# Generation Interconnection Feasibility Study

# GI-0822 – 250 MW
## (Project 261)

**Prepared for: Western Area Power Administration**

**CEII Removed - Critical Energy Infrastructure Information**

**Version 1.0**

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# Revision History

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# Executive Summary

Western Area Power Administration (Western, a.k.a WAPA) and Basin Electric Power Cooperative (BEPC) commissioned TranServ to perform an Interconnection Feasibility Study (IFS) for a 250 MW wind farm Large Generator Interconnection (LGI) to the Western/Heartland Consumers Power District/Basin Electric Power Cooperative Integrated System (IS) at Western's Conrad 230 kV substation. This Interconnection Request, identified as Request No. GI-0822 in Western's Generation Interconnection Queue, is posted on its Open Access Same Time Information System (OASIS). This IFS evaluated short-circuit impacts and injection related steady-state impacts attributed to the proposed request. This IFS also evaluated potential power quality impacts associated with the proposed request. An Ad Hoc Study Group was formed in the study process by WAPA.

This is a joint feasibility study report by WAPA and TranServ. As part of this study, steady state analysis was performed by TranServ under WAPA direction and oversight and the short circuit study and power quality analyses were performed by WAPA. This feasibility study report was compiled by TranServ based on the steady state results provided by TranServ and short circuit results and facility upgrade costs provided by WAPA. WAPA also made the determination of injection constraints that are required to be mitigated by the interconnection customer and developed the mitigation plan for interconnection with consultation from the Ad Hoc Study Group.

This IFS evaluated the impact of the proposed wind farm on transmission system performance, including steady-state and short-circuit analyses. The scope of the IFS is limited to identifying mitigation for injection constraints that likely would limit the ability of the generator to interconnect. In accordance with WAPA IFS practices, this study only identifies injection related steady-state impacts (i.e. local area thermal and voltage impacts under system intact and single contingency conditions) and short-circuit impacts that would be required to be mitigated in order for this LGI to interconnect at the requested point of interconnection (POI). WAPA also performed preliminary power quality analysis to determine the bulk electric system's (BES) relative stiffness for supporting interconnection of large variable generation at the POI. Partial Service calculations were performed to determine immediate interconnection service availability with no facility upgrades for single contingency thermal constraints.

Analyses were performed using a 2010 light autumn and a 2019 heavy summer peak model provided by WAPA. All higher queued projects and projects requested by the Ad Hoc Study

Group and WAPA, were added to the 2010 light autumn and 2019 heavy summer peak models to form the 2010 light autumn and 2019 heavy summer pre-GI-0822 models.

Due to sparse commercial and residential load within WAPA's WAUW control area, interconnection of large generation as a Network Resource (NR) to serve native load is generally not feasible as determined by Western. Available load within the WAUW control area to sink large generation interconnect requests is significantly inadequate.

The impacted study area is roughly defined as North Central Montana, which includes the bulk electric system (BES) from the Corp of Engineers Fort Peck Plant at the east boundary, Rocky Mountains at the west boundary, Canada to the north and NorthWestern Energy's (NWE's) Great Falls MT transmission hub to the south. The study area is also commonly referred to as the North of Great Falls area (NOGF). The study area transcends both the WAPA-WAUW and NWE-NWMT control areas. The BES within the study area includes WAPA, NWE and Rural Utility System (RUS) transmission facilities. Since the study area and WAUW control area are both electrically isolated to the East, West and North, all bulk generation in excess of local native load must be dispatched South of Great Falls (SOGF) over NWE's transmission system and the NWMT control area. GI-0822 generation is dispatch SOGF over NWE's transmission system to the USBR Grand Coulee Power Plant located in central Washington, within the Northwest Power Pool (NWPP) service territory. NWE's SOGF interface has been previously identified in numerous studies as a congested path.

This study is an interconnect study only and does not consider transmission service, deliverability or all possible operating conditions. This analysis considered the subject request's impact on steady-state Category A and Category B contingency conditions within the study area only, i.e. system intact and N-1 forced outages. Prior to interconnection, a system impact study (SIS) will be required to evaluate system stability impacts. An operating study will be required prior to the project being placed into service, which will identify any and all operating restrictions beyond a single forced contingency (Category B). A delivery study is needed to determine transmission service availability and impacts associated with delivery of the project's generation beyond the study area to the point of receipt (POR).

Any results related to the delivery of power from this project are for informational purposes only, including the BES SOGF. Such results are beyond the required scope of this IFS. A separate delivery study would be required to identify delivery related impacts and associated system upgrades, if required.

This IFS included all combined 'active' prior queue projects that resulted from ad-hoc input by the BES Transmission Operators (TOs) and RUS Cooperatives within and interconnecting the study area. This includes worst case scenario of the Glacier Wind 1 and Glacier Wind 2 projects generating at full output. These 'active' queued projects are currently interconnected and on-line without firm transmission service out of Cut Bank or Shelby. These projects do currently hold firm service for the Glacier Electric Cooperative Cut Bank – Shelby 115 kV line. Therefore, they are able to generate at full output only with available transmission service over NWE's 115 kV Cut Bank line outlet south to Conrad and SOGF. The BES is currently protected with local remedial action schemes (LRAS, a.k.a. SPS) at both projects in lieu of a new Cut Bank – Conrad – Great Falls 115 kV circuit, as required by NorthWestern Energy (NWE) for firm transmission service. With the addition of the GI-0822 project, a flow gate would likely need to be established on WAPA's 230 kV line south out of the Conrad facility. Based on 'active' prior queue projects within the WAUW and NWMT control areas and the Glacier Wind LRASs, interconnection of 0 MW of Energy Resource (ER) is feasible with no system improvements. Therefore, the following interconnect options with conceptual costing, provided by Western, were determined for GI-0822:

1) Interconnection of **60 MW** of Energy Resource (ER) is feasible with minimal modifications to terminal equipment associated with the Great Falls – Bole – Conrad 230 kV lines, installing a SPS to trip the GI-0822 generation for loss of any section of the Great Falls – Bole – Conrad 230 kV line, replacing the Great Falls Rainbow 161/100 kV transformer and upgrading the Havre – Verona – Great Falls 161 kV line, in addition to facilities required at the POI (Conrad 230 kV bus). This **conceptual cost** option is **$5,082,000.**[1]

2) Interconnection of **250 MW** of Energy Resource (ER) is feasible with the same minimal modifications to terminal equipment associated with the Great Falls – Bole – Conrad 230 kV line given in Option 1, conversion of the Conrad 230 kV ring bus to a breaker and a half scheme and the construction of a new (second) 230kV transmission line directly from Conrad to Great Falls. A special protection scheme (SPS) would be required for some local area contingencies. It should be noted that this option would require a transmission interconnect request with NWE for the Great Falls Substation terminal. This **conceptual cost** option is **$40,558,000**[2]**.**

[1] Planning level non-binding conceptual cost estimate for facilities required. See Section 6 for estimate details
[2] Planning level non-binding conceptual cost estimate for facilities required. See Section 6 for estimate details

Due to the relatively weak nature of the BES within the NOGF study area, which results from a lack of significant transmission West or North out of the study area, Option 2 may require a DVAR or STATCOM at the POI for power quality purposes. This is another potential cost in addition to the conceptual costing provided above.

It is also important to note that neither of these interconnect options address stability, operational or delivery constraints that may be identified in future studies. However, this study identified a substantial number of divergent conditions for contingencies outside the NOGF study area with GI-0822 modeled at 250 MW in the 2010 Light Autumn analysis, i.e. relate to delivery. To glean some understanding of possible discoveries in future delivery studies, this study investigated two additional scenarios:

A. The first additional scenario was a 2010 Light Autumn analysis with the output of the GI-0822 generation limited to 60 MW. This scenario was chosen because the maximum output level of GI-0822 generation, for which solution could be obtained, for all contingencies was 60 MW.

B. The second additional scenario was a 2010 Light Autumn analysis with the output of the GI-0822 generation limited to 85 MW and the addition of a new Conrad – Great Falls 230 kV 400 MVA line modeled. This scenario was chosen because the maximum output level of GI-0822 generation, for which solution could be obtained for all contingencies with the addition of a new Conrad – Great Falls 230 kV 400 MVA line modeled, was 85 MW.

The results of both of these scenarios are included in the detailed section of this report. These scenarios are given for informational purposes only; all injection constraints identified in this report are based on the output of the GI-0822 generation at 250 MW.

It should be noted that restrictions apply to the MW reduction of the interconnect request following completion of the Interconnect Feasibility Study (IFS).

GI-0822's impact as identified in this report may become invalid if the assumptions made about prior queued generation projects prove to be incorrect.

## Study Result Highlights

### *Thermal Constraints:*

Thermal loadings that exceed the element rating and are impacted by greater than a 3% DF due to the subject request, are identified in this study in Section 4 of this report. The proposed GI-0822 wind farm impacted several transmission facilities; therefore, these injection constraints must be mitigated prior to granting interconnection service to the subject request. It is important to note that the identification of the constraints listed below assume that both the Glacier Wind 1 and 2 generation outputs are at maximum. Many of the system improvements listed below may not be required if these two projects were modeled at 0 MW. However, some divergent solution conditions are indicative of stability constraints that would likely be identified in a system impact study, some of which would not be impacted by the transmission rights of prior queued projects.

Under Category A, system intact conditions, there is one facility overload impacted by the subject request at 250 MW that is considered as an injection constraint. This injection constraint must be mitigated prior to granting interconnection service to the subject request.

- **The existing Bole – Conrad 230 kV line is overloaded** above its normal rating due to the proposed project.

Under Category B, contingency conditions, there is one divergent condition and there are several facility overloads impacted by the subject request at 250 MW that are considered as injection constraints. These injection constraints must be mitigated prior to granting interconnection service to the subject request.

- Prior to the addition of a new (second) Conrad – Great Falls 230 kV line, **the steady-state power flow solution is divergent at GI-0822 output levels in excess of 60 MW** when the 5 MW margin criteria has been applied.

- After to the addition of a new (second) Conrad – Great Falls 230 kV line, **The Conrad – Bole and Bole – Great Falls 230 kV lines, the Rudyard – GI-0814, and Rudyard – Harve 115 kV lines are overloaded above their normal and emergency ratings** and impacted by the subject request following the loss of the new Conrad – Great Falls 230 kV line. **The Shelby – Conrad 230 kV line is overloaded above its normal and emergency rating** and impacted by the subject request following the loss of the Conrad – Val-Will 115 kV line. **The Shelby 230-115 kV transformer is overloaded above its normal and emergency rating** and impacted by the subject request following the loss

of the Meadowlark – Conrad Auto 115 kV line. Each of these thermal constraints are evidenced both Pre-Project and Post-Project.

**Under Category B contingency conditions, there are many potential delivery constraints** with DFs of at least 3% due to the subject request which are not considered injection constraints as determined by Western. However, these potential constraints would likely result from a transmission service study and are listed in Section 4 of this report for informational purposes only.

***Voltage Constraints***

Bus voltages outside the bus owner's acceptable voltage range, which are detrimentally impacted by at least 1% due to the subject request, are identified in Section 4 of this study report.

Under Category A, system intact conditions, there are no facility voltages impacted by the subject request at 250 MW that are considered as injection constraints with the addition of a new (second) Conrad – Great Falls 230 kV line.

Under Category B, contingency conditions, there is one divergent condition impacted by the subject request at 250 MW that is considered as an injection constraint. This injection constraint must be mitigated prior to granting interconnection service to the subject request. This constraint can be mitigated by either reducing GI-0822 output to 60MW or constructing a new Conrad-Great Falls 230kV line.

- Prior to the addition of a new (second) Conrad – Great Falls 230 kV line, **the steady-state power flow solution is divergent at GI-0822 output levels in excess of 60 MW** when the 5 MW margin criteria has been applied. Also the Havre and Dutton 115 kV and the Great Falls and Harlem 161 kV voltages are detrimentally impacted by the GI-0822 generation and must be mitigated.

It is important to note that numerous potential delivery voltage violations including divergent conditions were identified when GI-0822 was sunk SOGF. If the ultimate sink for the GI-0822 project is SOGF these voltage constraints would need to be ameliorated.

***Constrained Interface Analysis***

There are no constrained interfaces and/or flow gates defined in the study area NOGF. Therefore, no constrained interface analysis was performed.

### *Prior Outage Analysis*

A prior outage analysis is outside the scope of this study; therefore, a prior outage analysis was not performed.

### *Stability Analysis*

A dynamic stability analysis is outside the scope of this study; therefore, a dynamic stability analysis was not performed.

### *Short Circuit Analysis*

WAPA performed a short circuit analysis of available fault currents for the immediate project area for both interconnect options. A comparison of the available fault currents to the breaker capabilities at the applicable facilities indicates that the existing system has adequate interrupting capabilities to accommodate either interconnect option.

In addition to the short circuit analysis provided in the GI-0822 Feasibility Study, this study considered potential power quality degradation. The BES is considered to be a strong grid for Option 1 and no adverse power quality degradation is expected. The BES is considered to be weak for Option 2. Therefore power quality issues are probable for Option 2, which suggests the requirement of a DVAR or STATCOM to support the BES. Final determination of this requirement cannot be made until the wind turbines and control systems are specified by the manufacturer.

# 1. Introduction

WAPA and BEPC commissioned TranServ to perform an Interconnection Feasibility Study (IFS) for a 250 MW wind farm Large Generator Interconnection (LGI) to the Western/Heartland Consumers Power District/Basin Electric Power Cooperative Integrated System (IS) on Western's Conrad 230 kV substation. This Interconnection Request, identified as Request No. GI-0822 in Western's Generation Interconnection Queue, is posted on its Open Access Same Time Information System (OASIS). These IFS evaluated short-circuit impacts and injection related steady-state impacts attributed to the proposed request. An Ad Hoc Study Group was formed in the study process by WAPA.

This is a joint feasibility study report by WAPA and TranServ. As part of this study, steady state analysis was performed by TranServ under WAPA direction and oversight. The short circuit study and power quality analyses were performed by WAPA. This feasibility study report was compiled by TranServ based on the steady state results provided by TranServ and short circuit results and facility upgrade costs provided by WAPA. WAPA also made the determination of injection constraints that are required to be mitigated by the interconnection customer and developed the mitigation plan for interconnection with consultation from the Ad Hoc Study Group.

This IFS evaluated the impact of the proposed wind farm on the transmission system performance, including steady-state and short-circuit analyses. The scope of the IFS is limited to identifying mitigation for injection constraints that likely would limit the ability of the generator to interconnect. In accordance with WAPA IFS practices, this study only identifies injection related steady-state impacts (i.e. local area thermal and voltage impacts under system intact and single contingency conditions) and short-circuit impacts that would be required to be mitigated in order for this LGI to interconnect at the requested point of interconnection (POI). WAPA also performed preliminary power quality analysis to determine the bulk electric system's (BES) relative stiffness for supporting interconnection of large variable generation at the POI. Partial Service calculations were performed to determine immediate interconnection service availability with no facility upgrades for single contingency thermal constraints.

| Queue Position | Queue Date | County | State | Max Output (MW) | Point of Inter-connection | OASIS In Service Date | Inter-connection Service Type | Fuel Type |
|---|---|---|---|---|---|---|---|---|
| GI-0822 | 10-08-2008 | Pondera | Montana | 250 | Conrad 230 kV Substation | 12/01/2010 | ER | Wind |

As shown in the table above, this request seeks to interconnect a new 250 MW wind farm to Western's Conrad 230 kV Substation. This Generation Interconnection Feasibility Study analyzed the impact of this addition, located in Montana, in accordance with the most conservative of WECC, NWE or WAPA study criteria. An Ad Hoc Study Group was formed in the study process by WAPA.

The GI-0822 interconnection request only includes an ER service option. Therefore, this study did not address deliverability or transmission service from the project. The GI-0822 generation is dispatched South of Great Falls (SOGF) over NWE's transmission system to the USBR Grand Coulee Power Plant located in central Washington, within the Northwest Power Pool (NWPP) service territory. This analysis considered the subject request's impact on Category A and Category B contingency conditions, i.e. steady state and N-1.

Analyses were performed using both a 2010 Light Autumn model and a 2019 Heavy Summer peak model provided by WAPA. All higher queued projects and projects requested by the Ad Hoc Study Group and WAPA were added to the 2010 Light Autumn and 2019 Heavy Summer peak models to form the 2010 Light Autumn and 2019 Heavy Summer Pre-GI-0822 models.

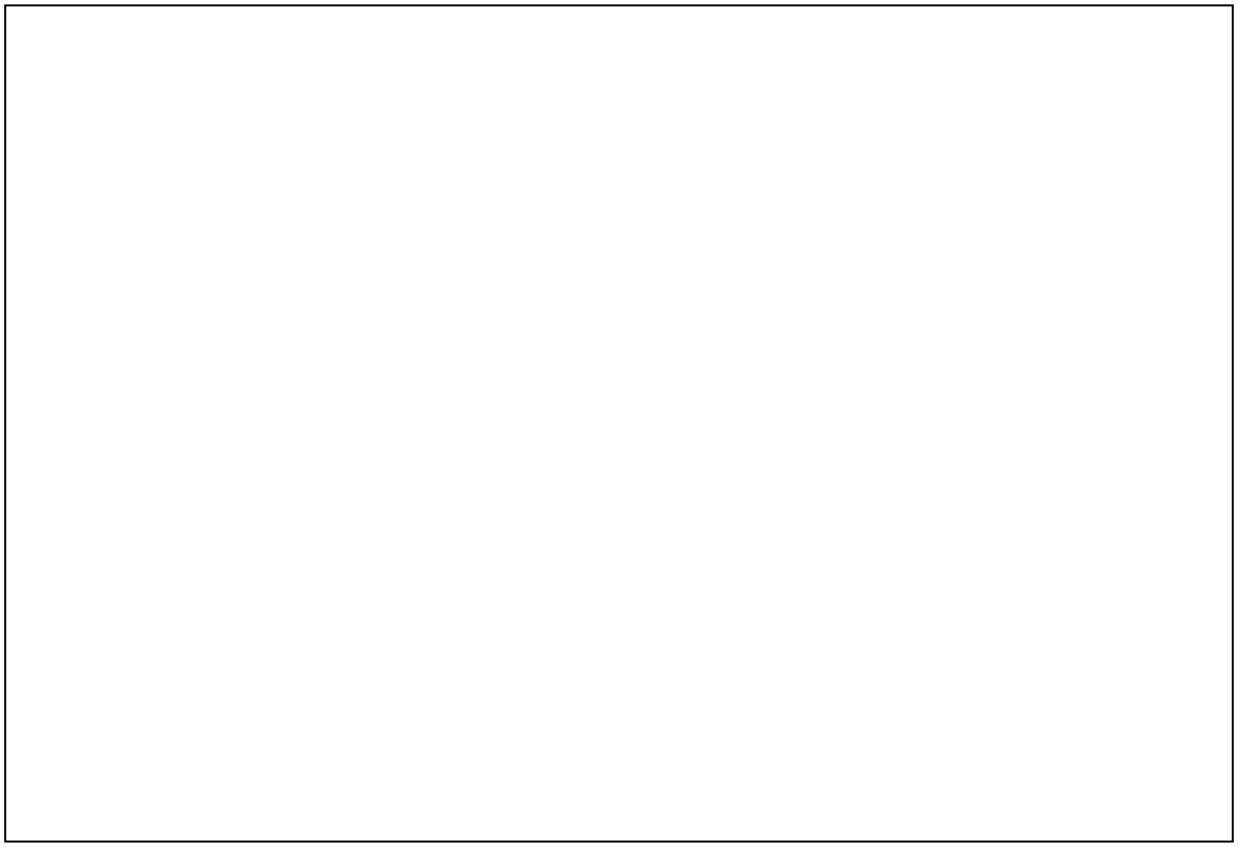
In addition to identifying the injection constraints, several limiting elements with DFs of at least 5% for system intact and 3% for single contingencies due to the subject request, were found to load beyond their applicable ratings in the post-GI-0822 models, SOGF. Therefore, these limiting elements are referred to as potential delivery constraints throughout this study report. These results relate to the delivery of power from GI-0822 and are identified for informational purposes only, including the bulk electric system (BES) South of Great Falls. Such results are beyond the required scope of this IFS. A separate delivery study would be required to identify delivery related impacts and associated system upgrades, if required.

Due to sparse commercial and residential load within WAPA's WAUW control area, interconnection of large generation as a Network Resource (NR) to serve native load is generally not feasible. Available load within the WAUW control area to sink large generation interconnect requests is significantly inadequate.

The impacted study area is roughly defined as North Central Montana, which includes the bulk electric system (BES) from the Corp of Engineers Fort Peck Plant at the east boundary, Rocky Mountains at the west boundary, Canada to the north and NorthWestern Energy's (NWE's) Great Falls, MT transmission hub to the south. The study area is also commonly referred to as the North of Great Falls area (NOGF). The study area transcends both the WAPA-WAUW and NWE-NWMT control areas. The BES within the study area includes WAPA, NWE and Rural Utility System (RUS) transmission facilities. Since the study area and WAUW control area are both electrically isolated to the East, West and North, all bulk generation in excess of local native load must be dispatched South of Great Falls (SOGF) over NWE's transmission system and the NWMT control area. NWE's SOGF interface has been previously identified in numerous studies as a congested path.

Figure 1-1 illustrates the assumed connections of GI-0822 to the existing/planned transmission system. This figure represents the 2010 Light Autumn system intact case with the addition of a second (new) 230 kV transmission line routed directly from Conrad to Great Falls.

**Figure 1-1**
**GI-0822 One-line Diagram (CEII)**



# 2. Description of Request

Figure 1-1 illustrates the assumed connections of GI-0822 to the existing/planned transmission system. This figure represents the 2010 Light Autumn system intact case with the addition of a second (new) 230 kV transmission line routed directly from Conrad to Great Falls.

Project GI-0822 is assumed to consist of one hundred and sixty seven GE 1.5 MW wind turbine generators or 250 MW of output capability. The wind farm was modeled as one equivalent generator rated at 250 MW with reactive power capability of + 95% and – 95% power factor (+82 MVAR and -82 MVAR) and a scheduled voltage of 1.02 p.u. at the POI. The equivalent generator was modeled as connected to a 0.6/34.5 kV equivalent generator step-up transformer rated at 293 MVA, 5.75% positive sequence impedance on transformer MVA base and an X/R ratio of 7.5. The 34.5/230 kV power transformer was modeled as rated at 270 MVA, with 9% positive sequence impedance on transformer MVA base and an X/R ratio of 8.13. WAPA's minimum requirement for generation VAR control is +/- 0.95 power factor at the POI.

These model assumptions are illustrated in Figure 1-1.

# 3. Study Criteria, Methodology, and Assumptions

## 3.1 Ad Hoc Study Group

This Interconnection Feasibility Study (IFS) for Project GI-0822 was performed by TranServ under the direct supervision of WAPA. An ad hoc study group was formed by WAPA for study input from the following transmission owners (TOs): Western Area Power Administration, Northwestern Energy, Glacier Electric Cooperative and Central Montana Electric Power Cooperative (and/or its members).

## 3.2 Network Analysis Criteria

A Network Analysis was performed to determine the impact of the request on all transmission facilities in the study area as shown in Table 3-3. Contingency analyses included single branch contingencies on facilities in the study area as shown in Table 3-3. The criterion used to flag thermal overloads was 100% of continuous rating (Rate A in PSS/E). Although thermal loadings were initially screened using Rate A, single contingency overloaded facilities were identified based on the most conservative of WECC, NWE or WAPA study criteria as it pertains to emergency ratings, NWE does not allow a 30 minute emergency rating of its facilities and WAPA does. All overloaded facilities that exceed the continuous rating system intact (Rate A) or applicable emergency rating (Rate B) post contingent that had a TDF (Transfer Distribution Factor) greater than 5% for system intact and 3% for single contingencies due to the generation addition were identified and are listed Section 4 of this report.

The following formula was used to calculate the % TDF on a given transmission facility:

$$TDF = 100 \times \frac{\text{MVA flow (with Subject Request)} - \text{MVA flow (w/o Subject Request)}}{\text{Project Size}}$$

## 3.3 Constrained Interface or Flowgate Analysis Criteria

There are no constrained interfaces and/or flowgates defined NOGF. Therefore, no constrained interface analysis was performed.

## 3.4 Computer Programs and Input Files Used

Siemens Power Technologies, Inc. (PTI) PSS/E and MUST computer power flow programs and evaluation software were used to determine system performance. Analysis was performed using MUST version 9.0 and PSS/E version 30.

## 3.5 Model Development Details

The following models provided by WAPA were used for this study.

