Feasibility Study Report for PSCo OASIS Request # GI-2003-4

Large Generation Interconnection Request for a 30 MW Wind Generation Test Facility

Xcel Energy Transmission Planning
February 2, 2004

Executive Summary:

Power flow studies were performed to determine the feasibility of interconnecting a Customer-proposed 30MW wind generation test facility into the Public Service Company of Colorado (PSCo) Ponnequin 115kV Substation, which in turn connects into Western Area Power Administration's (Western) 115kV Cheyenne – Rockport transmission line. The proposed new Customer wind generation test facility interconnection would be sited just north of the Colorado – Wyoming border, and would tie into PSCo's Ponnequin Substation, located just south of this border. The requested in-service date is late 2004.

The power flow studies performed for the Network Resource (NR) analysis portion of this Study show that the Customer generation facility would have minimal impact on the PSCo and Western transmission systems in this area. However, it appears that the new Customer generation injection at Ponnequin could have a slight negative impact on the TOT3 control area interface rating, as identified in similar studies performed by Western for this proposed Customer generation. The Energy Resource (ER) analysis portion of this study indicate that 20MW to 30MW of this proposed Customer generation could be delivered into the transmission system with no infrastructure modifications required to the existing transmission system. Based upon the studies performed for this LGIR, it would be feasible to interconnect this Customer 30MW wind generation facility into the PSCo Ponnequin Substation / Western 115kV transmission system.

The PSCo infrastructure modifications assumed to be required for this proposed interconnection include installing some minor 115kV equipment at PSCo's Ponnequin Substation. It is assumed that the Customer will install and own its associated interconnection equipment to be installed at the Ponnequin Substation,

such as the main 115 – 34.5kV transformer, 115kV fault interrupter, and other associated Customer–owned substation equipment. The total estimated indicative (+/-25%) cost for the PSCo portion of this Customer interconnection at Ponnequin Substation is $250,000.00. This estimate includes the costs for the PSCo engineering design and construction associated with this Customer generation interconnection at PSCo's Ponnequin Substation. The PSCo design and construction would require approximately 6 to 7 months to complete, after obtaining authorization to proceed. These estimates do not include any engineering or other costs that would likely be required associated with Western's Engineering and Planning personnel. Preliminary discussions with Western and the Customer have indicated that Western would have direct involvement in the later studies and work associated with the review of detailed Customer interconnection facilities design and controls.

Introduction

Xcel Energy Transmission received on November 11, 2003 a large generation interconnection request to interconnect a wind testing turbine facility, with a total installed net output capacity not to exceed 30MW, +/- 0.90 power factor. The project proposes to be completed in two phases, with each phase comprised of ten (10) wind turbines of varying design, and an approximate net output of 15MW. The original requested Commercial Operation In-Service Date was summer, 2004, however this was revised to late 2004 in meetings held with the Customer in December 2003, and January 2004. The location of the proposed wind farm for phase one is Section 18, Township 12-North, Range 66-West, and for phase two in Section 12, Township 12-North, Range 67-West, both of which are located in Laramie County, Wyoming.

As indicated by the information supplied by the Customer in this request, this wind farm proposes to install: generators and collector facilities in Wyoming, construct an approximately 2-mile 34.5kV underground distribution line to the existing PSCo Ponnequin Substation located just inside the northern Colorado border, and interconnect with the PSCo and Western transmission systems via a to be installed 34.5 – 115kV main transformer at PSCo's Ponnequin Substation. The Customer has requested that this Project be evaluated as a Network Resource (NR) and an Energy Resource (ER) with the energy going to PSCo customers.

Interconnection Feasibility Study Scope and Analysis

This Large Generation Interconnection Feasibility Study was performed to evaluate the feasibility of the proposed Customer 30MW wind generation interconnection to

the Transmission System at PSCo's Ponnequin Substation. The existing Ponnequin Substation is a transmission line tap off of Western's Cheyenne – Rockport 115kV line section. This section of 115 kV line is approximately 13.6 miles long, with Ponnequin Substation located approximately 8 miles from Cheyenne Substation, and 6 miles from Rockport Substation. As per section 6.2 of the FERC LGIP, the Study considered the Base Case as well as all Generating Facilities (and with respect to (iii), any identified Network Upgrades) that exist on the date the Interconnection Feasibility Study was commenced:

(i) are directly interconnected to the Transmission System;
(ii) are interconnected to Affected Systems and may have an impact on the Interconnection Request;
(iii) that have a pending higher queued Interconnection Request to interconnect to the Transmission System; and
(iv) have no Queue Position but have executed an LGIA or requested that an unexecuted LGIA be filed with FERC.

The Study consists of power flow, and short circuit analyses. PSCo adheres to NERC / WECC Reliability Criteria, as well as Company criteria for planning studies. During system intact conditions, criteria are to maintain transmission system bus voltages between 0.95 and 1.05 per-unit of system nominal / normal conditions, and steady state power flows within 1.0 per-unit of all elements thermal (continuous current or MVA) ratings. Operationally, PSCo tries to maintain a transmission system voltage profile ranging from 1.03 per-unit at generation buses, to 1.0 per-unit or higher at transmission load buses. Following a single contingency element outage, transmission system steady state bus voltages must remain within 0.90 per-unit to 1.10 per-unit, and power flows within 1.0 per-unit of the elements continuous thermal ratings.

The power flow study analysis provides a preliminary identification of any thermal or voltage limit violations resulting from the interconnection. For a Network Resource (NR) Interconnection Service Request, the power flow studies provide a preliminary identification of infrastructure required to deliver the proposed Customer generation to serve native load customers. For an Energy Resource (ER) Interconnection Service Request, the power flow studies provide a preliminary indication of the maximum proposed Customer generation level that can be delivered into the Company's existing transmission system, without requiring any infrastructure additions or modifications to the existing transmission system.

The short circuit analysis provides a preliminary identification of any circuit breaker short circuit capability limits exceeded as a result of the Interconnection, and for a NR request, the delivery of the proposed generation.

