 230 at 110% of 239	Maple River-Frontier 230	16.0	Equipment Limitation

680	Oahe-Sully Buttes 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.3	CT Limitation
705	Moorhead-Morris 230 at 110% of 239	Maple River-Frontier 230	17.0	Equipment Limitation
710	Maple River-Winger 230 at 110% of 342	Maple River-Sheyenne 230	25.9	
		Maple River-Frontier 230 (dckt)		
715	Granite Falls-Morris 230 at 110% of 240	Canby-Granite Falls 230	7.4	Equipment Limitation
750	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	6.7	Addressed by CapX 2020
790	Maple River-Red River 115 at 110% of 318	Maple River-Sheyenne 230	14.5	??? Already ACSS
		Maple River-Frontier 230 (dckt)		
835	Forbes-Chisago 500 at 110% of 1732	Arrowhead 345/230 tx	18.2	
865	Roseau Co. 500 series capacitors at 100% of 1732	(System Intact)	9.3	Add series comp to new 345
930	Fargo-MPS Brookdale 115 at 110% of 130	Fargo-Moorhead 230	5.7	Invalid Contingency;
950	Sheyenne-Maple River 230 at 110% of 620	Maple River-Frontier 230	31.4	(Already reconductored)
975	Sheyenne-Fargo 230 at 110% of 388	Buffalo-Jamestown 345	16.7	
		Buffalo-Maple River 345		
		Buffalo 345/115 tx		
		Maple River 345/230 tx 1 & 2		txs at Moorhead also trip
1000	(No further limiters encountered to this level)			

Observations:

This configuration works poorly. The Sheyenne-Audubon 230 kV limit is encountered at only 335 MW of incremental transfer.

Table 3.25
Southward Power Transfer Capability
Site 2 "Frontier" Configuration 1.1
(345 kV ends at Frontier, loop-in Sheyenne-Audubon 230 kV)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
-580	Maple River-Frontier 230 at 110% of 265 MVA	Sheyenne-Frontier 230	44.3	Increase ground clearance
-380	Sheyenne-Maple River 230 at 110% of 320	Maple River-Frontier 230	41.6	Equipment Limitation
-375	Sheyenne-Frontier 230 at 110% of 388	Maple River-Frontier 230	49.0	Reconductor
-220	Sheyenne-Frontier 230 at 100% of 318	(System Intact)	30.9	Equipment Limitation
-195	Sheyenne-Maple River 230 at 110% of 391	Maple River-Frontier 230	41.6	Reconductor
15	Sheyenne-Maple River 230 at 100% of 320	(System Intact)	25.8	Equipment Limitation
115	Cass Co.-Red River 115 at 110% of 199	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	18.5	Reconductor
150	Maple River-Frontier 230 at 100% of 265	(System Intact)	19.3	Increase ground clearance
150	Maple River 230/115 tx #5 or #6 at 115% of 187	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	12.1	Replace with larger units
150	Sheyenne-Frontier 230 at 110% of 620	Maple River-Frontier 230	49.0	(Already reconductored)
210	Maple River 345/230 tx 1 or 2 at 125% of 336	Maple River 345/230 tx 2 or 1	55.9	Replace with larger units
265	Sheyenne-Maple River 230 at 110% of 620	Maple River-Frontier 230	41.6	(Already reconductored)
290	Whitlock-Glenham 230 at 110% of 240 (600 amp)	Leland Olds-Fort Thompson 345	4.2	CT Limitation
295	Blackberry-Boswell 230 ckt 2 at 110% of 399	Fault of South 500 w/xtrip of north	3.3	(reconductor or revise xtrip)
300	Maple River-Frontier 230 at 110% of 620	Sheyenne-Frontier 230	44.3	(After Remedy)
355	Maple River-Red River 115 at 110% of 318	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	18.6	??? already ACSS
360	Maple River 115/69 tx at 115% of 112	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	5.6	Replace with larger units
415	Bismarck-Glenham 230 at 110% of 240 (600 amp)	Leland Olds-Fort Thompson 345	4.2	CT Limitation
430	Frontier 345/230 tx 1 or 2 at 115% of 336	Frontier 345/230 tx 2 or 1	22.8	Replace with larger units
470	Minn Valley Tap-Granite Falls 230 at 110% of 387	Watertown-White 345/ Watertown-Brookings 115 (double ckt) Arlington-Watertown 115 Arlington-Brookings 115	8.7	(xtrip no longer needed)
490	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.2	CT Limitations

585	Maple River 345/230 tx 1 or 2 at 100% of 336	(System Intact)	29.7	Replace with larger units
590	Wahpeton-Frontier 230 at 110% of 265	Alex SS-Frontier 345	19.7	Increase ground clearance
630	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	7.1	Addressed by CapX 2020
640	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345	6.1	Increase ground clearance
735	Oahe-Sully Buttes 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.2	CT Limitation
755	**Frontier-Audubon 230 at 110% of 318**	**Alex SS-Frontier 345**	**16.3**	**Reconductor or rebuild**
755	Sheyenne-Frontier 230 at 100% of 620	(System Intact)	30.9	(After Remedy)
765	Sheyenne-Fargo 230 at 110% of 388	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	15.7	
770	Granite Falls-Morris 230 at 110% of 240	Canby-Granite Falls 230	7.2	Equipment Limitation
775	Cass Co.-Red River 115 at 110% of 310	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	18.5	(After Remedy)
885	Forbes-Chisago 500 at 110% of 1732	Arrowhead 345/230 tx	17.9	
905	Roseau Co. 500 series capacitors at 100% of 1732	(System Intact)	9.0	
950	Maple River-Winger 230 at 110% of 342	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	22.9	
1000	(No more limitations encountered to this level)			

Observations:

This configuration has problems with Sheyenne-Frontier 230 kV loadings; even reconductoring the line is not enough. The transfer limit is 150 MW even with 795 ACSS on Sheyenne-Frontier 230 kV. Needs second Sheyenne-Frontier circuit; the addition of the second line is tested in Configuration 1.2.

Table 3.26
Southward Power Transfer Capability
Site 2 "Frontier" Configuration 1.2

(345 kV ends at Frontier, loop-in Sheyenne-Audubon 230 kV)
(Add Sheyenne-Frontier 230 kV #2)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
-460	Maple River-Frontier 230 at 110% of 265 MVA	Sheyenne-Frontier 230	38.0	Increase ground clearance
-385	Sheyenne-Maple River 230 at 110% of 320	Maple River-Frontier 230	41.8	Equipment Limitation
-200	Sheyenne-Maple River 230 at 110% of 391	Maple River-Frontier 230	41.8	Reconductor
-35	Sheyenne-Maple River 230 at 100% of 320	(System Intact)	26.8	Equipment Limitation
110	Cass Co.-Red River 115 at 110% of 199	Maple River-Sheyenne 230	18.6	Reconductor
130	Sheyenne-Frontier 230 ckt #1 or #2 at 110% of 388	Sheyenne-Frontier 230 # 2 or 1	30.9	Reconductor
145	Maple River 230/115 tx #5 or #6 at 115% of 187	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	12.1	Replace with larger units
210	Maple River 345/230 tx 1 or 2 at 125% of 336	Maple River 345/230 tx 2 or 1 Maple River-Frontier 230 (dckt)	55.9	Replace with larger units
230	Maple River-Frontier 230 at 100% of 265	(System Intact)	18.3	Increase ground clearance
295	Whitlock-Glenham 230 at 110% of 240 (600 amp)	Leland Olds-Fort Thompson 345	4.2	CT Limitation
300	Blackberry-Boswell 230 ckt 2 at 110% of 399	Fault of South 500 w/xtrip of north	3.3	(reconductor or revise xtrip)
350	Maple River-Red River 115 at 110% of 318	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	18.6	Already ACSS
405	Sheyenne-Maple River 230 at 110% of 620	Maple River-Frontier 230	41.8	(Already reconductored)
420	Bismarck-Glenham 230 at 110% of 240 (600 amp)	Leland Olds-Fort Thompson 345	4.2	CT Limitation
420	Frontier 345/230 tx 1 or 2 at 115% of 336	Frontier 345/230 tx 2 or 1	22.8	Replace with larger units
470	Minn Valley Tap-Granite Falls 230 at 110% of 387	Watertown-White 345/ Watertown-Brookings 115 (double ckt) Arlington-Watertown 115 Arlington-Brookings 115	8.7	(xtrip no longer needed)
500	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.2	CT Limitations
565	Maple River-Frontier 230 at 110% of 620	Sheyenne-Frontier 230	38.0	(Already reconductored)
585	Maple River 345/230 tx 1 or 2 at 100% of 336	(System Intact)	29.7	Replace with larger units
585	Wahpeton-Frontier 230 at 110% of 265	Alex SS-Frontier 345	19.8	Increase ground clearance

625	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	7.1	Addressed by CapX 2020
635	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345	6.2	Increase ground clearance
720	Sheyenne-Frontier 230 ckt #1 or #2 at 100% of 318	(System Intact)	16.1	Equipment Limitation
735	Sheyenne-Fargo 230 at 110% of 388	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	16.0	
740	Oahe-Sully Buttes 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.2	CT Limitation
750	**Frontier-Audubon 230 at 110% of 318**	**Alex SS-Frontier 345**	**16.4**	**Reconductor or rebuild**
775	Granite Falls-Morris 230 at 110% of 240	Canby-Granite Falls 230	7.2	Equipment Limitation
775	Cass Co.-Red River 115 at 110% of 310	Maple River-Sheyenne 230	18.6	(Already reconductored)
885	Forbes-Chisago 500 at 110% of 1732	Arrowhead 345/230 tx	17.8	
935	Roseau Co. 500 series capacitors at 100% of 1732	(System Intact)	9.0	
955	Sheyenne-Frontier 230 ckt #1 & #2 at 110% of 620	Maple River-Frontier 230	30.9	(Already reconductored)
960	Maple River-Winger 230 at 110% of 342	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	22.9	
1000	(No more limitations encountered to this level)			

Observations:

Even after adding a second Frontier-Sheyenne 230 kV line, there are intractable problems with 230 and 115 kV line loadings prior to hitting the Frontier-Audubon line loading limit, these limitations start at 350 MW vs. 750 MW for the Frontier-Audubon line limit.

Table 3.27
Southward Power Transfer Capability
Site 2 "Frontier" Configuration 2

(Add Frontier-Maple River 345 kV)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
-335	Maple River-Frontier 230 at 110% of 265 MVA	Maple River-Frontier 345	35.0	Increase ground clearance
50	Maple River-Frontier 230 at 110% of 388	Maple River-Frontier 345	35.0	Reconductor
380	Whitlock-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.8	CT Limitation
380	Blackberry-Boswell 230 #2 at 110% of 399	Fault of South 500 w/xtrip of north	3.0	(reconductor or revise xtrip)
430	Maple River-Sheyenne 230 at 110% of 320	Alex SS-Frontier 345	19.9	Equip Limitation
460	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	8.1	Addressed by CapX 2020
465	Alexandria-Alex SS at 100% of 160	Quarry-Alex SS 345	7.3	Increase ground clearance
470	Minn Valley Tap-Granite Falls 230 at 110% of 387	Watertown-White 345/ Watertown-Brookings 115 (double ckt) Arlington-Watertown 115 Arlington-Brookings 115	8.7	(xtrip no longer needed)
505	Wahpeton-Frontier 230 at 110% of 265	Alex SS-Frontier 345	21.1	Increase ground clearance
520	Bismarck-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.8	CT Limitation
600	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.8	CT Limitations
735	**Sheyenne-Audubon 230 at 110% of 318**	**Alex SS-Frontier 345**	**16.2**	**Reconductor or rebuild**
770	Granite Falls-Morris 230 at 110% of 240	Canby-Granite Falls 230	7.1	Big Stone Gen Runback
780	Maple River-Frontier 230 at 110% of 620	Maple River-Frontier 345	35.0	(Already reconductored)
805	Maple River-Sheyenne 230 at 110% of 388	Alex SS-Frontier 345	19.9	Reconductor
860	Oahe-Sully Buttes 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.8	CT Limitation
865	Maple River 345/230 tx 1 & 2 at 125% of 336	Maple River-Frontier 345	29.8	Replace with larger units
1000	(No more limitations encountered to this level)			

Observations:

This configuration works ok. The Sheyenne-Audubon limitation is reached with Maple River-Frontier 230 kV line being the only reconductor required.

Table 3.28
Southward Power Transfer Capability
Site 2 "Frontier" Configuration 2.1

(Frontier-Maple River 345 kV)
(Add Sheyenne-Frontier 230 kV)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
190	Maple River-Frontier 230 at 110% of 265 MVA	Maple River-Frontier 345	20.9	Increase ground clearance
200	Maple River-Sheyenne 230 at 110% of 320	Maple River-Frontier 230	24.4	Equip limitation
390	Whitlock-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.8	CT Limitation
390	Blackberry-Boswell 230 #2 at 110% of 399	Fault of South 500 w/xtrip of north	3.0	(reconductor or revise xtrip)
415	Minn Valley Tap-Granite Falls 230 at 110% of 387	Hazel-Granite Falls 230	9.2	
450	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	8.1	Addressed by CapX 2020
450	Minn Valley Tap-Granite Falls 230 at 110% of 387	Watertown-White 345/ Watertown-Brookings 115 (double ckt) Arlington-Watertown 115 Arlington-Brookings 115	8.8	(xtrip no longer needed)
465	Alexandria-Alex SS at 100% of 160	Quarry-Alex SS 345	7.2	Increase ground clearance
505	Maple River-Sheyenne 230 at 110% of 388	Maple River-Frontier 230	24.4	Reconductor
530	Wahpeton-Frontier 230 at 110% of 265	Alex SS-Frontier 345	20.5	Increase ground clearance
530	Bismarck-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.8	CT Limitation
610	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.8	CT Limitations
720	**Sheyenne-Audubon 230 at 110% of 318**	**Alex SS-Frontier 345**	**16.5**	**Reconductor or rebuild**
780	Granite Falls-Morris 230 at 110% of 240	Canby-Granite Falls 230	7.1	Big Stone Gen Runback
870	Oahe-Sully Buttes 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.8	CT Limitation
870	Maple River 345/230 tx 1 & 2 at 125% of 336	Maple River-Frontier 345	29.8	Replace with larger units
875	Sheyenne-Frontier 230 at 110% of 318	Maple River-Frontier 345	17.5	
1000	(No more limitations encountered to this level)			

Observations:

This configuration avoids the Maple River-Frontier 230 kV reconductor, but requires a Maple River-Sheyenne 230 kV reconductor.