- *2010 gi0822la_fej_base2.sav*: 2010 Light Autumn model
- *19hs_fej2.sav*: 2019 Heavy Summer peak model

### 3.5.1 Pre - GI-0822 Model Development

The subject request was evaluated using a 2010 Light Autumn and a 2019 Heavy Summer Peak models provided by WAPA. All higher queued projects and projects requested by the Ad Hoc Study Group and WAPA were added to the 2010 Light Autumn and 2019 Heavy Summer peak models to form the 2010 Light Autumn and 2019 Heavy Summer Pre-GI-0822 models. Based on the Ad Hoc Study Group recommendations of existing and prior queue generation capability, units in the geographic area of GI-0822 were dispatched at their maximum capability. These projects were sunk SOGF over NWE's transmission system to the USBR Grand Coulee Power Plant located in central Washington, within the Northwest Power Pool (NWPP) service territory.

The following Pre-GI-0822 models were developed:

- *10la-Pre-GI-0822.sav* : 2010 Light Autumn model
- *19hs_Pre-GI-0822.sav*: 2019 Heavy Summer Peak model

Table 3-1 lists all prior queued generation that were added to the 2010 Light Autumn and 2019 Heavy Summer peak models to form the 2010 and 2019 Pre-GI-0822 models.

**Table 3-1**
**NorthWestern/WAPA Energy Resource Prior Queued Projects**
**Included in the Pre-GI-0822 Models**

| NWE Project Number | Queue Date | Location | Point of Interconnection (POI) | In-Service Date Requested | Summer Output (MW) |
|---|---|---|---|---|---|
| 23-Horse Shoe Bend | 08/15/02 | Cascade County, Montana | Great Falls NW-Holter 100 kV line | 02/27/06 | 9 |
| 25-Two Dot Wind # 2 | 02/14/03 | Meagher County, Montana | Martinsdale Substation Distribution | 11/01/04 | 0.715 |
| 32 | 07/01/04 | Cascade County, Montana | Great Falls 230 kV Switchyard | 10/31/08 | 268 |
| 33 | 11/03/04 | Wheatland County, Montana | Martinsdale Substation | 06/30/09 | 52.5 |
| 44 (GW1) | 04/10/06 | Pondera County, Montana | South Cut Bank to Conrad Auto 115 kV | 10/15/08 | 104 MW |
| 46 | 06/05/06 | Meagher County, Montana | 100 kV line between Loweth and Two Dot at Groveland. | 09/01/07 | 10 MW |
| 47 | 06/08/06 | Liberty County, Montana | 69 kV line at Chester | 12/31/09 | 20 MW |
| 49 | 06/16/06 | Cascade County, Montana | Rainbow Switchyard | 12/31/11 | 23 MW |
| 53 | 12/06/06 | Cascade County, Montana | Great Falls 230 kV Switchyard | 07/01/07 | 277 MW |
| 62 (Turnbull 1) | 5/25/2007 | Teton County, Montana | Fairfield - Bole 69 kV | 06/01/09 | 11.5 |
| 73 (GW2) | 07/13/07 | Glacier County, Montana | Cut Bank 115 kV Substation between Cut Bank & Shelby | 11/30/08 | 100 MW |
| 78 (GW1) | 12/11/07 | Glacier County, Montana | 115kV between Cut Bank & Conrad | 11/30/08 | 100 MW |
| 81 | 03/11/08 | Cascade County, Montana | Near Rainbow Switchyard | 05/01/11 | 12 MW |

| NWE Project Number | Queue Date | Location | Point of Interconnection (POI) | In-Service Date Requested | Summer Output (MW) |
|---|---|---|---|---|---|
| 82 | 03/11/08 | Cascade County, Montana | Near Rainbow Switchyard | 12/01/12 | Efficiency Improvement |
| 87 (GW2) | 04/18/08 | Glacier County, Montana | Cut Bank 115 kV Substation between Cut Bank & Shelby | 11/30/08 | 100 MW |
| 89 | 04/24/08 | Meagher County, Montana | 100 kV line between Loweth and Two Dot at Groveland. | 07/31/09 | 20 MW |
| GI-0814 | 07/03/08 | Liberty County, Montana | Havre –Rudyard 115 kV line | 12/01/10 | Reduced to 90 MW |
| 95 | 7/18/2008 | Glacier County, Montana | 115 kV between Cut Bank and Conrad | 11/30/2008 | 5 |
| 100 | 9/30/2008 | Cascade County, Montana | Near Rainbow Switchyard | 11/01/11 | Efficiency Improvement |

All prior queued projects were dispatched SOGF over NWE's transmission system to the USBR Grand Coulee Power Plant located in central Washington, within the Northwest Power Pool (NWPP) service territory.

Per WAPA direction, existing generation and system transfers were set as shown in Table 3-2.

**Table 3-2**
**Pre-GI-0822 Modeling of Primary Generation and System Transfers**

| Unit | Output (MW) | Balancing Authority |
|---|---|---|
| Fort Peck Plant | 90 | WAPA-WAUW |
| Tiber Plant | 7.5 | WAPA-WAUW |
| Canyon Ferry Plant | 58 | NWE-NWMT |
| Great Falls Plant | 281 | NWE-NWMT |
| Glacier Wind 1 Plant | 104 | NWE-NWMT |
| Glacier Wind 2 Plant | 100 | NWE-NWMT |
| Miles City DC Tie | 200 East-West | WAPA-WAUW |
| Crossover Phase Shifter | 77 North-South | WAPA-WAUW |

The net transfer into WAUW and this generation was sunk over NWE's transmission system to the USBR Grand Coulee Power Plant located in central Washington, within the Northwest Power Pool (NWPP) service territory.

### 3.5.2 GI-0822 Study Request Model Development

This study is for Energy Resource Interconnection Service (ERIS). Since there is no transmission delivery associated with this request, only ERIS Post-GI-0822 models were developed.

The following Post-GI-0822 models were developed:

- *10la_Post-GI-0822.sav* : 2010 Light Autumn Post GI-0822 model with GI-0822 at 250 MW
- *10la_Post-GI-0822-60MW.sav* : 2010 Light Autumn Post GI-0822 model with GI-0822 at 60 MW
- *10la-Post-GI-0822_UPGRD.sav* : 2010 Light Autumn Post GI-0822 model with GI-0822 at 250 MW and a new Conrad – Great Falls 230 kV 400 MVA line modeled
- *10la-Post-GI-0822_UPG-85MW.sav :* 2010 Light Autumn Post GI-0822 model with GI-0822 at 85 MW and a new Conrad – Great Falls 230 kV 400 MVA line modeled
- *19hs_Post-GI-0822.sav*: 2019 Heavy Summer peak Post-GI-0822 model with GI-0822 at 250 MW and a new Conrad – Great Falls 230 kV 400 MVA line modeled

The Pre GI-0822 Models were modified to include the new generation at the proposed output level. The GI-0822 was also dispatched SOGF over NWE's transmission system to the USBR Grand Coulee Power Plant located in central Washington, within the Northwest Power Pool (NWPP) service territory.

Cases were solved with transformer tap adjustment enabled, area interchange enabled, phase shifter adjustment enabled and switched shunt adjustment enabled.

The following is a summary of Project GI-0822 parameters provided by WAPA.

**A. Summary of Project GI-0822 Parameters**

| | |
|---|---|
| Unit Type/Model | = GE 1.5 - 60 Hz, Double-fed Induction Turbine |
| Power Factor | = .95 Lead/Lag (Qmax: 82.3 MVAR, Qmin: -82.3 MVAR) |
| Unit Rating | = 1.5 MW |
| Total No. of Units | = 167 |
| Total Plant Capacity | = 250 MW |

| | |
|---|---|
| Collector System | = 0.6/34.5 kV equivalent step up transformer at 293 MVA |
| Delivery to POI | = 34.5/230 kV equivalent power transformer at 270 MVA |
| Regulation | = Voltage Control (scheduled to 1.02 p.u. at POI bus) |

## 3.6 Study Procedure

Impacts to the transmission system due to the new project were determined through steady state and short circuit analyses. The steady state and short circuit analyses determined whether the subject request's impact on the transmission system is within applicable limits in accordance with the WECC/NWE/WAPA study criteria.

## 3.7 Contingencies Considered

The study considered only the following contingency categories in the study areas as given in Table 3-3 for the steady state analysis.

- *Category A (System Intact)*
- *Category B (Single Contingencies)*

The study used a contingency file provided by WAPA. This file included all WAUW and NWMT contingencies NOGF, along with selected SOGF contingencies from NWE.

The study did not perform prior outage analysis per WAPA direction.

## 3.8 Monitored Elements and Study Area

All study area elements as defined in Table 3-3 were monitored.

**Table 3-3**
**Study Area**

| Balancing Authority | Area | Contingency | | Monitored Element | |
|---|---|---|---|---|---|
| | | kV min | kV max | kV min | kV max |
| NWE - NWMT | 62 | 69 | 500 | 69 | 500 |
| WAPA - WAUW | 63 | 69 | 500 | 69 | 500 |

Table 3-4 shows the study area transmission system voltage criteria, as given in the 2009 NWE Method Criteria and Process Manual, exceeds WAPA IFS study criteria and has been implemented in this study.

**Table 3-4**
**Study Area Voltage Criteria**

| Balancing Authority | Base kV | System Intact Conditions | | Single Contingency Conditions | |
|---|---|---|---|---|---|
| | | Max (pu) | Min (pu) | Max (pu) | Min (pu) |
| NWE - NWMT | 69 kV | 1.05 | 0.93 | 1.05 | 0.93 |
| | 100-115 kV | 1.05 | 0.95 | 1.05 | 0.93 |
| | 161 - 230 kV | 1.05 | 0.97 | 1.05 | 0.95 |
| | 500 kV | 1.10 | 1.00 | 1.10 | 0.95 |
| WAPA - WAUW | 69-500 kV | 1.05 | 0.95 | 1.10 | 0.90 |

# 4. Steady State Analysis Results

A contingency analysis was performed using models, criteria, and methodology described in Section 3. The incremental impact of the 250 MW request was evaluated by comparing flows and voltages with and without the 250 MW request. Analyses were performed using the MUST activity ACCC.

This study has identified the system intact and single-event contingency injection constraints. All system intact and single contingency injection constraints will require facility upgrades prior to granting the subject request.

In addition to identifying the injection constraints, several limiting elements with DFs of at least 5% for system intact and 3% for single contingency contingencies due to the subject request were found to load beyond their applicable ratings in the post-GI-0822 models. They have been determined by Western not to be injection constraints due to their remoteness from the GI-0822 POI. This study has identified the system intact and single contingency overloaded facilities. These facilities have been identified for informational purposes only and would not be considered to require mitigation prior to granting interconnection service. However, these facilities may be found in a delivery study as constraints to granting transmission service when long term transmission service is requested for the GI-0822 project. The results of any future deliverability or transmission service study would depend greatly on the assumptions included in the model and the assumed project dispatch.

This section includes three 2010 Light Autumn subsections:

- 2010 Light Autumn at 250 MW with Conrad-Great Falls 230 kV Analysis
- 2010 Light Autumn at 60 MW Analysis
- 2010 Light Autumn at 85 MW with Conrad – Great Falls 230 kV Analysis

The second and third analyses listed above were required to evaluate the impact of divergent conditions that are impacted by the level of output modeled for the GI-0822 request. Further discussion of these divergent conditions is given in these report subsections.

## 4.1 Contingency Analysis

The contingency analysis evaluated the incremental impact of project GI-0822 from the POI to SOGF. Maximum MW GI-0822 output is provided for each constraint and identifies the

curtailment level necessary to mitigate. Maximum MW GI-0822 output was calculated based on a 5 MVA margin as required by WAPA.

### 4.1.1 2010 Light Autumn at 250 MW with Conrad-Great Falls 230 kV Analysis

Initial 2010 Light Autumn analysis revealed that divergent contingency conditions in the vicinity of the POI resulted when the GI-0822 generation was modeled at 250MW. Specifically loss of the Conrad – Bole 230 kV line was found to be divergent. Further investigation indicated that the maximum GI-0822 generation level for which the Conrad- Bole 230 kV contingency was found to be convergent was 65 MW. After Western's 5 MW margin is applied, the convergent GI-0822 generation maximum is 60 MW for loss of the Conrad-Bole 230 kV line. It should also be noted that the maximum GI-0822 generation level for which the Bole – Great Falls 230 kV contingency was found to be convergent was 70 MW. Thus all analysis included in this report for GI-0822 at its requested outlet level of 250 MW was performed with a new Conrad – Great Falls 230 kV 400 MVA line modeled.

**Thermal Impacts**

***System Intact***

The 2010 Light Autumn system intact analysis thermal injection constraint with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service is given in Table 4-1.

**Table 4-1**
**2010 Light Autumn**
**250 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line**
**Thermal Injection Constraints – System Intact Results**

| Limiting Element | Rating N/E | Owner | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| BOLE-CNRDWAPA 230 kV Line 1 | 160 | MONTANA | 149.3 | 93.3 | 189.5 | 118.4 | 16.08% | 35 | System Intact |

The 2010 Light Autumn system intact analysis potential thermal constraints with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service are given in Table 4-1A.

**Table 4-1A**
**2010 Light Autumn**
**250 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line**
**Potential Thermal Constraints SOGF – System Intact Results**
***(For Information Purposes Only)***

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| BUTECORA-MONST TP 100 kV Line 1 | 91.8 | MONTANA | 81.4 | 88.7 | 96.4 | 105 | 6.00% | 90 | System Intact |
| HOLTER-CANYONCR 100 kV Line 1 | 83 | MONTANA | 71.3 | 85.9 | 83.8 | 101 | 5.00% | 134 | System Intact |
| CANYONCR-GILBERT 100 kV Line 1 | 83 | MONTANA | 70.7 | 85.2 | 83.2 | 100.2 | 5.00% | 146 | System Intact |

***Single Contingency***

The 2010 Light Autumn single contingency analysis thermal injection constraints with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service are given in Table 4-2.

**Table 4-2**
**2010 Light Autumn**
**250 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line**
**Thermal Injection Constraints - Single Contingency Results**

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| BOLE-CNRDWAPA 230 kV Line | 160 / 176 | MONTANA | 149.3 | 93 / 85 | 341.3 | 213 / 194 | 76.8% | 28 | CNRDWAPA-GT FALLS 230 kV Line 1 |
| BOLE-GT FALLS 230 kV Line | 200 / 220 | MONTANA | 152.7 | 76 / 69 | 344.2 | 172 / 156 | 76.6% | 81 | CNRDWAPA-GT FALLS 230 kV Line 1 |
| HAVRE-RUDYARD 115 kV Line 1 | 75 / 87 | WAPA U.M | 56 | 75 | 77 | 103 / 88 | 8.2 | 250 | CNRDWAPA - GT FALLS 230kV Line 1 |

The injection constraints shown in Tables 4-1 and 4-2 must be mitigated prior to granting interconnection service to the subject request. These may imply the need for a special protection scheme (SPS) and up-rating and/or up-grading the existing Conrad – Bole – Great Falls 230 kV line to achieve higher normal and emergency ratings. The Havre – Rudyard 115 kV line does not load beyond its emergency rating, thus it can be ameliorated with an operating guide.

The 2010 Light Autumn single contingency analysis potential thermal constraints with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service are given in Table 4-2A. For

all elements, only the contingency with the highest post project loading is listed. A complete listing of all elements loaded beyond expectable levels with 3% or greater DF, due to the subject request, is given in Appendix C.

**Table 4-2A**
**2010 Light Autumn**
**250 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line**
**Potential Thermal Constraints SOGF - Single Contingency Results**
***(For Information Purposes Only)***

| Limiting Element | Rating N/E | Owner | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| OVANDO-LANDRSFK 230 kV Line 1 | 478 | MONTANA | 412.5 | 86.3 | 507.6 | 106.2 | 38.04% | 159 | BV-GR-500 |
| GT FALLS-LANDRSFK 230 kV Line 1 | 478 | MONTANA | 413.1 | 86.4 | 508.2 | 106.3 | 38.04% | 157 | BV-GR-500 |
| E HELENA-CANFERTB 100 kV Line 1 | 91 | MONTANA | 137.7 | 150 | 161.6 | 176 | 9.56% | 0 | E HELENA-CANFERTA 100 kV Line 1 |
| E HELENA-CANFERTA 100 kV Line 1 | 91 | MONTANA | 137.9 | 150.2 | 161.7 | 176.2 | 9.52% | 0 | E HELENA-CANFERTB 100 kV Line 1 |
| BUTECORA-MONST TP 100 kV Line 1 | 91 | MONTANA | 114.3 | 124.5 | 136.6 | 148.8 | 8.92% | 0 | BUTECORA-PCIFICST 100 kV Line 1 |
| ANACOND-PCIFICST 100 kV Line 1 | 91 | MONTANA | 90.5 | 98.6 | 109.2 | 119 | 7.48% | 0 | BUTECORA-MONST TP 100 kV Line 1 |
| BUTECORA-PCIFICST 100 kV Line 1 | 91 | MONTANA | 92.3 | 100.5 | 111 | 120.9 | 7.48% | 0 | BUTECORA-MONST TP 100 kV Line 1 |
| ANACOND-ANACOND 161-100 kV Tx #2 | 63 | MONTANA | 69.7 | 111.5 | 87 | 139.2 | 6.92% | 0 | ANACOND-ANACOND 161-100 kV Tx #1 |
| ANACOND-ANACOND 161-100 kV Tx #1 | 63 | MONTANA | 68.7 | 109.9 | 85.7 | 137.2 | 6.80% | 0 | ANACOND-ANACOND 161-100 kV Tx #2 |
| E HELENA-HELSS TB 100 kV Line 1 | 91 | MONTANA | 87.5 | 95.3 | 103.7 | 112.9 | 6.48% | 0 | E HELENA-HELSS TA 100 kV Line 1 |
| E HELENA-HELSS TA 100 kV Line 1 | 91 | MONTANA | 86.1 | 93.8 | 102.2 | 111.4 | 6.44% | 0 | E HELENA-HELSS TB 100 kV Line 1 |
| HELSS TA-CLANCYTA 100 kV Line 1 | 91 | MONTANA | 86.1 | 93.8 | 102.2 | 111.3 | 6.44% | 0 | E HELENA-HELSS TB 100 kV Line 1 |
| HELSS TB-CLANCYTB 100 kV Line 1 | 91 | MONTANA | 82.3 | 89.7 | 98.4 | 107.2 | 6.44% | 57 | HELSS TA-CLANCYTA 100 kV Line 1 |
| MTTUNTPA-BOULDRTA 100 kV Line 1 | 91 | MONTANA | 82.3 | 89.6 | 98.4 | 107.2 | 6.44% | 57 | E HELENA-HELSS TB 100 kV Line 1 |
| MTTUNTPA-CLANCYTA 100 kV Line 1 | 91 | MONTANA | 86 | 93.7 | 102.1 | 111.2 | 6.44% | 0 | E HELENA-HELSS TB 100 kV Line 1 |
| BUTECORA-PRECIPIT 100 kV Line 1 | 91 | MONTANA | 80.4 | 87.6 | 96.4 | 105 | 6.40% | 87 | E HELENA-HELSS TB 100 kV Line 1 |
| PRECIPIT-BASINMT 100 kV Line 1 | 91 | MONTANA | 81 | 88.2 | 97 | 105.6 | 6.40% | 78 | E HELENA-HELSS TB 100 kV Line 1 |
| BARGE PM-BOULDRTB 100 kV Line 1 | 91 | MONTANA | 81.9 | 89.2 | 97.9 | 106.6 | 6.40% | 64 | E HELENA-HELSS TA 100 kV Line 1 |

| Limiting Element | Rating N/E | Owner | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| BASINMT-BOULDRTA 100 kV Line 1 | 91 | MONTANA | 81.1 | 88.3 | 97.1 | 105.8 | 6.40% | 77 | E HELENA-HELSS TB 100 kV Line 1 |
| MTTUNTAP-CLANCYTB 100 kV Line 1 | 91 | MONTANA | 82.1 | 89.4 | 98.1 | 106.9 | 6.40% | 61 | E HELENA-HELSS TA 100 kV Line 1 |
| MTTUNTAP-BOULDRTB 100 kV Line 1 | 91 | MONTANA | 82 | 89.3 | 98 | 106.8 | 6.40% | 63 | E HELENA-HELSS TA 100 kV Line 1 |
| BUTECORA-TAILBOS2 100 kV Line 1 | 91 | MONTANA | 81.4 | 88.6 | 97.3 | 106 | 6.36% | 72 | E HELENA-HELSS TA 100 kV Line 1 |
| TAILBOS2-BARGE PM 100 kV Line 1 | 91 | MONTANA | 81.4 | 88.6 | 97.3 | 106 | 6.36% | 72 | E HELENA-HELSS TA 100 kV Line 1 |
| BROADVU-BROADVU 100-230 kV Tx #1 | 100 | MONTANA | 117.1 | 117.1 | 131.7 | 131.7 | 5.84% | 0 | BROADVU-BROADVU 100-230 kV Tx #2 |
| BROADVU-BROADVU 100-230 kV Tx #2 | 100 | MONTANA | 116.8 | 116.8 | 131.3 | 131.3 | 5.80% | 0 | BROADVU-BROADVU 100-230 kV Tx #1 |
| HOLTER-CANYONCR 100 kV Line 1 | 83 | MONTANA | 83.5 | 100.6 | 97.7 | 117.7 | 5.68% | 0 | HLT-HVL-EHEL-100 |
| CANYONCR-GILBERT 100 kV Line 1 | 83 | MONTANA | 82.9 | 99.9 | 97.1 | 117 | 5.68% | 0 | HLT-HVL-EHEL-100 |
| GOLD CR-GILBERT 100 kV Line 1 | 83 | MONTANA | 82.5 | 99.3 | 96.6 | 116.4 | 5.64% | 0 | HOLTER-HELVLY T 100 kV Line 1 |
| GF SE-GF ES A 100 kV Line 1 | 91 | MONTANA | 83 | 90.5 | 96.1 | 104.7 | 5.24% | 57 | GT FALLS-GFCITYT1 100 kV Line 1 |
| BROADVU-HARLOWTN 100 kV Line 1 | 62 | MONTANA | 62.8 | 100.9 | 74.7 | 119.9 | 4.76% | 0 | HARLOWTN-PANTROBE 100 kV Line 1 |
| HARLOWTN-PANTROBE 100 kV Line 1 | 62 | MONTANA | 60.9 | 98.2 | 72.8 | 117.5 | 4.76% | 0 | BROADVU-HARLOWTN 100 kV Line 1 |
| CANYON F-SPOKANEA 100 kV Line 1 | 91 | MONTANA | 90.6 | 98.7 | 102.4 | 111.6 | 4.72% | 0 | E HELENA-CANFERTB 100 kV Line 1 |
| CANYON F-SPOKANEB 100 kV Line 1 | 91 | MONTANA | 89.1 | 97.1 | 100.8 | 109.8 | 4.68% | 0 | E HELENA-CANFERTA 100 kV Line 1 |
| CANFERTA-SPOKANEA 100 kV Line 1 | 91 | MONTANA | 89.7 | 97.7 | 101.4 | 110.5 | 4.68% | 0 | E HELENA-CANFERTB 100 kV Line 1 |
| CANFERTB-SPOKANEB 100 kV Line 1 | 91 | MONTANA | 89.1 | 97 | 100.7 | 109.7 | 4.64% | 0 | E HELENA-CANFERTA 100 kV Line 1 |
| E HELENA-HELVLY T 100 kV Line 1 | 57 | MONTANA | 69.8 | 122 | 80.5 | 140.8 | 4.28% | 0 | HOLTER-CANYONCR 100 kV Line 1 |
| MNTGMRY1-MNTGMRY 14-230 kV Tx #1 | 100 | MONTANA | 90.7 | 90.7 | 101.4 | 101.4 | 4.28% | 100 | GF SE-GF ES A 100 kV Line 1 |
| MNTGMRY2-MNTGMRY 14-230 kV Tx #1 | 100 | MONTANA | 90.7 | 90.7 | 101.4 | 101.4 | 4.28% | 100 | GF SE-GF ES A 100 kV Line 1 |
| HOLTER-HELVLY T 100 kV Line 1 | 57 | MONTANA | 70.4 | 123.1 | 81.1 | 141.8 | 4.28% | 0 | HOLTER-CANYONCR 100 kV Line 1 |

| Limiting Element | Rating N/E | Owner | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| CONLIM T-TOWNSEND 100 kV Line 1 | 57 | MONTANA | 50.9 | 89 | 61.2 | 106.9 | 4.12% | 32 | EH-BRGEPM-100 |
| E HELENA-CONLIM T 100 kV Line 1 | 57 | MONTANA | 52.1 | 91.1 | 62.3 | 109 | 4.08% | 2 | EH-BRGEPM-100 |
| GOLD CR-MT PHOST 100 kV Line 1 | 62 | MONTANA | 53.5 | 85.8 | 62.9 | 100.7 | 3.76% | 104 | GOLD CR-DRLDG CM 100 kV Line 1 |
| MT PHOST-DRUMPM T 100 kV Line 1 | 59 | MONTANA | 53.1 | 90 | 62.4 | 105.8 | 3.72% | 24 | GOLD CR-DRLDG CM 100 kV Line 1 |
| DRUMPM T-DRUMMNMT 100 kV Line 1 | 59 | MONTANA | 52.5 | 89.1 | 61.8 | 104.8 | 3.72% | 40 | GOLD CR-DRLDG CM 100 kV Line 1 |
| BUTTE MT-BTMINDPK 100 kV Line 1 | 51 | MONTANA | 45.5 | 89.3 | 54.6 | 107 | 3.64% | 14 | BUTECRSH-BUT CONC 100 kV Line 1 |
| HARLOWTN-TWO DOT 100 kV Line 1 | 57 | MONTANA | 80 | 139.8 | 87.8 | 153.5 | 3.12% | 0 | JUDITHGP-JUDITGPT 100 kV Line 1 |

The thermal results listed in Tables 4-1A and 4-2A were reviewed by WAPA and the ad hoc study group and determined that these facilities are remote from the POI of the subject request. Therefore, these facilities are listed as potential delivery constraints and are for informational purposes only. However, these constraints could be found in a delivery study to be constraints if long term firm transmission service is requested for the GI-0822 generating facility.