Power Flow Study Models:

The power flow study performed simulates load flow cases at or near the WECC published TOT3 rating limits for 2003 heavy summer system intact conditions, for a couple of different generation dispatch conditions. TOT 3 sensitivities were studied by changing the output of the Pawnee, Brush, and Laramie River generating stations that included a model of the full 30 MW output of the proposed wind farm, in addition to the 30MW total output of the existing PSCo Ponnequin Wind Farm generation facility. See Appendix C for TOT3 Details. The generation dispatch conditions used for this Study correspond to two of the several possible scenarios, specifically for the system intact TOT3 power flow transfers at 1579MW, and 1252MW levels. As was the case for recently run and completed studies performed by Western, the WECC approved, 2004hs1-sap scenario case model was used as a starting point.

The generation was re-dispatched, with PSCo and Western control area interchanges adjusted, and area swing generators redefined to stress flows from PSCo's northern transmission system to its southern system. As a NR request, the proposed new Customer 30MW generation was scheduled to the Denver Metro Area and/or Southeast Colorado peaking units, and single contingency outages performed using the PTI PSS/E power flow program's ACCC routine. For the ER portion of the study, power flow studies were repeated for the lines that exceeded their thermal ratings at the full 30MW Customer generation level, which were not overloaded at the 0MW Customer generation level. The contingency outage cases were repeated with the Customer generation lowered from 30MW (-14.5MVAR, 0.90 pf lead) to 20MW (-9.7MVAR, 0.90 pf lead), and finally to 10MW (-4.8MVAR, 0.90 pf lead). The reduced generation was compensated for by increased generation in the PSCo control area swing bus / plant (Comanche1 for these studies). The identified line flows were monitored, with corresponding single contingency outages taken for each case run. This procedure was used to identify the Customer generation level at which the thermal overloads of the specific transmission elements (lines) that were identified from the ACCC NR analysis were eliminated.

Note that this Xcel Energy performed Generation Interconnection Feasibility Study did not include a comprehensive analysis of TOT3. A full TOT3 analysis would be part of a later Interconnection System Impact Study during which the Affected System Operators would need to be included in the Study process, as per the LGIP rules. However, the more detailed TOT3 impact studies and related power flow cases and models already created and performed by Western, as supplied by the Customer to Xcel Energy, were referenced as deemed appropriate.

The 30MW Customer wind farm was modeled as a single 30MW equivalent generator, 34.5kV, with a +/- 0.90 per-unit power factor capability (+/-14.6 MVAR total), however the leading p.f. (14.6MVAR into the generator) condition was assumed to maximize the potential impact on the 115kV transmission system. To compensate for the VAR requirements of the generators, and consistent with Western's system operational criteria, switched capacitors were modeled on the Customer's 34.5kV generation bus. Customer specified 34.5kV UG cable was modeled from collector site to Ponnequin Substation, and a Customer 115-34.5kV, 60/80/100MVA (65C) transformer added at the PSCo Ponnequin Sub 115kV bus. This is consistent with the preliminary modeling information that Customer has provided with this request, noting that due to the nature of this test facility, individual generator detailed electrical data was not provided by the Customer with this request package. The existing PSCo Ponnequin Sub equipment was also included in the Study models, and included: a single lumped equivalent 30MW, -6.1MVAR (0.98 pf lead), 26.1kV generator, 115-26.1kV 18/24/30/33.6MVA transformer, and 5 x 3MVAR, 26.1kV switched capacitors. More detailed, site-specific data would need to be provided by the Customer when and if more detailed facility studies are performed in the future.

Power Flow Study Results and Conclusions:

Network Resource (NR) Study Results:

Two main power flow scenario cases were used to run the PTI PSS/E program's ACCC contingency analysis routine to perform single contingency outages of all system elements (transmission lines and transformers) in the PSCo and Western control areas in this Colorado – Wyoming region. The contingency runs were performed for cases with the proposed new Customer Ponnequin generation at levels of 0MW, and repeated for generation at 30MW / -14.5MVAR (0.90 pf lead). The existing PSCo Ponnequin wind generation was fixed at 30MW / -6.1MVAR (0.98 pf lead) for all runs. Sample power flow system one line diagrams of the immediate Ponnequin area, system intact conditions, are included in Appendix B for reference / information. The ACCC overload report generated lists the transmission system elements that exceed their thermal ratings, or fall outside of the voltage criteria. The listings were examined for differences between the listed elements with the new Customer generation off (0MW) versus on (30MW). This comparison provides insight as to what influence that this new generation could have on the transmission system elements, and an indication of the potential impact on the TOT3 limit ratings for these conditions.

The results of these studies illustrate that the injection of the proposed new 30MW Customer wind generation into the transmission system at PSCo Ponnequin Substation is feasible, with only minor impact on the contingency outage overloads on the PSCo and Western transmission systems. Of the new thermal overloads resulting from the added 30MW of Customer generation at Ponnequin, the TOT3 1579MW flow (CPP 68MW) dispatch case resulted in the following new transmission line overloads:

Owner	Transmission Line	Rating (MVA)	Outage (N-1)	Flow % Rate (Cust. 0MW)	Flow % Rate (Cust. 30MW)
PSCo (70)	Den Term – Elati3 230	405.9	Grn Vly-SkyRnchT 230	99	101
PSCo (70)	Den Term – Elati3 230	405.9	Spruce-SkyRnchT 230	99	101
Western (73)	CarterLk – Flatiron 115	80.0	Estes – Lyons 115	99	101
Western (73)	CarterLk – Flatiron 115	80.0	Weld LM – Kodak TP 115	99	101

There were no new transmission line overloads resulting from the added 30MW of Customer generation at Ponnequin for the TOT3 1252MW (CPP 243MW) flow case.

Comparisons of the voltage range violations listings indicated essentially no differences between either of the cases in the number or magnitudes of violations for the Customer generation on vs. off. There were no new transmission bus voltage range violations resulting from the added 30MW of Customer generation at Ponnequin, based upon reviewing the ACCC report listings, and additional manual outage solution runs for the monitored PSCo and Western systems, for either of the TOT3 flow dispatch cases.

Note that the overloaded elements that were common on the ACCC listings to both Customer generation level dispatches (30MW and 0MW) were not investigated any further as part of this Feasibility Study. It would take further, more detailed studies than the power flow studies performed for this Feasibility Study to determine the exact impact on the TOT3 rating. These types of studies would likely be performed as part of a future Interconnection Impact Study, and/or an Interconnection Facilities Study, and coordinated with Western.