Table 3.29
Southward Power Transfer Capability
Site 3 "WAPA Fargo" Configuration 1

(345 kV ends at Fargo Sub)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
-290	Maple River-Sheyenne 230 kV at 110% of 320 MVA	Maple River-Frontier 230	38.7	Equip limitation
-165	Maple River-Sheyenne 230 at 100% of 320	(System Intact)	38.7	Reconductor, or Config.2
-95	Maple River-Sheyenne 230 kV at 110% of 388 MVA	Maple River-Frontier 230	38.7	Reconductor
60	Cass Co.-Red River 115 at 110% of 199	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	20.5	Reconductor
225	Maple River 345/230 tx 1 or 2 at 125% of 336	Maple River 345/230 tx 2 or 1	55.4	Replace with larger units
280	Maple River-Red River 115 at 110% of 318	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	20.5	Already reconductored
285	Blackberry-Boswell 230 #2 at 110% of 399	Fault of South 500 w/xtrip of north 500	3.3	(reconductor or revise xtrip)
295	Maple River-Frontier 230 at 110% of 265	Maple River-Sheyenne 230	21.0	Increase ground clearance
300	Whitlock-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.2	CT Limitation
430	Bismarck-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.2	CT Limitation
470	Minn Valley Tap-Granite Falls 230 at 110% of 387	Watertown-White 345/ Watertown-Brookings 115 (double ckt) Arlington-Watertown 115 Arlington-Brookings 115	8.8	(xtrip no longer needed)
480	Wahpeton-Frontier 230 at 110% of 265	Sheyenne-Maple River 230	21.0	Increase ground clearance
505	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.2	CT Limitations
510	Maple River 230/115 tx #5 & #6 at 115% of 187	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	10.2	Replace with larger units
635	Fargo 345/230 tx #1 at 125% of 336	Fargo 345/230 tx #2	21.7	Install larger units
655	Cass Co.-Red River 115 at 110% of 310	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	20.5	Already reconductored
675	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345	6.0	Increase ground clearance
680	Sauk River-West Cloud 115 at 110% of 139	Monticello-Quarry 345	6.9	Addressed by CapX 2020
725	**Sheyenne-Audubon 230 at 110% of 318**	**Alex SS-Fargo 345**	**16.5**	**Reconductor or rebuild**
750	Oahe-Sully Buttes 230 at 110% of 240	Leland Olds-Fort Thompson 345	4.2	CT Limitation

760	Maple River-Frontier 230 at 100% of 265	(System Intact)	14.9	Increase ground clearance
770	Sheyenne-Fargo 230 at 110% of 388	Sheyenne-Flint 230	27.2	Reconductor (4.3 mi)
805	Granite Falls-Morris 230 at 110% of 240	Big Stone-Blair 230	7.1	Big Stone Gen Runback
820	Maple River-Winger 230 at 110% of 342	Maple River-Sheyenne 230 Maple River-Frontier 230 (dckt)	24.8	
930	Roseau Co. 500 series capacitors at 100% of 1732	(System Intact)	9.1	Add series comp to new 345
1000	(No further limiters encountered to this level)			

Observations:

In this configuration the Maple River 345/230 kV transformers need to be upgraded.

The power transfer limit of 280 MW is due to the already-reconductored Maple River-Red River 115 kV line this 280 MW limit is hit well before Sheyenne-Audubon 230 kV transfer limit of 725 MW.

Table 3.30
Southward Power Transfer Capability
Site 3 "WAPA Fargo" Configuration 2

(Add Fargo-Maple River 345 kV)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
-55	Maple River-Sheyenne 230 kV at 110% of 320 MVA	Fargo-Maple River 345	29.3	Equip limitation
200	Maple River-Sheyenne 230 kV at 110% of 388 MVA	Fargo-Maple River 345	29.3	Reconductor
385	Whitlock-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.9	CT Limitation
395	Blackberry-Boswell 230 #2 at 110% of 399	Fault of South 500 w/xtrip of north 500	3.0	(reconductor or revise xtrip)
450	Maple River-Frontier 230 at 110% of 265	Alex SS-Fargo 345	18.6	Increase ground clearance
460	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345	7.3	Increase ground clearance
465	Sauk River-West Cloud 115 at 110% of 139	Monticello-Quarry 345	8.1	Addressed by CapX 2020
515	Minn Valley Tap-Granite Falls 230 at 110% of 387	Watertown-White 345/ Watertown-Brookings 115 (double ckt) Arlington-Watertown 115 Arlington-Brookings 115	8.4	(xtrip no longer needed)
525	Bismarck-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.9	CT Limitation
600	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.9	CT Limitations
655	Wahpeton-Frontier 230 at 110% of 265	Alex SS-Fargo 345	18.6	Increase ground clearance
685	**Sheyenne-Audubon 230 at 110% of 318**	**Alex SS-Fargo 345**	**16.9**	**Reconductor or rebuild**
775	Granite Falls-Morris 230 at 110% of 240	Canby-Granite Falls 230	7.2	Big Stone Gen Runback
865	Oahe-Sully Buttes 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.9	CT Limitation
885	Maple River 345/230 tx 1 or 2 at 125% of 336	Maple River-Fargo 345	29.5	Replace with larger units
1000	(No further limiters encountered to this level)			

Observations:

This configuration works well. The Maple River-Sheyenne 230 kV line is the only Fargo area reconductor needed.

Table 3.31
Southward Power Transfer Capability
Site 4 "Bison" Configuration 1

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
385	Whitlock-Glenham 230 kV at 110% of 240 MVA	Leland Olds-Fort Thompson 345	3.9	CT Limitation
400	Blackberry-Boswell 230 #2 at 110% of 399	Fault of South 500 w/xtrip of north 500	3.1	(reconductor or revise xtrip)
405	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345	7.3	Increase ground clearance
420	Maple River-Frontier 230 at 110% of 265	Alex SS-Bison 345	19.5	Increase ground clearance
455	Sauk River-West Cloud 115 at 110% of 139	Monticello-Quarry 345	8.0	Addressed by CapX 2020
460	Maple River-Sheyenne 230 at 110% of 320	Alex SS-Bison 345	21.3	Equip limitation
515	Minn Valley Tap-Granite Falls 230 at 110% of 387	Watertown-White 345/ Watertown-Brookings 115 (double ckt) Arlington-Watertown 115 Arlington-Brookings 115	8.5	(xtrip no longer needed)
525	Bismarck-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.9	CT Limitation
605	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.9	CT Limitations
615	Wahpeton-Frontier 230 at 110% of 265	Alex SS-Bison 345	19.5	Increase ground clearance
715	**Sheyenne-Audubon 230 at 110% of 318**	**Alex SS-Bison 345**	**16.6**	**Reconductor or rebuild**
765	Granite Falls-Morris 230 at 110% of 240	Canby-Granite Falls 230	7.2	Generation runback
810	Maple River-Sheyenne 230 at 110% of 388	Alex SS-Bison 345	21.3	Reconductor
865	Oahe-Sully Buttes 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.9	CT Limitation
1065	Maple River 345/230 tx #1 & 2 at 125% of 336	Alex SS-Bison 345	23.8	Replace with larger units

Observations:

This configuration works very well. No reconductors or transformer upgrades are required prior to reaching the Sheyenne-Audubon 230 kV line loading limit.

Table 3.32
Southward Power Transfer Capability
Site 4 "Bison" Configuration 1.1

Recommended Plan, Phase 1

(Add Maple River-Cass County-Sheyenne 230 kV)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
380	Whitlock-Glenham 230 at 110% of 240 MVA	Leland Olds- Ft Thompson 345	3.9	Equip limit
405	Blackberry-Boswell 230 ckt 2 at 110% of 399	Fault of South 500 w/xtrip of north 500	3.1	(reconductor or revise xtrip)
420	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345	7.2	Increase ground clearance
450	Maple River-Frontier 230 at 110% of 265	Alex SS-Bison 345	19.1	Increase ground clearance
665	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	8.0	Addressed by CapX 2020
510	Minn Valley Tap-Granite Falls 230 at 110% of 387	Watertown-White 345/ Watertown-Brookings 115 (double ckt) Arlington-Watertown 115 Arlington-Brookings 115	8.5	(xtrip no longer needed)
525	Bismarck-Glenham 230 at 110% of 240	Leland Olds- Ft Thompson 345	3.9	Equip limit
600	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds- Ft Thompson 345	3.9	Equip limit
650	Wahpeton-Frontier 230 at 110% of 265	Alex SS-Bison 345	19.1	Increase ground clearance
675	**Sheyenne-Audubon 230 at 110% of 318**	**Alex SS-Bison 345**	**16.9**	**Reconductor or rebuild**
755	Granite Falls-Morris 230 at 110% of 239	Canby-Granite Falls 230	7.2	Equip limit
860	Oahe-Sully Butte 230 at 110% of 240	Leland Olds- Ft Thompson 345	3.9	
955	Chisago Co 500 kV series cap at 110% of 1732	Arrowhead 345/230 tx	17.9	
1000	(no further limiters encountered to this level)			

Observations:

This scenario tests the addition of the Maple River-Cass County-Sheyenne 230 kV line identified in the load serving study. The addition of the line works well, and eliminates the Maple River-Sheyenne 230 kV overload, but reduces the southward transfer capability from 715 to 675 due to increased loading on the Sheyenne-Audubon 230 kV line.

The Sheyenne-Audubon 230 kV limiter has been identified in previous studies; upgrades to approximately 400 MVA may occur due to pending generation interconnection requests.

Table 3.33
Southward Power Transfer Capability
Site 4 "Bison" Configuration 1.2

(Add Maple River-Cass County-Sheyenne 230 kV)
(Tap Alex SS-Bison 345 at "Flint" Configuration 1-1.1)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
390	Whitlock-Glenham 230 at 110% of 240 MVA	Leland Olds- Ft Thompson 345	3.9	Equip limit
420	Blackberry-Boswell 230 ckt 2 at 110% of 399	Fault of South 500 w/xtrip of north 500	3.0	(reconductor or revise xtrip)
440	Alexandria-Alex SS at 100% of 160	Quarry-Alex 345	7.0	Increase ground clearance
445	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	7.9	Addressed by CapX 2020
460	Maple River-Frontier 230 at 110% of 265	Alex SS-Flint 345	18.9	Increase ground clearance
520	Minn Valley Tap-Granite Falls 230 at 110% of 387	Watertown-White 345/ Watertown-Brookings 115 (double ckt) Arlington-Watertown 115 Arlington-Brookings 115	8.5	(xtrip no longer needed)
535	Bismarck-Glenham 230 at 110% of 240	Leland Olds- Ft Thompson 345	4.2	Equip limit
610	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds- Ft Thompson 345	3.9	Equip limit
650	**Flint-Audubon 230 at 110% of 318**	**Alex SS-Flint 345**	**17.3**	**Reconductor or rebuild**
665	Wahpeton-Frontier 230 at 110% of 265	Alex SS-Flint 345	18.9	Increase ground clearance
770	Granite Falls-Morris 230 at 110% of 239	Canby-Granite Falls 230	7.2	Equip limit
850	Maple River-Sheyenne 230 at 110% of 320	Sheyenne-Fargo 230	17.2	Equip limit
870	Oahe-Sully Butte 230 at 110% of 240	Leland Olds- Ft Thompson 345	3.9	
955	Maple River 345/230 tx 1 or 2 at 125% of 336	Flint-Bison 345	24.9	Replace txs
965	Chisago Co 500 kV series cap at 110% of 1732	Arrowhead 345/230 tx	17.2	
980	Sheyenne-Flint 230 ckt 1 at 110% of 388	Flint-Bison 345	18.6	Reconductor
1000	(no further limiters encountered to this level)			

Observations

This scenario tests tapping the 345 kV line at Flint with the addition of the Maple River-Cass County-Sheyenne 230 kV line. This addition reduces the Sheyenne-Audubon line loading limit to 650 MW incremental generation from 675 MW without the Flint substation. However, as noted previously, transfer capability would be higher if only one 345/230 kV transformer were added at Flint, rather than the two presumed in the modeling.

Table 3.34
Southward Power Transfer Capability
Site 4 "Bison" Configuration 1.3

Recommended Plan: Phase 2

(Add Maple River-Cass County-Sheyenne 230 kV)
(Tap Alex SS-Bison 345 at "Flint" Configuration 1-1.1)
(Rebuild Sheyenne-Riverton-Benton Co Double Circuit, Operating at 345kV & 230 kV)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
460	Sheyenne-Flint 230 ckt 1 at 110% of 388	Flint-Bison 345	22.4	Reconductor
645	Maple River-Sheyenne 230 at 110% of 320	Flint-Bison 345	19.2	Equip limit
655	Whitlock-Glenham 230 at 110% of 240	Leland Olds- Ft Thompson 345	3.3	Equip limit
775	Blackberry-Boswell 230 ckt 2 at 110% of 399	Fault of South 500 w/xtrip of north 500	3.3	(reconductor or revise xtrip)
835	Minn Valley Tap-Granite Falls 230 at 110% of 387	Watertown-White 345/ Watertown-Brookings 115 (double ckt) Arlington-Watertown 115 Arlington-Brookings 115	7.1	(xtrip no longer needed)
835	Bismarck-Glenham 230 at 110% of 240	Leland Olds- Ft Thompson 345	3.3	Equip limit
850	Maple River-Frontier 230 at 110% of 265	Audubon-Flint 230 Riverton-Flint 345	15.3	Increase ground clearance
855	Mud Lake-Brainerd 115 at 110% of 98	Riverton-Mud Lake 230 Benton-Riverton 345	5.7	Reconductor
910	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds- Ft Thompson 345	3.3	Equip limit
925	Maple River 345/230 tx 1 and 2 at 125% of 336	Flint-Bison 345	25.3	Add 3rd tx at Maple River
980	Brainerd-Riverton 115 at 110% of 90	Riverton-Mud Lake 230 Benton-Riverton 345	3.3	
1005	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	5.7	Addressed by CapX 2020
1030	Maple River-Bison 230 at 110% of 430	Flint-Bison 345	11.7	Add 3rd tx at Maple River
1035	Maple River-Sheyenne 230 at 110% of 388	Flint-Bison 345	19.2	Reconductor
1085	Alexandria-Alex SS at 100% of 160	Quarry-Alex 345	4.9	Increase ground clearance
1095	Wahpeton-Frontier 230 at 110% of 265	Audubon-Flint 230 Riverton-Flint 345	15.3	Increase ground clearance

1110	Minn Valley Tap-Granite Falls 230 at 110% of 387	Watertown-White 345/ Watertown-Brookings 115 (double ckt)	6.8	
1120	Granite Falls-Morris 230 at 110% of 239	Canby-Granite Falls 230	6.0	Equip limit
1200	Flint 345/230 tx #1 or #2 at 125% of 336	Flint-Bison 345	17.4	Increase tx size
1215	Oahe-Sully Butte 230 at 110% of 240	Leland Olds- Ft Thompson 345	3.3	
1315	**Chisago Co 500 kV series cap at 110% of 1732**	**Arrowhead 345/230 tx** or Arrowhead-Stone Lk 345 kV	**14.8**	**Series Comp New 345's**
1490	Roseau 500 kV series cap at 110% of 1732	(System Intact)	7.1	
1500	(no further limiters encountered to this level)			

Observations:

This configuration tests the transfer capability after the Flint-Audubon 230 kV limiter is addressed by rebuilding the Flint-Audubon-Riverton-Benton County line double circuit 230/345kV. This configuration results in an increase of approximately 600 MW (1300 vs. 700 MW).

The Sheyenne-Flint 230 kV reconductor (required at 460 MW) would be avoided if the new Maple River-Cass Co-Sheyenne 230 kV line were extended to Flint, or if this "east-side" development were installed at 345 kV.

The actual transfer level at which the ratings of the Dorsey-Roseau Co-Forbes-Chisago Co 500 kV series compensation and related facilities are reached is sensitive to the overall regional generation pattern. Series compensation of the new Fargo-Minnesota 345 kV lines may be necessary in order to ensure those 500 kV limitations are not reached at lower-than-indicated power transfer levels.

Configurations 1.4-1.6 test the value of double circuiting or adding series compensation to the Flint-Alexandria 345 kV line and/or the rebuilt Audubon line.