**Voltage Impacts**

***System Intact***

No 2010 Light Autumn system intact analysis voltage injection constraints, with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service, were found.

The 2010 Light Autumn system intact potential voltage constraints with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service are given in Table 4-3.

**Table 4-3**
**2010 Light Autumn**
**250 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line**
**Potential Voltage Constraints SOGF – System Intact Results**
***(For Information Purposes Only)***

| BUS/NAME | | KV | Owner | Pre Project | Post Project | Delta Volt % | Contingency |
|---|---|---|---|---|---|---|---|
| 62126 | LANDRSFK | 230 | MONTANA | 0.9662 | 0.9238 | -4.240% | System Intact |
| 62921 | EHELENA | 230 | MONTANA | 0.982 | 0.9484 | -3.360% | System Intact |
| 62072 | OVANDO | 230 | MONTANA | 0.9917 | 0.9625 | -2.920% | System Intact |
| 62271 | CONTLIME | 100 | MONTANA | 0.9788 | 0.9499 | -2.890% | System Intact |

***Single Contingency***

No 2010 Light Autumn single contingency analysis voltage injection constraints, with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service, were found.

The 2010 Light Autumn single contingency analysis potential voltage constraints with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service are given in Table 4-3A. It should be noted that although some bus voltages may be found to be outside of acceptable levels under several contingency conditions, only the contingency with the lowest post project voltage is shown. A complete listing of all voltage results is given in Appendix C.

**Table 4-3A**
**2010 Light Autumn**
**250 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line**
**Potential Voltage Constraints SOGF – Single Contingency Results**
***(For Information Purposes Only)***

| BUS/NAME | | KV | Owner | Pre Project | Post Project | Delta Volt % | Contingency |
|---|---|---|---|---|---|---|---|
| 62126 | LANDRSFK | 230 | MONTANA | 0.9478 | 0.8901 | -5.770% | GARRISON-OVANDO 230 kV line |
| 62072 | OVANDO | 230 | MONTANA | 0.9505 | 0.8946 | -5.590% | GARRISON-OVANDO 230 kV line |
| 7023 | ELKHORN | 69 | MONTANA | 0.948 | 0.9066 | -4.140% | GARRISON-OVANDO 230 kV line |
| 7019 | BOULDERA | 69 | MONTANA | 0.9488 | 0.9075 | -4.130% | GARRISON-OVANDO 230 kV line |
| 7020 | BOULDERB | 69 | MONTANA | 0.9488 | 0.9075 | -4.130% | GARRISON-OVANDO 230 kV line |
| 7061 | BOULDRAT | 69 | MONTANA | 0.9493 | 0.908 | -4.130% | GARRISON-OVANDO 230 kV line |
| 7065 | BOULDTIE | 69 | MONTANA | 0.9493 | 0.908 | -4.130% | GARRISON-OVANDO 230 kV line |
| 7029 | JEFRSNSM | 69 | MONTANA | 0.9494 | 0.9081 | -4.130% | GARRISON-OVANDO 230 kV line |
| 62921 | EHELENA | 230 | MONTANA | 0.9659 | 0.9201 | -4.580% | GARRISON-OVANDO 230 kV line |
| 62271 | CONTLIME | 100 | MONTANA | 0.9644 | 0.924 | -4.040% | GARRISON-OVANDO 230 kV line |

| BUS/NAME | | KV | Owner | Pre Project | Post Project | Delta Volt % | Contingency |
|---|---|---|---|---|---|---|---|
| 62264 | CONLIM T | 100 | MONTANA | 0.9648 | 0.9244 | -4.040% | GARRISON-OVANDO 230 kV line |
| 62265 | TOWNSEND | 100 | MONTANA | 0.9644 | 0.9245 | -3.990% | GARRISON-OVANDO 230 kV line |
| 62273 | TOWNSD-R | 100 | MONTANA | 0.9644 | 0.9245 | -3.990% | GARRISON-OVANDO 230 kV line |
| 62283 | MTTUNELS | 100 | MONTANA | 0.9698 | 0.9254 | -4.440% | GARRISON-OVANDO 230 kV line |
| 62279 | MTTUNTPA | 100 | MONTANA | 0.9702 | 0.9258 | -4.440% | GARRISON-OVANDO 230 kV line |
| 62280 | MTTUNTIE | 100 | MONTANA | 0.9702 | 0.9258 | -4.440% | GARRISON-OVANDO 230 kV line |
| 62327 | BOULDRTA | 100 | MONTANA | 0.968 | 0.9259 | -4.210% | GARRISON-OVANDO 230 kV line |
| 62329 | BOULDTIE | 100 | MONTANA | 0.968 | 0.9259 | -4.210% | GARRISON-OVANDO 230 kV line |
| 62316 | BOULDRAT | 100 | MONTANA | 0.9679 | 0.9259 | -4.200% | GARRISON-OVANDO 230 kV line |
| 3286 | ROUNDUP | 69 | MONTANA | 0.9414 | 0.9263 | -1.510% | BROADVU 100/230 kV Tx |
| 62023 | GT FALLS | 161 | MONTANA | 0.9631 | 0.9266 | -3.650% | TD-HT-100 |
| 62259 | BASINMT | 100 | MONTANA | 0.9673 | 0.9269 | -4.040% | GARRISON-OVANDO 230 kV line |
| 62328 | BOULDRTB | 100 | MONTANA | 0.9694 | 0.9275 | -4.190% | GARRISON-OVANDO 230 kV line |
| 62278 | MTTUNTAP | 100 | MONTANA | 0.9722 | 0.928 | -4.420% | GARRISON-OVANDO 230 kV line |
| 62266 | TOSTON | 100 | MONTANA | 0.9698 | 0.9294 | -4.040% | TOSTON-BRDWTR T 100 kV line |
| 62272 | TOSTON-R | 100 | MONTANA | 0.9698 | 0.9294 | -4.040% | TOSTON-BRDWTR T 100 kV line |

The 2010 Light Autumn potential voltage constraints listed in Tables 4-3 and Table 4-3A were reviewed by WAPA and the ad hoc study group and were determined to be remote from the POI of the subject request. These are listed for informational purposes only. Therefore, no voltage injection constraints were identified that meet the WAPA feasibility study criteria for the requested interconnection service. However, these could be found in a transmission service study to be constraints, if long term firm transmission service is requested for the GI-0822 generating facility.

**Divergent Conditions**

Table 4-4 shows a list of 2010 Light Autumn divergent contingencies when the GI-0822 Output is 250 MW with a new Conrad – Great Falls 230 kV 400 MVA line assumed in-service.

**Table 4-4**
**2010 Light Autumn**
**250 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line**
**Divergent Conditions**
***(For Information Purposes Only)***

| Contingency | Pre-Project | Post-Project |
|---|---|---|
| JUDITHGP-STH_TAP 230 kV line | Convergent | Divergent |
| JUDITHGP-JGWIND 230 kV line | Convergent | Divergent |
| GT FALLS - LANDRSFK 230 kV line | Convergent | Divergent |
| GT FALLS - EHELENA 230 kV line | Convergent | Divergent |
| OVANDO-LANDRSFK 230 kV line | Convergent | Divergent |
| BROADVU-JGWIND 230 kV line | Convergent | Divergent |
| THREERIV-EHELENA 230 kV line | Convergent | Divergent |
| N-1-1<br>Great Falls-Landrsfk-Ovando-230 | Convergent | Divergent |
| N-1-5<br>STAP-Judith-JGWind-230 | Convergent | Divergent |
| N-1-48<br>BroadVu-JGWind-230 | Convergent | Divergent |

Table 4-4 indicates that the addition of the new Conrad – Great Falls 230 kV line, as expected, does not address the divergent condition for contingencies south of Great Falls. These divergent conditions, while not considered injections constraints as determined by Western, due to their remoteness from the GI-0822 POI, are likely to be found in a transmission service study to be constraints if long term firm transmission service is requested for the GI-0822 generating facility. These divergent contingencies are listed here for informational purposes only.

### 4.1.2 2010 Light Autumn at 60 MW Analysis

This section contains a discussion of study results without the addition of a new Conrad – Great Falls 230 kV 400 MVA line, but with the GI-0822 project modeled at 60 MW. The 60 MW output level was studied because it was found to be the highest GI-0822 output level, after considering the 5 MW margin, for which all contingencies are convergent without any modifications to the existing transmission system.

## Thermal Impacts

### *System Intact*

The 2010 Light Autumn system intact analysis thermal injection constraint, when the GI-0822 output is limited to 60 MW, is given in Table 4-5.

**Table 4-5**
**2010 Light Autumn**
**60 MW GI-0822 Output**
**Thermal Injection Constraints – System Intact Results**

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Maximum MW Ouput with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| BOLE-CNRDWAPA 230 kV line | 160 | MONTANA | 149.3 | 93.3 | 191 | 119.4 | 70% | 8 | System Intact |

### *Single Contingency*

The 2010 Light Autumn single contingency analysis thermal injection constraints when the GI-0822 output is limited to 60 MW are given in Table 4-6.

**Table 4-6**
**2010 Light Autumn**
**60 MW GI-0822 Output**
**Thermal Injection Constraints – Single Contingency Results**

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Maximum MW Ouput with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| BOLE-GT FALLS 230 kV Line | 200 / 220 | MONTANA | 199 | 99.5 / 90 | 251.2 | 125.6 / 114 | 87% | 24 | CNRDWAPA-DUTTON 115 kV Line 1 |
| BOLE-CNRDWAPA 230 kV Line | 160 / 176 | MONTANA | 196.3 | 122.7 / 112 | 248 | 155 / 141 | 86% | 0 | CNRDWAPA-DUTTON 115 kV Line 1 |
| CNRDWAPA-DUTTON 115 kV Line 1 | 134 | MONTANA | 161.7 | 121.6 | 207.1 | 155.1 | 75.67% | 0 | BOLE-GT FALLS 230 kV Line 1 |
| GT FALLS-DUTTON 115 kV Line 1 | 134 | MONTANA | 160.6 | 120.7 | 206 | 154.3 | 75.67% | 0 | BOLE-GT FALLS 230 kV Line 1 |
| GT FALL 115/100 kV Tx #1 | 150 | MONTANA | 161.5 | 107.7 | 205.6 | 137.1 | 73.50% | 0 | BOLE-GT FALLS 230 kV Line 1 |
| RUDYARD-GI-0814 115 kV Line 1 | 80 / 88 | WAPA U.M | 104.3 | 130.4 | 124.8 | 156 | 34.17% | 0 | BOLE-GT FALLS 230 kV Line 1 |

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Maximum MW Ouput with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| HAVRE-RUDYARD 115 kV Line 1 | 75 / 87 | WAPA U.M | 102.7 | 136.9 | 123.1 | 164.1 | 34.00% | 0 | BOLE-GT FALLS 230 kV Line 1 |
| HAVRE-HAVRE 115/161 kV Tx #1 | 75 / 93 | WAPA U.M | 96 | 128 | 111.6 | 148.8 | 26.00% | 0 | BOLE-GT FALLS 230 kV Line 1 |
| HAVRE-VERONA 161 kV Line 1 | 81 | WAPA U.M | 86.8 | 107.2 | 90.4 | 111.6 | 6.00% | 0 | GT FALLS-HAVRE 161 kV Line 1 |
| VERONA-GTF WAPA 161 kV Line 1 | 81 | WAPA U.M MONTANA | 84.7 | 104.6 | 88.3 | 109 | 6.00% | 0 | GT FALLS-HAVRE 161 kV Line 1 |
| GT FALLS-RAINBOW 161/100 kV Tx #1 | 60 | MONTANA | 83.4 | 139.1 | 86.8 | 144.7 | 5.67% | 0 | HAVRE-VERONA 161 kV Line 1 |

As can be seen from Tables 4-5 and 4-6, the GI-0822 project generation is limited to 0 MW due to loading on the several elements without a new Conrad - Great Falls 230 kV 400 MVA line in-service. These may imply the need for a special protection scheme (SPS) and up-rating and/or up-grading the existing Conrad – Bole – Great Falls 230 kV line and the Havre – Verona – Great Falls 161 kV line and replacing the Great Falls Rainbow 161/100 kV transformer to achieve higher normal and emergency ratings.

The 2010 Light Autumn single contingency analysis potential thermal constraints, when the GI-0822 output is limited to 60 MW, are given in Table 4-6A. For all elements, only the contingency with the highest post project loading is listed. A complete listing of all elements loaded beyond expectable levels with 3% or greater DF due to the subject request is given in Appendix C.

It should be noted that although some elements may become loaded beyond acceptable levels under several contingency conditions, only the contingency with the highest post project loading is listed.

## Table 4-6A
## 2010 Light Autumn
## 60 MW GI-0822 Output
## Potential Thermal Constraints SOGF – Single Contingency Results
## *(For Information Purposes Only)*

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Maximum MW Ouput with 5 MVA Margin | Contingency with the Highest Post Project Loading |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| BROADVU-JGWIND 230 kV Line 1 | 478 | MONTANA | 486.3 | 101.7 | 529.1 | 110.7 | 71.33% | 0 | GF-LF-OV-230 |
| OVANDO-LANDRSFK 230 kV Line 1 | 478 | MONTANA | 500.8 | 104.8 | 540.8 | 113.1 | 66.67% | 0 | BROADVU-JGWIND 230 kV Line 1 |
| GT FALLS-LANDRSFK 230 kV Line 1 | 478 | MONTANA | 501.4 | 104.9 | 541.3 | 113.3 | 66.50% | 0 | BROADVU-JGWIND 230 kV Line 1 |
| GOLD CR-GILBERT 100 kV Line 1 | 83 | MONTANA | 98.2 | 118.3 | 106.5 | 128.3 | 13.83% | 0 | GF-LF-OV-230 |
| HOLTER-CANYONCR 100 kV Line 1 | 83 | MONTANA | 99.3 | 119.6 | 107.6 | 129.7 | 13.83% | 0 | GF-LF-OV-230 |
| CANYONCR-GILBERT 100 kV Line 1 | 83 | MONTANA | 98.7 | 118.9 | 107 | 128.9 | 13.83% | 0 | GF-LF-OV-230 |
| MNTGMRY 14/230 kV Tx #1 | 100 | MONTANA | 93.4 | 93.4 | 101.2 | 101.2 | 13.00% | 18 | OVANDO-LANDRSFK 230 kV Line 1 |
| HOLTER-CRAIGMT 100 kV Line 1 | 83 | MONTANA | 85.1 | 102.5 | 92.8 | 111.7 | 12.83% | 0 | GF-LF-OV-230 |
| MISSIONM-ULM TAP 100 kV Line 1 | 83 | MONTANA | 86.8 | 104.6 | 94.5 | 113.8 | 12.83% | 0 | GT FALLS-LANDRSFK 230 kV Line 1 |
| GF NWEST-GF NW T1 100 kV Line 1 | 92 | MONTANA | 87.5 | 95.3 | 95.1 | 103.6 | 12.67% | 2 | GT FALLS-LANDRSFK 230 kV Line 1 |
| MISSIONM-CRAIGMT 100 kV Line 1 | 83 | MONTANA | 85.7 | 103.3 | 93.3 | 112.4 | 12.67% | 0 | GT FALLS-LANDRSFK 230 kV Line 1 |
| GF NW T1-ULM TAP 100 kV Line 1 | 83 | MONTANA | 87.5 | 105.4 | 95.1 | 114.6 | 12.67% | 0 | GT FALLS-LANDRSFK 230 kV Line 1 |
| E HELENA 100/230 kV Tx #1 | 100 | MONTANA | 138.4 | 138.4 | 145.2 | 145.2 | 11.33% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| BUTECORA-MONST TP 100 kV Line 1 | 92 | MONTANA | 133.9 | 145.9 | 140.6 | 153.2 | 11.17% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| E HELENA-CANFERTB 100 kV Line 1 | 92 | MONTANA | 137.7 | 150 | 143.4 | 156.2 | 9.50% | 0 | E HELENA-CANFERTA 100 kV Line 1 |
| E HELENA-CANFERTA 100 kV Line 1 | 92 | MONTANA | 137.9 | 150.2 | 143.5 | 156.3 | 9.33% | 0 | E HELENA-CANFERTB 100 kV Line 1 |
| GT FALLS-GF ESIDE 100 kV Line 1 | 92 | MONTANA | 94.4 | 102.8 | 99.9 | 108.9 | 9.17% | 0 | GT FALLS-EHELENA 230 kV Line 1 |
| GF ESIDE-CANFERTB 100 kV Line 1 | 92 | MONTANA | 88.6 | 96.5 | 94 | 102.4 | 9.00% | 0 | GT FALLS-EHELENA 230 kV Line 1 |
| ADEL-CANFERTA 100 kV Line 1 | 92 | MONTANA | 88 | 95.8 | 93.2 | 101.5 | 8.67% | 0 | GT FALLS-EHELENA 230 kV Line 1 |

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Maximum MW Ouput with 5 MVA Margin | Contingency with the Highest Post Project Loading |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| GF SSIDE-ADEL 100 kV Line 1 | 92 | MONTANA | 88.4 | 96.3 | 93.6 | 101.9 | 8.67% | 0 | GT FALLS-EHELENA 230 kV Line 1 |
| E HELENA-HELSS TA 100 kV Line 1 | 92 | MONTANA | 101.3 | 110.4 | 106.4 | 115.9 | 8.50% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| E HELENA-HELSS TB 100 kV Line 1 | 92 | MONTANA | 103.3 | 112.5 | 108.4 | 118 | 8.50% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| BARGE PM-BOULDRTB 100 kV Line 1 | 92 | MONTANA | 97.6 | 106.3 | 102.7 | 111.8 | 8.50% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| HELSS TA-CLANCYTA 100 kV Line 1 | 92 | MONTANA | 101.3 | 110.4 | 106.4 | 115.9 | 8.50% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| BUTECORA-TAILBOS2 100 kV Line 1 | 92 | MONTANA | 97.1 | 105.8 | 102.1 | 111.3 | 8.33% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| BUTECORA-PRECIPIT 100 kV Line 1 | 92 | MONTANA | 95.6 | 104.1 | 100.6 | 109.6 | 8.33% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| TAILBOS2-BARGE PM 100 kV Line 1 | 92 | MONTANA | 97.2 | 105.8 | 102.2 | 111.3 | 8.33% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| PRECIPIT-BASINMT 100 kV Line 1 | 92 | MONTANA | 96.1 | 104.7 | 101.1 | 110.1 | 8.33% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| BASINMT-BOULDRTA 100 kV Line 1 | 92 | MONTANA | 96.2 | 104.8 | 101.2 | 110.3 | 8.33% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| HELSS TB-CLANCYTB 100 kV Line 1 | 92 | MONTANA | 98 | 106.8 | 103 | 112.2 | 8.33% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| MTTUNTAP-CLANCYTB 100 kV Line 1 | 92 | MONTANA | 97.8 | 106.5 | 102.8 | 112 | 8.33% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| MTTUNTAP-BOULDRTB 100 kV Line 1 | 92 | MONTANA | 97.7 | 106.4 | 102.7 | 111.9 | 8.33% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| MTTUNTPA-CLANCYTA 100 kV Line 1 | 92 | MONTANA | 101.3 | 110.3 | 106.3 | 115.8 | 8.33% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| MTTUNTPA-BOULDRTA 100 kV Line 1 | 92 | MONTANA | 97.4 | 106.1 | 102.4 | 111.6 | 8.33% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| COCHRAN-COCHRAN 100/14 kV Tx #1 | 60 | MONTANA | 57.3 | 95.5 | 61.6 | 102.7 | 7.17% | 0 | GT FALLS-LANDRSFK 230 kV Line 1 |
| ANACOND-PCIFICST 100 kV Line 1 | 92 | MONTANA | 90.5 | 98.6 | 94.8 | 103.2 | 7.17% | 0 | BUTECORA-MONST TP 100 kV Line 1 |
| BUTECORA-PCIFICST 100 kV Line 1 | 92 | MONTANA | 92.3 | 100.5 | 96.6 | 105.2 | 7.17% | 0 | BUTECORA-MONST TP 100 kV Line 1 |
| HARLOWTN-TWO DOT 100 kV Line 1 | 57 | MONTANA | 91.8 | 160.5 | 95.9 | 167.7 | 6.83% | 0 | GF-LF-OV-230 |
| CONLIM T-TOWNSEND 100 kV | 57 | MONTANA | 77.2 | 135 | 81.2 | 141.9 | 6.67% | 0 | THREERIV-EHELENA 230 kV Line 1 |

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Maximum MW Ouput with 5 MVA Margin | Contingency with the Highest Post Project Loading |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| Line 1 | | | | | | | | | |
| TOWNSEND-TOSTON 100 kV Line 1 | 62 | MONTANA | 73.8 | 119.1 | 77.8 | 125.4 | 6.67% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| CROWCREK-BRDWTR T 100 kV Line 1 | 62 | MONTANA | 72.5 | 116.2 | 76.4 | 122.4 | 6.50% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| E HELENA-CONLIM T 100 kV Line 1 | 57 | MONTANA | 78.4 | 137 | 82.3 | 143.9 | 6.50% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| TWO DOT-MARTNSDA 100 kV Line 1 | 57 | MONTANA | 73.9 | 54.7 | 77.8 | 135.9 | 6.50% | 0 | GF-LF-OV-230 |
| EUSTIS-CROWCREK 100 kV Line 1 | 62 | MONTANA | 71.4 | 115.2 | 75.3 | 121.4 | 6.50% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| TOSTON-BRDWTR T 100 kV Line 1 | 62 | MONTANA | 71.7 | 114.8 | 75.6 | 121.2 | 6.50% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| TRIDENT-EUSTIS 100 kV Line 1 | 62 | MONTANA | 71.1 | 114.6 | 74.9 | 120.9 | 6.33% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| ANACOND 161/100 kV Tx #1 | 63 | MONTANA | 68.7 | 109.9 | 72 | 115.2 | 5.50% | 0 | ANACOND 161/100 kV Tx #2 |
| ANACOND 161/100 kV Tx #2 | 63 | MONTANA | 69.7 | 111.5 | 73 | 116.8 | 5.50% | 0 | ANACOND 161/100 kV Tx #1 |
| JUDITHGP-JUDITGPT 100 kV Line 1 | 62 | MONTANA | 64 | 47.3 | 67.2 | 107.6 | 5.33% | 0 | JUDITHGP-JGWIND 230 kV Line 1 |
| HARLOWTN-JUDITGPT 100 kV Line 1 | 62 | MONTANA | 62.8 | 46.4 | 65.9 | 106.4 | 5.17% | 0 | JUDITHGP-JGWIND 230 kV Line 1 |
| CANYON F-SPOKANEA 100 kV Line 1 | 92 | MONTANA | 90.6 | 98.7 | 93.5 | 101.9 | 4.83% | 0 | E HELENA-CANFERTB 100 kV Line 1 |
| CANFERTA-SPOKANEA 100 kV Line 1 | 92 | MONTANA | 89.7 | 97.7 | 92.6 | 100.8 | 4.83% | 0 | E HELENA-CANFERTB 100 kV Line 1 |
| BROADVU-HARLOWTN 100 kV Line 1 | 62 | MONTANA | 99.3 | 159.4 | 102.1 | 163.8 | 4.67% | 0 | BROADVU-JGWIND 230 kV Line 1 |
| HARLOWTN-PANTROBE 100 kV Line 1 | 62 | MONTANA | 96.8 | 156.2 | 99.6 | 160.7 | 4.67% | 0 | BROADVU-JGWIND 230 kV Line 1 |
| CANYON F-SPOKANEB 100 kV Line 1 | 92 | MONTANA | 89.1 | 97.1 | 91.8 | 100 | 4.50% | 0 | E HELENA-CANFERTA 100 kV Line 1 |
| CANFERTB-SPOKANEB 100 kV Line 1 | 92 | MONTANA | 89.1 | 97 | 91.8 | 100 | 4.50% | 0 | E HELENA-CANFERTA 100 kV Line 1 |
| JUDITHGP 230/100 kV Tx #1 | 100 | MONTANA | 131 | 131 | 133.5 | 133.5 | 4.17% | 0 | BROADVU-JGWIND 230 kV Line 1 |
| BROADVU 100/230 kV Tx #1 | 100 | MONTANA | 117.1 | 117.1 | 119.5 | 119.5 | 4.00% | 0 | BROADVU 100/230 kV Tx #2 |
| BROADVU 100/230 kV Tx #2 | 100 | MONTANA | 116.8 | 116.8 | 119.2 | 119.2 | 4.00% | 0 | BROADVU 100/230 kV Tx #1 |

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Maximum MW Ouput with 5 MVA Margin | Contingency with the Highest Post Project Loading |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| HOLTER-HELVLY T 100 kV Line 1 | 57 | MONTANA | 70.4 | 123.1 | 72.4 | 126.5 | 3.33% | 0 | HOLTER-CANYONCR 100 kV Line 1 |
| E HELENA-HELVLY T 100 kV Line 1 | 57 | MONTANA | 69.8 | 122 | 71.8 | 125.5 | 3.33% | 0 | HOLTER-CANYONCR 100 kV Line 1 |

The 2010 Light Autumn potential thermal constraints listed in Table 4-6A were reviewed by WAPA and the ad hoc study group and were determined to be remote from the POI of the subject request. These are listed for informational purposes only. However, these could be found in a transmission service study to be constraints if long term firm transmission service is requested for the GI-0822 generating facility.