Energy Resource (ER) Study Results:

Power flow studies were repeated for the two new line overload cases identified in the NR studies (PSCo Den Term – Elati3 230, and Western Carter Lk – Flatiron 115), using the TOT3 1579MW (CPP 68MW) dispatch case. The

contingency outage cases were repeated with the Customer generation lowered from 30MW (-14.5MVAR, 0.90 pf lead) to 20MW (-9.7MVAR, 0.90 pf lead), and finally to 10MW (-4.8MVAR, 0.90 pf lead). The reduced generation was compensated for by increased generation in the PSCo control area swing bus / plant (Comanche1 for these studies). The identified line flows were monitored, with corresponding single contingency outages taken. The monitored line flows reduced to approximately 100% of line rating for the 20MW Customer generation level, and to approximately 99% of line rating for the 10MW Customer generation level. However, with the possible influence of variable local existing Ponnequin wind generation levels, this study indicates that 20MW to 30MW of this proposed Customer generation could be delivered into the transmission system with no infrastructure modifications required to the existing transmission system. More detailed power flow studies, and investigation / verification of exact line ratings would be warranted before further recommendations could be made regarding requiring any infrastructure improvements associated with this Customer generation as an ER.

Comments on Studies Performed by Western:

As part of performing this Feasibility Study, the Study Reports Part 1 (10-1-03) and Part 2 (12-9-03), Western – RMR & (Customer) Wind Turbine Test Facility (60MW Max Output) Insertion at Ponnequin were reviewed, and copies of two similar PTI PSS/E case models were obtained from Western. It appears that Western's power flow studies concentrated in particular on the Customer Facility's impacts at the 30MW and possible future 60MW new injection levels at Ponnequin. The Western studies appear to have been a more complete and thorough examination on the TOT3 ratings limits, and indicate that any new Customer generation injection at Ponnequin would potentially require operating restrictions on this Customer generation levels under certain system conditions. It further indicates that no Western transmission system improvements would be required for the 30MW Customer generation specifically proposed for consideration in PSCo's Feasibility Study. With respect to the feasibility of the proposed Customer generation interconnection, and general impact on the TOT3 ratings, these results appear to be consistent with the PSCo power flow studies. However, the specific contingency outage overloaded elements listings vary between the Western and similar PSCo case models, likely due to the slightly different generation dispatch and area interchange conditions used for these studies. It also does not appear that the Western power flow studies took single contingency outages for all of the PSCo (area 70) and Western (area 73) control areas. This could lend itself to different ACCC-identified overloaded element listings.

It should further be noted that during this Feasibility Study process, PSCo and Western have shared information relating to not only the power flow and short circuit study data, but have also discussed technical issues relating to the proposed interconnection scope and related design requirements and alternatives. This sharing of information and direct involvement between PSCo, Western, and the Customer would need to continue to an even greater extent should additional studies be requested, and the proposed Customer project proceed towards implementation.

Short Circuit Study Results:

The short circuit analysis at Ponnequin Sub consisted of faulting the 115kV bus at Ponnequin and recording values for 3 phase and single line to ground faults. These values were then compared to Western's fault values for consistency. All fault values are for present (2004) system normal conditions, and do not include any fault current contribution from the existing PSCo or proposed additional Customer wind generation at Ponnequin. The actual fault current contribution from the wind generation, or lack thereof, would have to be determined from additional, more detailed studies, assuming that detailed wind generator model data would be made available.

Fault Type	Estimated Fault Current
3-phase (115kV)	5,800A
Single Line-to-Ground (3I0, SLG)	4,000A

Costs Estimates and Assumptions:

Based upon the Feasibility Study performed here, in order for PSCo to provide an interconnection for the Customer requested generation interconnection at PSCo Ponnequin Substation, transmission system improvements must be made at the PSCo Ponnequin Substation.

The estimated indicative total cost for the identified PSCo additions at Ponnequin Substation is:

$250, 000.00

The estimated cost shown is an "indicative" (+/-25%) preliminary budgetary cost in 2004 dollars, and is based upon typical construction costs for previously performed

similar construction. These estimated costs include all applicable labor and overheads associated with the engineering, design, and construction of these new PSCo facilities. This estimate does not include any costs for any Customer-owned, supplied, and installed equipment and associated design and engineering. This estimate also does not include any costs that may, or may not be required for other entities' systems, e.g. Western.

The improvements assumed necessary to be performed by PSCo include the following. See Appendix A for a preliminary informational Ponnequin Substation One-Line Diagram, and General Arrangement plan drawing.

Ponnequin Substation Improvements (subject to change upon more detailed analysis):

- PSCo will install a new 115kV 3-phase bus tie switch, a new 115kV 3-phase disconnect switch for the Customer step-up transformer tap, (3) 115kV CT/VT combination metering units, and associated revenue metering equipment (electronic meter, recorder, and possible telemetry equipment). The 115kV CT/VT metering units would likely be the longest lead-time delivery items.

- The demarcation point between PSCo and the Customer will be between PSCo's metering units and the Customer's high-side 115kV fault interrupting device (Circuit Switcher, breaker, or equivalent).

- Assumes that Western is not requiring the installation of 115kV line circuit breakers at Ponnequin.

- Since the Customer facility generation will be connected into PSCo's Ponnequin Substation, which is connected directly into Western's 115kV Cheyenne – Rockport transmission line, the Customer will have to meet Western's protection and operational requirements for interconnection into Western's transmission system. Furthermore, it will be a cooperative effort between Western and PSCo for any further / future engineering reviews of the Customer generation and associated equipment designs as it pertains to detailed equipment and control designs associated with the Customer – PSCo – Western interconnection.

- No significant grading or fill work needs to be completed at Ponnequin.

- No additional landscaping needs to be installed at Ponnequin.

- PSCo (or its contractor) crews will perform all construction and wiring associated with PSCo-owned and maintained equipment.

- Customer's wind turbines generators will contribute no or insignificant fault current to Xcel Energy's 115kV bus.

- The estimated time for design and construction for the PSCo additions at Ponnequin Substation is 7 months after authorization to proceed has been received, and based upon other identified assumptions for Siting and Land Rights, and Transmission (see below).