Table 3.35
Southward Power Transfer Capability
Site 4 "Bison" Configuration 1.4

(Add Maple River-Cass County-Sheyenne 230 kV)
(Tap Alex SS-Bison 345 at "Flint" Configuration 1-1.1)
(Rebuild Sheyenne-Riverton-Benton Co Double Circuit, Operating at 345kV & 230 kV)
(Add 3rd Maple River 345/230 kV Transformer)
(75% Series Comp Fargo-Monti & Fargo-Audubon-Riverton-Benton Co 345kV Lines)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
55	Sheyenne-Fargo 230 at 110% of 388	Buffalo-Jamestown 345	9.1	Reconductor
260	Sheyenne-Flint 230 ckt 1 at 110% of 388	Flint-Bison 345	28.9	Reconductor
370	Maple River-Sheyenne 230 at 110% of 320	Flint-Bison 345	22.9	Equip limit
495	Flint 345/230 tx #1 or #2 at 125% of 336	Flint-Bison 345	17.4	Increase tx size
625	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	5.6	Addressed by CapX 2020
695	Maple River-Sheyenne 230 at 110% of 388	Flint-Bison 345	22.9	Reconductor
1140	Sheyenne-Flint 230 ckt 1 at 110% of 620	Flint-Bison 345	28.9	Reconductor 954 ACSS
1145	Sheyenne-Fargo 230 at 100% of 388	System Intact	11.0	Reconductor
1405	Sheyenne-Flint 230 ckt 1 & 2 at 110% of 689	Flint-Bison 345	28.9	Already 954 ACSS
1490	Maple River 345/230 tx 1, 2 & 3 at 125% of 336	Flint-Bison 345	25.3	Larger tx
1595	Maple River-Bison 345 at 110% of 720	Buffalo-Bison 345	43.8	Equip limit
1645	Maple River-Bison 230 at 110% of 430	Flint-Bison 345	8.6	
1735	Maple River-Bison 345 at 100% of 720	System Intact	46.0	Equip limit
1745	Fargo-Moorhead 230 at 110% of 240	Sheyenne-Fargo 230	8.7	Equip limit
1760	Moorhead-Morris 230 at 110% of 239	Sheyenne-Fargo 230	9.1	Equip limit
1785	Sheyenne-Flint 230 ckt 1 at 100% of 388	System Intact	13.0	Reconductor
1810	Maple River-Sheyenne 230 at 110% of 620	Flint-Bison 345	22.9	Already ACSS
1830	Mud Lake-Brainerd 115 at 110% of 98	Riverton-Mud Lake 230 Benton-Riverton 345	5.7	Reconductor
1840	Maple River-Frontier 230 at 110% of 265	Audubon-Flint 230 Riverton-Flint 345	10.3	Increase ground clearance
2000	Cass Co-Maple River 230 at 110% of 689	Flint-Bison 345	23.0	Already ACSS
2000	(no further limiters encountered to this level)			

Observations:

Series compensation of the 345 kV lines results in only approximately 90 MW transfer capability increase (1405 – 1315 = 90). This configuration needs a number of reconductors and upgraded conductor sizes in the Fargo vicinity 230 kV system to reach the 1405 MW transfer level, at which it has problems with loading on the two Sheyenne-Flint 230 kV lines.

An alternative would be to have the “east-side” 230 kV addition be constructed as a 345 kV line; this eliminates the Sheyenne-Flint, Maple River-Sheyenne, and Maple River-Cass Co 230 kV loading issues, and would also eliminate the need for the third Maple River 345/230 kV transformer. The resultant incremental transfer capability would be over 2000 MW.

Table 3.36
Southward Power Transfer Capability
Site 4 "Bison" Configuration 1.5

(Add Maple River-Cass County-Sheyenne 230 kV)
(Tap Alex SS-Bison 345 at "Flint" Configuration 1-1.1)
(Rebuild Sheyenne-Riverton-Benton Co Double Circuit, Operating at 345kV & 230 kV)
(Add 3rd Maple River 345/230 kV Transformer)
(Double Circuit Flint-Monticello 345kV line)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
320	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345 Double Ckt	7.7	Addressed by CapX 2020
445	Sheyenne-Flint 230 ckt 1 at 110% of 388	Flint-Bison 345	25.2	Reconductor 795 ACSS
505	Maple River-Sheyenne 230 at 110% of 320	Flint-Bison 345	20.1	Equip limit
775	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345 Double Ckt	5.4	Increase ground clearance
835	Flint 345/230 tx #1 or #2 at 125% of 336	Flint-Bison 345	20.7	Increase tx size
860	Maple River-Sheyenne 230 at 110% of 388	Flint-Bison 345	20.1	Reconductor
970	Sheyenne-Fargo 230 at 110% of 388	Buffalo-Jamestown 345	4.1	Reconductor
1010	Frontier-Maple River 230 at 110% of 265	Alex SS-Flint 345 Double Ckt	14.3	Increase ground clearance
1270	Wahpeton-Frontier 230 at 110% of 265	Alex SS-Flint 345 Double Ckt	14.3	Increase ground clearance
1435	Mud Lake-Brainerd 115 at 110% of 98	Riverton-Mud Lake 230 Benton-Riverton 345	4.4	Reconductor
1460	Sheyenne-Flint 230 ckt 1 at 110% of 620	Flint-Bison 345	28.9	Reconductor 954 ACSS
1480	Granite Falls-Morris 230 at 110% of 239	Canby-Granite Falls 230	5.2	Equip limit
1505	Minn Valley Tap-Granite Falls 230 at 110% of 387	Watertown-White 345/ Watertown-Brookings 115 (double ckt)	5.8	(xtrip no longer needed)
1525	Maple River 345/230 tx 1, 2 & 3 at 125% of 336	Flint-Bison 345	18.5	Larger txs, or east-side development at 345 kV
1560	MEI INT-Westwood 115 at 110% of 191	Monticello-Quarry 345 Double Ckt	7.9	
1570	Westwood-West St. Cloud at 110% of 194	Monticello-Quarry 345 Double Ckt	7.9	
1640	Fargo-Moorhead 230 at 110% of 240	Sheyenne-Fargo 230	9.0	Equip limit
1715	Moorhead-Morris 230 at 110% of 239	Sheyenne-Fargo 230	9.5	Equip limit
1725	**Chisago Co 500 kV series cap at 110% of 1732**	**Arrowhead 345/230 tx or Arrowhead-Stone Lk 345 kV**	**14.8**	

1735	Maple River-Bison 230 at 110% of 430	Flint-Bison 345	8.3	
1760	**Sheyenne-Flint 230 ckt 1 & 2 at 110% of 689**	**Flint-Bison 345**	**28.9**	**Already 954 ACSS**
1760	XRDS-MEI INT at 110% of 191	Monticello-Quarry 345 Double Ckt	7.9	
1860	Maple River-Bison 345 at 110% of 720	Buffalo-Jamestown 345	4.0	
1920	Roseau 500 kV series cap at 110% of 1732	(System Intact)	6.1	
2000	(no further limiters encountered to this level)			

Observations:

Double-circuiting the new Twin Cities-Fargo line adds approximately 350 MW transfer capability versus single circuit with no compensation (1760-1405 = 355).

This configuration needs reconductors and upgraded conductor sizes in the Fargo vicinity 230 kV system to reach the 1725 MW transfer level, but the 230 kV system is less stressed than with the 75% series compensation in Configuration 1.4.

Again, it is seen that developing the “east-side load-serving” improvements at 345 kV rather than 230 kV would help improve transfer capability, as nearly all the required reconductors shown in blue would be avoided; this is tested in the following configuration.

Table 3.37
Southward Power Transfer Capability
Site 4 "Bison" Configuration 1.6

(Tap Alex SS-Bison 345 at "Flint")
(Rebuild Sheyenne-Riverton-Benton Co Double Circuit, Operating at 345kV & 230 kV)
(Add 3rd Maple River 345/230 kV Transformer)
(75% Series Comp New 345kV tie Lines)
(Add Maple River-Cass County-Flint 345 kV)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
-40	Sheyenne-Fargo 230 at 110% of 388	Buffalo-Jamestown 345	10.4	Reconductor
525	Sheyenne-Flint 230 at 110% of 388	Cass Co-Flint 345	24.6	Reconductor
550	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	5.9	Addressed by CapX 2020
1345	Sheyenne-Fargo 230 at 100% of 388	System Intact	12.0	Reconductor
1560	Sheyenne-Flint 230 at 110% of 620	Cass Co-Flint 345	24.6	Recond heavier than 795kcm
1780	Fargo-Moorhead 230 at 110% of 240	Sheyenne-Fargo 230	8.5	Equip limit
1865	Mud Lake-Brainerd 115 at 110% of 98	Riverton-Mud Lake 230/ Riverton-Benton Co 345 (double ckt)	3.7	Reconductor
1870	Sheyenne-Flint 230 at 110% of 689	Cass Co-Flint 345	24.6	Already Reconductored
1870	Moorhead-Morris 230 at 110% of 239	Sheyenne-Fargo 230	9.0	Equip limit
1905	Maple River-Sheyenne 230 at 110% of 320	Cass Co-Maple River 345	12.2	Equip limit
2000	(no further limiters encountered to this level)			

Observations:

Series compensation of the 345 kV lines, coupled with establishment of a second Flint-Maple River 345kV path (via the Maple River-Cass County-Flint line built at 345kV instead of 230kV) results in an incremental transfer capability of approximately 1870 MW. The number of 230 kV lines which need to be reconductored could likely be reduced by further optimization of the amount of 345/230 kV transformer capacity installed at Maple River and Flint, and/or the addition of 345/230 kV transformation at the WAPA Fargo substation; it is likely that over 2000 MW of transfer capability could then be achieved.

Table 3.38
Southward Power Transfer Capability
Site 4 "Bison" Configuration 3

(Add Maple River-Cass County-Sheyenne 230 kV)
(Tap Alex SS-Bison 345 at "Flint" Configuration 1-1.1)
(Add Flint-Hankinson-Big Stone-Brookings County 345 kV)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
400	Split Rock-White 345 at 110% of 717 MVA	Brookings Co.-Lyon Co. 345	10.9	(obsolete rating)
685	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345	6.5	Addressed by CapX 2020
745	Maple River-Sheyenne 230 at 110% of 320	Flint-Bison 345	19.3	Equip limit
795	Whitlock-Glenham 230 at 110% of 240	Fort Thompson-Leland Olds 345	3.0	Equip limit
795	Sheyenne-Flint 230 ckt 1 at 110% of 388	Flint-Bison 345	22.8	Reconductor 795 ACSS
800	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345	5.2	Increase ground clearance
930	Maple River 345/230 tx 1, 2 at 125% of 336	Flint-Bison 345	25.4	3rd Maple River tx
995	Bismarck-Glenham 230 at 110% of 240	Fort Thompson-Leland Olds 345	3.0	Equip limit
1135	Maple River-Sheyenne 230 at 110% of 388	Flint-Bison 345	19.3	Reconductor
1015	Frontier-Maple River 230 at 110% of 265	Hankinson-Flint 345	14.3	Reconductor
1040	Split Rock-White 345 at 100% of 717	(System Intact)	8.4	(obsolete rating)
1040	Maple River-Bison 230 at 110% of 430	Flint-Bison 345	11.7	Reconductor
1070	Sully Buttes-Whitlock 230 at 110% of 240	Fort Thompson-Leland Olds 345	3.0	Equip limit
1100	**Audubon-Flint 230 at 110% of 318**	**Alex SS-Flint 345**	**13.1**	**Reconductor or rebuild**
1215	Roseau 500 kV series cap at 100% of 1732	(System Intact)	8.0	
1235	Minn Valley Tap-Granite Falls 230 at 110% of 387	Brookings Co-Lyon Co 345	7.9	
1280	Wahpeton-Frontier 230 at 110% of 265	Hankinson-Flint 345	14.3	Increase ground clearance
1400	Oahe-Sully Buttes 230 at 110% of 240	Fort Thompson-Leland Olds 345	3.0	
1455	Flint 345/230 tx #1 or #2 at 125% of 336	Flint-Bison 345	17.6	Increase tx size
1500	Fargo-Moorhead 230 at 110% of 240	Sheyenne-Fargo 230	8.9	
1500	(no further limiters encountered to this level)			

Observations:

This configuration tests the transfer capability benefit of building a second Twin Cities - Fargo 345kV path via Brookings County Substation. This configuration yields approximately 1100 MW transfer capability, a 400 MW increase from Bison configuration 1.1. This configuration requires reconductoring several 230 kV lines in the Fargo vicinity. The Audubon-Flint 230kV line overload is still the limiting constraint for higher transfer capabilities.

Table 3.39
Southward Power Transfer Capability
Site 4 "Bison" Configuration 3.1

(Add Maple River-Cass County-Sheyenne 230 kV)
(Tap Alex SS-Bison 345 at "Flint" Configuration 1-1.1)
(Add Flint-Hankinson-Big Stone-Brookings County 345 kV)
(Double Circuit Flint-Monticello 345kV line)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
95	Sauk River-West St. Cloud 115 at 110% of 139	Monticello-Quarry 345 Double Ckt	8.6	Addressed by CapX 2020
515	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345 Double Ckt	5.8	Increase ground clearance
610	Sheyenne-Flint 230 ckt 1 at 110% of 388	Flint-Bison 345	25.1	Reconductor 795 ACSS
635	Maple River-Sheyenne 230 at 110% of 320	Flint-Bison 345	20.5	Equip limit
710	Split Rock-White 345 at 110% of 717	Brookings Co.-Lyon Co. 345	9.1	(obsolete rating)
910	Maple River 345/230 tx 1, 2 at 125% of 336	Flint-Bison 345	25.6	3rd Maple River tx
1000	Maple River-Bison 230 at 110% of 430	Flint-Bison 345	12.0	Reconductor
1000	Maple River-Sheyenne 230 at 110% of 388	Flint-Bison 345	19.3	Reconductor
1065	Flint 345/230 tx #1 or #2 at 125% of 336	Flint-Bison 345	20.7	Increase tx size
1095	**Audubon-Flint 230 at 110% of 318**	**Alex SS-Flint 345 Double Ckt**	**13.2**	**Reconductor or rebuild**
1110	Frontier-Maple River 230 at 110% of 265	Alex SS-Flint 345 Double Ckt	11.8	Increase ground clearance
1190	MEI Int.-Westwood 115 at 110% of 191	Quarry-Alex SS 345 Double Ckt	9.2	
1200	Westwood-West St. Cloud 115 at 110% of 194	Quarry-Alex SS 345 Double Ckt	9.2	
1365	MEI-Int-XRDS 115 at 110% of 191	Monticello-Quarry 345 Double Ckt	9.2	
1405	Split Rock-White 345 at 100% of 717	System Intact	7.1	(obsolete rating)
1430	Wahpeton-Frontier 230 at 110% of 265	Alex SS-Flint 345 Double Ckt	11.8	Increase ground clearance
1470	Sheyenne-Fargo 230 at 110% of 388	Jamestown-Center 345	5.9	Reconductor
1500	(no further limiters encountered to this level)			

Observations:

Adding the second circuit to the Alex SS-Flint 345 kV line does not increase transfer capability since the outage of that line, whether single circuit or double circuit, causes the Audubon-Flint 230 kV overload.

Table 3.40
Southward Power Transfer Capability
Site 4 "Bison" Configuration 2

(Add Bison-Maple River 345 #2)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
385	Whitlock-Glenham 230 kV at 110% of 240 MVA	Leland Olds-Fort Thompson 345	3.9	CT Limitation
405	Blackberry-Boswell 230 #2 at 110% of 483	Fault of South 500 w/xtrip of north 500	3.0	(reconductor or revise xtrip)
410	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345	7.4	Increase ground clearance
415	Maple River-Frontier 230 at 110% of 265	Alex SS-Bison 345	19.4	Increase ground clearance
455	Sauk River-West Cloud 115 at 110% of 139	Monticello-Quarry 345	8.1	Addressed by CapX 2020
450	Maple River-Sheyenne 230 at 110% of 320	Alex SS-Bison 345	21.1	Equip limitation
515	Minn Valley Tap-Granite Falls 230 at 110% of 387	Watertown-White 345/ Watertown-Brookings 115 (double ckt) Arlington-Watertown 115 Arlington-Brookings 115	8.5	(xtrip no longer needed)
525	Bismarck-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.9	CT Limitation
605	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.9	CT Limitations
610	Wahpeton-Frontier 230 at 110% of 265	Alex SS-Bison 345	19.4	Increase ground clearance
710	**Sheyenne-Audubon 230 at 110% of 318**	**Alex SS-Bison 345**	**16.6**	**Reconductor**
765	Granite Falls-Morris 230 at 110% of 240	Canby-Granite Falls 230	7.2	Generation runback
805	Maple River-Sheyenne 230 at 110% of 388	Alex SS-Bison 345	21.1	Reconductor
865	Oahe-Sully Buttes 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.9	CT Limitation
1060	Maple River 345/230 tx #1 & 2 at 125% of 336	Alex SS-Bison 345	23.1	Replace with larger units

Observations:

This configuration is ok, but not any better than Configuration 1; adding 2nd Bison-Maple River 345kV line did not improve performance.