**Voltage Impacts**

***System Intact***

The 2010 Light Autumn system intact potential voltage constraints, when the GI-0822 output is limited to 60 MW, are given in Table 4-7.

**Table 4-7**
**2010 Light Autumn**
**60 MW GI-0822 Output**
**Potential Voltage Constraints SOGF – System Intact Results**
***(For Information Purposes Only)***

| BUS/NAME | | KV | Area | Pre Project | Post Project | Delta Volt % | Contingency |
|---|---|---|---|---|---|---|---|
| 62126 | LANDRSFK | 230 | MONTANA | 0.9665 | 0.9559 | -1.060% | System Intact |

***Single Contingency***

The 2010 Light Autumn single contingency analysis thermal injection constraints when the GI-0822 output is limited to 60 MW are given in Table 4-8.

**Table 4-8**
**2010 Light Autumn**
**60 MW GI-0822 Output**
**Voltage Injection Constraints – Single Contingency Result**

| BUS/NAME | | KV | Area | Pre Project | Post Project | Delta Volt % | Contingency |
|---|---|---|---|---|---|---|---|
| 63007 | HAVRE | 115 | WAPA U.M | 0.9314 | 0.8936 | -3.780% | GF-BOLE-CRWAPA-230 |
| 62180 | DUTTON | 115 | MONTANA | 0.9496 | 0.9069 | -4.270% | GF-BOLE-CRWAPA-230 |
| 62023 | GT FALLS | 161 | MONTANA | 0.9507 | 0.9362 | -1.450% | GF-BOLE-CRWAPA-230 |
| 63006 | HARLEM | 161 | WAPA U.M | 0.9604 | 0.9372 | -2.320% | GF-BOLE-CRWAPA-230 |

As can be seen from Table 4-8, the GI-0822 project generation detrimentally impacts the Havre and Dutton 115 kV and the Great Falls and Harlem 161 kV bus voltages for loss of the Great Falls - Bole – Conrad 230 kV line without a new Conrad- Great Falls 230 kV 400 MVA line in-service. This may imply the need for a special protection scheme (SPS) and/or capacitor additions.

The 2010 Light Autumn single contingency analysis potential voltage constraints, when the GI-0822 output is limited to 60 MW, are given in Table 4-8A. It should be noted that although some bus voltages may be found to be outside of acceptable levels under several contingency conditions, only the contingency with the lowest post project voltage is shown. A complete listing of all voltage results is given in Appendix C.

## Table 4-8A
## 2010 Light Autumn
## 60 MW GI-0822 Output
## Potential Voltage Constraints SOGF – Single Contingency Results
## *(For Information Purposes Only)*

| BUS/NAME | | KV | Area | Pre Project | Post Project | Delta Volt % | Contingency with the Lowest Post Project Voltage |
|---|---|---|---|---|---|---|---|
| 62277 | HELENASS | 100 | MONTANA | 0.9098 | 0.8543 | -5.550% | GF-LF-OV-230 |
| 62262 | CANYONCR | 100 | MONTANA | 0.9092 | 0.8538 | -5.540% | GF-LF-OV-230 |
| 62121 | E HELENA | 100 | MONTANA | 0.9135 | 0.8581 | -5.540% | GF-LF-OV-230 |
| 62275 | HELSS TA | 100 | MONTANA | 0.9103 | 0.8549 | -5.540% | GF-LF-OV-230 |
| 62276 | HELSS TB | 100 | MONTANA | 0.9101 | 0.8547 | -5.540% | GF-LF-OV-230 |
| 62270 | HELVALLY | 100 | MONTANA | 0.9195 | 0.8641 | -5.540% | GF-LF-OV-230 |
| 62269 | HELVLY T | 100 | MONTANA | 0.9195 | 0.8642 | -5.530% | GF-LF-OV-230 |
| 62285 | CLANCYTA | 100 | MONTANA | 0.9047 | 0.8495 | -5.520% | GF-LF-OV-230 |
| 62260 | CANFERTA | 100 | MONTANA | 0.9185 | 0.8634 | -5.510% | GF-LF-OV-230 |
| 62261 | CANFERTB | 100 | MONTANA | 0.9185 | 0.8634 | -5.510% | GF-LF-OV-230 |
| 62289 | CLANCY | 100 | MONTANA | 0.9057 | 0.8506 | -5.510% | GF-LF-OV-230 |
| 62284 | CLANCYTB | 100 | MONTANA | 0.9057 | 0.8506 | -5.510% | GF-LF-OV-230 |
| 62287 | CLNCYTIE | 100 | MONTANA | 0.9057 | 0.8506 | -5.510% | GF-LF-OV-230 |
| 62281 | SPOKANEA | 100 | MONTANA | 0.9234 | 0.8684 | -5.500% | GF-LF-OV-230 |
| 62282 | SPOKANEB | 100 | MONTANA | 0.9234 | 0.8685 | -5.490% | GF-LF-OV-230 |
| 62122 | CANYON F | 100 | MONTANA | 0.9274 | 0.8726 | -5.480% | GF-LF-OV-230 |
| 62921 | EHELENA | 230 | MONTANA | 0.8959 | 0.8414 | -5.450% | GF-LF-OV-230 |
| 62280 | MTTUNTIE | 100 | MONTANA | 0.9008 | 0.8467 | -5.410% | GF-LF-OV-230 |
| 62279 | MTTUNTPA | 100 | MONTANA | 0.9008 | 0.8467 | -5.410% | GF-LF-OV-230 |
| 62283 | MTTUNELS | 100 | MONTANA | 0.9004 | 0.8463 | -5.410% | GF-LF-OV-230 |
| 62120 | HOLTER | 100 | MONTANA | 0.9336 | 0.8796 | -5.400% | GF-LF-OV-230 |
| 62278 | MTTUNTAP | 100 | MONTANA | 0.903 | 0.8492 | -5.380% | GF-LF-OV-230 |
| 62274 | CRAIGMT | 100 | MONTANA | 0.9332 | 0.8806 | -5.260% | GF-LF-OV-230 |
| 62327 | BOULDRTA | 100 | MONTANA | 0.9018 | 0.8497 | -5.210% | GF-LF-OV-230 |
| 62329 | BOULDTIE | 100 | MONTANA | 0.9018 | 0.8497 | -5.210% | GF-LF-OV-230 |
| 62271 | CONTLIME | 100 | MONTANA | 0.8997 | 0.8476 | -5.210% | GF-LF-OV-230 |
| 62316 | BOULDRAT | 100 | MONTANA | 0.9017 | 0.8496 | -5.210% | GF-LF-OV-230 |
| 62264 | CONLIM T | 100 | MONTANA | 0.9001 | 0.8481 | -5.200% | GF-LF-OV-230 |
| 62328 | BOULDRTB | 100 | MONTANA | 0.9034 | 0.8515 | -5.190% | GF-LF-OV-230 |
| 62273 | TOWNSD-R | 100 | MONTANA | 0.9003 | 0.8485 | -5.180% | GF-LF-OV-230 |
| 62265 | TOWNSEND | 100 | MONTANA | 0.9003 | 0.8485 | -5.180% | GF-LF-OV-230 |
| 7023 | ELKHORN | 69 | MONTANA | 0.8828 | 0.8315 | -5.130% | GF-LF-OV-230 |
| 7019 | BOULDERA | 69 | MONTANA | 0.8838 | 0.8326 | -5.120% | GF-LF-OV-230 |
| 7020 | BOULDERB | 69 | MONTANA | 0.8838 | 0.8326 | -5.120% | GF-LF-OV-230 |
| 7061 | BOULDRAT | 69 | MONTANA | 0.8843 | 0.8331 | -5.120% | GF-LF-OV-230 |
| 7065 | BOULDTIE | 69 | MONTANA | 0.8843 | 0.8331 | -5.120% | GF-LF-OV-230 |
| 7029 | JEFRSNSM | 69 | MONTANA | 0.8844 | 0.8332 | -5.120% | GF-LF-OV-230 |
| 62259 | BASINMT | 100 | MONTANA | 0.9034 | 0.8527 | -5.070% | GF-LF-OV-230 |
| 62263 | GILBERT | 100 | MONTANA | 0.9109 | 0.8619 | -4.900% | GF-LF-OV-230 |
| 62172 | ADEL | 100 | MONTANA | 0.9301 | 0.882 | -4.810% | GF-LF-OV-230 |
| 62106 | HARLOWTN | 100 | MONTANA | 0.9551 | 0.9078 | -4.730% | GF-LF-OV-230 |

| BUS/NAME | | KV | Area | Pre Project | Post Project | Delta Volt % | Contingency with the Lowest Post Project Voltage |
|---|---|---|---|---|---|---|---|
| 62266 | TOSTON | 100 | MONTANA | 0.9157 | 0.8689 | -4.680% | GF-LF-OV-230 |
| 62272 | TOSTON-R | 100 | MONTANA | 0.9157 | 0.8689 | -4.680% | GF-LF-OV-230 |
| 62286 | BRDWTR T | 100 | MONTANA | 0.9197 | 0.874 | -4.570% | GF-LF-OV-230 |
| 62288 | BRODWATR | 100 | MONTANA | 0.921 | 0.8754 | -4.560% | GF-LF-OV-230 |
| 62267 | CROWCREK | 100 | MONTANA | 0.922 | 0.8773 | -4.470% | GF-LF-OV-230 |
| 62162 | MISSIONM | 100 | MONTANA | 0.9477 | 0.9039 | -4.380% | GF-LF-OV-230 |
| 62117 | GOLD CR | 100 | MONTANA | 0.9243 | 0.8816 | -4.270% | GF-LF-OV-230 |
| 62133 | DRLDGCTY | 100 | MONTANA | 0.9256 | 0.8845 | -4.110% | GF-LF-OV-230 |
| 62134 | DRLDG CM | 100 | MONTANA | 0.9269 | 0.8858 | -4.110% | GF-LF-OV-230 |
| 62036 | JUDITHGP | 230 | MONTANA | 0.9377 | 0.8967 | -4.100% | GF-LF-OV-230 |
| 90105 | JGWIND | 230 | MONTANA | 0.9379 | 0.8974 | -4.050% | GF-LF-OV-230 |
| 62149 | BARGE PM | 100 | MONTANA | 0.9245 | 0.8841 | -4.040% | GF-LF-OV-230 |
| 62244 | EUSTIS | 100 | MONTANA | 0.9361 | 0.8962 | -3.990% | GF-LF-OV-230 |
| 62144 | TAILBOS2 | 100 | MONTANA | 0.9263 | 0.8865 | -3.980% | GF-LF-OV-230 |
| 62131 | DERLDG T | 100 | MONTANA | 0.9308 | 0.8914 | -3.940% | GF-LF-OV-230 |
| 62176 | ULM TAP | 100 | MONTANA | 0.9589 | 0.9195 | -3.940% | GF-LF-OV-230 |
| 62160 | ULM MT | 100 | MONTANA | 0.9588 | 0.9195 | -3.930% | GF-LF-OV-230 |
| 62148 | PRECIPIT | 100 | MONTANA | 0.9277 | 0.8885 | -3.920% | GF-LF-OV-230 |
| 62231 | STANFRDM | 100 | MONTANA | 0.9446 | 0.9054 | -3.920% | GF-LF-OV-230 |
| 62228 | UTICAPMP | 100 | MONTANA | 0.9387 | 0.8996 | -3.910% | GF-LF-OV-230 |
| 62229 | UTICATAP | 100 | MONTANA | 0.9389 | 0.8998 | -3.910% | GF-LF-OV-230 |
| 62230 | BENCHLND | 100 | MONTANA | 0.9394 | 0.9004 | -3.900% | GF-LF-OV-230 |
| 62236 | JUDTHPMP | 100 | MONTANA | 0.9375 | 0.8985 | -3.900% | GF-LF-OV-230 |
| 62238 | UTICA | 100 | MONTANA | 0.9387 | 0.8997 | -3.900% | GF-LF-OV-230 |
| 62237 | UTICA-R | 100 | MONTANA | 0.9387 | 0.8997 | -3.900% | GF-LF-OV-230 |
| 62234 | JUDGAPSM | 100 | MONTANA | 0.9387 | 0.8998 | -3.890% | GF-LF-OV-230 |
| 62233 | JUDITGPT | 100 | MONTANA | 0.9389 | 0.9 | -3.890% | GF-LF-OV-230 |
| 62239 | JUDTHSMT | 100 | MONTANA | 0.9387 | 0.8998 | -3.890% | GF-LF-OV-230 |
| 62137 | BUTECORA | 100 | MONTANA | 0.9289 | 0.8902 | -3.870% | GF-LF-OV-230 |
| 62322 | FRONTRGT | 100 | MONTANA | 0.9378 | 0.8991 | -3.870% | GF-LF-OV-230 |
| 62323 | FRONTRNG | 100 | MONTANA | 0.9378 | 0.8991 | -3.870% | GF-LF-OV-230 |
| 62135 | MT PHOST | 100 | MONTANA | 0.9307 | 0.892 | -3.870% | GF-LF-OV-230 |
| 62104 | JUDITHGP | 100 | MONTANA | 0.9382 | 0.8998 | -3.840% | GF-LF-OV-230 |
| 62138 | PCIFICST | 100 | MONTANA | 0.9301 | 0.8918 | -3.830% | GF-LF-OV-230 |
| 62240 | STRAWXPT | 100 | MONTANA | 0.9344 | 0.8963 | -3.810% | GF-LF-OV-230 |
| 62073 | TRIDENT | 100 | MONTANA | 0.9419 | 0.9039 | -3.800% | GF-LF-OV-230 |
| 62247 | TRIDTPLT | 100 | MONTANA | 0.9418 | 0.9038 | -3.800% | GF-LF-OV-230 |
| 62021 | THREERIV | 100 | MONTANA | 0.9443 | 0.9068 | -3.750% | GF-LF-OV-230 |
| 62232 | GLENGARY | 100 | MONTANA | 0.9268 | 0.8894 | -3.740% | GF-LF-OV-230 |
| 1033 | BUTTE WC | 69 | MONTANA | 0.9402 | 0.9033 | -3.690% | GF-LF-OV-230 |
| 1031 | DIVIDE | 69 | MONTANA | 0.9402 | 0.9033 | -3.690% | GF-LF-OV-230 |
| 1032 | FEELYHIL | 69 | MONTANA | 0.941 | 0.9041 | -3.690% | GF-LF-OV-230 |
| 62139 | MONST TP | 100 | MONTANA | 0.9332 | 0.8964 | -3.680% | GF-LF-OV-230 |
| 62248 | THREFORK | 100 | MONTANA | 0.9472 | 0.9104 | -3.680% | GF-LF-OV-230 |
| 1030 | MONT ST | 69 | MONTANA | 0.9416 | 0.9049 | -3.670% | GF-LF-OV-230 |
| 62136 | BUTECRSH | 100 | MONTANA | 0.9338 | 0.8972 | -3.660% | GF-LF-OV-230 |
| 62252 | WILLWCKM | 100 | MONTANA | 0.9474 | 0.9109 | -3.650% | GF-LF-OV-230 |

| BUS/NAME | | KV | Area | Pre Project | Post Project | Delta Volt % | Contingency with the Lowest Post Project Voltage |
|---|---|---|---|---|---|---|---|
| 62140 | BUT CONC | 100 | MONTANA | 0.9341 | 0.8977 | -3.640% | GF-LF-OV-230 |
| 62141 | MONT ST | 100 | MONTANA | 0.9346 | 0.8982 | -3.640% | GF-LF-OV-230 |
| 62142 | TAILBOOS | 100 | MONTANA | 0.9342 | 0.8979 | -3.630% | GF-LF-OV-230 |
| 62253 | MONTTALC | 100 | MONTANA | 0.9474 | 0.9113 | -3.610% | GF-LF-OV-230 |
| 62151 | CONDR TB | 100 | MONTANA | 0.9359 | 0.9002 | -3.570% | GF-LF-OV-230 |
| 62153 | CONTDRVE | 100 | MONTANA | 0.9358 | 0.9001 | -3.570% | GF-LF-OV-230 |
| 62150 | CONDR TA | 100 | MONTANA | 0.936 | 0.9004 | -3.560% | GF-LF-OV-230 |
| 62254 | COBLSTNT | 100 | MONTANA | 0.9541 | 0.9186 | -3.550% | GF-LF-OV-230 |
| 62245 | COBLSTON | 100 | MONTANA | 0.954 | 0.9185 | -3.550% | GF-LF-OV-230 |
| 62152 | BTMINDPK | 100 | MONTANA | 0.9376 | 0.9023 | -3.530% | GF-LF-OV-230 |
| 62331 | THREERIV | 230 | MONTANA | 0.9624 | 0.9272 | -3.520% | GF-LF-OV-230 |
| 62143 | RAMSAYPM | 100 | MONTANA | 0.94 | 0.9052 | -3.480% | GF-LF-OV-230 |
| 62145 | RENOVA | 100 | MONTANA | 0.9484 | 0.9137 | -3.470% | GF-LF-OV-230 |
| 62116 | BUTTE MT | 100 | MONTANA | 0.9395 | 0.9049 | -3.460% | GF-LF-OV-230 |
| 62156 | MAYFLWRM | 100 | MONTANA | 0.953 | 0.9187 | -3.430% | GF-LF-OV-230 |
| 62155 | MAYFLWRT | 100 | MONTANA | 0.953 | 0.9187 | -3.430% | GF-LF-OV-230 |
| 62168 | RAYNE PM | 100 | MONTANA | 0.9602 | 0.926 | -3.420% | GF-LF-OV-230 |
| 62182 | RNFRDP T | 100 | MONTANA | 0.9602 | 0.926 | -3.420% | GF-LF-OV-230 |
| 62251 | HAR-PONY | 100 | MONTANA | 0.9619 | 0.9287 | -3.320% | GF-LF-OV-230 |
| 62132 | FAIRMTMT | 100 | MONTANA | 0.9456 | 0.9126 | -3.300% | GF-LF-OV-230 |
| 62157 | DRUMN PM | 100 | MONTANA | 0.9419 | 0.909 | -3.290% | GF-LF-OV-230 |
| 62146 | DRUMPM T | 100 | MONTANA | 0.942 | 0.9091 | -3.290% | GF-LF-OV-230 |
| 62313 | DRUMMNMT | 100 | MONTANA | 0.9441 | 0.912 | -3.210% | GF-LF-OV-230 |
| 62147 | DRMCLARK | 100 | MONTANA | 0.9443 | 0.9123 | -3.200% | GF-LF-OV-230 |
| 62130 | MOREL | 100 | MONTANA | 0.9514 | 0.9197 | -3.170% | GF-LF-OV-230 |
| 62126 | LANDRSFK | 230 | MONTANA | 0.911 | 0.8797 | -3.130% | BROADVU-JGWIND 230 kV line |
| 62159 | GLDNSNLT | 161 | MONTANA | 0.974 | 0.9438 | -3.020% | GF-LF-OV-230 |
| 62077 | BUTTE MT | 161 | MONTANA | 0.969 | 0.9404 | -2.860% | GF-LF-OV-230 |
| 62014 | BUTTEMHD | 161 | MONTANA | 0.9704 | 0.9424 | -2.800% | GF-LF-OV-230 |
| 62017 | MT ASIMI | 161 | MONTANA | 0.9747 | 0.9485 | -2.620% | GF-LF-OV-230 |
| 62192 | PANTROBE | 100 | MONTANA | 0.9135 | 0.8954 | -1.810% | BROADVU-JGWIND 230 kV line |
| 62218 | ROUNDUPM | 100 | MONTANA | 0.9252 | 0.9114 | -1.380% | BROADVU-JGWIND 230 kV line |
| 62216 | LAVINAPM | 100 | MONTANA | 0.93 | 0.9169 | -1.310% | BROADVU-JGWIND 230 kV line |
| 62215 | LAVINAPT | 100 | MONTANA | 0.9301 | 0.917 | -1.310% | BROADVU-JGWIND 230 kV line |
| 62072 | OVANDO | 230 | MONTANA | 0.9509 | 0.9386 | -1.230% | GARRISON-OVANDO 230 kV line |
| 3286 | ROUNDUP | 69 | MONTANA | 0.919 | 0.9074 | -1.160% | BROADVU-JGWIND 230 kV line |

The 2010 Light Autumn potential voltage constraints, when the GI-0822 output is limited to 60 MW listed in Tables 4-7 and 4-8, were reviewed by WAPA and the ad hoc study group and were determined to be remote from the POI of the subject request. These are listed for informational purposes only. Therefore, no voltage injection constraints were identified that meet the WAPA feasibility study criteria for the requested interconnection service. However, these could be found in a transmission service study to be constraints if long term firm transmission service is requested for the GI-0822 generating facility.

### 4.1.3 2010 Light Autumn at 85 MW with Conrad – Great Falls 230 kV Analysis

This section contains a discussion of study results with the addition of a new Conrad – Great Falls 230 kV 400 MVA line, but with the GI-0822 project modeled at only 85 MW. The 85 MW output level was studied because it was found to be the highest GI-0822 output level for which all contingencies are convergent with a new Conrad – Great Falls 230 kV 400 MVA line modeled.

**Thermal Impacts**

***System Intact***

The 2010 Light Autumn system intact analysis thermal injections constraints with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service when the GI-0822 output is limited to 85 MW are given in Table 4-9.

**Table 4-9**
**2010 Light Autumn**
**85 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line**
**Thermal Injection Constraints – System Intact Results**

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| SHELBY 230/115 kV Tx | 100 | MONTANA | 110 | 110 | 115 | 115 | 5.29% | 0 | System Intact |

As can be seen from Table 4-9, the GI-0822 project generation would be limited to 0 MW with the addition of the new Conrad – Great Falls 230 kV line due to the loading on the Shelby 230/115 transformer.

No 2010 Light Autumn system intact potential thermal constraints were found with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service, when the GI-0822 output is limited to 85 MW.

***Single Contingency***

The 2010 Light Autumn single contingency thermal injections constraints, with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service when the GI-0822 output is limited to 85 MW, are given in Table 4-10.

**Table 4-10**
**2010 Light Autumn**
**85 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line**
**Thermal Injection Constraints – Single Contingency Results**

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| BOLE-CNRDWAPA 230 kV Line | 160 / 176 | MONTANA | 149 | 93 / 85 | 209 | 131 / 119 | 70.43% | 31 | CNRDWAPA-GT FALLS 230 kV Line 1 |
| SHELBY 2 230/115 kV Tx #1 | 100 / 125 | MONTANA | 193 | 193 / 154 | 199 | 198.8 / 159 | 7% | 0 | MLRK-CRA-115 |
| SHELBY 2-CNRDWAPA 230 kV Line 1 | 160 / 176 | MONTANA | 200 | 125.2 / 114 | 203 | 126.7 / 115 | 3% | 0 | CONRAD-VAL-WILL 115 kV Line 1 |

As can be seen from Table 4-10, the GI-0822 project generation would be limited to 0 MW with the addition of the new Conrad – Great Falls 230 kV line due to the loading on the Shelby 230/115 transformer and the Shelby – Conrad 230 kV line. As can also be seen from Table 4-10, the GI-0822 project generation is limited to 31 MW due to loading on the Bole – Conrad 230 kV line for loss of the new Conrad- Great Falls 230 kV 400 MVA line when the new Conrad- Great Falls 230 kV 400 MVA line is assumed in-service. These imply the need for a special protection scheme (SPS) and up-rating and/or up-grading the existing Shelby - Conrad – Bole – Great Falls 230 kV line, to achieve higher normal and emergency ratings and replacing the Shelby transformer.

The 2010 Light Autumn single contingency analysis potential thermal constraints with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service, when the GI-0822 output is limited to 85 MW, are given in Table 4-10A. It should be noted that although some elements may become loaded beyond acceptable levels under several contingency conditions, only the contingency with the highest post project loading is listed. A complete listing of all results above 3% DF is given in Appendix C.