Transmission Engineering and Line Construction:

There is no transmission engineering or line construction required by PSCo with the current scope definition. If Western or the Customer requires/requests an upgrade or change-out of the existing conductor of the span from the dead-end structure outside of Ponnequin Sub to the dead-end structure inside Ponnequin Sub, PSCo will need to provide support.

Siting and Land Rights:

Siting and Land Rights does not anticipate any formal involvement in the project proposal. This assumption is based upon an understanding that the proposed Customer wind generation project will be located north of the existing Ponnequin site within Section 18 in Laramie County, Wyoming and only interconnected to the Ponnequin Substation via one 34.5kV underground distribution line. However, two issues should be addressed involving access and reclamation.

Access: Should the project move forward and access to this proposed site involve use of any portion of the existing access road developed by PSCo for Ponnequin access from the Terry Ranch Road, then the Customer should reimburse PSCo for a reasonable portion of the development costs previously incurred to construct this access road. Additionally, the Customer should commit to repair any damages to this access road incurred during project construction.

Revegetation: The Customer must commit to reclaim any disturbed lands within PSCo's Ponnequin site that occur during construction of the 34.5kV underground distribution line or within the substation site.

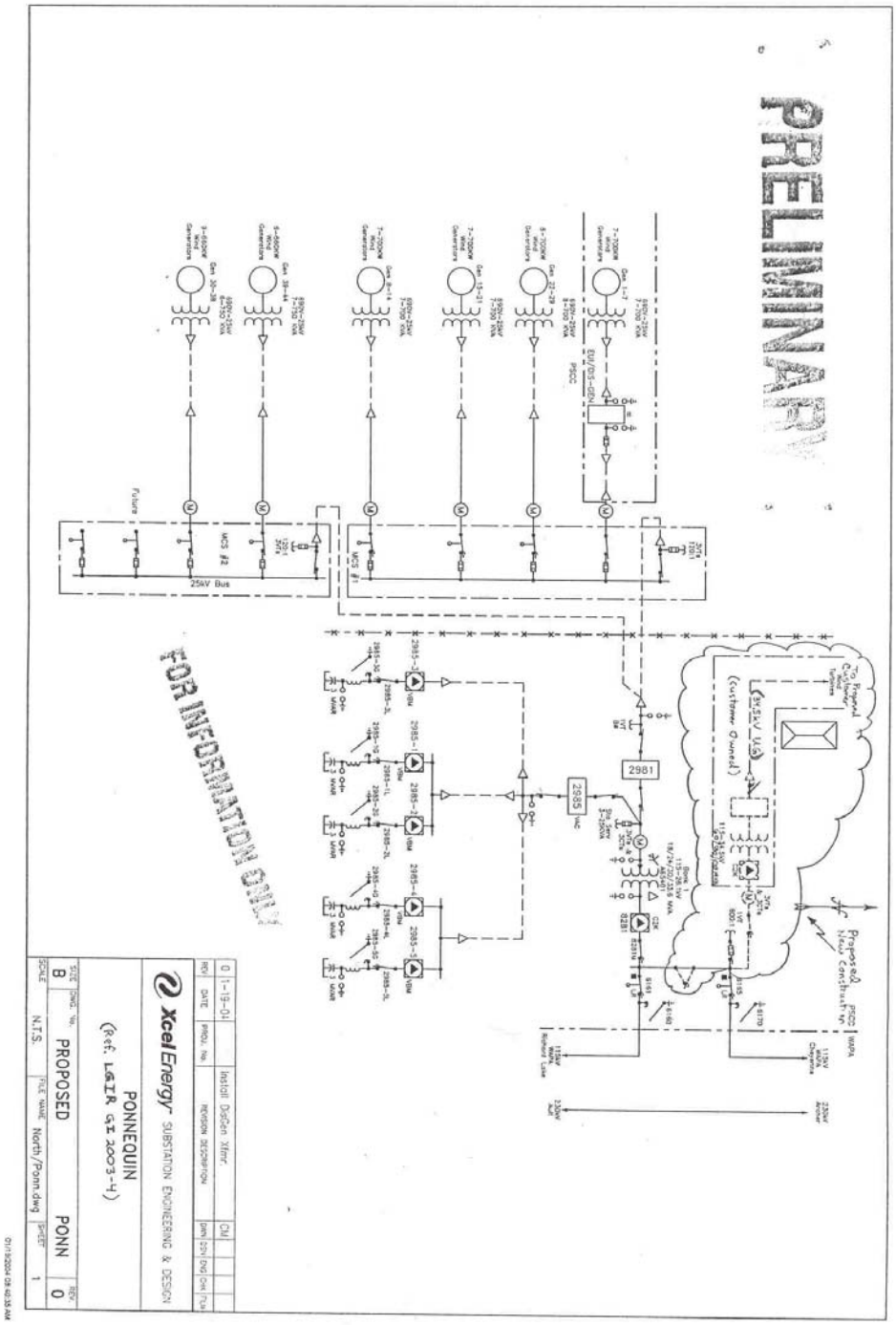
APPENDIX A

PONNEQUIN SUBSTATION

PROPOSED ONE-LINE DIAGRAM

AND

GENERAL ARRANGEMENT DRAWING


PRELIMINARY
FOR INFORMATION ONLY
Xcel Energy SUBSTATION ENGINEERING & DESIGN
PONNEQUIN
(ref. LGIR Gi 2003-4)
PROPOSED
PONN
North/Ponn.dwg
N.T.S.
B
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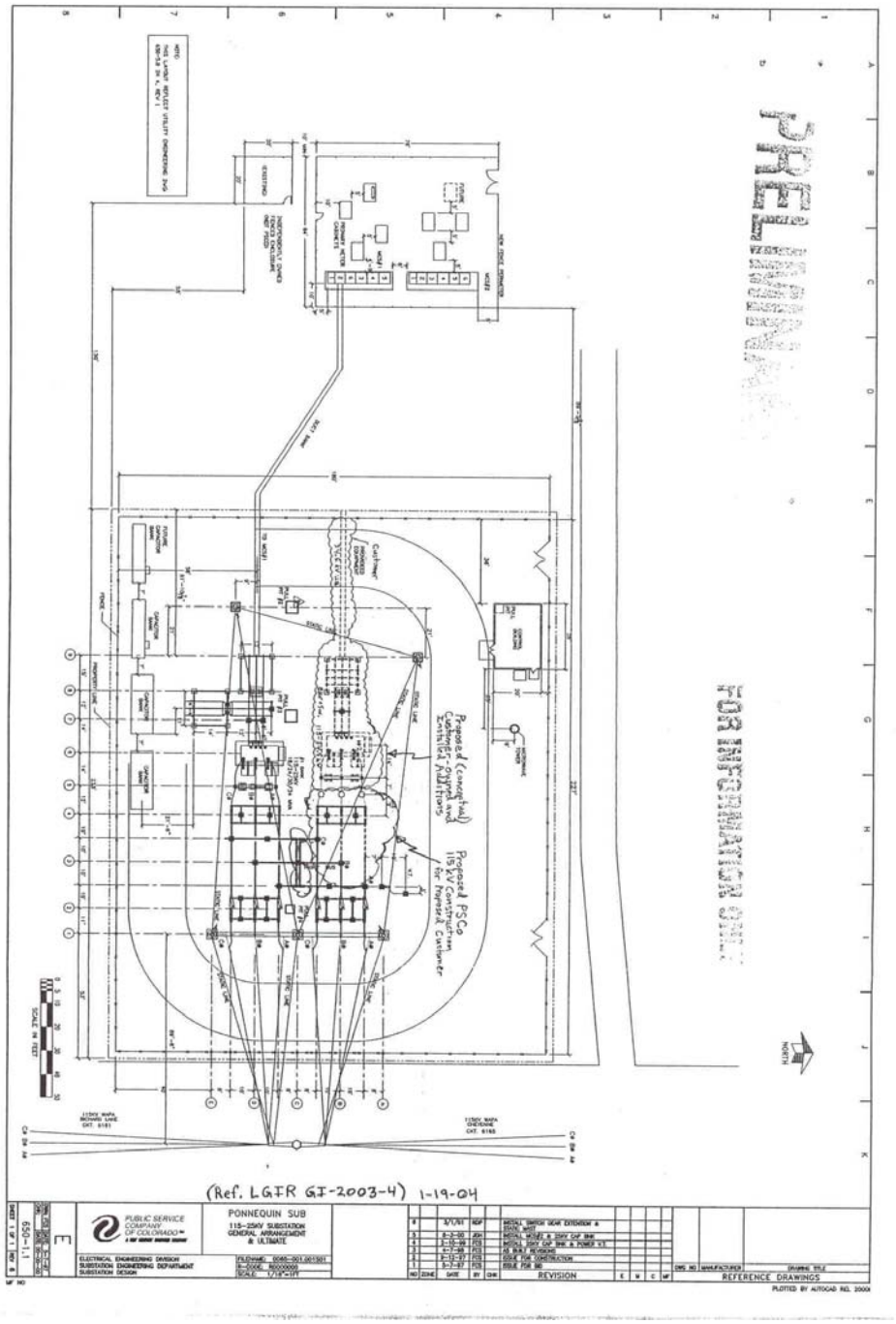
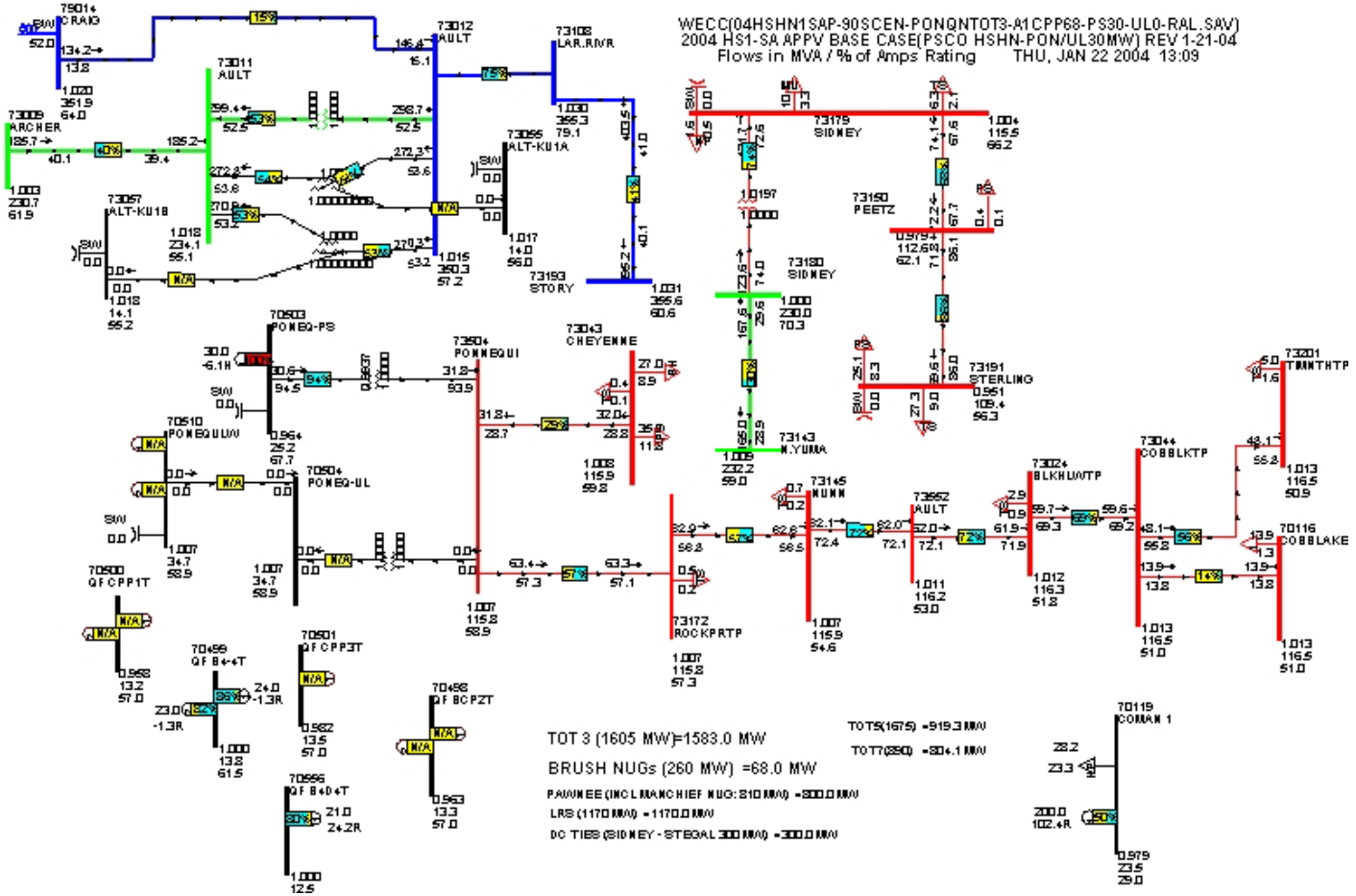
1-15-04
Install Dedon Xfmr
2981
2985
25kV Bus