Table 3.41
Southward Power Transfer Capability
Site 5 "NW Angle" Configuration 1

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
380	Whitlock-Glenham 230 kV at 110% of 240 MVA	Leland Olds-Fort Thompson 345	3.8	CT Limitation
385	Blackberry-Boswell 230 #2 at 110% of 483	Fault of South 500 w/xtrip of north 500	4.7	(reconductor or revise xtrip)
420	Maple River-Frontier 230 at 110% of 265	Maple River-Sheyenne230	19.3	Increase ground clearance
435	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345	7.6	Increase ground clearance
460	Maple River-Sheyenne 230 at 110% of 320	Alex SS-NW Angle 345	20.7	Equip limitation
470	Sauk River-West Cloud 115 at 110% of 139	Monticello-Quarry 345	8.3	Addressed by CapX 2020
510	Minn Valley Tap-Granite Falls 230 at 110% of 387	Watertown-White 345/ Watertown-Brookings 115 (double ckt) Arlington-Watertown 115 Arlington-Brookings 115	8.4	(xtrip no longer needed)
525	Bismarck-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.8	CT Limitation
600	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.8	CT Limitations
615	Wahpeton-Frontier 230 at 110% of 265	Alex SS- NW Angle 345	19.3	Increase ground clearance
715	**Sheyenne-Audubon 230 at 110% of 318**	**Alex SS-NW Angle 345**	**16.5**	**Reconductor**
760	Granite Falls-Morris 230 at 110% of 240	Canby-Granite Falls 230	7.1	Generation runback
820	Maple River-Sheyenne 230 at 110% of 388	Alex SS-NW Angle 345	20.7	Reconductor
865	Oahe-Sully Buttes 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.8	CT Limitation
970	Maple River 345/230 tx #1 or 2 at 125% of 336	Alex SS-NW Angle 345	28.5	Replace with larger units
1000	(No more limitations encountered to this level)			

Observations:

This configuration works very well. No reconductor or transformer upgrades required prior to reaching Sheyenne-Audubon 230 kV loading limit.

Table 3.42
Southward Power Transfer Capability
Site 5 "NW Angle" Configuration 2

(Add NW Angle-Maple River 345 kV #2)

Incremental Generation MW	Limiting Facility	Outage	DF %	Remedy
385	Whitlock-Glenham 230 kV at 110% of 240 MVA	Leland Olds-Fort Thompson 345	3.8	CT Limitation
395	Blackberry-Boswell 230 #2 at 110% of 483	Blackberry-Boswell 230	3.0	(reconductor or revise xtrip)
420	Maple River-Frontier 230 at 110% of 265	Maple River-Sheyenne230	19.3	Increase ground clearance
425	Alexandria-Alex SS 115 at 100% of 160	Quarry-Alex SS 345	7.7	Increase ground clearance
455	Maple River-Sheyenne 230 at 110% of 320	Alex SS-NW Angle 345	20.6	Reconductor
460	Sauk River-West Cloud 115 at 110% of 139	Monticello-Quarry 345	8.4	Addressed by CapX 2020
510	Minn Valley Tap-Granite Falls 230 at 110% of 387	Watertown-White 345/ Watertown-Brookings 115 (double ckt) Arlington-Watertown 115 Arlington-Brookings 115	8.3	(xtrip no longer needed)
525	Bismarck-Glenham 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.8	CT Limitation
605	Sully Buttes-Whitlock 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.8	CT Limitations
615	Wahpeton-Frontier 230 at 110% of 265	Alex SS- NW Angle 345	19.3	Increase ground clearance
715	**Sheyenne-Audubon 230 at 110% of 318**	**Alex SS-NW Angle 345**	**16.5**	**Reconductor**
770	Granite Falls-Morris 230 at 110% of 240	Canby-Granite Falls 230	7.1	Generation runback
865	Oahe-Sully Buttes 230 at 110% of 240	Leland Olds-Fort Thompson 345	3.8	CT Limitation
965	Maple River 345/230 tx #1 or 2 at 125% of 336	Alex SS-NW Angle 345	28.4	Replace with larger units
1000	(No more limitations encountered to this level)			

Observations:

This configuration is ok, but not any better than Configuration 1; adding 2nd NW Angle-Maple River 345 line did not improve performance.

Summer Off-Peak Southward Transfer Capability Analysis Summary

The results of the southward transfer capability study show that terminating the CapX Fargo line at any of the southern Fargo area sites (Flint, Frontier, WAPA Fargo) would result in numerous overloads on the Fargo vicinity 230 kV system. The additional configurations looping in nearby 230 kV lines at these sites showed that the transfer capability improves slightly, but still remains limited by overloads on the Fargo vicinity 230 kV system, even after line reconductoring.

Configurations testing a continuation of the CapX 345 kV from the southern Fargo sites to Maple River (or equivalent north-side site) eliminate most of the overloads on the 230 kV system; however, the Maple River-Sheyenne or Maple River-Frontier 230 kV line needs to be reconductored before reaching the limitation presented by the Audubon 230kV line.

The two northern sites (Bison, NW Angle) tested a connection to the Buffalo-Maple River 345 kV line without stopping at one of the southern sites. The results of these "express" configurations show that the Sheyenne-Audubon 230 kV line limitation is reached without need for any intermediate line reconductoring or transformer upgrades. These configurations encounter the Sheyenne-Audubon limiter at a slightly higher transfer level than the configurations which have stops at either Flint or WAPA Fargo (~715 MW vs ~675 - 650 MW). However, this slight difference is not considered significant because the results are highly sensitive to the presumed "source" locations for the incremental power transfer.

The Sheyenne-Audubon 230 kV line is a common limiter for all of the configurations studied. Since addressing this limiter requires improvements to a long section of line, it is considered to be the appropriate "stopping point" for first-phase transfer capability. The Sheyenne-Audubon limitation is due to the outage of the CapX Fargo line regardless of the Fargo termination site. Since the outage of the new line is the limiting contingency, series compensation or double circuiting the Twin Cities - Fargo line will not increase transfer capability until the Sheyenne-Audubon 230 kV line overload is addressed.

Terminating the single circuit CapX Fargo 345 kV line at Bison without stopping at one of the southern sites yields approximately 715 MW (nominal 700 MW) of additional transfer capability via nine minor improvements and without the need to reconductor any lines.

While the first-phase results indicate that a direct connection without stopping at one of the southern sites provides the best transfer capability with only minor upgrades, the results of the studies with connection at the southern sites need to be considered for future increments of power transfer capability. The limiting constraint for the transfer capability is the Sheyenne-Audubon 230 kV line. When the Sheyenne-Audubon line is upgraded--presumably to 345 kV or double circuit 345/230 kV--a Flint or Frontier site would be beneficial because it provides a 345 kV source for the new Audubon 345 kV line, and because it directly interconnects the two Fargo-Minnesota 345 kV lines, so that back-up is mostly through the remaining 345 kV rather than through the lower-voltage system.

The second-phase transfer capability increment studied addresses the Sheyenne-Audubon 230 kV line limitation by presuming a rebuild of the line from Flint to Riverton to Benton County to be double circuit, operating one circuit at 230 kV and one at 345 kV. This configuration, which includes a new Maple River-Cass County-Sheyenne-Flint 230 kV, results in approximately 1315 MW (nominal 1300 MW) of increased transfer capability, 600 MW greater than the Bison base configuration of 715 MW (nominal 700 MW).

The third-phase development studied (double circuiting the CapX Fargo line) results in approximately 1760 MW (1750 MW nominal) of increased transfer capability; this is 450 MW greater than with the single circuit line. The 75% series compensation configuration studied resulted in overloads on the Fargo vicinity 230 kV system, indicating that at this stage of system development, double circuiting or an equivalent level of series compensation (55 – 60%) will provide greater transfer capability than would such high levels of series compensation.

Tests of a configuration building the new Maple River-Cass County-Sheyenne ("east-side") line to 345 kV instead of 230 kV show the potential for southward transfer capability is over 2000 MW when a second 345 kV line is established from the Flint site to Maple River in this fashion. With this configuration, series compensation of the two Fargo-Minnesota 345kV circuits is likely to yield significant transfer capability increments; analysis beyond the 2000 MW level was beyond the scope of this study.

An alternative course of action for the third phase of southward transfer capability increase is to build a 345 kV line from Fargo (Flint substation) southward to Brookings County Substation. This additional line delays the overload of the Flint-Audubon 230 kV line to the 1100 MW transfer level, 400 MW greater than the first phase improvements. The limiting overload is due to the outage of Alex SS-Flint 345 kV line; therefore building that line double circuit or with series compensation does not increase transfer capability for this configuration.

Regardless of which termination configuration is chosen for the new Twin Cities-Fargo line, achieving incremental southward power transfer capabilities of the magnitude studied requires new generation additions near Fargo, or new lines from remote generation to the Fargo transmission system. Consequently, the exact set of Fargo transmission upgrades required in order to utilize these increments of southward transfer capability will be sensitive to the actual pattern of generation and transmission developments that occur independently of the implementation of the Twin Cities - Fargo line. Included in these not-yet-defined possible developments are a new 500 kV line from Winnipeg to Fargo, and a new 345 kV line from west-central North Dakota to either Grand Forks or Fargo.

3.5.3 Winter Peak Transfer Capability Analysis

This study identifies the winter peak (northward flow) transfer capability limitations. The purpose of this analysis is to identify whether the various Fargo Line terminations yield significantly different winter peak northward flow transfer capabilities. MHEX for these cases is at -700 MW (northward 700 MW).

"Source" for the incremental northward transfers is the Twin Cities and eastern Wisconsin. The "sink" is 75% Maple River and 25% WAPA Fargo. Consequently, this analysis evaluates the ability to deliver power to the Fargo load center; it does not test cross-border transfer capability.

Comparing Winter Peak N-1 system performance of the different sites and configurations, the limitations are very similar among the five sites. The identified limiters are most likely best addressed individually (reconductors, transformer additions, terminal upgrades). It is recognized, however, that if large amounts of northward transfer capability increase were sought, further transmission line additions would likely occur from Fargo northward to the Manitoba Hydro system.

Detailed output listings for the northward transfer capability analysis are provided in Appendix D.

3.5.4 Double-Contingency (N-2) Transfer Capability Analysis

This portion of the technical analysis examines double-contingency (N-2) performance. The N-2 study zone is defined by tie lines described in Section 3.2. The base configurations for each of the five sites were studied under both winter peak and summer off-peak conditions. The detailed N-2 results are located in Appendix E.

The results of the N-2 transfer capability analysis show that:

- The N-2 system performances of the different sites studied are very similar. None of the configurations distinguished itself with a more robust performance.
- Building a new Maple River-Cass County-Sheyenne 230 kV line with a 336 MVA 230/115 kV transformer at Cass County (alternate: build line/transformer 345kV) will eliminate most of the N-2 contingency limitations for all five sites.
- The Sheyenne-Audubon 230 kV line rating is again a common limiter as it was in the N-1 contingency studies.
- There are a number of new limiting elements encountered in the N-2 contingency studies, not encountered or addressed from the N-1 studies. Many of these limiters are 115 kV lines with DFs under 7%. The Maple River-Cass Co-Sheyenne/Flint "east-side" 230 (or 345 kV) development is very helpful in neutralizing these contingencies.

3.5.5 Manitoba-U.S. (MHEX) Interface Considerations

General/Background

The incremental southward power transfer capability achieved with the addition of the Fargo line was tested by using the Maple River 345 kV (75%) and the Fargo 230 kV buses (25%) as the presumed incremental power sources. Although a large fraction of the power transfer will use the new "direct" path offered by the Fargo line, some of the transfer will take indirect paths, including northward to Winnipeg, then southward on the Winnipeg-Twin Cities 500 kV system.

Previous studies relating to North Dakota and Minnesota generation outlet have identified incremental loading of the Dorsey-Roseau Co-Forbes 500 kV path as a concern; specifically the Dorsey 230/500 kV transformation, and the Roseau Co series capacitors. This concern is relevant because one of the several factors which determine the Manitoba-U.S. (MHEX) interface rating is the loading of the Winnipeg-Twin Cities 500 kV path. With the MHEX interface pre-loaded to its present 2175 MW Total Transfer Capability (TTC) limit, the Dorsey-Roseau Co-Forbes 500 kV ("North Line") is loaded at or very near its loading limit of 1732 MVA, a rating that is actually due to the Roseau Co series capacitors rather than the line's conductor thermal limit.

Due to the high initial loading, any additional inadvertent southward flow arising caused by additional deliveries from North Dakota/northwestern Minnesota generation additions, to the Twin Cities or similar destinations, can quickly cause overloads on the 500 kV system. If significant additional amounts of inadvertent loading of the 500 kV path were to occur due to

large new North Dakota "southward" power transfers, it could cause a reduction in MHEX capability; this deterioration of existing transfer capability would be an intolerable situation from the perspective of MHEX interface owners and users.

The 500 kV loading concerns are identified in terms of steady-state loading limits, but the limits are due to both steady-state and dynamic stability considerations. The following sections describe these loading limits in greater detail, and then summarize the observed results achieved with the Fargo line addition.

Steady-state limits

The Dorsey 230/500 kV transformation consists of two 1200 MVA transformer banks. Since these transformers are the only source for the Dorsey 500 kV bus, outage of either transformer limits loading of the Dorsey-Roseau Co-Forbes 500 kV line to the rating of the remaining transformer. Presently, outage of either transformer initiates a Manitoba Hydro "dc runback" corresponding to 50% of the Dorsey-Forbes line's pre-contingent MW loading.

This automatic action prevents excessive loading of the remaining transformer. However, if the pre-contingent loadings were to be increased due to inadvertent flows, this would cause a need for increased dc runback, which would potentially affect all scheduled MHEX-related transactions. This would likely be considered an inequitable burden, since the cause of the increased runback is unrelated to the MHEX-related transactions.

The long-term solution to the Dorsey transformer loading issue is the addition of the planned Riel 500/230 kV substation southeast of Winnipeg, on the Dorsey-Roseau Co portion of the existing 500 kV line. This new station will provide additional 230/500 kV transformer capability.

Roseau Co Series capacitors

The two Roseau Co 500 kV series capacitor banks have a continuous rating of 2000 amps, which corresponds to a rating of 1732 MVA. These capacitors were designed to be capable of future upgrade to 2500 amps (2165 MVA). The present emergency rating of 125% of continuous is sufficient, because the only increase in loading that can occur is in response to outage of one of the parallel 230 kV lines. Although a MH dc runback is triggered for any such outage, even if the dc runback were to fail to occur, the resultant post-contingent 500 kV loading is less than the 125% emergency rating. Consequently, it is the series capacitors' continuous rating that is the limiting consideration.

Reactive consumption of 500 kV line

The addition of the Roseau Co series capacitors in 1993 reduced substantially the Dorsey-(Roseau Co)-Forbes line's net reactive power consumption. However, at a loading of 1732 MVA, the line's net reactive consumption is still significant: 996 MVAR.

If an incremental loading of 60 MW[1] is added to the initial 1732 MVA loading, the line's net reactive consumption increases by 70 MVAR, to 1066 MVAR. This increased reactive consumption would need to be compensated for, presumably by additional shunt capacitors at Dorsey and/or Forbes. However, such installations will aggravate the "load rejection" overvoltages that occur upon tripout of the line; this in turn can cause need for additional Static VAR Compensator (SVC) capability, or higher "momentary withstand" voltage ratings for all the substation equipments (breakers, transformers, and instrumentation).

Dynamic Stability limits

The existing 2175 MW southward MHEX capability is only possible from a dynamic stability standpoint because of the sophisticated "DC runback" scheme which has been implemented by Manitoba Hydro. During southward flow conditions, tripout of any section of any of the 500 or 230 kV Manitoba-U.S. interconnections results in the "power order" for the two Manitoba Hydro DC lines being reduced by a pre-determined amount, generally corresponding to the pre-contingent flow on the outaged facility. This prevents a dynamic "out-of-step" condition from arising, which would result in cascade tripping of all the Manitoba-U.S. interconnections.