## Table 4-10A

## 2010 Light Autumn
## 85 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line
## Potential Thermal Constraints – Single Contingency Results
## *(For Information Purposes Only)*

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| OVANDO-LANDRSFK 230 kV Line 1 | 478 | MONTANA | 501 | 105 | 554 | 116 | 62% | 0 | BROADVU-JGWIND 230 kV Line 1 |
| GT FALLS-LANDRSFK 230 kV Line 1 | 478 | MONTANA | 502 | 105 | 554 | 116 | 61% | 0 | BROADVU-JGWIND 230 kV Line 1 |
| BROADVU-JGWIND 230 kV Line 1 | 478 | MONTANA | 485 | 101 | 536 | 112 | 60% | 0 | OVANDO-LANDRSFK 230 kV Line 1 |
| JUDITHGP-JUDITGPT 100 kV Line 1 | 135 | MONTANA | 124 | 90 | 135 | 100 | 16% | 52 | BROADVU-JGWIND 230 kV Line 1 |
| JUDITHGP 230/100 kV Tx #1 | 100 | MONTANA | 132 | 131 | 143 | 143 | 14% | 0 | BROADVU-JGWIND 230 kV Line 1 |
| E HELENA 100/230 kV Tx #1 | 100 | MONTANA | 138 | 138 | 149 | 149 | 13% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| GOLD CR-GILBERT 100 kV Line 1 | 83 | MONTANA | 98 | 118 | 108 | 130 | 12% | 0 | OVANDO-LANDRSFK 230 kV Line 1 |
| CANYONCR-GILBERT 100 kV Line 1 | 83 | MONTANA | 98 | 119 | 109 | 131 | 12% | 0 | OVANDO-LANDRSFK 230 kV Line 1 |
| HOLTER-CANYONCR 100 kV Line 1 | 83 | MONTANA | 99 | 119 | 109 | 131 | 12% | 0 | OVANDO-LANDRSFK 230 kV Line 1 |
| MISSIONM-ULM TAP 100 kV Line 1 | 83 | MONTANA | 87 | 104 | 96 | 116 | 11% | 0 | OVANDO-LANDRSFK 230 kV Line 1 |
| BUTECORA-MONST TP 100 kV Line 1 | 92 | MONTANA | 134 | 146 | 144 | 156 | 11% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| GF NWEST-GF NW T1 100 kV Line 1 | 92 | MONTANA | 87 | 95 | 97 | 105 | 11% | 0 | OVANDO-LANDRSFK 230 kV Line 1 |
| HOLTER-CRAIGMT 100 kV Line 1 | 83 | MONTANA | 85 | 102 | 94 | 114 | 11% | 0 | OVANDO-LANDRSFK 230 kV Line 1 |
| MISSIONM-CRAIGMT 100 kV Line 1 | 83 | MONTANA | 85 | 103 | 95 | 114 | 11% | 0 | OVANDO-LANDRSFK 230 kV Line 1 |
| GF NW T1-ULM TAP 100 kV Line 1 | 83 | MONTANA | 87 | 105 | 97 | 117 | 11% | 0 | OVANDO-LANDRSFK 230 kV Line 1 |
| HARLOWTN-PANTROBE 100 kV Line 1 | 62 | MONTANA | 96 | 156 | 105 | 170 | 10% | 0 | BROADVU-JGWIND 230 kV Line 1 |
| BROADVU-HARLOWTN 100 kV Line 1 | 62 | MONTANA | 98 | 159 | 108 | 173 | 10% | 0 | BROADVU-JGWIND 230 kV Line 1 |
| MNTGMRY1 14/230 kV Tx #1 | 100 | MONTANA | 93 | 93 | 101 | 101 | 9% | 17 | OVANDO-LANDRSFK 230 kV Line 1 |
| MNTGMRY2 14/230 kV Tx #1 | 100 | MONTANA | 93 | 93 | 101 | 101 | 9% | 17 | OVANDO-LANDRSFK 230 kV Line 1 |
| BROADVU 100/230 kV Tx #1 | 100 | MONTANA | 116 | 116 | 123 | 123 | 9% | 0 | BROADVU-JGWIND 230 kV Line 1 |
| HARLOWTN-TWO DOT 100 kV Line 1 | 57 | MONTANA | 92 | 160 | 99 | 173 | 9% | 0 | OVANDO-LANDRSFK 230 kV Line 1 |

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| E HELENA-CANFERTB 100 kV Line 1 | 92 | MONTANA | 138 | 150 | 145 | 158 | 9% | 0 | E HELENA-CANFERTA 100 kV Line 1 |
| GT FALLS-GF ESIDE 100 kV Line 1 | 92 | MONTANA | 94 | 103 | 102 | 111 | 9% | 0 | GT FALLS-EHELENA 230 kV Line 1 |
| ADEL-CANFERTA 100 kV Line 1 | 92 | MONTANA | 88 | 96 | 95 | 104 | 9% | 0 | GT FALLS-EHELENA 230 kV Line 1 |
| E HELENA-HELSS TA 100 kV Line 1 | 92 | MONTANA | 101 | 110 | 109 | 118 | 9% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| HELSS TA-CLANCYTA 100 kV Line 1 | 92 | MONTANA | 101 | 110 | 109 | 118 | 9% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| E HELENA-HELSS TB 100 kV Line 1 | 92 | MONTANA | 103 | 113 | 111 | 120 | 9% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| E HELENA-CANFERTA 100 kV Line 1 | 92 | MONTANA | 138 | 150 | 145 | 158 | 9% | 0 | E HELENA-CANFERTB 100 kV Line 1 |
| GF ESIDE-CANFERTB 100 kV Line 1 | 92 | MONTANA | 89 | 97 | 96 | 104 | 8% | 0 | GT FALLS-EHELENA 230 kV Line 1 |
| BASINMT-BOULDRTA 100 kV Line 1 | 92 | MONTANA | 96 | 105 | 103 | 113 | 8% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| BUTECORA-PRECIPIT 100 kV Line 1 | 92 | MONTANA | 96 | 104 | 103 | 112 | 8% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| PRECIPIT-BASINMT 100 kV Line 1 | 92 | MONTANA | 96 | 105 | 103 | 113 | 8% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| BUTECORA-TAILBOS2 100 kV Line 1 | 92 | MONTANA | 97 | 106 | 104 | 114 | 8% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| BARGE PM-BOULDRTB 100 kV Line 1 | 92 | MONTANA | 98 | 106 | 105 | 114 | 8% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| HELSS TB-CLANCYTB 100 kV Line 1 | 92 | MONTANA | 98 | 107 | 105 | 115 | 8% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| MTTUNTAP-BOULDRTB 100 kV Line 1 | 92 | MONTANA | 98 | 106 | 105 | 114 | 8% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| MTTUNTAP-CLANCYTB 100 kV Line 1 | 92 | MONTANA | 98 | 107 | 105 | 114 | 8% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| MTTUNTPA-CLANCYTA 100 kV Line 1 | 92 | MONTANA | 101 | 110 | 109 | 118 | 8% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| GF SSIDE-ADEL 100 kV Line 1 | 92 | MONTANA | 88 | 96 | 96 | 104 | 8% | 0 | GT FALLS-EHELENA 230 kV Line 1 |
| MTTUNTPA-BOULDRTA 100 kV Line 1 | 92 | MONTANA | 97 | 106 | 105 | 114 | 8% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| TAILBOS2-BARGE PM 100 kV Line 1 | 92 | MONTANA | 97 | 106 | 104 | 114 | 8% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| ANACOND-PCIFICST 100 kV Line 1 | 92 | MONTANA | 91 | 99 | 97 | 105 | 7% | 0 | BUTECORA-MONST TP 100 kV Line 1 |
| BUTECORA-PCIFICST 100 kV Line 1 | 92 | MONTANA | 92 | 101 | 99 | 107 | 7% | 0 | BUTECORA-MONST TP 100 kV Line 1 |
| ANACOND 161/100 kV Tx #2 | 63 | MONTANA | 70 | 112 | 75 | 121 | 7% | 0 | ANACOND-ANACOND 161/100 kV Tx #1 |

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| ANACOND 161/100 kV Tx #1 | 63 | MONTANA | 69 | 110 | 74 | 119 | 6% | 0 | ANACOND-ANACOND 161/100 kV Tx #2 |
| TOSTON-BRDWTR T 100 kV Line 1 | 62 | MONTANA | 72 | 115 | 77 | 124 | 6% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| TOWNSEND-TOSTON 100 kV Line 1 | 62 | MONTANA | 74 | 119 | 79 | 128 | 6% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| CONLIM T-TOWNSEND 100 kV Line 1 | 57 | MONTANA | 77 | 135 | 83 | 145 | 6% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| E HELENA-CONLIM T 100 kV Line 1 | 57 | MONTANA | 78 | 137 | 84 | 147 | 6% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| TRIDENT-EUSTIS 100 kV Line 1 | 62 | MONTANA | 71 | 115 | 77 | 123 | 6% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| CROWCREK-BRDWTR T 100 kV Line 1 | 62 | MONTANA | 73 | 116 | 78 | 125 | 6% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| EUSTIS-CROWCREK 100 kV Line 1 | 62 | MONTANA | 71 | 115 | 77 | 124 | 6% | 0 | THREERIV-EHELENA 230 kV Line 1 |
| BROADVU 100/230 kV Tx #2 | 100 | MONTANA | 117 | 117 | 122 | 122 | 6% | 0 | BROADVU-BROADVU 100/230 kV Tx #1 |
| CANYON F-SPOKANEB 100 kV Line 1 | 92 | MONTANA | 89 | 97 | 93 | 101 | 4% | 0 | E HELENA-CANFERTA 100 kV Line 1 |
| CANYON F-SPOKANEA 100 kV Line 1 | 92 | MONTANA | 91 | 99 | 94 | 103 | 4% | 0 | E HELENA-CANFERTB 100 kV Line 1 |
| CANFERTA-SPOKANEA 100 kV Line 1 | 92 | MONTANA | 90 | 98 | 93 | 102 | 4% | 0 | E HELENA-CANFERTB 100 kV Line 1 |
| CANFERTB-SPOKANEB 100 kV Line 1 | 92 | MONTANA | 89 | 97 | 93 | 101 | 4% | 0 | E HELENA-CANFERTA 100 kV Line 1 |
| COCHRAN-COCHRAN 100/14 kV Tx #1 | 60 | MONTANA | 57 | 96 | 60 | 101 | 4% | 0 | BROADVU-JGWIND 230 kV Line 1 |
| E HELENA-HELVLY T 100 kV Line 1 | 57 | MONTANA | 70 | 122 | 73 | 127 | 3% | 0 | HOLTER-CANYONCR 100 kV Line 1 |
| HOLTER-HELVLY T 100 kV Line 1 | 57 | MONTANA | 70 | 123 | 73 | 128 | 3% | 0 | HOLTER-CANYONCR 100 kV Line 1 |

The 2010 Light Autumn potential thermal constraints listed in Tables 4-10A were reviewed by WAPA and the ad hoc study group and were determined to be remote from the POI of the subject request. These are listed for informational purposes only. However, these could be found in a transmission service study to be constraints if long term firm transmission service is requested for the GI-0822 generating facility.

## Voltage Impacts

### ***System Intact***

No 2010 Light Autumn system intact voltage injections constraints were found with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service when the GI-0822 output is limited to 85 MW.

The 2010 Light Autumn system intact analysis potential voltage constraints with the new Conrad – Great Falls 230 kV 400 MVA line, assumed in-service when the GI-0822 output is limited to 85 MW, are given in Table 4-11.

**Table 4-11**
**2010 Light Autumn**
**85 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line**
**Potential Voltage Constraints SOGF – System Intact Results**
**(For Information Purposes Only)**

| BUS/NAME | KV | Area | Pre Project | Post Project | Delta Volt % | Contingency |
|---|---|---|---|---|---|---|
| 62126 LANDRSFK | 230 | MONTANA | 0.9665 | 0.9528 | -1.370% | System Intact |

### ***Single Contingency***

No 2010 Light Autumn single contingency voltage injections constraints were found with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service when the GI-0822 output is limited to 85 MW.

The 2010 Light Autumn single contingency analysis potential voltage constraints with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service when the GI-0822 output is limited to 85 MW are given in Table 4-12. It should be noted that although some bus voltages may be found to be outside of acceptable levels under several contingency conditions, only the contingency with the lowest post project voltage is shown. A complete listing of all voltage results is given in Appendix C.

**Table 4-12**
**2010 Light Autumn**
**85 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line**
**Potential Voltage Constraints SOGF – Single Contingency Results**
***(For Information Purposes Only)***

| BUS/NAME | | KV | Area | Pre Project | Post Project | Delta Volt % | Contingency with the Lowest Post Project Voltage |
|---|---|---|---|---|---|---|---|
| 62121 | E HELENA | 100 | MONTANA | 0.9163 | 0.8481 | -6.820% | GF-LF-OV-230 |
| 62275 | HELSS TA | 100 | MONTANA | 0.913 | 0.8448 | -6.820% | GF-LF-OV-230 |
| 62277 | HELENASS | 100 | MONTANA | 0.9125 | 0.8443 | -6.820% | GF-LF-OV-230 |
| 62276 | HELSS TB | 100 | MONTANA | 0.9128 | 0.8447 | -6.810% | GF-LF-OV-230 |
| 62261 | CANFERTB | 100 | MONTANA | 0.9214 | 0.8535 | -6.790% | GF-LF-OV-230 |
| 62260 | CANFERTA | 100 | MONTANA | 0.9214 | 0.8536 | -6.780% | GF-LF-OV-230 |
| 62269 | HELVLY T | 100 | MONTANA | 0.9223 | 0.8545 | -6.780% | GF-LF-OV-230 |
| 62270 | HELVALLY | 100 | MONTANA | 0.9223 | 0.8545 | -6.780% | GF-LF-OV-230 |
| 62282 | SPOKANEB | 100 | MONTANA | 0.9263 | 0.8586 | -6.770% | GF-LF-OV-230 |
| 62281 | SPOKANEA | 100 | MONTANA | 0.9262 | 0.8586 | -6.760% | GF-LF-OV-230 |
| 62122 | CANYON F | 100 | MONTANA | 0.9303 | 0.8628 | -6.750% | GF-LF-OV-230 |
| 62285 | CLANCYTA | 100 | MONTANA | 0.9072 | 0.8397 | -6.750% | GF-LF-OV-230 |
| 62284 | CLANCYTB | 100 | MONTANA | 0.9082 | 0.8408 | -6.740% | GF-LF-OV-230 |
| 62287 | CLNCYTIE | 100 | MONTANA | 0.9082 | 0.8408 | -6.740% | GF-LF-OV-230 |
| 62289 | CLANCY | 100 | MONTANA | 0.9082 | 0.8408 | -6.740% | GF-LF-OV-230 |
| 62262 | CANYONCR | 100 | MONTANA | 0.9116 | 0.8448 | -6.680% | GF-LF-OV-230 |
| 62921 | EHELENA | 230 | MONTANA | 0.8981 | 0.8314 | -6.670% | GF-LF-OV-230 |
| 62279 | MTTUNTPA | 100 | MONTANA | 0.9031 | 0.8375 | -6.560% | GF-LF-OV-230 |
| 62280 | MTTUNTIE | 100 | MONTANA | 0.9031 | 0.8375 | -6.560% | GF-LF-OV-230 |
| 62283 | MTTUNELS | 100 | MONTANA | 0.9026 | 0.837 | -6.560% | GF-LF-OV-230 |
| 62120 | HOLTER | 100 | MONTANA | 0.9364 | 0.871 | -6.540% | GF-LF-OV-230 |
| 62278 | MTTUNTAP | 100 | MONTANA | 0.9053 | 0.8399 | -6.540% | GF-LF-OV-230 |
| 62274 | CRAIGMT | 100 | MONTANA | 0.9362 | 0.8726 | -6.360% | GF-LF-OV-230 |
| 62316 | BOULDRAT | 100 | MONTANA | 0.9038 | 0.8409 | -6.290% | GF-LF-OV-230 |
| 62327 | BOULDRTA | 100 | MONTANA | 0.9038 | 0.841 | -6.280% | GF-LF-OV-230 |
| 62329 | BOULDTIE | 100 | MONTANA | 0.9038 | 0.841 | -6.280% | GF-LF-OV-230 |
| 62328 | BOULDRTB | 100 | MONTANA | 0.9055 | 0.8429 | -6.260% | GF-LF-OV-230 |
| 7023 | ELKHORN | 69 | MONTANA | 0.8849 | 0.823 | -6.190% | GF-LF-OV-230 |
| 62271 | CONTLIME | 100 | MONTANA | 0.9018 | 0.84 | -6.180% | GF-LF-OV-230 |
| 7019 | BOULDERA | 69 | MONTANA | 0.8858 | 0.8241 | -6.170% | GF-LF-OV-230 |
| 7020 | BOULDERB | 69 | MONTANA | 0.8858 | 0.8241 | -6.170% | GF-LF-OV-230 |
| 7029 | JEFRSNSM | 69 | MONTANA | 0.8864 | 0.8247 | -6.170% | GF-LF-OV-230 |
| 7065 | BOULDTIE | 69 | MONTANA | 0.8863 | 0.8246 | -6.170% | GF-LF-OV-230 |
| 62264 | CONLIM T | 100 | MONTANA | 0.9021 | 0.8404 | -6.170% | GF-LF-OV-230 |
| 7061 | BOULDRAT | 69 | MONTANA | 0.8863 | 0.8247 | -6.160% | GF-LF-OV-230 |
| 62265 | TOWNSEND | 100 | MONTANA | 0.9023 | 0.841 | -6.130% | GF-LF-OV-230 |
| 62273 | TOWNSD-R | 100 | MONTANA | 0.9023 | 0.841 | -6.130% | GF-LF-OV-230 |
| 62259 | BASINMT | 100 | MONTANA | 0.9054 | 0.8445 | -6.090% | GF-LF-OV-230 |
| 62263 | GILBERT | 100 | MONTANA | 0.9127 | 0.854 | -5.870% | GF-LF-OV-230 |
| 62172 | ADEL | 100 | MONTANA | 0.9334 | 0.8751 | -5.830% | GF-LF-OV-230 |
| 62036 | JUDITHGP | 230 | MONTANA | 0.9391 | 0.8825 | -5.660% | GF-LF-OV-230 |

| BUS/NAME | | KV | Area | Pre Project | Post Project | Delta Volt % | Contingency with the Lowest Post Project Voltage |
|---|---|---|---|---|---|---|---|
| 90105 | JGWIND | 230 | MONTANA | 0.9393 | 0.8834 | -5.590% | GF-LF-OV-230 |
| 62229 | UTICATAP | 100 | MONTANA | 0.9411 | 0.8853 | -5.580% | GF-LF-OV-230 |
| 62231 | STANFRDM | 100 | MONTANA | 0.9473 | 0.8915 | -5.580% | GF-LF-OV-230 |
| 62228 | UTICAPMP | 100 | MONTANA | 0.9409 | 0.8851 | -5.580% | GF-LF-OV-230 |
| 62237 | UTICA-R | 100 | MONTANA | 0.9409 | 0.8851 | -5.580% | GF-LF-OV-230 |
| 62238 | UTICA | 100 | MONTANA | 0.9409 | 0.8851 | -5.580% | GF-LF-OV-230 |
| 62230 | BENCHLND | 100 | MONTANA | 0.9417 | 0.886 | -5.570% | GF-LF-OV-230 |
| 62322 | FRONTRGT | 100 | MONTANA | 0.9395 | 0.8839 | -5.560% | GF-LF-OV-230 |
| 62323 | FRONTRNG | 100 | MONTANA | 0.9395 | 0.8839 | -5.560% | GF-LF-OV-230 |
| 62104 | JUDITHGP | 100 | MONTANA | 0.9397 | 0.8845 | -5.520% | GF-LF-OV-230 |
| 62236 | JUDTHPMP | 100 | MONTANA | 0.939 | 0.8839 | -5.510% | GF-LF-OV-230 |
| 62234 | JUDGAPSM | 100 | MONTANA | 0.9402 | 0.8852 | -5.500% | GF-LF-OV-230 |
| 62239 | JUDTHSMT | 100 | MONTANA | 0.9402 | 0.8852 | -5.500% | GF-LF-OV-230 |
| 62233 | JUDITGPT | 100 | MONTANA | 0.9404 | 0.8855 | -5.490% | GF-LF-OV-230 |
| 62240 | STRAWXPT | 100 | MONTANA | 0.9359 | 0.8814 | -5.450% | GF-LF-OV-230 |
| 62266 | TOSTON | 100 | MONTANA | 0.9173 | 0.8636 | -5.370% | GF-LF-OV-230 |
| 62272 | TOSTON-R | 100 | MONTANA | 0.9173 | 0.8636 | -5.370% | GF-LF-OV-230 |
| 62232 | GLENGARY | 100 | MONTANA | 0.9284 | 0.8753 | -5.310% | GF-LF-OV-230 |
| 62162 | MISSIONM | 100 | MONTANA | 0.951 | 0.8988 | -5.220% | GF-LF-OV-230 |
| 62286 | BRDWTR T | 100 | MONTANA | 0.9212 | 0.8691 | -5.210% | GF-LF-OV-230 |
| 62288 | BRODWATR | 100 | MONTANA | 0.9226 | 0.8705 | -5.210% | GF-LF-OV-230 |
| 62117 | GOLD CR | 100 | MONTANA | 0.9258 | 0.8751 | -5.070% | GF-LF-OV-230 |
| 62267 | CROWCREK | 100 | MONTANA | 0.9235 | 0.8728 | -5.070% | GF-LF-OV-230 |
| 62106 | HARLOWTN | 100 | MONTANA | 0.9561 | 0.906 | -5.010% | GF-LF-OV-230 |
| 62133 | DRLDGCTY | 100 | MONTANA | 0.9269 | 0.8783 | -4.860% | GF-LF-OV-230 |
| 62134 | DRLDG CM | 100 | MONTANA | 0.9282 | 0.8796 | -4.860% | GF-LF-OV-230 |
| 62168 | RAYNE PM | 100 | MONTANA | 0.9632 | 0.9158 | -4.740% | GF-LF-OV-230 |
| 62182 | RNFRDP T | 100 | MONTANA | 0.9632 | 0.9159 | -4.730% | GF-LF-OV-230 |
| 62149 | BARGE PM | 100 | MONTANA | 0.9258 | 0.8787 | -4.710% | GF-LF-OV-230 |
| 62176 | ULM TAP | 100 | MONTANA | 0.9622 | 0.9158 | -4.640% | GF-LF-OV-230 |
| 62131 | DERLDG T | 100 | MONTANA | 0.932 | 0.8856 | -4.640% | GF-LF-OV-230 |
| 62160 | ULM MT | 100 | MONTANA | 0.9621 | 0.9158 | -4.630% | GF-LF-OV-230 |
| 62144 | TAILBOS2 | 100 | MONTANA | 0.9275 | 0.8813 | -4.620% | GF-LF-OV-230 |
| 62135 | MT PHOST | 100 | MONTANA | 0.9319 | 0.886 | -4.590% | GF-LF-OV-230 |
| 62148 | PRECIPIT | 100 | MONTANA | 0.9288 | 0.8834 | -4.540% | GF-LF-OV-230 |
| 62137 | BUTECORA | 100 | MONTANA | 0.93 | 0.8852 | -4.480% | GF-LF-OV-230 |
| 62138 | PCIFICST | 100 | MONTANA | 0.9313 | 0.887 | -4.430% | GF-LF-OV-230 |
| 62244 | EUSTIS | 100 | MONTANA | 0.9372 | 0.8937 | -4.350% | GF-LF-OV-230 |
| 1031 | DIVIDE | 69 | MONTANA | 0.9412 | 0.8989 | -4.230% | GF-LF-OV-230 |
| 1033 | BUTTE WC | 69 | MONTANA | 0.9412 | 0.8989 | -4.230% | GF-LF-OV-230 |
| 62139 | MONST TP | 100 | MONTANA | 0.9343 | 0.892 | -4.230% | GF-LF-OV-230 |
| 1030 | MONT ST | 69 | MONTANA | 0.9427 | 0.9005 | -4.220% | GF-LF-OV-230 |
| 1032 | FEELYHIL | 69 | MONTANA | 0.942 | 0.8998 | -4.220% | GF-LF-OV-230 |
| 62136 | BUTECRSH | 100 | MONTANA | 0.9348 | 0.893 | -4.180% | GF-LF-OV-230 |
| 62141 | MONT ST | 100 | MONTANA | 0.9357 | 0.894 | -4.170% | GF-LF-OV-230 |
| 62140 | BUT CONC | 100 | MONTANA | 0.9351 | 0.8935 | -4.160% | GF-LF-OV-230 |
| 62142 | TAILBOOS | 100 | MONTANA | 0.9352 | 0.8938 | -4.140% | GF-LF-OV-230 |