PRELIMINARY
FOR INFORMATION ONLY
Proposed (conceptual) Customer Equipment Additions
Proposed PSCo 115kV Construction for Planned Customer
(Ref. LGIR GI-2003-4) 1-19-04
PUBLIC SERVICE COMPANY OF COLORADO
PONNEQUIN SUB
115-25kV SUBSTATION GENERAL ARRANGEMENT & ULTIMATE
ELECTRICAL ENGINEERING DIVISION
SUBSTATION ENGINEERING DEPARTMENT
SUBSTATION DESIGN
REVISION
REFERENCE DRAWINGS

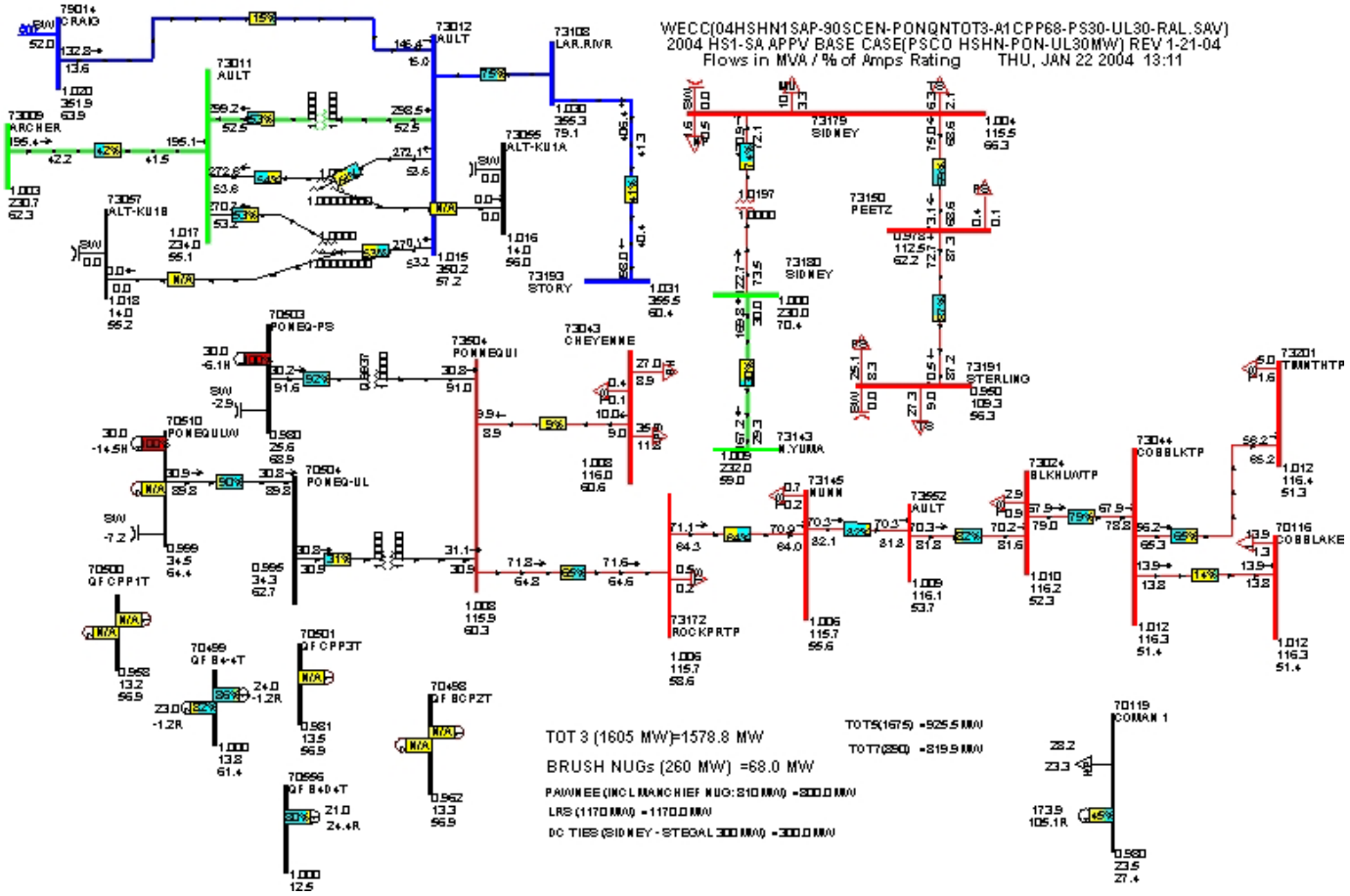
APPENDIX B

SAMPLE POWER FLOW SYSTEM ONE-LINES



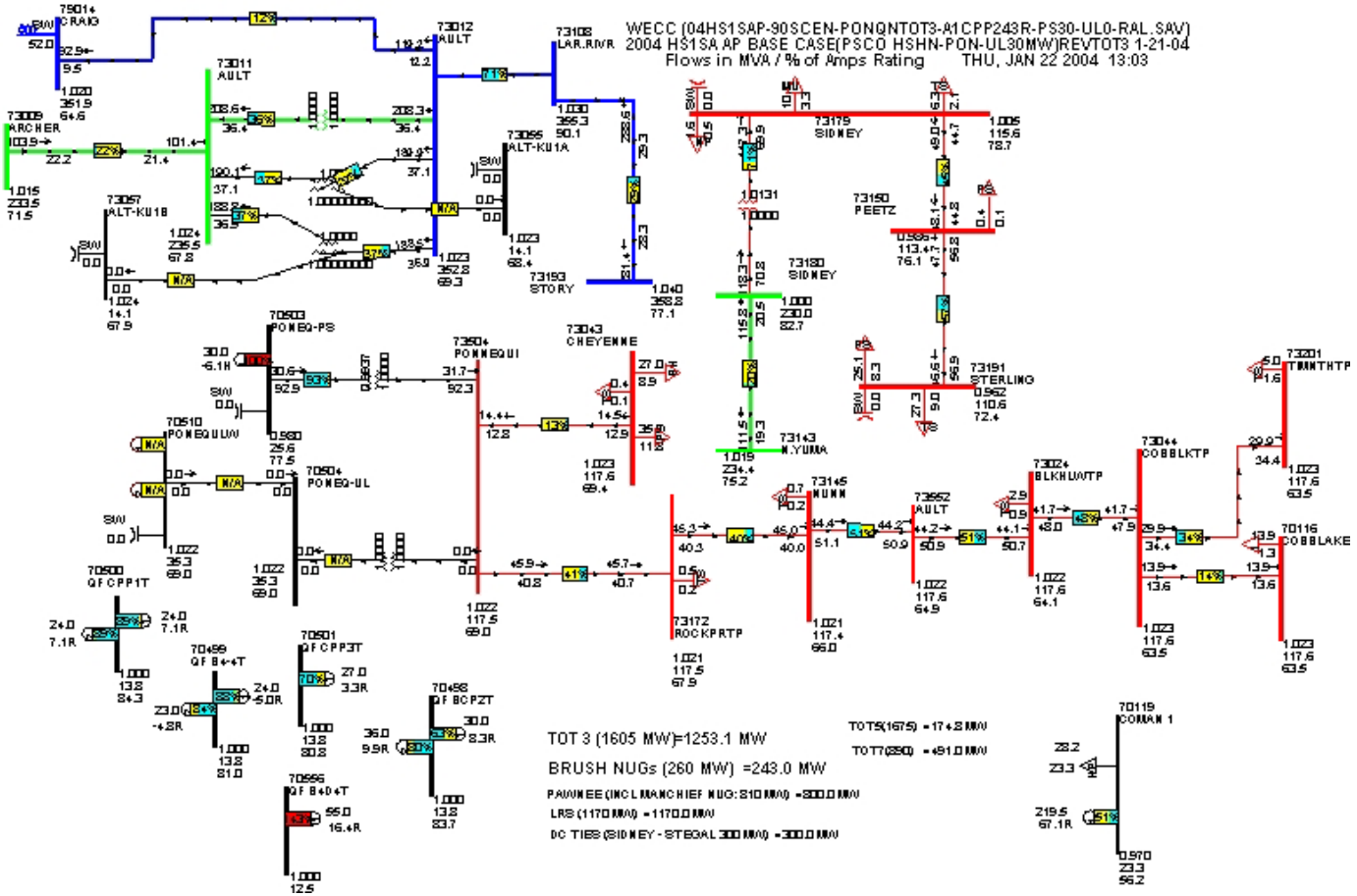
Ponnequin Area Transmission System

System Intact Conditions: TOT3 Flow 1588MW (CPP 68MW, Ponnequin Customer Gen at 0MW)