The largest DC runback is that which occurs for loss of the Dorsey-Roseau Co-Forbes 500 kV line. This runback is equivalent to 100% of the line's pre-contingent MW loading. Consequently, if additional loading of the Dorsey-Roseau Co-Forbes line occurs due to inadvertent flow, the resultant maximum DC runback would need to be increased. This poses operational challenges to the Northern Manitoba generation system because of the additional temporary overspeed duty that this imposes on the generators.

Manitoba Hydro has no obligation to provide for increased DC runback capability. Furthermore, Special Protection Systems (SPS) of this type are presently prohibited by MISO with regard to new generation interconnection requests, except for use as a temporary measure until transmission upgrades are installed. Consequently, if new generation were added on the MISO system in North Dakota or western Minnesota, and it caused a need for increased Manitoba DC runback due to inadvertent flow on the 500 kV system, this action would appear to be disallowed by MISO.

Reserve Sharing Pool considerations

The maximum Manitoba DC runback of approximately 1500 MW represents the largest single-contingency generation capacity outage in the Generation Reserve Sharing Pool (GRSP). If the amount of DC runback were increased further, the operating reserves would need to be increased. This is a burden on all members of the GRSP, not just those who benefit from the increased transfer capability.

Effect of Twin Cities-Fargo 345 kV Addition

Addition of the Fargo line has two effects on the MHEX interface, both of which are beneficial. There is a one-time reduction of loading on the Winnipeg-Twin Cities 500 kV path, and there is

[1] The 60 MW increment is based on 8.5% of a presumed 700 MW increase in Fargo "southward" transfer.

a reduction in the percentage of North Dakota "southward" power transfer that contributes to the 500 kV loading.

- At a MHEX interface loading of 2175 MW, addition of the Fargo line (single circuit) reduces loading on the Winnipeg-Twin Cities 500 kV path by approximately 30 MW. Addition of a second 345 kV circuit (or equivalent series compensation of a single circuit) yields an additional 18 MW reduction.

- The amount of inadvertent flow appearing on the Dorsey-Roseau Co-Forbes 500 kV line is reduced, from approximately 14% of the incremental North Dakota "southward" transfer, to approximately 8.5% (single circuit) or 6.9% (double circuit). These reductions in the "Distribution Factor" delay onset of the 500 kV overload.

This combination of reduced initial 500 kV loading and reduction in inadvertent flow onto the 500 kV means that additional North Dakota export capability can be established without causing any net increase in the 500 kV line loading. This avoids the need to address the many ramifications of increased 500 kV loading. Taking into account the initial loading reductions and the reduced distribution factors, the amount of incremental North Dakota export capability that is enabled is approximately

Single-Circuit:	30.5/0.085	=	360 MW
Double-Circuit: (or series comp)	48.0/0.069	=	700 MW

The exact amount of incremental North Dakota export capability achieved is sensitive to the assumed "source" location(s). The above figures are based on this study's Fargo source assumption of 75% Maple River/25% WAPA Fargo. The resultant MW values would generally be higher for generation locations south, east, or west of Fargo, and lower for locations north, northeast, or northwest of Fargo.

Summary

Incremental loading of the Dorsey-Roseau Co-Forbes 500 kV path due to inadvertent flows is an important and relevant issue with respect to North Dakota "southward" transfer capability. The best "fix" is to avoid causing any incremental loading.

Following addition of the Twin Cities-Fargo line, increased North Dakota "southward" power transfers of up to approximately 700 MW can be accommodated without causing any net increase in the Dorsey-Roseau Co-Forbes 500 kV line loading, provided that either the new 345 kV line is sufficiently series compensated, or the second circuit is installed on this line.

4.0 Dynamic Stability Analysis

The dynamic stability performance of the transmission system was examined on the 2008 NMORWG stability study package (pkg2008-05-05-2008) using PSS/E Revision 29. The dynamic stability analysis was used to ensure that the bulk power system dynamic stability performance is acceptable for the increased NDEX at 3150 MW. The 3150 MW target level is 700 MW incremental capability beyond the suggested Big Stone II outlet NDEX level of 2450 MW.

4.1 Model Development

A 2016 Summer Off-Peak Base Case was derived from the latest NMORWG "Existing System" ("urg-so08aa.save") case from the 2008 Study Package. The "urg-so08aa.save" case has the North Dakota (ND) load at 65% of 2880 MW and NDEX at 1950 MW. The new Watertown and Groton shunt capacitors were added to enable representing a case with NDEX at 2080 MW. The Big Stone II generation and its outlet facilities were then added in; these Big Stone II outlet facilities have been previously shown to accommodate a NDEX interface loading increase to 2450 MW. In summary, the Summer 2016 Off-Peak Base Case has the following:

- Watertown and Groton capacitors
- Big Stone II generation (657 MW gross) and its outlet facilities
- NDEX loading adjusted to 2450 MW
- BRIGO facilities
- Brookings Co-Twin Cities 345 kV line
- Twin Cities-LaCrosse 345 kV line
- Bemidji-Grand Rapids 230 kV line
- Queued Generation projects:
  - Southwest Minnesota wind level at 1800 MW
  - 358 MW at Pillsbury; MPC Project MPC00500;
  - 600 MW at Big Stone (Big Stone II); MISO Project G392;
  - 150 MW at Rugby; MISO Project G380;
  - 100 MW at Ladish; MISO Projects G645 and G788

The summer off-peak case had the queued projects dispatched to load within the NDEX boundary except for the 400 MW of Big Stone II intended to be dispatched across the NDEX boundary. Although it is recognized that the planned Big Stone II generation and associated transmission developments cannot be considered certain, there are many other proposed generation interconnection requests in the Big Stone vicinity; regardless of which generation projects actually proceed first, the initial transmission outlet developments would be very similar to those presently proposed for Big Stone II.

Ladish generation (G645 and G788) and Big Stone II were at full output for the study. In order to represent off-peak load levels within the NDEX boundary, the two prior-queued wind projects were modeled at 20% of their nameplate rating similar to other ND wind generation to keep load within and near the NDEX boundary as close to 65-70% as possible.

MISO Projects G821 (201 MW on Sheyenne-Audubon) and G859 (600 MW at Maple River) were not included in this study. Due to their relatively late queue position, no technical studies have yet been performed for these requests and accordingly the required Network Upgrades have not been identified.

Dynamic performance was evaluated at the following points:

1. Pre- Twin Cities - Fargo 345 kV ("Pre-Fargo-TC 345")
2. Post- Twin Cities - Fargo 345 kV

    - Fargo line terminated at Bison ("Post-Fargo-TC 345")
    - Fargo line terminated at Bison, with tap at Flint ("Post-Fargo-TC 345 (Flint)")

4.2 Dynamic Case Naming Convention

The case titles were developed for the specific three-place prefix allowed in the NMORG's models. The first character designates the NDEX increment in each scenario. The second character denotes if the case is original system ("0") or has system improvement. The third character denotes the three study points.

Table 4.1
Dynamic Case Naming Convention

Case Name	Study Points	NDEX (MW)	NDEX Increment (MW)
000-so16aa	"Pre-Fargo-TC 345"	2450	0
001-so16aa	"Post-Fargo-TC 345"	2450	0
002-so16aa	"Post-Fargo-TC 345 (Flint)"	2450	0
101-so16aa	"Post-Fargo-TC 345"	2550	100
102-so16aa	"Post-Fargo-TC 345 (Flint)"	2550	100
201-so16aa	"Post-Fargo-TC 345"	2650	200
202-so16aa	"Post-Fargo-TC 345 (Flint)"	2650	200
301-so16aa	"Post-Fargo-TC 345"	2750	300
302-so16aa	"Post-Fargo-TC 345 (Flint)"	2750	300
401-so16aa	"Post-Fargo-TC 345"	2850	400
402-so16aa	"Post-Fargo-TC 345 (Flint)"	2850	400
501-so16aa	"Post-Fargo-TC 345"	2950	500
502-so16aa	"Post-Fargo-TC 345 (Flint)"	2950	500
601-so16aa	"Post-Fargo-TC 345"	3050	600
602-so16aa	"Post-Fargo-TC 345 (Flint)"	3050	600
701-so16aa	"Post-Fargo-TC 345"	3150	700
702-so16aa	"Post-Fargo-TC 345 (Flint)"	3150	700
801-so16aa	"Post-Fargo-TC 345"	3250	800
802-so16aa	"Post-Fargo-TC 345 (Flint)"	3250	800

4.3 Faults Studied

Six major system disturbances were tested for the various conditions studied. These are listed in Table 4.2.

Table 4.2
Fault Description

Name	Description
ag1	Single-line-to-ground, 4 cycle fault w/breaker failure at Leland Olds on Leland Olds-Ft. Thompson 345 kV - 11 cycle backup clearing of faulted line
ei2	10 cycle, CU DC Permanent Bi-pole fault –7 cycles backup clearing by tripping both Coal Creek units.
mts *	Single-line-to-ground fault w/breaker failure at Monticello, 8N6 stuck, clear Monticello-Elm Creek 345 kV
nmz	3 phase, 4 cycle fault at Chisago Co, trip Chisago Co – Forbes 500 kV, 100 % DC reduction
pjz	5 cycle 3 phase fault at Bison, trip Bison – Buffalo – Jamestown 345 kV, cross trip Buffalo TX and Maple River reactors
fa3	4 cycle 3 phase fault at Alex SS 345, trip Alex SS –Bison 345 kV

Note:

* "mts" fault clearing will change after Monticello substation expansion for the Twin Cities - Fargo line termination addition. It is anticipated that back-up fault clearing will no longer involve loss of the 345/230 kV transformer. This beneficial revision is not reflected in these simulations.

Appendix F contains the "regional" and "local" dynamic stability simulation output plots for all the cases.

4.4 Results

For all system configurations and disturbances studied, dynamic stability performance was found to be satisfactory with regard to angular stability, relay margins, and damping. The only performance limitations found relate to dynamic undervoltages; these are discussed in the following paragraphs.

Of all the disturbances studied, it appears that the "pjz" disturbance (5 cycle 3 phase fault at Bison, trip Bison – Buffalo – Jamestown 345 kV, cross trip Buffalo 345/115 tx and Maple River reactors) is the most limiting condition. Upon study of the stability plots it was found that both of the "post-Fargo-TC 345" and "Post-Fargo-TC 345 (Flint)"systems have acceptable dynamic performance for NDEX up to 3150 MW (2450 + 700 MW) for all the disturbances studied except "pjz". Speeding up the "pjz" fault clearing to a more-typical 4 cycles allows the power system to achieve satisfactory performance to more than 800 MW incremental capability on the NDEX interface.

The "next-most-limiting disturbance" (whether 3-phase or single-phase with delayed clearing) is difficult to identify at this stage of project development, as it will be sensitive to the substation bus configurations employed, autotransformer neutral grounding provisions chosen, and the amount of series compensation, if any, used in the new 345 kV line sections. The "fa3" 3-phase fault on the new Alexandria-Bison 345 kV line was tested as a representative fault for the new 345 kV facilities; its results suggest faults on the new Twin Cities-Fargo 345 kV line are not

likely to be more severe than the existing "regional" faults of interest.. More-detailed studies will be necessary to better define the future "most-limiting faults".

The dynamic voltage profiles at Arrowhead, Dickinson, Groton, Tioga, and Watertown for faults "ei2", "nmz", "pjz (4 cycles)", and "mts" are listed in Table 4.3. Faults "ag1" and "fa3" were found to be less severe; full plots are provided in Appendix F.

Table 4.3
Dynamic Voltage Performance
for Bison-Alexandria-Waite Park-Monticello 345 kV
at 700 and 800 MW increments of NDEX w/r to 2450 MW Base

Disturbance	Voltage, p.u.				
	Criterion	700 MW Increase		800 MW Increase	
		"701-so16aa"	"702-so16aa" (Flint tap)	"801-so16aa"	"802-so16aa" (Flint tap)
ei2					
Arrowhead 230 kV	.82	.93	.93	.92	.92
Dickinson 345 kV	.70	.82	.82	.81	.81
Groton 115 kV	.70	.85	.85	.84	.84
Tioga 230 kV	.80	.98	.98	.95	.97
Watertown 345 kV	.75	.92	.92	.91	.91
nmz					
Arrowhead 230 kV	.82	.91	.91	.90	.90
Dickinson 345 kV	.70	.82	.82	.81	.81
Groton 115 kV	.70	.86	.86	.84	.84
Tioga 230 kV	.80	.96	.96	.95	.95
Watertown 345 kV	.75	.92	.92	.91	.91
pjz (4 cycles)					
Arrowhead 230 kV	.82	.93	.93	.92	.93
Dickinson 345 kV	.70	.89	.88	.89	.88
Groton 115 kV	.70	**.76**	**.76**	**.74**	**.74**
Tioga 230 kV	.80	.96	.96	.95	.95
Watertown 345 kV	.75	.88	.88	.87	.87
mts					
Arrowhead 230 kV	.82	**.89**	**.89**	**.88**	**.87**
Dickinson 345 kV	.70	.91	.91	.91	.90
Groton 115 kV	.70	.91	.91	.90	.89
Tioga 230 kV	.80	.89	.89	.88	.88
Watertown 345 kV	.75	.95	.95	.94	.94

It is observed from the table above that:

- The stability-based transfer limit is increased by at least 800 MW on the NDEX interface; this is more than the 700 MW thermal-based increment.
- Faults “pjz” (following speed-up to 4 cycles) and “mts” are expected to be the most limiting conditions, with margins of 4% and 5%, respectively, relative to their respective voltage criteria. However, the “mts” fault performance should improve slightly if we take into account the Monticello substation reconfiguration associated with the addition of the new line termination.

- The “ei2” fault has considerable margin; this is due to the new Twin Cities-Fargo 345 kV line providing a new parallel path for power flow during the “dc line block” condition. A similar improvement was noted for the “ag1” fault.

In conclusion, with the addition of the 345 kV Twin Cities - Fargo line with the Fargo end terminated at Bison or an equivalent “northwest” site, dynamic stability performance will be satisfactory to permit full utilization of the 700 MW incremental southward power transfer capability identified in the thermal analysis.

5.0 Loss Analysis

The following tables show the transmission system demand (MW) losses for the summer off-peak and winter on-peak conditions studied. Losses are calculated for transfer increments of 0 and 1000 MW[2].

The Winter (northward) losses are of less interest than the Summer (southward) losses because the predominant flow during the course of most years is southward.

Summer

Table 5.1
Summer Off-Peak (southward) System Losses

Site	Config	Losses 0 MW Transfer (MW)	Configuration Loss Differential (MW)	Losses 1000 MW Transfer (MW)	Configuration Loss Differential (MW)
Flint	1	17673.1	0.0	17884.6	0.0
	1.1	17672.7	-0.4	17882.8	-1.8
	1.2	17671.8	-1.3	17879.8	-4.8
	1.3	17671.3	-1.8	17879.7	-4.9
(extend 345)	2	17666.4	-6.7	17865.2	-19.4
(Cass 230)	2.1	17666.3	-6.8	17865.0	-19.6
(Cass 345)	2.2	17662.2	-10.9	17860.0	-24.6
Frontier	1	17675.7	2.6	17895.3	10.7
	1.1	17673.4	0.3	17881.8	-2.8
	1.2	17673.2	0.1	17880.6	-4.0
(extend 345)	2	17670.3	-2.8	17866.3	-18.3
	2.1	17669.9	-3.2	17864.3	-20.3
WAPA Fargo	1	17672.6	-0.5	17885.5	0.9
(extend 345)	2	17665.3	-7.8	17866.3	-18.3
Bison	1	17664.1	-9.0	17865.5	-19.1
	1.1	17663.9	-9.2	17864.6	-20.0
	1.2	17663.5	-9.6	17862.9	-21.7
	2	17664.1	-9.0	17865.0	-19.6
NW Angle	1	17665.7	-7.4	17866.4	-18.2
	2	17665.7	-7.4	17864.7	-19.9

Second-stage configurations

Audubon	1.3	17656.3	-16.8	17825.3	-59.3
	1.4	17650.8	-22.3	17823.0	-61.6
(2nd ckt to Monti)	1.5	17640.7	-32.4	17790.8	-93.8
(series comp)	1.6	17650.7	-22.4	17820.0	-64.6
Brookings Co	3	17654.4	-18.7	17832.3	-52.3
(2nd ckt to Monti)	3.1	17640.6	-32.5	17790.0	-94.6

[2] The 1000 MW level was chosen prior to identification of the Phase 1 thermal and dynamic stability limits of 700 and 800 MW, respectively. If desired, interpolation can be performed to approximate losses at any intermediate transfer level.