| BUS/NAME | | KV | Area | Pre Project | Post Project | Delta Volt % | Contingency with the Lowest Post Project Voltage |
|---|---|---|---|---|---|---|---|
| 62073 | TRIDENT | 100 | MONTANA | 0.943 | 0.9021 | -4.090% | GF-LF-OV-230 |
| 62247 | TRIDTPLT | 100 | MONTANA | 0.9428 | 0.902 | -4.080% | GF-LF-OV-230 |
| 62153 | CONTDRVE | 100 | MONTANA | 0.9368 | 0.8961 | -4.070% | GF-LF-OV-230 |
| 62150 | CONDR TA | 100 | MONTANA | 0.937 | 0.8964 | -4.060% | GF-LF-OV-230 |
| 62151 | CONDR TB | 100 | MONTANA | 0.9369 | 0.8963 | -4.060% | GF-LF-OV-230 |
| 62021 | THREERIV | 100 | MONTANA | 0.9453 | 0.9052 | -4.010% | GF-LF-OV-230 |
| 62152 | BTMINDPK | 100 | MONTANA | 0.9386 | 0.8985 | -4.010% | GF-LF-OV-230 |
| 62126 | LANDRSFK | 230 | MONTANA | 0.9115 | 0.8716 | -3.990% | BROADVU-JGWIND 230 kV Line 1 |
| 62143 | RAMSAYPM | 100 | MONTANA | 0.9409 | 0.901 | -3.990% | GF-LF-OV-230 |
| 62331 | THREERIV | 230 | MONTANA | 0.9633 | 0.9241 | -3.920% | GF-LF-OV-230 |
| 62116 | BUTTE MT | 100 | MONTANA | 0.9404 | 0.9014 | -3.900% | GF-LF-OV-230 |
| 62146 | DRUMPM T | 100 | MONTANA | 0.9431 | 0.9041 | -3.900% | GF-LF-OV-230 |
| 62157 | DRUMN PM | 100 | MONTANA | 0.943 | 0.904 | -3.900% | GF-LF-OV-230 |
| 62248 | THREFORK | 100 | MONTANA | 0.9481 | 0.9092 | -3.890% | GF-LF-OV-230 |
| 62252 | WILLWCKM | 100 | MONTANA | 0.9483 | 0.9095 | -3.880% | GF-LF-OV-230 |
| 62253 | MONTTALC | 100 | MONTANA | 0.9484 | 0.9099 | -3.850% | GF-LF-OV-230 |
| 62132 | FAIRMTMT | 100 | MONTANA | 0.9465 | 0.9086 | -3.790% | GF-LF-OV-230 |
| 62313 | DRUMMNMT | 100 | MONTANA | 0.9451 | 0.9072 | -3.790% | GF-LF-OV-230 |
| 62147 | DRMCLARK | 100 | MONTANA | 0.9453 | 0.9075 | -3.780% | GF-LF-OV-230 |
| 62145 | RENOVA | 100 | MONTANA | 0.9493 | 0.9121 | -3.720% | GF-LF-OV-230 |
| 62245 | COBLSTON | 100 | MONTANA | 0.9549 | 0.9179 | -3.700% | GF-LF-OV-230 |
| 62254 | COBLSTNT | 100 | MONTANA | 0.9549 | 0.9179 | -3.700% | GF-LF-OV-230 |
| 62130 | MOREL | 100 | MONTANA | 0.9522 | 0.9159 | -3.630% | GF-LF-OV-230 |
| 62155 | MAYFLWRT | 100 | MONTANA | 0.9538 | 0.9176 | -3.620% | GF-LF-OV-230 |
| 62156 | MAYFLWRM | 100 | MONTANA | 0.9538 | 0.9176 | -3.620% | GF-LF-OV-230 |
| 62251 | HAR-PONY | 100 | MONTANA | 0.9627 | 0.9286 | -3.410% | GF-LF-OV-230 |
| 62129 | ANA CITY | 100 | MONTANA | 0.9609 | 0.9279 | -3.300% | GF-LF-OV-230 |
| 1111 | 100--115 | 100 | MONTANA | 0.9612 | 0.9283 | -3.290% | GF-LF-OV-230 |
| 62115 | ANACOND | 100 | MONTANA | 0.9612 | 0.9283 | -3.290% | GF-LF-OV-230 |
| 62077 | BUTTE MT | 161 | MONTANA | 0.9697 | 0.9381 | -3.160% | GF-LF-OV-230 |
| 62159 | GLDNSNLT | 161 | MONTANA | 0.9748 | 0.9433 | -3.150% | GF-LF-OV-230 |
| 62014 | BUTTEMHD | 161 | MONTANA | 0.9711 | 0.9401 | -3.100% | GF-LF-OV-230 |
| 62017 | MT ASIMI | 161 | MONTANA | 0.9753 | 0.9462 | -2.910% | GF-LF-OV-230 |
| 62072 | OVANDO | 230 | MONTANA | 0.9577 | 0.9331 | -2.460% | BROADVU-JGWIND 230 kV Line 1 |
| 62023 | GT FALLS | 161 | MONTANA | 0.9642 | 0.9402 | -2.400% | GF-LF-OV-230 |
| 62089 | BROADVU | 100 | MONTANA | 0.9494 | 0.9286 | -2.080% | GF-LF-OV-230 |
| 62192 | PANTROBE | 100 | MONTANA | 0.9134 | 0.8943 | -1.910% | BROADVU-JGWIND 230 kV Line 1 |
| 62218 | ROUNDUPM | 100 | MONTANA | 0.9251 | 0.9097 | -1.540% | BROADVU-JGWIND 230 kV Line 1 |
| 62215 | LAVINAPT | 100 | MONTANA | 0.9301 | 0.915 | -1.510% | BROADVU-JGWIND 230 kV Line 1 |
| 62216 | LAVINAPM | 100 | MONTANA | 0.93 | 0.9149 | -1.510% | BROADVU-JGWIND 230 kV Line 1 |
| 3286 | ROUNDUP | 69 | MONTANA | 0.9189 | 0.906 | -1.290% | BROADVU-JGWIND 230 kV Line 1 |

The 2010 Light Autumn potential voltage constraints listed in Tables 4-11 and Table 4-12 were reviewed by WAPA and the ad hoc study group and were determined to be remote from the POI of the subject request. These are listed for informational purposes only. Therefore, no voltage injection constraints were identified that meet the WAPA feasibility study criteria for

the requested interconnection service. However, these could be found in a transmission service study to be constraints if long term firm transmission service is requested for the GI-0822 generating facility.

### 4.1.4 2019 Heavy Summer Peak Analysis at 250 MW with Conrad – Great Falls 230 kV

Initial 2010 Light Autumn analysis revealed that divergent contingency conditions in the vicinity of the POI resulted when the GI-0822 generation was modeled at 250MW. Specifically loss of the Conrad – Bole 230 kV line was found to be divergent. Further investigation indicated that the maximum GI-0822 generation level for which the Conrad-Bole 230 kV contingency was found to be convergent was 65 MW. It should also be noted that the maximum GI-0822 generation level for which the Bole – Great Falls 230 kV contingency was found to be convergent was 70 MW. After Western's 5 MW margin is applied, the convergent GI-0822 generation maximum is 60 MW for loss of the Conrad-Bole 230 kV line. Thus all analysis included in this report for GI-0822 at its requested outlet level of 250 MW was performed with a new Conrad – Great Falls 230 kV 400 MVA line modeled.

**Thermal Impacts**

***System Intact***

The 2019 Heavy Summer Peak system intact analysis thermal injection constraint with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service is given in Table 4-13.

**Table 4-13**
**2019 Heavy Summer Peak**
**250 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line**
**Thermal Injection Constraints – System Intact Results**

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| BOLE-CNRDWAPA 230 kV Line | 160 | MONTANA | 104.4 | 65.2 | 167.6 | 104.7 | 25.28% | 220 | System Intact |

The 2019 Heavy Summer Peak system intact analysis potential thermal constraints with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service are given in Table 4-13A.

**Table 4-13A**
**2019 Heavy Summer Peak**
**250 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line**
**Potential Thermal Constraints SOGF – System Intact Results**
***(For Information Purposes Only)***

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| E HELENA-E HELENA 69-100 kV Tx #2 | 50 | MONTANA | 35.2 | 70 | 55.6 | 111 | 8.16% | 120 | System Intact |
| E HELENA-HELSS TA 100 kV Line | 91.8 | MONTANA | 89.1 | 97 | 105.5 | 115 | 6.56% | 0 | System Intact |
| HELSS TA-CLANCYTA 100 kV Line | 91.8 | MONTANA | 78.9 | 86 | 94.9 | 103 | 6.40% | 123 | System Intact |
| MTTUNTPA-CLANCYTA 100 kV Line | 91.8 | MONTANA | 78.8 | 86 | 94.8 | 103 | 6.40% | 125 | System Intact |
| BUTECORA-MONST TP 100 kV Line | 91.8 | MONTANA | 86 | 94 | 101.3 | 110 | 6.12% | 13 | System Intact |

***Single Contingency***

The 2019 Heavy Summer Peak single contingency thermal injections constraints with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service are given in Table 4-14.

**Table 4-14**
**2019 Heavy Summer Peak**
**250 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line**
**Thermal Injection Constraints – Single Contingency Results**

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| BOLE-CNRDWAPA 230 kV Line | 160 / 176 | MONTANA | 104.3 | 65 / 59 | 289.5 | 181 / 164 | 74.08% | 90 | CNRDWAPA-GT FALLS 230 kV Line 1 |
| BOLE-GT FALLS 230 kV Line | 200 / 220 | MONTANA | 84.8 | 42 / 39 | 269.8 | 135 / 123 | 74.00% | 176 | CNRDWAPA-GT FALLS 230 kV Line 1 |
| RUDYARD-GI-0814 115 kV Line 1 | 80 / 88 | WAPA U.M | 73.819 | 92.3 / 83.9 | 93.6 | 117/106.3 | 7.91% | 179 | CNRDWAPA - GT FALLS 230kV Line 1 |
| HAVRE-RUDYARD 115 kV Line 1 | 75 / 87 | WAPA U.M | 68.781 | 91.7 / 79.1 | 88.4 | 117.9/101.6 | 7.85% | 232 | CNRDWAPA - GT FALLS 230kV Line 1 |
| HAVRE 161-115 kV Tx #1 | 75 / 93 | WAPA U.M | 65.754 | 87.7 / 70.7 | 83.6 | 111.5/89.89 | 7.14% | 382 | CNRDWAPA - GT FALLS 230kV Line 1 |

The injection constraints shown in Tables 4-13 and 4-14 must be mitigated prior to granting interconnection service to the subject request. These may imply the need for a special protection scheme (SPS) and up-rating and/or up-grading the existing Conrad – Bole – Great Falls 230 kV line and the existing GI-0814 – Rudyard – Havre 115 kV line to achieve higher normal and emergency ratings. The Havre 161/115 kV transformer does not load beyond its emergency rating, thus it can be ameliorated with an operating guide.

The 2019 Heavy Summer Peak single contingency analysis potential thermal constraints with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service are given in Table 4-14A. It should be noted that although some elements may become loaded beyond acceptable levels under several contingency conditions, only the contingency with the highest post project loading is listed. A complete listing of all results above 3% DF is given in Appendix C.

**Table 4-14A**
**2019 Heavy Summer Peak**
**250 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line**
**Potential Thermal Constraints – Single Contingency Results**
***(For Information Purposes Only)***

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| BUTECORA-MONST TP 100 kV Line 1 | 92 | MONTANA | 94.6 | 103.1 | 117.9 | 128.4 | 9.32% | 0 | MILL CRK - PCIFICST 100 kV Line 1 |
| E HELENA-HELSS TA 100 kV Line 1 | 92 | MONTANA | 92.3 | 100.5 | 114.4 | 124.7 | 8.84% | 0 | JUDITHGP- STH_TAP 230 kV Line 1 |
| MTTUNTPA-BOULDRTA 100 kV Line 1 | 92 | MONTANA | 71.9 | 78.3 | 93.5 | 101.8 | 8.64% | | JUDITHGP- STH_TAP 230 kV Line 1 |
| HELSS TA-CLANCYTA 100 kV Line 1 | 92 | MONTANA | 82 | 89.3 | 103.5 | 112.7 | 8.60% | 114 | JUDITHGP- STH_TAP 230 kV Line 1 |
| MTTUNTPA-CLANCYTA 100 kV Line 1 | 92 | MONTANA | 81.9 | 89.2 | 103.4 | 112.6 | 8.60% | 115 | JUDITHGP- STH_TAP 230 kV Line 1 |
| E HELENA-CANFERTA 100 kV Line 1 | 92 | MONTANA | 134.2 | 146.2 | 155.5 | 169.3 | 8.52% | 0 | E HELENA-CANFERTB 100 kV Line 1 |
| E HELENA-CANFERTB 100 kV Line 1 | 92 | MONTANA | 134.2 | 146.2 | 155.4 | 169.3 | 8.48% | 0 | E HELENA-CANFERTA 100 kV Line 1 |

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| E HELENA-E HELENA 69-100 kV Tx #2 | 50 | MONTANA | 35.3 | 70.5 | 56.2 | 112.4 | 8.36% | 176 | DILLON S -BIGGRASS 161kV Line 1 |
| E HELENA-E HELENA 69-100 kV Tx #2 | 50 | MONTANA | 35.183 | 70.4 | 55.5 | 111 | 8.13% | 182 | CNRDWAPA - GT FALLS 230kV Line 1 |
| BUTECORA-PRECIPIT 100 kV Line 1 | 92 | MONTANA | 84.9 | 92.5 | 105 | 114.3 | 8.04% | 86 | N-1-39 |
| PRECIPIT-BASINMT 100 kV Line 1 | 92 | MONTANA | 82.1 | 89.5 | 101.9 | 111 | 7.92% | 122 | N-1-67 |
| BASINMT-BOULDRTA 100 kV Line 1 | 92 | MONTANA | 81.5 | 88.8 | 101.3 | 110.3 | 7.92% | 130 | BUTECORA - TAILBOS2 100kV Line 1 |
| GT FALLS-GFCITYT1 100 kV Line 1 | 135 | MONTANA | 130.7 | 96.7 | 146.3 | 108.3 | 6.24% | 71 | CNRDWAPA - GT FALLS 230kV Line 1 |
| HELSS TA-CLANCYTA 100 kV Line 1 | 92 | MONTANA | 78.9 | 85.9 | 94.4 | 102.9 | 6.20% | 208 | CNRDWAPA - GT FALLS 230kV Line 1 |
| MTTUNTPA-CLANCYTA 100 kV Line 1 | 92 | MONTANA | 78.824 | 85.9 | 94.3 | 102.8 | 6.19% | 210 | CNRDWAPA - GT FALLS 230kV Line 1 |
| BUTECORA-MONST TP 100 kV Line 1 | 92 | MONTANA | 86.019 | 93.7 | 100.9 | 109.9 | 5.95% | 97 | CNRDWAPA - GT FALLS 230kV Line 1 |
| ULM TAP-HORSHOET 100 kV Line 1 | 83 | MONTANA | 70.4 | 84.8 | 85 | 102.3 | 5.84% | 217 | N-1-24 |
| MISSIONM-ULM TAP 100 kV Line 1 | 83 | MONTANA | 68.7 | 82.8 | 83.2 | 100.3 | 5.80% | 247 | N-1-24 |
| GF NW T1-HORSHOET 100 kV Line 1 | 83 | MONTANA | 71.6 | 86.2 | 86.1 | 103.6 | 5.80% | 198 | GT FALLS- GF ESIDE 100kV Line 1 |
| BUTECRSH-BUT CONC 100 kV Line 1 | 92 | MONTANA | 78.7 | 85.7 | 92.3 | 100.6 | 5.44% | 241 | MONST TP - MONT ST 100kV Line 1 |
| BUTECRSH-MONST TP 100 kV Line 1 | 92 | MONTANA | 80.3 | 87.5 | 93.8 | 102.2 | 5.40% | 213 | MONST TP - MONT ST 100kV Line 1 |
| GT FALLS-GF RVRVW 100 kV Line 1 | 83 | MONTANA | 88.1 | 106 | 101.4 | 122 | 5.32% | 0 | N-1-30 |
| GT FALLS-GF ESIDE 100 kV Line 1 | 92 | MONTANA | 82.3 | 89.7 | 95.5 | 104.1 | 5.28% | 180 | 62166 GF SSIDE 100<br>62172 ADEL 100 1 |

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| GF NWEST-GF NW T2 100 kV Line 1 | 92 | MONTANA | 94.2 | 102.7 | 107.3 | 116.9 | 5.24% | 0 | 62118 GT FALLS 100 62177 GFCITYT1 100 1 |
| GF NW T2-GF RVRVW 100 kV Line 1 | 83 | MONTANA | 94.2 | 113.4 | 107.3 | 129.1 | 5.24% | 0 | 62118 GT FALLS 100 62177 GFCITYT1 100 1 |
| HARLOWTN-TWO DOT 100 kV Line 1 | 57 | MONTANA | 74.9 | 130.9 | 87.4 | 152.8 | 5.00% | 0 | JUDITHGP- STH_TAP 230 kV Line 1 |
| GF SSIDE-GF ES A 100 kV Line 1 | 92 | MONTANA | 101.2 | 110.2 | 112.8 | 122.9 | 4.64% | 0 | 62118 GT FALLS 100 62177 GFCITYT1 100 1 |
| CANYON F-SPOKANEA 100 kV Line 1 | 60 / 91 | MONTANA | 85.5 | 142.6/93.9 | 96.2 | 160.3/105.7 | 4.28% | 129 | E HELENA-CANFERTB 100 kV Line 1 |
| CANFERTA-SPOKANEA 100 kV Line 1 | 60 / 91 | MONTANA | 82.3 | 137.1/90.4 | 92.8 | 154.6/101.9 | 4.20% | 207 | E HELENA-CANFERTB 100 kV Line 1 |
| MNTGMRY1-MNTGMRY 14-230 kV Tx #1 | 100 | MONTANA | 90.8 | 90.8 | 101.2 | 101.2 | 4.16% | 221 | N-1-5 |
| CANYON F-SPOKANEB 100 kV Line 1 | 60 / 91 | MONTANA | 81.4 | 135.6/89.4 | 91.8 | 153/100.8 | 4.16% | 231 | E HELENA-CANFERTA 100 kV Line 1 |
| CANFERTB-SPOKANEB 100 kV Line 1 | 60 / 91 | MONTANA | 81.4 | 135.6/89.4 | 91.8 | 153/100.8 | 4.16% | 231 | E HELENA-CANFERTA 100 kV Line 1 |
| GF CITY-GFCITYT1 100 kV Line 1 | 92 | MONTANA | 99.1 | 107.9 | 109.2 | 118.9 | 4.04% | 0 | RAINBOW - GF NEAST 100 kV Line 1 |
| HOLTER-HELVLY T 100 kV Line 1 | 57 | MONTANA | 61.9 | 108.2 | 71.7 | 125.3 | 3.92% | 0 | GOLD CR- GILBERT 100kV Line 1 |
| E HELENA-HELVLY T 100 kV Line 1 | 57 | MONTANA | 50.8 | 88.8 | 60.1 | 105 | 3.72% | 172 | N-1-41 |
| BUTTE MT-BTMINDPK 100 kV Line 1 | 51 | MONTANA | 49.2 | 96.5 | 58.2 | 114.2 | 3.60% | 50 | BUTECRSH- BUT CONC 100kV Line 1 |
| MONT ST-BTMINDPK 100 kV Line 1 | 59 | MONTANA | 52.6 | 89.4 | 61.5 | 104.4 | 3.56% | 177 | BUTECRSH- BUT CONC 100kV Line 1 |
| WILSALL-CLYDE P 161 kV Line 1 | 111 / 203 | MONTANA | 153.2 | 137.4/75.46 | 161.6 | 144.9/79.6 | 3.36% | 1482 | THRRIVER- THRRIVER 230 kV Line 1 |
| RUDYARD-GI-0814 115 kV Line 1 | 80 / 88 | WAPA U.M | 74 | 92.5/84 | 82.1 | 102.7/92.3 | 3.24% | 432 | JUDITHGP- STH_TAP 230 kV Line 1 |

| Limiting Element | Rating N/E | Area | Pre Project | | Post Project | | DF | Max MW Output with 5 MVA Margin | Contingency |
|---|---|---|---|---|---|---|---|---|---|
| | | | MVA | % | MVA | % | | | |
| HAVRE-RUDYARD 115 kV Line 1 | 75 / 87 | WAPA U.M | 69 | 92/79.3 | 77 | 102.7/88.5 | 3.20% | 563 | JUDITHGP- STH_TAP 230 kV Line 1 |
| E HELENA-CONLIM T 100 kV Line 1 | 57 | MONTANA | 49.5 | 86.6 | 57.3 | 100.1 | 3.12% | 247 | E HELENA-HELSS TA 100 kV Line 1 |

The 2019 heavy summer peak potential thermal constraints listed in Tables 4-13A and 4-14A were reviewed by WAPA and the ad hoc study group and were determined to be remote from the POI of the subject request. These are listed for informational purposes only. However, these could be found in a transmission service study to be constraints if long term firm transmission service is requested for the GI-0822 generating facility.

**Voltage Impacts**

***System Intact***

No 2010 Heavy Summer Peak system intact voltage injections constraints were found with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service.

The 2010 Heavy Summer Peak system intact analysis potential voltage constraints with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service are given in Table 4-15.