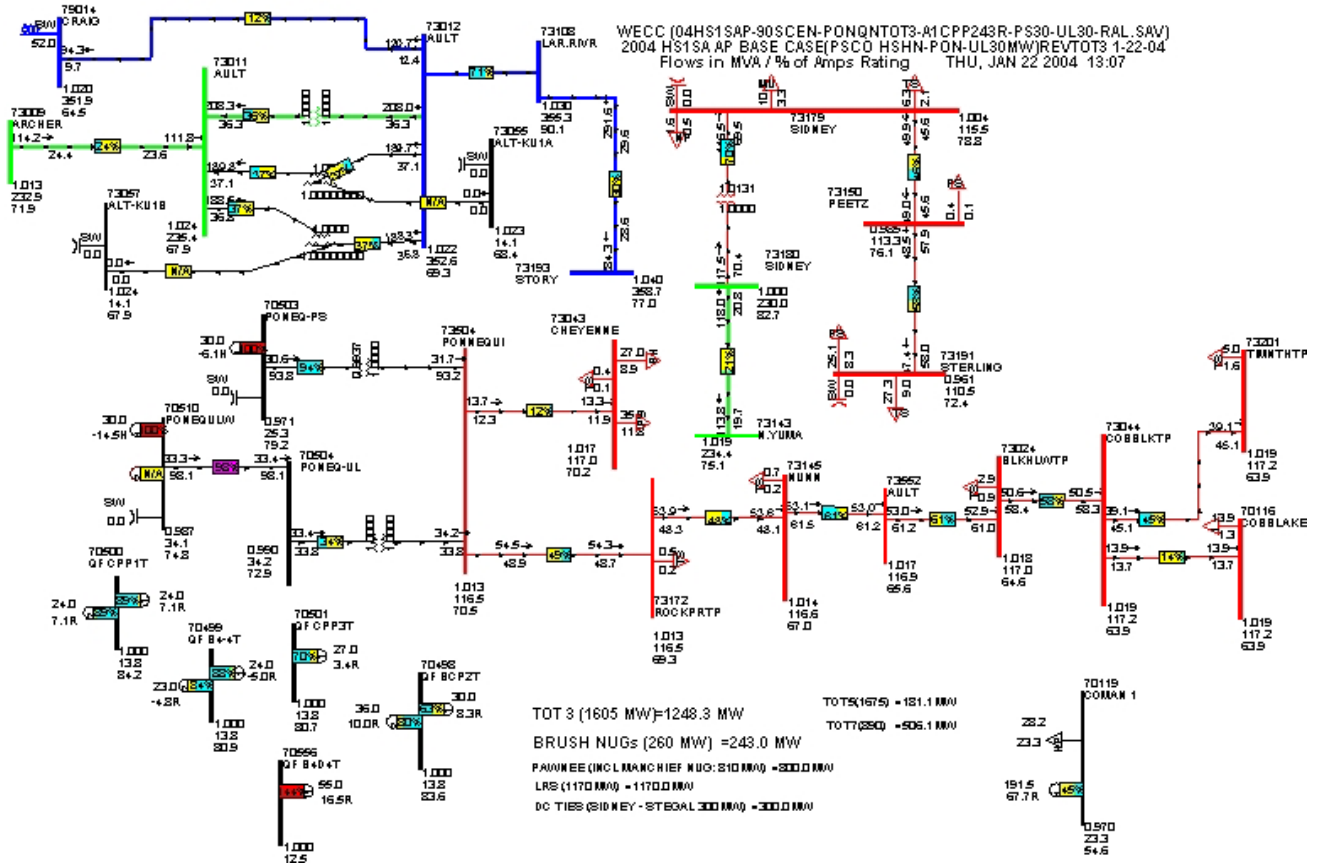
Ponnequin Area Transmission System

System Intact Conditions: TOT3 Flow 1579MW (CPP 68MW, Ponnequin Customer Gen at 30MW)



Ponnequin Area Transmission System

System Intact Conditions: TOT3 Flow 1253MW (CPP 243MW, Ponnequin Customer Gen at 0MW)



Ponnequin Area Transmission System

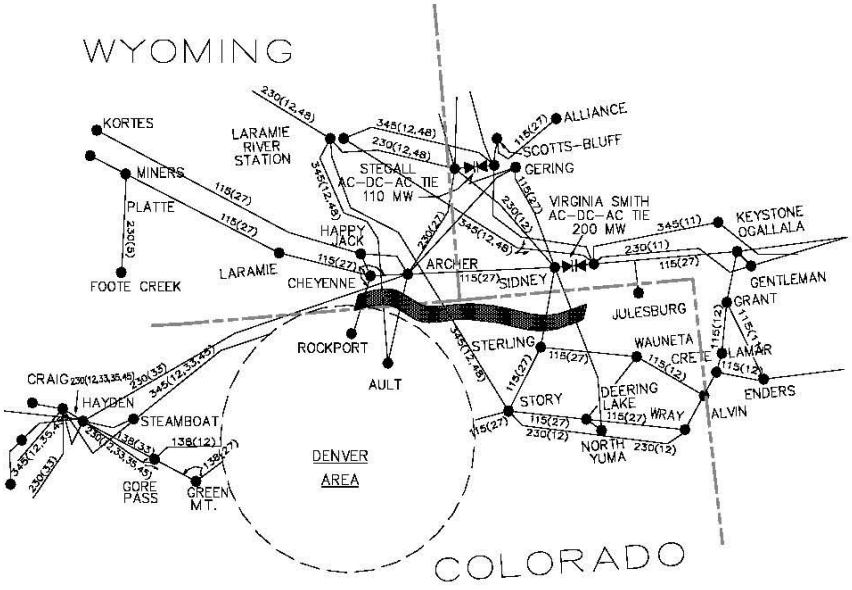
System Intact Conditions: TOT3 Flow 1253MW (CPP 243MW, Ponnequin Customer Gen at 30MW)

APPENDIX C

TOT 3 DETAILS

Revised February 2003

36. TOT 3



Revised February 2003

36. TOT 3

Accepted Rating ☒
Existing Rating ☐
Other ☐

Location:	Border between Northeast Colorado and Southeast Wyoming
Definition:	Sum of the flows on the following transmission lines: Line — Metered End Archer-Ault 230 kV — Archer Laramie River-Ault 345 kV — Laramie River Laramie River-Story 345 kV — Laramie River Cheyenne-Rockport 115 kV — Cheyenne Sidney-Sterling 115 kV — Sidney Sidney-N. Yuma 230 kV — Sidney
Transfer Limit:	North to South: 1605 MW (Maximum) South to North: Not defined Depending on local generation levels, DC tie levels and direction, the real-time rating can range between a maximum of 1605 W and a minimum of 843 MW. Typically, the real-time rating is calculated dynamically and updated every minute based on Table 1B.
Critical Disturbance that limits the transfer capability:	The critical disturbances and limiting elements vary with the various scenarios. Reference Table 1B for further information.
When:	Rating was first established in 1981. The current rating was established in July 1999 with publication of the "Comprehensive Progress Report for the Revised Rating of the TOT 3 Transfer Path." The study was conducted by Western and the revised rating was jointly proposed by: Western Area Power Administration (WAPA) - Loveland Tri-State Generation & Transmission Association, Inc. (TSGT) Public Service Company of Colorado (PSC) Basin Electric Power Cooperative (BEPC)