The following comparisons are with respect to the "zero incremental transfer" condition, unless noted otherwise. The loss differences are substantially higher in the "1000 MW incremental transfer" condition.

Relative to the Flint reference site,

- Going to the Frontier site instead (site 2), causes a loss increase of 2.6 MW
- Going to the WAPA "Fargo" site (site 3) gives a 0.5 MW reduction
- Going to the Bison site (site 4) gives a 9 MW loss reduction
- Going to the "NW Angle" site (site 5) gives a 7.4 MW loss reduction.

Flint site:

- Loop-in of additional 230 kV lines (beyond initial Sheyenne-Audubon) reduces losses a fraction of a MW
- Extending the 345 kV to Maple River yields an additional loss reduction of approximately 6 MW.
- Constructing the Maple River-Cass Co-Sheyenne/Flint "east-side" development at 345 kV rather than at 230 kV yields an additional loss reduction of 4 MW; this is the lowest-loss configuration tested.

Frontier site:

- Extending the line to Maple River gives approximately 3 MW loss reduction.

WAPA "Fargo" site:

- Extending to Maple River gives approximately 7 MW additional loss reduction.

Bison site:

- Starts with good loss reduction compared to Flint (9 MW)
- Adding 2nd MPR-Bison line does not provide any additional loss reduction.

"NW Angle" site:

- Losses are 1.6 MW higher than Bison site (7.4 vs 9.0 MW reduction). This is because NW Angle is several miles east of Bison; further "downstream" from coalfields source.

Second-stage configurations (Rebuild of Audubon line to 345 kV or addition of Brookings Co 345 kV line; Site 4 Configurations 1.3-1.6 and 3-3.1):

- Adding the Fargo-Brookings County 345 kV line (config 3) initially gives 2 MW better loss reduction than rebuilding the Audubon line (config 1.3) for the 0 MW incremental transfer. However, at the high (1000 MW) incremental transfer condition, the loss reduction is greater for the Audubon line rebuild configuration (59 vs 52 MW).
- The losses are similar for both second stage configurations if the second circuit is added to the Flint-Monticello 345 kV line.

Series compensation of both Fargo paths (Twin Cities - Fargo and Fargo-Riverton-Benton Co) can yield similar transfer capability as addition of the second circuit to the Fargo line, but the resultant losses are 30 MW higher at the 1000 MW incremental transfer level (Config. 1.5 vs 1.6).

Summary:

- Compared to stopping at a southern site (Flint, Frontier, or WAPA Fargo) extending the new line all the way to a northern site (Bison, Maple River, or NW Angle) yields an additional loss reduction of approximately 6 MW (at zero incremental transfer). Looking at a 1000 MW incremental transfer level, this difference increases to approximately 20-30 MW.
- Establishing the "east-side" transmission development (needed for local load serving) at 345 kV provides a 4 – 5 MW loss reduction compared to a 230 kV development.

Winter

Table 5.2
Winter Peak (northward) System Losses

Site	Config	Losses 0 MW Transfer (MW)	Configuration Loss Differential (MW)	Losses 1000 MW Transfer (MW)	Configuration Loss Differential (MW)
Flint	1	10714.0	0.0	10820.9	0.0
	1.1	10714.0	0.0	10820.7	-0.2
	1.2	10713.1	-0.9	10820.6	-0.3
	1.3	10713.0	-1.0	10820.8	-0.1
(extend 345)	2	10711.6	-2.4	10820.3	-0.6
	2.1	10711.6	-2.4	10820.3	-0.6
	2.2	10711.9	-2.1	10820.3	-0.6
Frontier	1	10714.1	0.1	10830.6	7.5
	1.1	10713.4	-0.6	10820.7	-0.2
	1.2	10713.3	-0.7	10820.9	0.0
(extend 345)	2	10713.2	-0.8	10822.3	1.4
	2.1	10712.1	-1.9	10820.4	-0.5
WAPA Fargo	1	10714.5	0.5	10824.0	3.1
(extend 345)	2	10711.7	-2.3	10821.3	0.4
Bison	1	10713.8	-0.2	10825.7	4.8
	2	10713.0	-1.0	10823.8	2.9
NW Angle	1	10713.2	-0.8	10823.8	2.9
	2	10712.7	-1.3	10822.1	1.2

There is relatively little loss difference among the sites and their various configurations studied. If the new line is terminated at Flint, extending the line to Maple River yields a 2 MW loss reduction.

In contrast, if the new line is terminated at Frontier, extending it to Maple River does not by itself yield a loss reduction, but adding a Frontier-Sheyenne 230 kV line in conjunction with the 345 kV extension does give a 1.9 MW loss reduction.

For the WAPA termination (site 3) losses are initially 0.5 MW higher than for the Flint termination, but extending the line to Maple River gives a 2.3 MW net loss reduction.

At the 1000 MW incremental transfer level, compared to Flint, all the other sites have higher losses. Frontier can be "rehabilitated" by the loop-in of the Sheyenne-Audubon 230 kV line (config 1.1). The Bison site has the second-worst performance, (4.8 MW higher losses than Flint) because it is electrically further from the loads. This disadvantage can be mitigated by making an intermediate connection at any of the southern sites (Flint, Frontier, or WAPA Fargo).

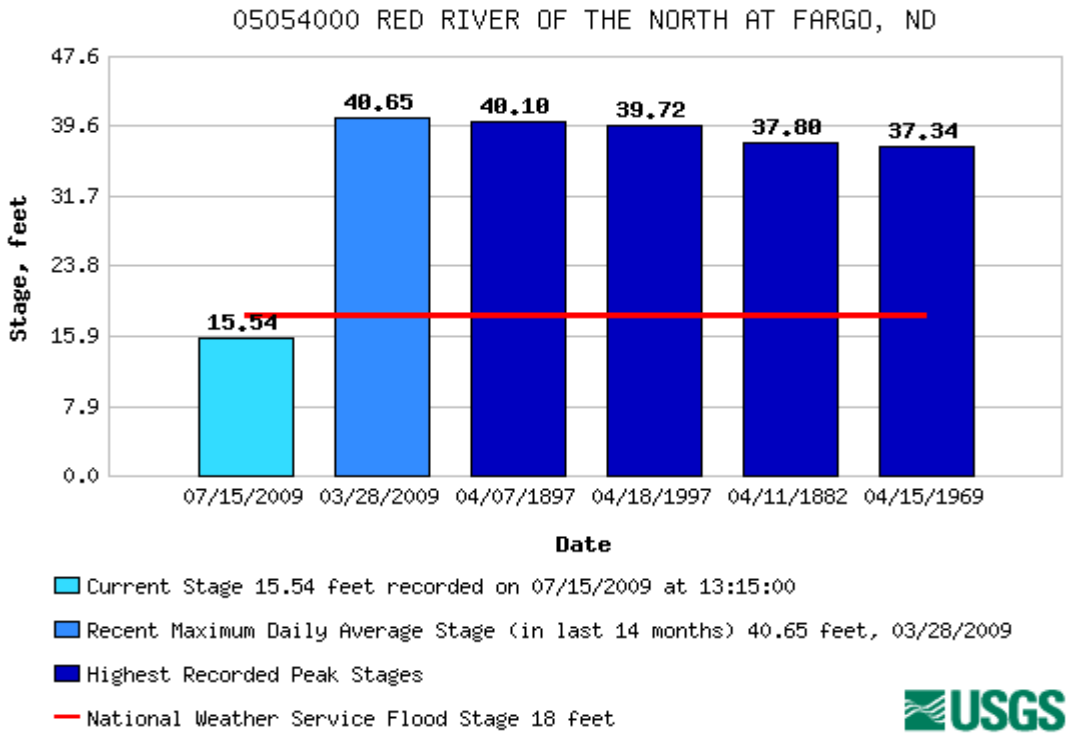
Summary:

- At low northward transfer levels, there is relatively little difference in system losses among the sites and their various configurations.
- At higher transfer levels, the Flint site has the best (lowest) losses, while Frontier has the worst performance, unless a connection is added between Frontier and Sheyenne; this makes the Frontier site effectively equivalent to the Flint site.
- The northwest sites (Bison or NW Angle) have higher losses unless an intermediate connection is made at one of the southern sites. This is because an express line connecting directly to a northwestern site overshoots the Fargo load center, whereas if a tap is provided at one of the southern sites, power can be dropped off into the 230/115 kV system at an earlier point.

6.0 Geographic Analysis

6.1 Flood Elevation

The USGS Fargo flood records indicate the highest flood elevation experienced is approximately 902.45 ft (902.45 in 2009, 901.90 ft in 1897, and 901.52 ft in 1997.).



Datum = 861.8 ft above sea level.

Table 6.1 shows the approximate existing elevation at each of the potential Fargo vicinity termination sites. The southern sites have a higher elevation than the northern sites. The maximum flood elevation is below the elevation of the southern sites and above the elevation of the northern sites.

Table 6.1
Substation Site Elevations

Site	Elevation (ft)
Flint	904
Frontier	904
WAPA Fargo	904
(max flood elevation)	902.45
Bison	899
NW Angle	894
Maple River	894

From this tabulation it is evident that the southern sites will require less fill than the northern sites to achieve comparable flood protection levels. Also, it may not be practical to raise any of the northern sites by the 10 feet necessary to achieve an elevation of approximately 904 ft, which would seem to be a desirable elevation, particularly if the substation were essential for local load serving purposes.

The electrical analysis results presented in other sections of this report indicate a need for the new Fargo line to have a "northside" connection to the existing Jamestown-Buffalo-Maple River 345 kV line. Flood considerations suggest that it would be also desirable to have a "southside" 345/230 kV substation, as this would be help ensure the new line's usefulness during adverse water conditions.

6.2 River Crossings

All candidate Fargo termination sites for the new Twin Cities-Fargo line are west of the Red River, and consequently require that it be crossed at some location. Therefore, with regard to river crossings, the only difference between the termination sites under consideration is the number of new crossings required of the Sheyenne River.

The Flint and Frontier termination sites avoid any new crossing of the Sheyenne River. However, the configurations for these sites that offer the best electrical performance include an extension of the 345 kV line around the West side of Fargo in order to connect to the Jamestown-Buffalo-Maple River 345 kV line at some "north-side" site (Bison, NW Angle, or Maple River). This requires a crossing of the Sheyenne River; in the case of Maple River, a second crossing is required.

Termination at the WAPA Fargo site requires crossing the Sheyenne River south of Fargo. Similar to the Flint and Frontier sites, the WAPA Fargo configuration that offers the best electrical performance includes an extension of the 345 kV line to a northside site; this would require a second crossing if Maple River were the ultimate destination.

The Bison and NW Angle sites require one crossing of the Sheyenne River.

The Maple River site would require two crossings of the Sheyenne River: once from east to west on the south side of Fargo, and another to cross west to east on the north side of Fargo. The only practical method of avoiding this double crossing would be to approach the Maple River substation from the east; this would require routing the new 345 kV line around the east side of Moorhead, and then sufficiently north to avoid the airport "Obstruction-Free Zone", and then west and south to Maple River Substation. This is a lengthy, awkward routing, and Maple River is not preferred from a flood vulnerability standpoint, so these considerations collectively render the Maple River site as relatively undesirable for termination of the Monticello line.

The need for a "new" crossing of the Sheyenne River can likely be avoided by double-circuiting with the existing Sheyenne-Fargo 115 kV line. Double-circuiting with this 115 kV line will not present any system reliability concerns because the 115 kV line serves a local load-serving function, while the new 345 kV line serves bulk power supply function. Any remaining potential reliability concerns arising from such double-circuiting would be allayed if the new 345 kV line were to have an intermediate connection to the 230 kV network east of the Sheyenne River, at Flint or Frontier.

6.3 Crossings of Existing Lines

Terminating the new Twin Cities-Fargo line at the Flint site eliminates the need to cross any of the existing 230 kV lines in the Fargo vicinity, provided that the line approaches Fargo from the southeast, between the Sheyenne-Audubon 230 kV line and the WAPA Fargo-Morris 230 kV line; a likely scenario.

Terminating at Frontier would require crossing the WAPA Fargo-Morris 230 kV line somewhere, as Frontier and Alexandria (the 345 kV line's last stop in Minnesota) are on opposite sides of the WAPA line.

Terminating the new 345 kV line at the WAPA Fargo substation would require crossing at some point of the Maple River-Frontier-Wahpeton 230 kV line, and is almost certain to also require crossing of the WAPA Fargo-Moorhead-Morris 230 kV line. Avoidance of this second crossing would require routing the 345 kV line through the Flint substation site, in the narrow gap between the corner of the Sheyenne-Audubon 230 kV line and the WAPA line, which passes diagonally through the adjacent quarter-section.

The electrical analysis has resulted in the recommendation that the new 345 kV line proceed to a connection to the existing 345 kV at a "north-side" site. If the new line were to terminate at Maple River by taking a route east and north of Fargo/Moorhead, it would need to cross the Sheyenne-Audubon 230 kV line, which is likely to be a future 345 or 345/230 kV line; this is highly undesirable.

For the new 345 kV line to proceed from any of the south-side sites to a north-side site (Bison, NW Angle, or Maple River) generally requires crossing two 230 kV lines in the vicinity of the WAPA Fargo Substation; either the two Jamestown-Fargo lines, or the Fargo-Sheyenne and the Fargo-Moorhead-Morris line.

The number of 230 kV crossings near the WAPA substation could theoretically be reduced to one if the new 345 kV line were routed parallel to (and north of) the Fargo-Morris line; at some point east of the WAPA Fargo Substation the new 345 kV would then cross (only) the Fargo-Sheyenne line. However, from a Fargo load-serving reliability standpoint it is better to avoid any crossing of the Fargo-Sheyenne 230 kV line; it is preferable to cross the two Jamestown-Fargo lines. This is because if the new 345 kV line were to fall into either of the Jamestown circuits, there is one Jamestown circuit remaining; if it were to fall into the Sheyenne line, there is no other Fargo-Sheyenne circuit or equivalent, unless the Fargo-Moorhead-Morris 230 kV line were to be "looped-in" to the Flint Substation site.

Potential reliability concerns about the number of 230/345 kV line crossings is reduced by developing the Flint 345/230 kV substation site, because this creates a new connection between the new 345 kV line and the existing 230 kV Fargo area network prior to (south/east of) any locations where the new 345 kV must cross existing 230 kV lines.

6.4 Future Lines

Development of the Fargo area 345 kV system configuration should take into consideration the facilitation of connections to future new or upgraded lines.

The size and timing of future transmission developments is dependent on generation development patterns and schedules, load growth rates, relative fuel costs, and other economic considerations. Although the exact characteristics of, and schedules for, future transmission additions and upgrades are not precisely predictable, the following bulk power transmission improvements, although not certain, are reasonably foreseeable for the Fargo vicinity:

- Winnipeg-Fargo 500 kV
- Central North Dakota-Fargo (or Grand Forks) 345 kV
- Sheyenne-Audubon-Hubbard-Riverton rebuild to 345 kV
- Fargo-Brookings Co 345 kV (or higher)
- Additional connections of windfarm outlet lines to the Fargo 230 or 345 kV system
- Upgrade or rebuild of existing WAPA 115 and 230 kV lines to higher voltage.