**Table 4-15**
**2019 Heavy Summer Peak**
**250 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line**
**Potential Voltage Constraints SOGF – System Intact Results**
***(For Information Purposes Only)***

| BUS/NAME | | KV | Owner | Pre Project | Post Project | Delta Volt % | Contingency |
|---|---|---|---|---|---|---|---|
| 62271 | CONTLIME | 100 | MONTANA | 0.9094 | 0.868 | -4.140% | SYSTEM INTACT |
| 62264 | CONLIM T | 100 | MONTANA | 0.9103 | 0.869 | -4.130% | SYSTEM INTACT |
| 62265 | TOWNSEND | 100 | MONTANA | 0.9095 | 0.8682 | -4.130% | SYSTEM INTACT |
| 62273 | TOWNSD-R | 100 | MONTANA | 0.9095 | 0.8682 | -4.130% | SYSTEM INTACT |
| 62121 | E HELENA | 100 | MONTANA | 0.9458 | 0.9052 | -4.060% | SYSTEM INTACT |
| 62276 | HELSS TB | 100 | MONTANA | 0.9444 | 0.9039 | -4.050% | SYSTEM INTACT |
| 62275 | HELSS TA | 100 | MONTANA | 0.942 | 0.9016 | -4.040% | SYSTEM INTACT |
| 62277 | HELENASS | 100 | MONTANA | 0.9416 | 0.9012 | -4.040% | SYSTEM INTACT |
| 62261 | CANFERTB | 100 | MONTANA | 0.9542 | 0.9142 | -4.000% | SYSTEM INTACT |
| 62284 | CLANCYTB | 100 | MONTANA | 0.9415 | 0.9015 | -4.000% | SYSTEM INTACT |
| 62287 | CLNCYTIE | 100 | MONTANA | 0.9415 | 0.9015 | -4.000% | SYSTEM INTACT |

| BUS/NAME | | KV | Owner | Pre Project | Post Project | Delta Volt % | Contingency |
|---|---|---|---|---|---|---|---|
| 62289 | CLANCY | 100 | MONTANA | 0.9413 | 0.9013 | -4.000% | SYSTEM INTACT |
| 62260 | CANFERTA | 100 | MONTANA | 0.9537 | 0.9138 | -3.990% | SYSTEM INTACT |
| 62282 | SPOKANEB | 100 | MONTANA | 0.9582 | 0.9184 | -3.980% | SYSTEM INTACT |
| 62281 | SPOKANEA | 100 | MONTANA | 0.9577 | 0.9179 | -3.980% | SYSTEM INTACT |
| 62122 | CANYON F | 100 | MONTANA | 0.9615 | 0.9218 | -3.970% | SYSTEM INTACT |
| 62270 | HELVALLY | 100 | MONTANA | 0.9491 | 0.9098 | -3.930% | SYSTEM INTACT |
| 62285 | CLANCYTA | 100 | MONTANA | 0.9365 | 0.8973 | -3.920% | SYSTEM INTACT |
| 62269 | HELVLY T | 100 | MONTANA | 0.9529 | 0.9138 | -3.910% | SYSTEM INTACT |
| 62278 | MTTUNTAP | 100 | MONTANA | 0.9391 | 0.9001 | -3.900% | SYSTEM INTACT |
| 62266 | TOSTON | 100 | MONTANA | 0.9171 | 0.8785 | -3.860% | SYSTEM INTACT |
| 62272 | TOSTON-R | 100 | MONTANA | 0.9171 | 0.8785 | -3.860% | SYSTEM INTACT |
| 62286 | BRDWTR T | 100 | MONTANA | 0.92 | 0.882 | -3.800% | SYSTEM INTACT |
| 62288 | BRODWATR | 100 | MONTANA | 0.9215 | 0.8836 | -3.790% | SYSTEM INTACT |
| 62921 | EHELENA | 230 | MONTANA | 0.9507 | 0.9129 | -3.780% | SYSTEM INTACT |
| 62328 | BOULDRTB | 100 | MONTANA | 0.9373 | 0.8997 | -3.760% | SYSTEM INTACT |
| 62267 | CROWCREK | 100 | MONTANA | 0.9211 | 0.8836 | -3.750% | SYSTEM INTACT |
| 62280 | MTTUNTIE | 100 | MONTANA | 0.9317 | 0.8952 | -3.650% | SYSTEM INTACT |
| 62279 | MTTUNTPA | 100 | MONTANA | 0.9317 | 0.8953 | -3.640% | SYSTEM INTACT |
| 62283 | MTTUNELS | 100 | MONTANA | 0.9306 | 0.8942 | -3.640% | SYSTEM INTACT |
| 62244 | EUSTIS | 100 | MONTANA | 0.9285 | 0.8937 | -3.480% | SYSTEM INTACT |
| 62262 | CANYONCR | 100 | MONTANA | 0.9753 | 0.9409 | -3.440% | SYSTEM INTACT |
| 62247 | TRIDTPLT | 100 | MONTANA | 0.931 | 0.8972 | -3.380% | SYSTEM INTACT |
| 62073 | TRIDENT | 100 | MONTANA | 0.9313 | 0.8976 | -3.370% | SYSTEM INTACT |
| 62021 | THREERIV | 100 | MONTANA | 0.9344 | 0.901 | -3.340% | SYSTEM INTACT |
| 62248 | THREFORK | 100 | MONTANA | 0.9302 | 0.8973 | -3.290% | SYSTEM INTACT |
| 62327 | BOULDRTA | 100 | MONTANA | 0.933 | 0.9003 | -3.270% | SYSTEM INTACT |
| 62329 | BOULDTIE | 100 | MONTANA | 0.933 | 0.9003 | -3.270% | SYSTEM INTACT |
| 62326 | BOULDRAT | 100 | MONTANA | 0.9327 | 0.9 | -3.270% | SYSTEM INTACT |
| 62252 | WILLWCKM | 100 | MONTANA | 0.9294 | 0.8969 | -3.250% | SYSTEM INTACT |
| 62245 | COBLSTON | 100 | MONTANA | 0.9327 | 0.9003 | -3.240% | SYSTEM INTACT |
| 62254 | COBLSTNT | 100 | MONTANA | 0.9328 | 0.9005 | -3.230% | SYSTEM INTACT |
| 62253 | MONTTALC | 100 | MONTANA | 0.9286 | 0.8966 | -3.200% | SYSTEM INTACT |
| 62172 | ADEL | 100 | MONTANA | 0.9716 | 0.94 | -3.160% | SYSTEM INTACT |
| 62105 | BRADLEYC | 100 | MONTANA | 0.9406 | 0.9098 | -3.080% | SYSTEM INTACT |
| 62022 | MADISON | 100 | MONTANA | 0.9435 | 0.9128 | -3.070% | SYSTEM INTACT |
| 62149 | BARGE PM | 100 | MONTANA | 0.9344 | 0.9038 | -3.060% | SYSTEM INTACT |
| 62251 | HAR-PONY | 100 | MONTANA | 0.9327 | 0.9022 | -3.050% | SYSTEM INTACT |
| 62144 | TAILBOS2 | 100 | MONTANA | 0.9345 | 0.9043 | -3.020% | SYSTEM INTACT |
| 62259 | BASINMT | 100 | MONTANA | 0.9346 | 0.9044 | -3.020% | SYSTEM INTACT |
| 62148 | PRECIPIT | 100 | MONTANA | 0.9347 | 0.9046 | -3.010% | SYSTEM INTACT |
| 62155 | MAYFLWRT | 100 | MONTANA | 0.9297 | 0.8997 | -3.000% | SYSTEM INTACT |
| 62156 | MAYFLWRM | 100 | MONTANA | 0.9297 | 0.8997 | -3.000% | SYSTEM INTACT |
| 62145 | RENOVA | 100 | MONTANA | 0.928 | 0.8982 | -2.980% | SYSTEM INTACT |
| 62137 | BUTECORA | 100 | MONTANA | 0.9352 | 0.9056 | -2.960% | SYSTEM INTACT |
| 62263 | GILBERT | 100 | MONTANA | 0.9711 | 0.9416 | -2.950% | SYSTEM INTACT |
| 62138 | PCIFICST | 100 | MONTANA | 0.9367 | 0.9076 | -2.910% | SYSTEM INTACT |
| 62064 | BRADLEYC | 161 | MONTANA | 0.9511 | 0.9224 | -2.870% | SYSTEM INTACT |
| 62256 | JACKRABT | 161 | MONTANA | 0.9613 | 0.9329 | -2.840% | SYSTEM INTACT |
| 62139 | MONST TP | 100 | MONTANA | 0.9342 | 0.906 | -2.820% | SYSTEM INTACT |

| BUS/NAME | | KV | Owner | Pre Project | Post Project | Delta Volt % | Contingency |
|---|---|---|---|---|---|---|---|
| 62324 | BOZMN WS | 161 | MONTANA | 0.9625 | 0.9343 | -2.820% | SYSTEM INTACT |
| 62065 | ENNIS MT | 161 | MONTANA | 0.9474 | 0.9193 | -2.810% | SYSTEM INTACT |
| 62136 | BUTECRSH | 100 | MONTANA | 0.9332 | 0.9052 | -2.800% | SYSTEM INTACT |
| 62249 | EGALLTIN | 161 | MONTANA | 0.9647 | 0.9367 | -2.800% | SYSTEM INTACT |
| 62140 | BUT CONC | 100 | MONTANA | 0.9328 | 0.9048 | -2.800% | SYSTEM INTACT |
| 62142 | TAILBOOS | 100 | MONTANA | 0.9329 | 0.905 | -2.790% | SYSTEM INTACT |
| 62141 | MONT ST | 100 | MONTANA | 0.9352 | 0.9074 | -2.780% | SYSTEM INTACT |
| 62331 | THRRIVER | 230 | MONTANA | 0.9773 | 0.9496 | -2.770% | SYSTEM INTACT |
| 62150 | CONDR TA | 100 | MONTANA | 0.9351 | 0.9077 | -2.740% | SYSTEM INTACT |
| 62076 | THRRIVER | 161 | MONTANA | 0.9678 | 0.9404 | -2.740% | SYSTEM INTACT |
| 62151 | CONDR TB | 100 | MONTANA | 0.9356 | 0.9082 | -2.740% | SYSTEM INTACT |
| 62153 | CONTDRVE | 100 | MONTANA | 0.9357 | 0.9083 | -2.740% | SYSTEM INTACT |
| 62152 | BTMINDPK | 100 | MONTANA | 0.9371 | 0.9101 | -2.700% | SYSTEM INTACT |
| 62158 | SHERDNMT | 161 | MONTANA | 0.945 | 0.9183 | -2.670% | SYSTEM INTACT |
| 62116 | BUTTE MT | 100 | MONTANA | 0.9393 | 0.9127 | -2.660% | SYSTEM INTACT |
| 62257 | EMIGT AT | 161 | MONTANA | 0.9759 | 0.9494 | -2.650% | SYSTEM INTACT |
| 62346 | SHERDNMT | 69 | MONTANA | 0.9228 | 0.8966 | -2.620% | SYSTEM INTACT |
| 62108 | CLYDE P | 161 | MONTANA | 0.9734 | 0.9473 | -2.610% | SYSTEM INTACT |
| 62143 | RAMSAYPM | 100 | MONTANA | 0.9458 | 0.9202 | -2.560% | SYSTEM INTACT |
| 62345 | DILLON S | 69 | MONTANA | 0.9376 | 0.912 | -2.560% | SYSTEM INTACT |
| 62117 | GOLD CR | 100 | MONTANA | 0.9719 | 0.9465 | -2.540% | SYSTEM INTACT |
| 62133 | DRLDGCTY | 100 | MONTANA | 0.9677 | 0.9428 | -2.490% | SYSTEM INTACT |
| 62134 | DRLDG CM | 100 | MONTANA | 0.9697 | 0.9448 | -2.490% | SYSTEM INTACT |
| 62225 | CHROMEAT | 100 | MONTANA | 0.9105 | 0.8858 | -2.470% | SYSTEM INTACT |
| 62131 | DERLDG T | 100 | MONTANA | 0.969 | 0.9447 | -2.430% | SYSTEM INTACT |
| 62159 | GLDNSNLT | 161 | MONTANA | 0.9613 | 0.9376 | -2.370% | SYSTEM INTACT |
| 62200 | ABSRKE-R | 100 | MONTANA | 0.9241 | 0.9004 | -2.370% | SYSTEM INTACT |
| 62201 | ABSAROKE | 100 | MONTANA | 0.9241 | 0.9004 | -2.370% | SYSTEM INTACT |
| 62084 | DILLON S | 161 | MONTANA | 0.9405 | 0.9169 | -2.360% | SYSTEM INTACT |
| 62325 | DUCKCR-R | 161 | MONTANA | 0.9684 | 0.9449 | -2.350% | SYSTEM INTACT |
| 62132 | FAIRMTMT | 100 | MONTANA | 0.9575 | 0.9341 | -2.340% | SYSTEM INTACT |
| 62321 | STLWTRSM | 100 | MONTANA | 0.9405 | 0.918 | -2.250% | SYSTEM INTACT |
| 62224 | COLBUSAT | 100 | MONTANA | 0.9425 | 0.9202 | -2.230% | SYSTEM INTACT |
| 62015 | COLUMBUS | 100 | MONTANA | 0.9454 | 0.9232 | -2.220% | SYSTEM INTACT |
| 62250 | BGTMBERA | 161 | MONTANA | 0.9679 | 0.9461 | -2.180% | SYSTEM INTACT |
| 62130 | MOREL | 100 | MONTANA | 0.9662 | 0.9447 | -2.150% | SYSTEM INTACT |
| 62077 | BUTTE MT | 161 | MONTANA | 0.9587 | 0.9386 | -2.010% | SYSTEM INTACT |
| 62014 | BUTTEMHD | 161 | MONTANA | 0.9601 | 0.9407 | -1.940% | SYSTEM INTACT |
| 62354 | BASNCKGN | 161 | MONTANA | 0.9601 | 0.9407 | -1.940% | SYSTEM INTACT |
| 62386 | PTRSNFUR | 69 | MONTANA | 0.918 | 0.8989 | -1.910% | SYSTEM INTACT |
| 62205 | COLRPLJE | 161 | MONTANA | 0.9744 | 0.9565 | -1.790% | SYSTEM INTACT |
| 62030 | PTRSNFLT | 230 | MONTANA | 0.9452 | 0.928 | -1.720% | SYSTEM INTACT |
| 62017 | MT ASIMI | 161 | MONTANA | 0.964 | 0.9469 | -1.710% | SYSTEM INTACT |
| 62218 | ROUNDUPM | 100 | MONTANA | 0.9626 | 0.9469 | -1.570% | SYSTEM INTACT |
| 62215 | LAVINAPT | 100 | MONTANA | 0.9646 | 0.949 | -1.560% | SYSTEM INTACT |
| 62216 | LAVINAPM | 100 | MONTANA | 0.9643 | 0.9488 | -1.550% | SYSTEM INTACT |
| 62055 | BASELINE | 230 | MONTANA | 0.9796 | 0.967 | -1.260% | SYSTEM INTACT |
| 62016 | WILSALL | 161 | MONTANA | 0.9863 | 0.9613 | -2.500% | SYSTEM INTACT |
| 62019 | WILSALL | 230 | MONTANA | 0.9895 | 0.965 | -2.450% | SYSTEM INTACT |

| BUS/NAME | | KV | Owner | Pre Project | Post Project | Delta Volt % | Contingency |
|---|---|---|---|---|---|---|---|
| 62058 | SHOREYRD | 230 | MONTANA | 0.9821 | 0.9694 | -1.270% | SYSTEM INTACT |

***Single Contingency***

No 2010 Heavy Summer Peak single contingency voltage injections constraints were found with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service.

The 2010 Heavy Summer Peak single contingency analysis potential voltage constraints with the new Conrad – Great Falls 230 kV 400 MVA line assumed in-service are given in Table 4-16. It should be noted that although some bus voltages may be found to be outside of acceptable levels under several contingency conditions, only the contingency with the lowest post project voltage is shown. A complete listing of all voltage results is given in Appendix C.

**Table 4-16**
**2019 Heavy Summer Peak**
**250 MW GI-0822 Output with Conrad – Great Falls 230 kV 400 MVA line**
**Potential Voltage Constraints SOGF – Single Contingency Results**
***(For Information Purposes Only)***

| BUS/NAME | | KV | Owner | Pre Project | Post Project | Delta Volt % | Contingency |
|---|---|---|---|---|---|---|---|
| 62289 | CLANCY | 100 | MONTANA | 0.9357 | 0.8698 | -6.590% | JUDITHGP- STH_TAP 230 kV Line 1 |
| 62287 | CLNCYTIE | 100 | MONTANA | 0.9359 | 0.87 | -6.590% | JUDITHGP- STH_TAP 230 kV Line 1 |
| 62284 | CLANCYTB | 100 | MONTANA | 0.9359 | 0.87 | -6.590% | JUDITHGP- STH_TAP 230 kV Line 1 |
| 62921 | EHELENA | 230 | MONTANA | 0.9447 | 0.8806 | -6.410% | JUDITHGP- STH_TAP 230 kV Line 1 |
| 62120 | HOLTER | 100 | MONTANA | 0.9794 | 0.9215 | -5.790% | JUDITHGP-STH_TAP 230kV Line 1 |
| 62262 | CANYONCR | 100 | MONTANA | 0.97 | 0.9121 | -5.790% | JUDITHGP - STH_TAP 230kV Line 1 |
| 62274 | CRAIGMT | 100 | MONTANA | 0.9795 | 0.9234 | -5.610% | JUDITHGP-STH_TAP 230kV Line 1 |
| 62165 | GF ESIDE | 100 | MONTANA | 0.8779 | 0.8264 | -5.150% | GT FALLS- GF ESIDE 100kV Line 1 |
| 62120 | HOLTER | 100 | MONTANA | 0.9808 | 0.9293 | -5.150% | N-1-5 |
| 62286 | BRDWTR T | 100 | MONTANA | 0.8973 | 0.849 | -4.830% | GARRISON- MILL CRK 230 kV Line 1 |
| 62285 | CLANCYTA | 100 | MONTANA | 0.9145 | 0.8662 | -4.830% | GARRISON- MILL CRK 230 kV Line 1 |
| 62288 | BRODWATR | 100 | MONTANA | 0.8989 | 0.8507 | -4.820% | GARRISON- MILL CRK 230 kV Line 1 |
| 62278 | MTTUNTAP | 100 | MONTANA | 0.9171 | 0.8689 | -4.820% | GARRISON- MILL CRK 230 kV Line 1 |
| 62267 | CROWCREK | 100 | MONTANA | 0.8984 | 0.8506 | -4.780% | GARRISON- MILL CRK 230 kV Line 1 |
| 62328 | BOULDRTB | 100 | MONTANA | 0.9147 | 0.8674 | -4.730% | GARRISON- MILL CRK 230 kV Line 1 |
| 62272 | TOSTON-R | 100 | MONTANA | 0.8711 | 0.8244 | -4.670% | TOSTON -BRDWTR T 100 kV Line 1 |
| 62266 | TOSTON | 100 | MONTANA | 0.8711 | 0.8244 | -4.670% | TOSTON -BRDWTR T 100 kV Line 1 |
| 62283 | MTTUNELS | 100 | MONTANA | 0.9075 | 0.861 | -4.650% | GARRISON- MILL CRK 230 kV Line 1 |
| 62280 | MTTUNTIE | 100 | MONTANA | 0.9085 | 0.8621 | -4.640% | GARRISON- MILL CRK 230 kV Line 1 |
| 62279 | MTTUNTPA | 100 | MONTANA | 0.9085 | 0.8621 | -4.640% | GARRISON- MILL CRK 230 kV Line 1 |
| 62273 | TOWNSD-R | 100 | MONTANA | 0.8784 | 0.8321 | -4.630% | TOSTON -BRDWTR T 100 kV Line 1 |

| BUS/NAME | | KV | Owner | Pre Project | Post Project | Delta Volt % | Contingency |
|---|---|---|---|---|---|---|---|
| 62271 | CONTLIME | 100 | MONTANA | 0.8794 | 0.8331 | -4.630% | TOSTON -BRDWTR T 100 kV Line 1 |
| 62265 | TOWNSEND | 100 | MONTANA | 0.8784 | 0.8321 | -4.630% | TOSTON -BRDWTR T 100 kV Line 1 |
| 62264 | CONLIM T | 100 | MONTANA | 0.8803 | 0.8341 | -4.620% | TOSTON -BRDWTR T 100 kV Line 1 |
| 62244 | EUSTIS | 100 | MONTANA | 0.8976 | 0.8531 | -4.450% | TRIDENT -EUSTIS 100 kV Line 1 |
| 62073 | TRIDENT | 100 | MONTANA | 0.9088 | 0.8644 | -4.440% | GARRISON- MILL CRK 230 kV Line 1 |
| 62247 | TRIDTPLT | 100 | MONTANA | 0.9084 | 0.864 | -4.440% | GARRISON- MILL CRK 230 kV Line 1 |
| 62021 | THREERIV | 100 | MONTANA | 0.9119 | 0.8679 | -4.400% | GARRISON- MILL CRK 230 kV Line 1 |
| 62248 | THREFORK | 100 | MONTANA | 0.9077 | 0.864 | -4.370% | GARRISON- MILL CRK 230 kV Line 1 |
| 62252 | WILLWCKM | 100 | MONTANA | 0.9068 | 0.8634 | -4.340% | GARRISON- MILL CRK 230 kV Line 1 |
| 62329 | BOULDTIE | 100 | MONTANA | 0.9093 | 0.866 | -4.330% | GARRISON- MILL CRK 230 kV Line 1 |
| 62327 | BOULDRTA | 100 | MONTANA | 0.9093 | 0.866 | -4.330% | GARRISON- MILL CRK 230 kV Line 1 |
| 62326 | BOULDRAT | 100 | MONTANA | 0.9089 | 0.8656 | -4.330% | GARRISON- MILL CRK 230 kV Line 1 |
| 62172 | ADEL | 100 | MONTANA | 0.9523 | 0.909 | -4.330% | GF SSIDE -ADEL 100 kV Line 1 |
| 62245 | COBLSTON | 100 | MONTANA | 0.9105 | 0.8673 | -4.320% | GARRISON- MILL CRK 230 kV Line 1 |
| 62254 | COBLSTNT | 100 | MONTANA | 0.9106 | 0.8675 | -4.310% | GARRISON- MILL CRK 230 kV Line 1 |
| 62253 | MONTTALC | 100 | MONTANA | 0.9059 | 0.8629 | -4.300% | GARRISON- MILL CRK 230 kV Line 1 |
| 62126 | LANDRSFK | 230 | MONTANA | 0.9866 | 0.9446 | -4.200% | GARRISON-OVANDO 230kV Line 1 |
| 62149 | BARGE PM | 100 | MONTANA | 0.9105 | 0.869 | -4.150% | GARRISON- MILL CRK 230 kV Line 1 |
| 62251 | HAR-PONY | 100 | MONTANA | 0.9105 | 0.8691 | -4.140% | GARRISON- MILL CRK 230 kV Line 1 |
| 62144 | TAILBOS2 | 100 | MONTANA | 0.9106 | 0.8694 | -4.120% | GARRISON- MILL CRK 230 kV Line 1 |
| 62156 | MAYFLWRM | 100 | MONTANA | 0.9068 | 0.8657 | -4.110% | GARRISON- MILL CRK 230 kV Line 1 |
| 62155 | MAYFLWRT | 100 | MONTANA | 0.9068 | 0.8657 | -4.110% | GARRISON- MILL CRK 230 kV Line 1 |
| 62259 | BASINMT | 100 | MONTANA | 0.9106 | 0.8695 | -4.110% | GARRISON- MILL CRK 230 kV Line 1 |
| 62148 | PRECIPIT | 100 | MONTANA | 0.9107 | 0.8697 | -4.100% | GARRISON- MILL CRK 230 kV Line 1 |
| 62145 | RENOVA | 100 | MONTANA | 0.9048 | 0.8639 | -4.090% | GARRISON- MILL CRK 230 kV Line 1 |
| 62072 | OVANDO | 230 | MONTANA | 0.9891 | 0.9485 | -4.060% | GARRISON-OVANDO 230kV Line 1 |
| 62137 | BUTECORA | 100 | MONTANA | 0.9112 | 0.8707 | -4.050% | GARRISON- MILL CRK 230 kV Line 1 |
| 62138 | PCIFICST | 100 | MONTANA | 0.9127 | 0.8726 | -4.010% | GARRISON- MILL CRK 230 kV Line 1 |
| 62139 | MONST TP | 100 | MONTANA | 0.9101 | 0.8707 | -3.940% | GARRISON- MILL CRK 230 kV Line 1 |
| 62136 | BUTECRSH | 100 | MONTANA | 0.9091 | 0.8698 | -3.930% | GARRISON- MILL CRK 230 kV Line 1 |
| 62140 | BUT CONC | 100 | MONTANA | 0.9086 | 0.8694 | -3.920% | GARRISON- MILL CRK 230 kV Line 1 |
| 62064 | BRADLEYC | 161 | MONTANA | 0.9303 | 0.8912 | -3.910% | GARRISON- MILL CRK 230 kV Line 1 |
| 62142 | TAILBOOS | 100 | MONTANA | 0.9087 | 0.8696 | -3.910% | GARRISON- MILL CRK 230 kV Line 1 |
| 62141 | MONT ST | 100 | MONTANA | 0.9111 | 0.8721 | -3.900% | GARRISON- MILL CRK 230 kV Line 1 |
| 62150 | CONDR TA | 100 | MONTANA | 0.911 | 0.8723 | -3.870% | GARRISON- MILL CRK 230 kV Line 1 |
| 62256 | JACKRABT | 161 | MONTANA | 0.9397 | 0.901 | -3.870% | GARRISON- MILL CRK 230 kV Line 1 |
| 62153 | CONTDRVE | 100 | MONTANA | 0.9115 | 0.8729 | -3.860% | GARRISON- MILL CRK 230 kV Line 1 |
| 62151 | CONDR TB | 100 | MONTANA | 0.9114 | 0.8728 | -3.860% | GARRISON- MILL CRK 230 kV Line 1 |