System Conditions:	This rating is independent of transfer levels between major areas of WECC. The transfer limit is impacted by local area generation and the direction and magnitude of DC tie flows. Historically, the flows have all been north to south across the path. Under certain operating conditions when TOT 3 is loaded to its limit, the TOT 5 capability cannot be used since additional schedule on TOT 5 will overload TOT 3.

Revised February 2000

Study Criteria:	(Summary) System intact: • Per unit voltages between 0.95 p.u. and 1.05 p.u. • All lines and transformers loaded to less than continuous rating. Single contingency outage conditions: • Per unit voltages between 0.90 p.u. and 1.10 p.u. • All lines loaded to less than 15-minute emergency ratings. • All transformers loaded to less than 30-minute emergency ratings. • Transient voltage swings down to 0.7 p.u. permitted.
Remedial Actions Required:	Remedial actions are required to achieve the rated transfer capability. Following an outage, all overloaded lines and transformers must have their loadings reduced to continuous ratings within 15 minutes. This is accomplished by reducing schedules and adjusting generation.
Formal Operating Procedure:	There is a formal operating procedure dated November 1999. WAPA-Loveland is the operating agent and uses real-time flows to monitor the path.
Allocation:	The transfer capability of the path is divided between WAPA, Missouri Basin Power Project (MBPP), Public Service Company of Colorado (PSC), and Tri-State Generation & Transmission (TSGT). TSGT and BEPC are members of MBPP.
Interaction w/Other Transfer Paths:	None
Contact Person:	Thu-Hong Tran Western Area Power Administration Rocky Mountain Region P. O. Box 3700 Loveland, CO 80539-3003 (970) 461-7404 (970) 461-7213 - fax trant@wapa.gov