Consideration of these possible future developments is undertaken in the following section.

Connecting one or more 500 kV lines to the Fargo area transmission system is best accomplished at a new site, where connection can be made to multiple 345 kV lines; this would be most practical at a new “north-side” site, or adjacent to the existing WAPA Fargo substation. The Flint site is also a candidate, but will soon be engulfed by urbanization, rendering it of limited long-term accessibility for new 345 or 500 kV lines unless suitable rights-of-way are reserved now.

Establishing the 500/345 kV transformation is not recommended at Maple River, as that would tend to cause excessive concentration of EHV facilities at one site; this would lead to on-going reliability concerns. Maple River’s relatively low elevation is also a disadvantage. A northwest site, such as Bison, or a site adjacent to the WAPA substation would be best for this 500/345 kV development.

The Central North Dakota-Fargo 345 kV line is likely to be motivated by increased need for west-east transmission capacity to accommodate generation developments in central and western North Dakota. For reliability reasons it is best to keep this line separate from the existing center-Jamestown-Buffalo 345 kV line. Development of a Fargo 345 kV “west side loop” provides flexibility with regard to this line’s eastern terminus.

The Sheyenne-Audubon rebuild to 345 kV or double circuit 345/230 kV is a likely future development because it would establish a second North Dakota-Twin Cities 345 kV path, without need for a new transmission right-of-way. The Flint substation development is an important component because the existing Sheyenne site is not capable of the expansion necessary to accommodate a 345 kV switchyard and 345/230 kV transformers.

A Fargo-Brookings Co line at 345 kV--or possibly higher voltage--is likely if additional north-south power transfer capability (beyond that provided by the Twin Cities - Fargo and Sheyenne-Audubon projects) is desired. If developed at 345 kV, it could originate at Flint, or any location on the "west side loop". If developed at 500 kV, it would most likely be an extension of the Winnipeg-Fargo 500 kV development, and would therefore originate at whatever Fargo location was selected for the Winnipeg-Fargo 500 kV connection.

There is considerable interest in exploitation of wind energy resources in the region immediately west of Fargo. Hundreds of MWs of wind-powered generation are presently under construction, and many hundreds or thousands more are likely to proceed during the next 10 years. Some of these developments may lead to the construction of 230 or 345 kV lines eastward to the Fargo power system, for ultimate delivery of windfarm output to remote consumers. Development of a "west side loop" will facilitate connection of such generator outlet lines.

Upgrade of WAPA 230 kV lines to 345 kV would be facilitated if the "west side loop" portion of the new Fargo line were routed in the vicinity of the WAPA Fargo Substation.

Considering all the above information, it is evident that the Recommended Plan for the Twin Cities-Fargo line's Fargo termination should, at minimum, include

- routing of the 345 kV line through the future Flint Substation site and then around the west side of Fargo, passing near the WAPA substation if possible;
- acquisition of the Flint Substation site
- establishment of a 345/230 kV substation northwest of Fargo ("Bison" or equivalent)

6.5 Land Use Considerations

Routing the Twin Cities - Fargo 345kV line around the east and north sides of Fargo/Moorhead would require significant extra mileage to avoid height restriction areas associated with the Hector International Airport, which is located directly east of Maple River Substation.

The existing Maple River substation site is relatively unencumbered, but does have a small housing development immediately to the north. Access for future lines is believed to be fairly constrained, as some recent transmission line easement acquisitions in the area have proven difficult and contentious. In addition, installation of large amounts of additional transformer capacity could lead to noise complaints. This site is suitable for continued 345 and 230 kV expansion but is not recommended for 500/345 kV development. From Maple River southward, the 45th St alignment offers a wide road/drainage ditch corridor for an additional transmission line to the Cass Co substation.

The Cass County substation site has land available for development of additional 115, 230 or 345 kV facilities.

The Sheyenne 230/115 kV substation is located on the south side of Fargo. Until recently, it was in a rural setting, but Fargo's expansion has reached Sheyenne on the north, east, and south, and some development is occurring to the west and southwest. The site is constrained by roads on the north and west, development on the east, and a holding pond to the south. Acquisition of transmission line access to this location has become commensurately more difficult; future circuits will likely need to be established by double-circuiting existing lines.

The Sheyenne site is not suitable for 345 or 500 kV development but can support some additional 230 and 115 kV development.

The WAPA Fargo 230/115 kV substation site is 4 miles directly west of Sheyenne Substation. Transmission line access directly from the north is beginning to get constrained by the westward expansion of West Fargo. The site is still accessible from the northwest, west, and south.

The "Flint" site is located approximately 2 miles south of Sheyenne. Undeveloped land is present where the WAPA Fargo-Moorhead-Morris 230 kV line crosses 45th St diagonally.

7.0 Conclusions and Recommendations

The Recommended Plan for the Fargo termination of the Twin Cities-Fargo line and continued development, if desired, of increased southward power transfer capability consists of three phases:

Phase 1

- Route the new Twin Cities-Fargo 345 kV line to the south and west of Fargo;
- Terminate the 345 kV line at a new Bison Substation or a similar "northwest" site on the existing Buffalo-Maple River 345 kV line;
- Install two 336 MVA 345/230 kV transformers at selected northwest site;
- Upgrade termination equipment on various 230 kV circuits;
- Build a new Maple River-Cass County 345 kV line; operate at 230 kV; add a 336 MVA 230/115 kV transformer at Cass County

Incremental Southward Transfer Capability: approx. 700 MW
Limiter: Sheyenne-Audubon 230 kV loading following outage of Bison-Alexandria 345 kV

Note that the Maple River-Cass County 230 kV line is not necessary to achieve 700 MW of generation output deliverability; its purpose at this stage is for Fargo area load-serving.

Phase 2

- Route Twin Cities - Fargo 345 kV line through Flint site, loop-in the Sheyenne-Audubon 230 kV line, install 345/230 kV transformer (336 MVA);
- Rebuild Sheyenne-Audubon-Hubbard-Riverton-Benton County 230 kV line as 345/230 kV double circuit from Flint eastward;
- Extend Maple River-Cass County 230 kV circuit to Flint Substation by double-circuiting the southern portion of the Maple River-Sheyenne 230 kV line and the eastern section of the Sheyenne-Fargo 115 kV line;
- Add 345/230 kV transformer at Riverton;
- Reconductor Sheyenne-Flint 230 kV to 954 kcm ACSS;
- Reconductor Maple River-Sheyenne 230 kV;
- Upgrade termination equipment on various 230 kV circuits

Incremental Southward Transfer Capability: approx. 600 MW (total of 1300 MW)
Limiter: Dorsey-Roseau Co-Forbes-Chisago Co 500 kV

Note: an alternate "Phase II" option is addition of a Fargo-Brookings Co 345 kV line; see below.

Phase 3

- Add second circuit to Twin Cities-Fargo 345 kV line;
- Convert Maple River-Cass Co-Flint 230 to 345 kV;
- 3 other minor upgrades

Incremental Southward Transfer Capability: approx. 400 MW (total of 1700 MW)
Limiter: Dorsey-Roseau Co-Forbes-Chisago Co 500 kV

Figure 7.1
Recommended Plan, Phase 1

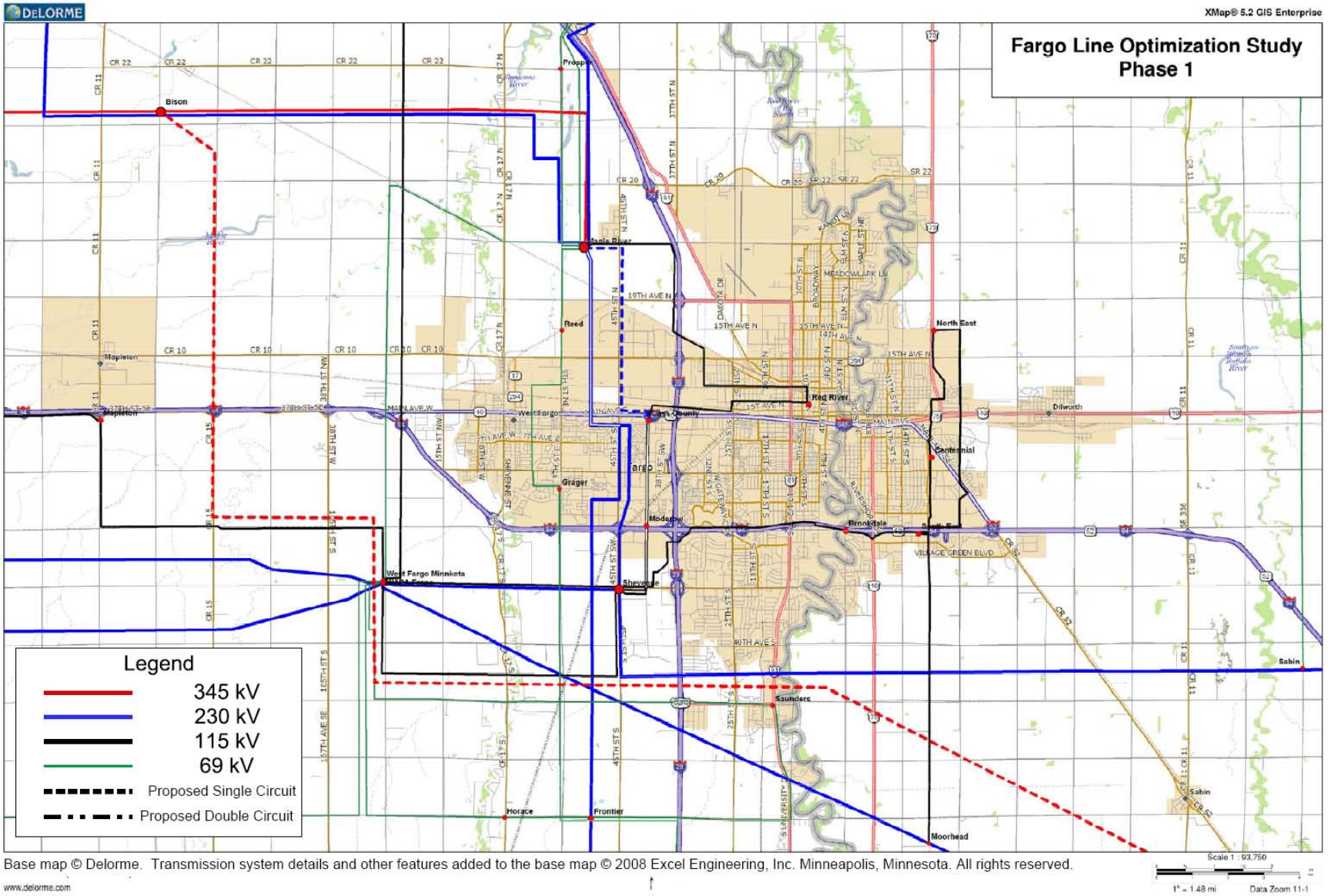


Figure 7.2
Recommended Plan, Phase 2

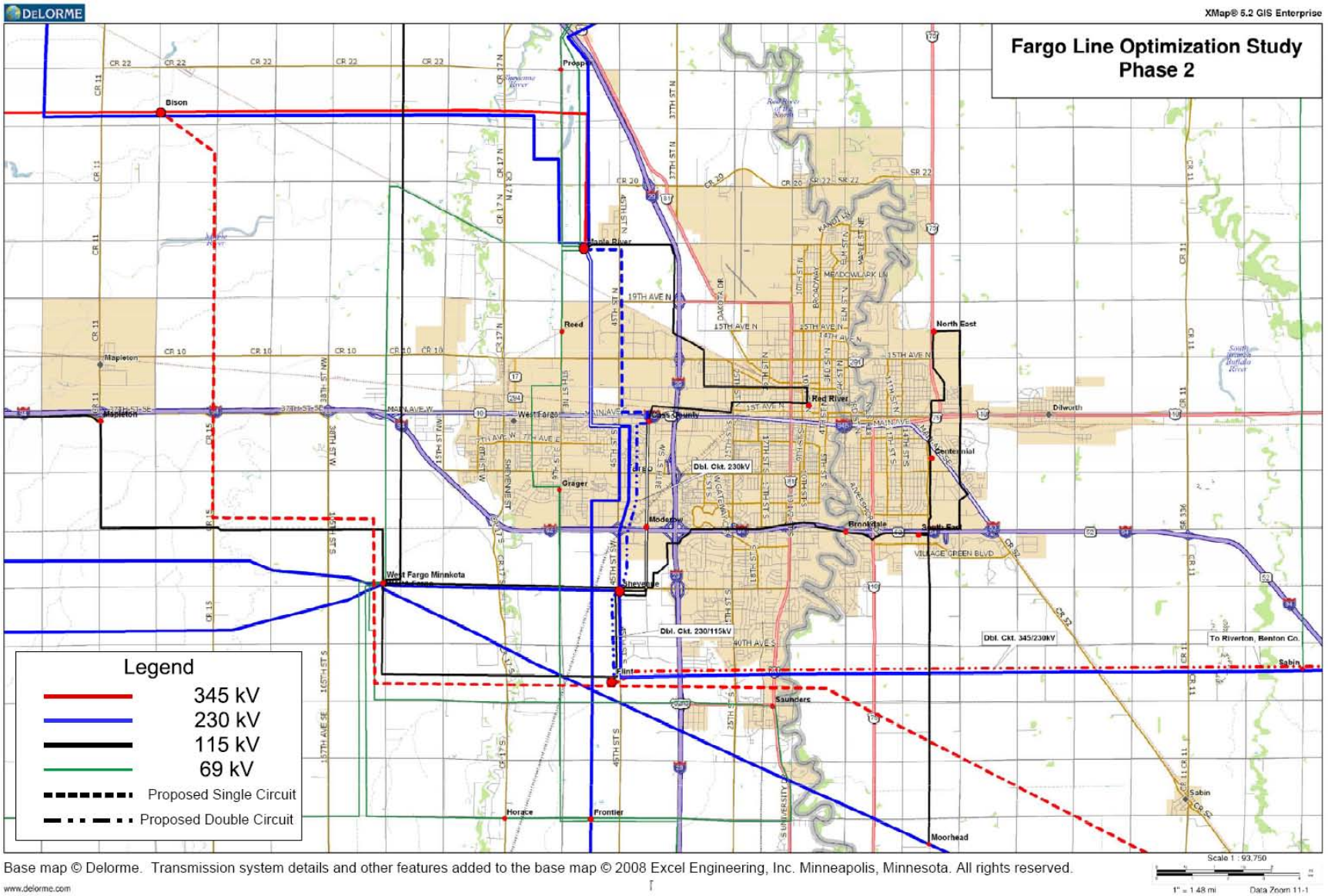
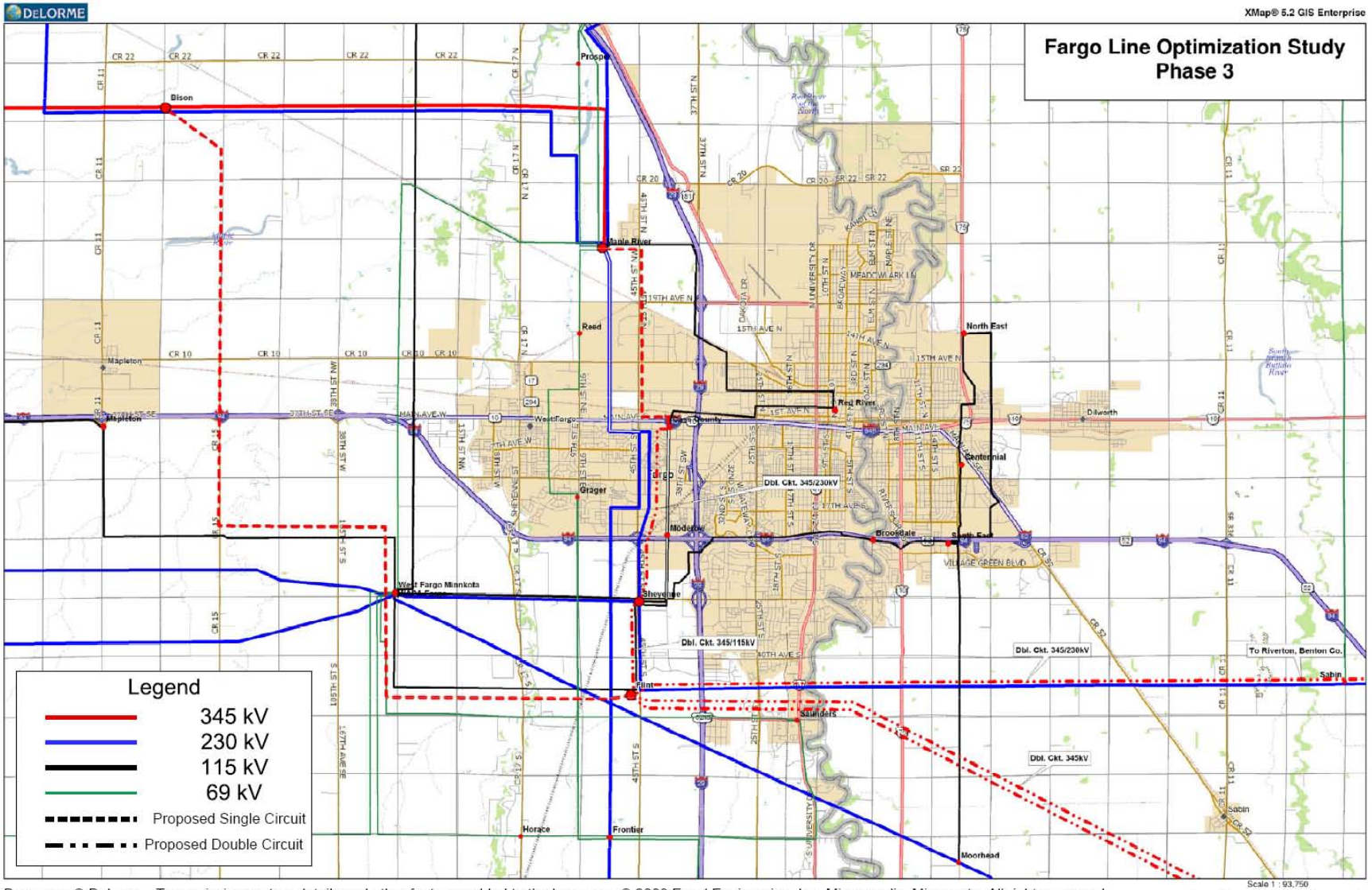


Figure 7.3
Recommended Plan, Phase 3



Alternate Phase 2 (or alternate to/addition to, Phase 3)

- Build Fargo-Brookings County 345 kV line
- Reconductor Maple River-Sheyenne-Flint 230 kV with ACSS
- Reconductor Maple River-Frontier 230 kV with ACSS
- Reconductor Maple River-Bison 230 kV with ACSS
- 6 other minor upgrades

Incremental Transfer Capability: approx 400 MW (total of 1100 MW as Phase 2 alternate)
Limiter: Sheyenne-Audubon 230 kV line

Verification of Daniel P. Kline

STATE OF NORTH DAKOTA
BEFORE THE
NORTH DAKOTA PUBLIC SERVICE COMMISSION

NORTHERN STATES POWER COMPANY
FARGO-MONTICELLO MN 345 KV
CAP-X TRANSMISSION LINE
SITING APPLICATION

CASE NO. PU-07-759

VERIFICATION

STATE OF MINNESOTA)
) ss.
COUNTY OF HENNEPIN**)**

I, Daniel P. Kline, being first duly sworn on oath, deposes and says that he is the Manager, Regulatory Administration (Transmission), for Xcel Energy Services Inc. as agent for Applicant Northern States Power Company, a Minnesota corporation, in the above captioned matter; that he has read Applicant's late-filed exhibit 30, knows the contents thereof, and that the same is true and correct to the best of his knowledge and belief.

Daniel P. Kline

Subscribed and sworn to before me this 24th day of February, 2012.

Notary Public
My Commission Expires:

CYNTHIA D. HARRINGTON
NOTARY PUBLIC
MINNESOTA
My Commission Expires Jan. 31, 2015

Late-Filed Exhibits 32 and 33

NORTH DAKOTA

PUBLIC SERVICE COMMISSION

NORTHERN STATES POWER COMPANY
FARGO-MONTICELLO MN 345 KV
CAP-X TRANSMISSION LINE SITING
APPLICATION

Case No. PU-07-759

AFFIDAVIT OF DARRIN F. LAHR

STATE OF MINNESOTA)
) ss
COUNTY OF Hennepin)

I, Darrin F. Lahr, under oath, state the following:

Introductory Information

1. My name is Darrin F. Lahr and I am a Supervisor, Siting and Land Rights, Xcel Energy Services Inc., as agent for Northern States Power Company, a Minnesota corporation, ("Xcel Energy" or the "Company") applicant in the above referenced case.

2. As Supervisor, Siting and Land Rights, I am the Company employee responsible for all state permitting activities related to the North Dakota portion of the Fargo to Monticello 345 kV Transmission Project ("Fargo Project").

3. I am the same Darrin Lahr that testified before the North Dakota Public Service Commission (the "Commission") at the hearing for the above referenced case held in Fargo, North Dakota on January 30, 2012 (the "Hearing").

4. The purpose of my affidavit is to provide information to the Commission related to the assessment of mitigation options for the Kraft property with respect to the airstrips and the routing options on the boundary of the City of Mapleton, North Dakota. This information is intended to serve as late-filed exhibits 32 and 33 in the above referenced case.

Assessment of Mitigation Options for Kraft Airstrips

5. At the Hearing, the Company was asked to provide a late-filed exhibit regarding mitigation options of the airstrips owned by the Krafts, who also testified at the Hearing. This exhibit was labeled as late-filed exhibit 32. This section of my affidavit is intended to provide this information.

6. Mr. Kraft owns two airstrips that are facing north-south and are adjacent to each other. The airstrips are located Mapleton and Durbin Townships, Cass County approximately, 2,700 feet east of the Proposed Route for the Fargo Project. The airstrips are private airstrips and are not governed by Federal Aviation Authority ("FAA") rules and guidelines.

7. In assessing possible mitigation options for the Krafts' airstrips, the Company first prepared a drawing showing what clearances would have been necessary if the Krafts' airstrips were governed by FAA rules and guidelines. This evaluation was used to provide some guidance as to appropriate mitigation measures. This drawing is attached as Schedule 1.

8. As Schedule 1 demonstrates, the proposed Route for the Fargo Project would comply with FAA clearances for public airports and the FAA clearances would not, if they were applicable to the Krafts' airstrips, bar construction of the Fargo Project along the proposed Route, except for the poles which must be engineered to be somewhat taller than the FAA imposed 150 feet height limit which are required to clear the existing 230 kV transmission lines in the area (approximately 185 feet tall). However, these taller poles will be very near to the more impactful obstruction of the existing 230 kV transmission lines.

9. Although the proposed Route for the Fargo Project would generally not affect an FAA governed airstrip , as demonstrated by Schedule 1, the Company is prepared to explore mitigation options with the Krafts. These options include: (a) marking a section of the Fargo Project with marker balls or similar aids to improve visibility of the transmission line; and (b) slightly adjusting the proposed Route of the Fargo Project by moving it approximately 2,600 feet west in order to provide additional clearances for the Krafts' airstrips.

10. The potential adjustment to the proposed Route described above, and shown in Schedule 1, would provide additional clearances but will require a waiver of the neighboring landowner as such adjustment would move the Fargo Project within 500 feet of the neighboring landowner's residence. Preliminary engineering work for such an adjustment shows that making the adjustment would add at least $1.6 million to the cost of the Fargo Project.

11. The Company has been diligently trying to schedule time with the Krafts to discuss these options but has not been able to do so. Specifically, land rights agents, at my direction, contacted Mr. Kraft on February 10, 13, and 20, 2012 to schedule a meeting . The Company will continue to work with the Krafts and the neighboring landowners to try to accommodate their concerns and keep the Commission apprised of this on-going work.

Routing Options on the Boundary of the City of Mapleton

12. At the Hearing, the Company was asked to provide a late-filed exhibit regarding routing options on the boundary of the City of Mapleton. This exhibit was labeled as late-filed exhibit 33. This section of my affidavit is intended to provide this information.

13. The centerline of the proposed Route for the Fargo Project will be approximately 40 feet from the city limits of the City of Mapleton, and the City of Mapleton asserts that it will be fully within the City's extraterritorial boundaries. The proposed Route in this area was selected in consultation with impacted landowners to minimize agricultural impacts by avoiding placement of the project through the center of their fields. The placement of the poles remains on the same affected landowner's property.

14. While the centerline of the transmission line will be located outside the City of Mapleton's boundaries, approximately 32 feet of the 150-foot right-of-way is proposed to be within the City of Mapleton's boundaries. Due to this slight impact, the Company requires a Conditional Use Permit ("CUP") from the City of Mapleton.

15. In December of 2011, the Company applied for a CUP from the City of Mapleton.

16. After receiving the Company's CUP application, the City of Mapleton imposed an additional requirement on the Company to obtain signed easement options or other evidence that affected landowners do not oppose the Proposed Route for the Fargo Project. The Company then set about complying with the requirement.

17. The area affected by the City of Mapleton's request comprises 9 different tax identification parcels with 7 different owners. Of these 7 owners, 4 are members of the same family and are represented by the a single representative of that family.

18. As of the date of this affidavit, the Company has received signed options from 3 of the landowners comprising 5 of the 9 parcels.

19. The remaining 4 parcels and remaining 4 landowners are all represented by a single representative of that family. The Company has been in contact with the representative of that family who has confirmed that all the family members owning a fee interest in the remaining 4 parcels are willing to enter into option agreements with the Company. The Company has provided option agreements to these landowners for signature. However, due to logistical reasons, including that 3 of the 4 landowners live outside of North Dakota, the Company has not, as of the date of this affidavit, received the signed option agreements from these landowners. The Company believes the executed option agreements to be forthcoming shortly and will update the Commission when they are received. One of these parcels for which the Company has reached tentative agreement with this family contains the developable land identified in the Letter of the City of Mapleton, dated January 27, 2012 and entered into the record in the above referenced case as exhibit Hillman 1.

20. Because the Company has been able to reach agreement with all affected landowners, Xcel Energy does not believe that additional routing options on the boundary of the City of Mapleton need be developed. The Company intends to proceed with the CUP process with the City of Mapleton.

21. Further, Affiant sayeth not.

Darrin F. Lahr

Subscribed and sworn to before me this

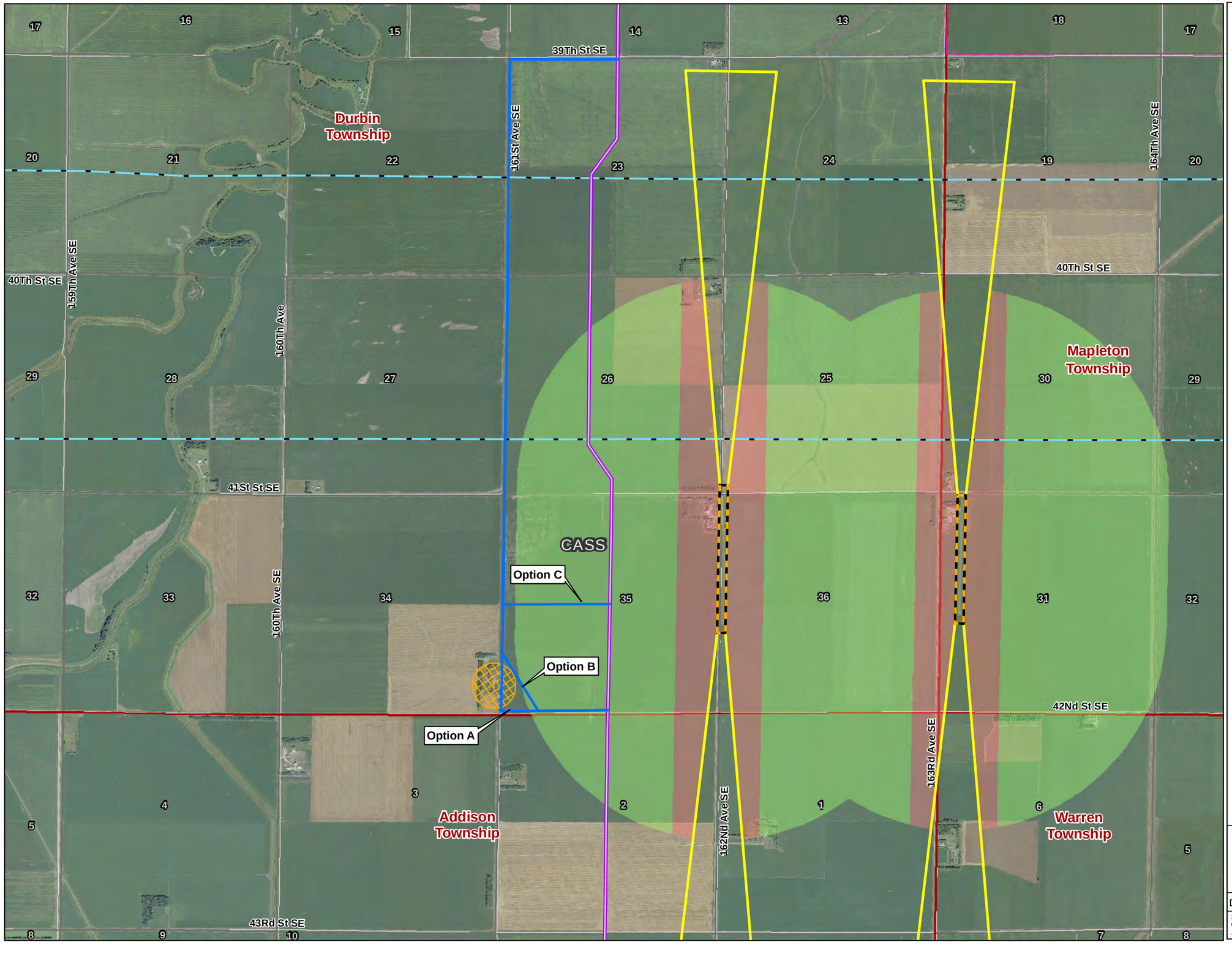
27th day of February, 2012.

Theresa A. Senart

Notary Public

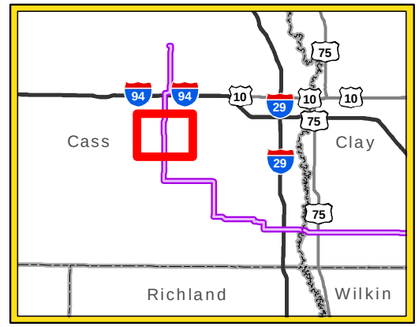
THERESA A. SENART
Notary Public
Minnesota
My Commission Expires January 31, 2015

Schedule 1 to Lahr Affidavit



CapX2020

Delivering electricity you can rely on



Legend

- Potential Alignment Alternative
- Residence 500 ft Setback
- Proposed Alignment
- FAA Allowable Height 150 Ft
- FAA Allowable Height (less than 150 ft)
- Primary Surface
- Approach Slope Clearance Zone
- Municipal Boundary
- Township Boundary
- Existing Substation

Existing Transmission Line

- 345
- 230
- 115
- 69

FAA Standards Source:
NDCC 6-02-03

DRAFT

1:27,000

N W E S

0 1,000 2,000 4,000 Feet

Fargo to St. Cloud
ND Kraft Airport
Alignment Alternatives

DRAWN BY: MLTEICHERT	DATE: 02/24/12
Xcel\0122295 CapX Monticello to Fargo\GIS\Fargo\MXD\2011\01\Airports_ND_CapxF_ND_Southern_Airport.mxd	