| BUS/NAME | | KV | Owner | Pre Project | Post Project | Delta Volt % | Contingency |
|---|---|---|---|---|---|---|---|
| 62065 | ENNIS MT | 161 | MONTANA | 0.9275 | 0.8889 | -3.860% | GARRISON- MILL CRK 230 kV Line 1 |
| 62263 | GILBERT | 100 | MONTANA | 0.9527 | 0.9143 | -3.840% | GARRISON- MILL CRK 230 kV Line 1 |
| 62324 | BOZMN WS | 161 | MONTANA | 0.9409 | 0.9026 | -3.830% | GARRISON- MILL CRK 230 kV Line 1 |
| 62152 | BTMINDPK | 100 | MONTANA | 0.913 | 0.8748 | -3.820% | GARRISON- MILL CRK 230 kV Line 1 |
| 62116 | BUTTE MT | 100 | MONTANA | 0.9152 | 0.8774 | -3.780% | GARRISON- MILL CRK 230 kV Line 1 |
| 62076 | THRRIVER | 161 | MONTANA | 0.9461 | 0.9086 | -3.750% | GARRISON- MILL CRK 230 kV Line 1 |
| 62331 | THRRIVER | 230 | MONTANA | 0.9561 | 0.9187 | -3.740% | GARRISON- MILL CRK 230 kV Line 1 |
| 62158 | SHERDNMT | 161 | MONTANA | 0.9266 | 0.8895 | -3.710% | GARRISON- MILL CRK 230 kV Line 1 |
| 62143 | RAMSAYPM | 100 | MONTANA | 0.922 | 0.8853 | -3.670% | GARRISON- MILL CRK 230 kV Line 1 |
| 62345 | DILLON S | 69 | MONTANA | 0.9207 | 0.8841 | -3.660% | GARRISON- MILL CRK 230 kV Line 1 |
| 62346 | SHERDNMT | 69 | MONTANA | 0.9048 | 0.8684 | -3.640% | GARRISON- MILL CRK 230 kV Line 1 |
| 62291 | CLINTN-R | 100 | MONTANA | 0.9521 | 0.9163 | -3.580% | MISSLA - CLINTN-R 100 kV Line 1 |
| 62313 | DRUMMNMT | 100 | MONTANA | 0.9557 | 0.9202 | -3.550% | MISSLA - CLINTN-R 100 kV Line 1 |
| 62147 | DRMCLARK | 100 | MONTANA | 0.9557 | 0.9202 | -3.550% | MISSLA - CLINTN-R 100 kV Line 1 |
| 62157 | DRUMN PM | 100 | MONTANA | 0.956 | 0.9206 | -3.540% | MISSLA - CLINTN-R 100 kV Line 1 |
| 62146 | DRUMPM T | 100 | MONTANA | 0.956 | 0.9206 | -3.540% | MISSLA - CLINTN-R 100 kV Line 1 |
| 62135 | MT PHOST | 100 | MONTANA | 0.9577 | 0.9225 | -3.520% | MISSLA - CLINTN-R 100 kV Line 1 |
| 62159 | GLDNSNLT | 161 | MONTANA | 0.9385 | 0.9038 | -3.470% | GARRISON- MILL CRK 230 kV Line 1 |
| 62133 | DRLDGCTY | 100 | MONTANA | 0.948 | 0.9136 | -3.440% | GARRISON- MILL CRK 230 kV Line 1 |
| 62117 | GOLD CR | 100 | MONTANA | 0.9531 | 0.9187 | -3.440% | GARRISON- MILL CRK 230 kV Line 1 |
| 62134 | DRLDG CM | 100 | MONTANA | 0.95 | 0.9157 | -3.430% | GARRISON- MILL CRK 230 kV Line 1 |
| 62131 | DERLDG T | 100 | MONTANA | 0.9485 | 0.9144 | -3.410% | GARRISON- MILL CRK 230 kV Line 1 |
| 62084 | DILLON S | 161 | MONTANA | 0.9249 | 0.8912 | -3.370% | GARRISON- MILL CRK 230 kV Line 1 |
| 62016 | WILSALL | 161 | MONTANA | 0.9669 | 0.9334 | -3.350% | GARRISON- MILL CRK 230 kV Line 1 |
| 62019 | WILSALL | 230 | MONTANA | 0.9705 | 0.9379 | -3.260% | GARRISON- MILL CRK 230 kV Line 1 |
| 62130 | MOREL | 100 | MONTANA | 0.943 | 0.9104 | -3.260% | GARRISON- MILL CRK 230 kV Line 1 |
| 62253 | MONTTALC | 100 | MONTANA | 0.9286 | 0.8966 | -3.200% | CNRDWAPA - GT FALLS 230kV Line 1 |
| 62077 | BUTTE MT | 161 | MONTANA | 0.9353 | 0.9038 | -3.150% | GARRISON- MILL CRK 230 kV Line 1 |
| 62105 | BRADLEYC | 100 | MONTANA | 0.9091 | 0.8776 | -3.150% | BRADLEYC -JACKRABT 161kV Line 1 |
| 62022 | MADISON | 100 | MONTANA | 0.912 | 0.8806 | -3.140% | BRADLEYC -JACKRABT 161kV Line 1 |
| 62249 | EGALLTIN | 161 | MONTANA | 0.9354 | 0.9042 | -3.120% | WILSALL-CLYDE P 161 kV Line 1 |
| 62129 | ANA CITY | 100 | MONTANA | 0.946 | 0.9151 | -3.090% | GARRISON- MILL CRK 230 kV Line 1 |
| 62354 | BASNCKGN | 161 | MONTANA | 0.9367 | 0.9059 | -3.080% | GARRISON- MILL CRK 230 kV Line 1 |
| 62115 | MILL CRK | 100 | MONTANA | 0.9477 | 0.9169 | -3.080% | GARRISON- MILL CRK 230 kV Line 1 |
| 62014 | BUTTEMHD | 161 | MONTANA | 0.9367 | 0.9059 | -3.080% | GARRISON- MILL CRK 230 kV Line 1 |
| 62022 | MADISON | 100 | MONTANA | 0.9435 | 0.9129 | -3.060% | CNRDWAPA - GT FALLS 230kV Line 1 |
| 62257 | EMIGT AT | 161 | MONTANA | 0.9396 | 0.9094 | -3.020% | WILSALL-CLYDE P 161 kV Line 1 |
| 62156 | MAYFLWRM | 100 | MONTANA | 0.9297 | 0.8998 | -2.990% | CNRDWAPA - GT FALLS 230kV Line 1 |

| BUS/NAME | | KV | Owner | Pre Project | Post Project | Delta Volt % | Contingency |
|---|---|---|---|---|---|---|---|
| 62108 | CLYDE P | 161 | MONTANA | 0.9376 | 0.9078 | -2.980% | WILSALL-CLYDE P 161 kV Line 1 |
| 62132 | FAIRMTMT | 100 | MONTANA | 0.9263 | 0.8969 | -2.940% | MOREL-FAIRMTMT 100 kV Line 1 |
| 62017 | MT ASIMI | 161 | MONTANA | 0.9407 | 0.9119 | -2.880% | GARRISON- MILL CRK 230 kV Line 1 |
| 62036 | JUDITHGP | 230 | MONTANA | 0.9707 | 0.942 | -2.870% | N-1-5 |
| 62225 | CHROMEAT | 100 | MONTANA | 0.8847 | 0.8569 | -2.780% | WILSALL-CLYDE P 161 kV Line 1 |
| 62325 | DUCKCR-R | 161 | MONTANA | 0.9364 | 0.9097 | -2.670% | WILSALL-CLYDE P 161 kV Line 1 |
| 62201 | ABSAROKE | 100 | MONTANA | 0.8994 | 0.8729 | -2.650% | WILSALL-CLYDE P 161 kV Line 1 |
| 62200 | ABSRKE-R | 100 | MONTANA | 0.8994 | 0.8729 | -2.650% | WILSALL-CLYDE P 161 kV Line 1 |
| 62218 | ROUNDUPM | 100 | MONTANA | 0.9525 | 0.926 | -2.650% | N-1-48 |
| 62216 | LAVINAPM | 100 | MONTANA | 0.9543 | 0.9284 | -2.590% | N-1-48 |
| 62215 | LAVINAPT | 100 | MONTANA | 0.9545 | 0.9286 | -2.590% | N-1-48 |
| 62270 | HELVALLY | 100 | MONTANA | 0.9035 | 0.878 | -2.550% | E HELENA -EHELENA 230-100 XFMR |
| 62269 | HELVLY T | 100 | MONTANA | 0.9075 | 0.8821 | -2.540% | E HELENA -EHELENA 230-100 XFMR |
| 62261 | CANFERTB | 100 | MONTANA | 0.9024 | 0.8771 | -2.530% | E HELENA -EHELENA 230-100 XFMR |
| 62282 | SPOKANEB | 100 | MONTANA | 0.9066 | 0.8814 | -2.520% | E HELENA -EHELENA 230-100 XFMR |
| 62260 | CANFERTA | 100 | MONTANA | 0.902 | 0.8768 | -2.520% | E HELENA -EHELENA 230-100 XFMR |
| 62005 | MILL CRK | 161 | MONTANA | 0.9644 | 0.9393 | -2.510% | GARRISON- MILL CRK 230 kV Line 1 |
| 62321 | STLWTRSM | 100 | MONTANA | 0.9171 | 0.892 | -2.510% | WILSALL-CLYDE P 161 kV Line 1 |
| 62281 | SPOKANEA | 100 | MONTANA | 0.906 | 0.8809 | -2.510% | E HELENA -EHELENA 230-100 XFMR |
| 62122 | CANYON F | 100 | MONTANA | 0.91 | 0.8849 | -2.510% | E HELENA -EHELENA 230-100 XFMR |
| 62224 | COLBUSAT | 100 | MONTANA | 0.9192 | 0.8942 | -2.500% | WILSALL-CLYDE P 161 kV Line 1 |
| 62015 | COLUMBUS | 100 | MONTANA | 0.9223 | 0.8974 | -2.490% | WILSALL-CLYDE P 161 kV Line 1 |
| 62250 | BGTMBERA | 161 | MONTANA | 0.9393 | 0.9146 | -2.470% | WILSALL-CLYDE P 161 kV Line 1 |
| 62275 | HELSS TA | 100 | MONTANA | 0.8918 | 0.868 | -2.380% | E HELENA -EHELENA 230-100 XFMR |
| 62277 | HELENASS | 100 | MONTANA | 0.8913 | 0.8675 | -2.380% | E HELENA -EHELENA 230-100 XFMR |
| 62276 | HELSS TB | 100 | MONTANA | 0.8924 | 0.8686 | -2.380% | E HELENA -EHELENA 230-100 XFMR |
| 62121 | E HELENA | 100 | MONTANA | 0.8914 | 0.8676 | -2.380% | E HELENA -EHELENA 230-100 XFMR |
| 62355 | MLCK PHA | 230 | MONTANA | 0.969 | 0.9454 | -2.360% | GARRISON- MILL CRK 230 kV Line 1 |
| 62220 | COLRPLJE | 100 | MONTANA | 0.9514 | 0.9284 | -2.300% | WILSALL-CLYDE P 161 kV Line 1 |
| 62386 | PTRSNFUR | 69 | MONTANA | 0.9049 | 0.8823 | -2.260% | DILLON S -BIGGRASS 161 kV Line 1 |
| 62030 | PTRSNFLT | 230 | MONTANA | 0.9334 | 0.9131 | -2.030% | DILLON S -BIGGRASS 161 kV Line 1 |
| 62205 | COLRPLJE | 161 | MONTANA | 0.9557 | 0.9359 | -1.980% | WILSALL-CLYDE P 161 kV Line 1 |
| 62241 | STRAWXPT | 100 | MONTANA | 0.9282 | 0.9133 | -1.490% | JUDITHGP -STRAWXPT 100 kV Line 1 |
| 62240 | STRAWXPM | 100 | MONTANA | 0.928 | 0.9131 | -1.490% | JUDITHGP -STRAWXPT 100 kV Line 1 |
| 62232 | GLENGARY | 100 | MONTANA | 0.9333 | 0.9185 | -1.480% | JUDITHGP -STRAWXPT 100 kV Line 1 |
| 62183 | WAYNEPMT | 100 | MONTANA | 0.9425 | 0.9289 | -1.360% | RAINBOW -WAYNEPMT 100 kV Line 1 |
| 62167 | WAYNE PM | 100 | MONTANA | 0.9424 | 0.9288 | -1.360% | RAINBOW -WAYNEPMT 100 kV Line 1 |

The potential voltage constraints listed in Tables 4-15 and 4-16 were reviewed by WAPA and the ad hoc study group and were determined to be remote from the local area of the subject request. Therefore, no voltage injection constraints were identified that meet the WAPA feasibility study criteria for the requested interconnection service. However, these could be found in a transmission service study to be constraints if long term firm transmission service is requested for the GI-0822 generating facility.

## 4.2 Constrained Interface Analysis

There are no constrained interfaces and/or flow gates defined North of Great Falls. Therefore, no constrained interface analysis was performed.

# 5. Short Circuit Analysis

This IFS Short-Circuit Study analyzed the impact of the new 250 MW wind farm located in Pondera County, Montana. The GI-0822 project will interconnect at WAPA's existing Conrad 230 kV substation bus. WAPA performed the Short-Circuit Study to determine the impact of the project to the bulk electric system (BES

## 5.1 Base Case Development

The pre-project model used for this analysis was WAPA's current ASPEN One-Liner model of the Upper Great Plains Region (UGPR), which includes Montana, North Dakota, South Dakota, and portions of Minnesota, Iowa and Nebraska.

Starting from this case, the post-project model was developed by adding 250 MW of project generation at the Conrad 230 kV bus and a second 230 kV line from Conrad to Great Falls (per Option 2 discussed previously in this report). All existing and prior queued generation projects NOGF where included at full output.

## 5.2 Short – Circuit Calculations

Short-circuit calculations were performed to determine the impact of the proposed project at 250 MW (Option 2) on the pre-project fault current levels at the POI (Conrad), Shelby-2 and Great Falls Substations. Classical fault assumptions were used with a pre-fault voltage of 1.0 p.u.

Table 5-1 lists the three-phase to ground symmetrical fault levels that were calculated both pre-project and post-project at 250 MW output (Option 2). These fault currents were compared against the lowest rated circuit breaker at each of these substation buses to determine whether or not the existing circuit breaker ratings exceeded the expected available fault current.

A comparison of expected available fault currents to the lowest rated circuit breaker interrupting capability at these buses indicates that there is adequate interrupting capability following the addition of project GI-0822. Therefore, the 60 MW output (Option 1) applied to the existing BES was not evaluated since the fault levels for Option 2 are worst case due to increased generation and lower BES thevenin impedance with a second Conrad – Great Falls 230 kV line modeled.

## 5.3 Weak BES Grid Evaluation for Potential Power Quality Degradation

Weak BES grids are prone to voltage/VAR regulation fluctuations and voltage/current harmonics with large amounts of variable generation applied, including wind turbines. Generation interconnects applied to moderate or weak BES grids may require the addition of DVARs, STATCOMs or special control equipment to ride through voltage/VAR fluctuations and/or dampen harmonics. This section of this report evaluates the potential for power quality control degradation based on the pre-project system short circuit ratio (SCR). The BES SCR is defined as the ratio of three phase short circuit MVA to three phase project MVA output. A pre-project SCR above 10 is ideal and indicates a strong grid. A pre-project SCR between 10 and 5 indicate possible power quality control issues and a moderate to weak BES grid. Pre-project SCRs below 5 indicate likely power quality control issues and a weak BES grid.

Table 5-1 also lists the BES SCRs calculated pre-project for both Options 1 and 2 and post-project for Option 2. The SCR for the 60 MW output, Option 1, with interconnection to the Conrad 230 kV bus is **15.8**. The BES is considered to be a strong grid for Option 1 and no adverse power quality degradation is expected. The SCR for the 250 MW, Option 2, with interconnection to the Conrad 230 kV bus is **3.8**. The BES is considered to be weak for Option 2. Therefore, power quality issues are likely for Option 2 and suggest the requirement of a DVAR, STATCOM or special control equipment. Final determination of this requirement will be made following finalization by the customer of the wind turbines and control system to be utilized. This evaluation must occur no later than completion of an Operating Study prior to energization for either Option 1 or 2. Consequently, the conceptual cost estimates provided in the next section of this report do not include the possible requirement of a DVAR, STATCOM or special control equipment.

## Table 5-1:
## Pre-Project and Post-Project Fault Currents and SCRs

| OPTION 1: 60 MW<br>MAX FAULT TYPE & LOCATION | EXISTING LEAST CAPABLE BKR INTERRUPTING kA (1ph) | PRE-PROJECT 3LG FAULT kA (1ph) | PRE-PROJECT 3LG FAULT MVA (3ph) | POST-PROJECT 3LG FAULT kA (1ph) | POST-PROJECT 3LG FAULT MVA (3ph) | POST-PROJECT BREAKER DEFICIENCY kA (1ph) | PRE-PROJECT SHORT CIRCUIT RATIO *See Note 1* | POST-PROJECT SHORT CIRCUIT RATIO *See Note 1* |
|---|---|---|---|---|---|---|---|---|
| 3PH @ Conrad 115 kV Bus | 20 | 4.1 | 813 | TBD | TBD | None | 13.6 | TBD |
| 3PH @ Conrad 230 kV Bus | 31.5 | 2.4 | 945 | TBD | TBD | None | 15.8 | TBD |
| 3PH @ Shelby-2 230 kV Bus | 31 | 1.9 | 771 | TBD | TBD | None | 12.9 | TBD |
| 3PH @ Great Falls 230 kV Bus | per NWE | 4.3 | 1715 | TBD | TBD | None | 28.6 | TBD |

| OPTION 2: 250 MW<br>MAX FAULT TYPE & LOCATION | EXISTING LEAST CAPABLE BKR INTERRUPTING kA (1ph) | PRE-PROJECT 3LG FAULT kA (1ph) | PRE-PROJECT 3LG FAULT MVA (3ph) | POST-PROJECT 3LG FAULT kA (1ph) | POST-PROJECT 3LG FAULT MVA (3ph) | POST-PROJECT BREAKER DEFICIENCY kA (1ph) | PRE-PROJECT SHORT CIRCUIT RATIO *See Note* | POST-PROJECT SHORT CIRCUIT RATIO *See Note* |
|---|---|---|---|---|---|---|---|---|
| 3PH @ Conrad 115 kV Bus | 20 | 4.1 | 813 | 4.6 | 924 | None | 3.3 | 3.7 |
| 3PH @ Conrad 230 kV Bus | 31.5 | 2.4 | 945 | 3.1 | 1251 | None | 3.8 | 5.0 |
| 3PH @ Shelby-2 230 kV Bus | 31 | 1.9 | 771 | 2.3 | 911 | None | 3.1 | 3.6 |
| 3PH @ Great Falls 230 kV Bus | per NWE | 4.3 | 1715 | 4.5 | 1802 | None | 6.9 | 7.2 |

**The BES Short Circuit Ratio (SCR) = 3ph short circuit MVA / 3ph project MVA output.**

**NOTE:** **The pre-project SCR is used to identify potential power quality issues of voltage fluctuations and/or harmonics that are associated with variable generation applied to a weak grid, i.e. bulk electric system (BES)**

| | |
|---|---|
| **Pre-Project SCR > 10** | **Ideal (strong grid)** |
| **5 < Pre-Project SCR < 10** | **Possible Voltage Fluctuations and/or Harmonics (moderate to weak grid)** |
| **Pre-Project SCR < 5** | **Likely Voltage Fluctuations and/or Harmonics (weak grid)** |

# 6. Conceptual Cost Estimate

This non-binding good faith cost estimate is provided for system improvements associated with the interconnection of project GI-0822. Also included is a non-binding good faith cost estimates for Network Reinforcements required to mitigate the impacts of project GI-0822. This is only a conceptual cost estimate for planning purposes. These were compiled by Western Area Power Administration and will be further developed and refined in the Facility Study.

Table 6-1 provides a conceptual cost estimate for Option 1, 60 MW of project output, with the point of interconnection (POI) on the existing 230 kV transmission system, installation of a special protection system (SPS, a.k.a. a remedial action scheme, RAS), replacement of NWE's 161/100 kV Rainbow transformer and up-rating the Havre-Verona-Great falls 161 kV Line. It should be noted that additional costs to up-rate this transmission line built in 1935 may be incurred which have not yet been identified, e.g. replacing transmission structures to maintain required conductor sag clearances at increased power transfers.

Table 6-2 provides a conceptual cost estimate for Option 2, 250 MW of project output, with the point of interconnection (POI) on the existing 230 kV transmission system, all improvements required for Option 1) plus a new second 230 kV line directly from Conrad to NWE's Great Falls Substation. It should be noted that this option would require a transmission interconnect request with NWE for the Great Falls Substation terminal.

**Table 6-1[3]**
**Conceptual Costing**
**Option 1 – 60 MW Output, 230 kV Interconnect**

| ***Facility / Addition*** | ***Installed Cost (2012 U.S.)*** |
|---|---|
| **POI - Conrad Ring Bus Terminal Addition** | |
| 230 kV Ring Bus Line Terminal, 1600 Amp | $1,632,000 |
| Control Building Modifications | $50,000 |
| Metering & Instrumentation | $100,000 |
| Flow Gate and/or RAS | $300,000 |
| **Upgrade/Replace NWE's Rainbow Transformer** | |
| 161/100 kV, 100 MVA Autotransformer, Complete | $2,800,000 |
| **Up-rating Havre-Verona-Great Falls 161kV Line** | |
| Survey / Verify Conductor Sag | $100,000 |
| CT and Relay Changes | $100,000 |

[3] Costs include 20% to 40% adder for planning, lands and rights, environmental, surveys, geologic investigations, designs/specifications and construction supervision, plus 10% adder for unknown contingencies (total adder = 30% to 50%). Costs do not include possible DVAR or STATCOM required for power quality degradation.

| | |
|---|---|
| **TOTAL CONCEPTUAL COST – OPTION 1** | **$5,082,000** |

## Table 6-2[4]
## Conceptual Costing
## Option 2 – 250 MW Output, 230 kV Interconnect

| *Facility / Addition* | *Installed Cost (2012 U.S.)* |
|---|---|
| **POI - Conrad Breaker & Half Addition / Conversion** | |
| 230 kV Breaker & Half Line Terminal, 1600 Amp | $3,522,000 |
| 230 kV Breaker & Half Line Terminal, 1600 Amp | $3,522,000 |
| Convert Existing 230 kV Ring Bus to Breaker & Half | $5,000,000 |
| Control Building Modifications | $150,000 |
| Metering & Instrumentation | $100,000 |
| Flow Gate and/or RAS | $300,000 |
| **Upgrade/Replace NWE's Rainbow Transformer** | |
| 161/100 kV, 100 MVA Autotransformer, Complete | $2,800,000 |
| **Up-rating Havre-Verona-Great Falls 161kV Line** | |
| Survey / Verify Conductor Sag | $100,000 |
| CT and Relay Changes | $100,000 |
| **Conrad – Great Falls 230 kV Transmission Line** | |
| 60 Miles, Wood H-Frame, 954 ACSR | $20,942,000 |
| **NWE Great Falls Substation Addition** | |
| 230 kV Breaker & Half Line Terminal, 1600 Amp | $3,522,000 |
| Additional Coordination and Requirements by NWE | $500,000 |
| **TOTAL CONCEPTUAL COST – OPTION 2** | **$40,558,000** |

[4] Costs include 20% to 40% adder for planning, lands and rights, environmental, surveys, geologic investigations, designs/specifications and construction supervision, plus 10% adder for unknown contingencies (total adder = 30% to 50%). Costs do not include possible DVAR or STATCOM required for power quality degradation.

# Appendix A: Model Documentation for Steady State

## Appendix A.1 Generator Data for Power flow model

| | |
|---|---|
| Unit Type/Model | = GE 1.5 - 60 Hz, Double-fed Induction Turbine |
| Power Factor | = .95 Lead/Lag (Qmax: 82.3 MVAR, Qmin: -82.3 MVAR) |
| Unit Rating | = 1.5 MW |
| Total No. of Units | = 167 |
| Total Plant Capacity | = 250 MW |
| Collector System | = 0.6/34.5 kV equivalent step up transformer at 293 MVA |
| Delivery to POI | = 34.5/230 kV equivalent power transformer at 270 MVA |
| Regulation | = Voltage Control (scheduled to 1.02 p.u. at POI bus) |

## Appendix A.2 Prior Queued Projects included in the study

### Table A-2
### NorthWestern/WAPA Energy Resource (ER) Prior Queued Projects Included in the Pre-GI-0822 Models

| NWE Project Number | Queue Date | Location | Point of Interconnection (POI) | In-Service Date Requested | Summer Output (MW) |
|---|---|---|---|---|---|
| 23-Horse Shoe Bend | 08/15/02 | Cascade County, Montana | Great Falls NW-Holter 100 kV line | 02/27/06 | 9 |
| 25-Two Dot Wind # 2 | 02/14/03 | Meagher County, Montana | Martinsdale Substation Distribution | 11/01/04 | 0.715 |
| 32 | 07/01/04 | Cascade County, Montana | Great Falls 230 kV Switchyard | 10/31/08 | 268 |
| 33 | 11/03/04 | Wheatland County, Montana | Martinsdale Substation | 06/30/09 | 52.5 |
| 44 (GW1) | 04/10/06 | Pondera County, Montana | South Cut Bank to Conrad Auto 115 kV | 10/15/08 | 104 MW |
| 46 | 06/05/06 | Meagher County, Montana | 100 kV line between Loweth and Two Dot at Groveland. | 09/01/07 | 10 MW |
| 47 | 06/08/06 | Liberty County, Montana | 69 kV line at Chester | 12/31/09 | 20 MW |
| 49 | 06/16/06 | Cascade County, Montana | Rainbow Switchyard | 12/31/11 | 23 MW |
| 53 | 12/06/06 | Cascade County, Montana | Great Falls 230 kV Switchyard | 07/01/07 | 277 MW |
| 62 (Turnbull 1) | 5/25/2007 | Teton County, Montana | Fairfield - Bole 69 kV | 06/01/09 | 11.5 |
| 73 (GW2) | 07/13/07 | Glacier County, Montana | Cut Bank 115 kV Substation between Cut Bank & Shelby | 11/30/08 | 100 MW |

| NWE Project Number | Queue Date | Location | Point of Interconnection (POI) | In-Service Date Requested | Summer Output (MW) |
|---|---|---|---|---|---|
| 78 (GW1) | 12/11/07 | Glacier County, Montana | 115kV between Cut Bank & Conrad | 11/30/08 | 100 MW |
| 81 | 03/11/08 | Cascade County, Montana | Near Rainbow Switchyard | 05/01/11 | 12 MW |
| 82 | 03/11/08 | Cascade County, Montana | Near Rainbow Switchyard | 12/01/12 | Efficiency Improvement |
| 87 (GW2) | 04/18/08 | Glacier County, Montana | Cut Bank 115 kV Substation between Cut Bank & Shelby | 11/30/08 | 100 MW |
| 89 | 04/24/08 | Meagher County, Montana | 100 kV line between Loweth and Two Dot at Groveland. | 07/31/09 | 20 MW |
| 95 | 7/18/2008 | Glacier County, Montana | 115 kV between Cut Bank and Conrad | 11/30/2008 | 5 |
| 100 | 9/30/2008 | Cascade County, Montana | Near Rainbow Switchyard | 11/01/11 | Efficiency Improvement |

**Table A-2A**
**Pre-GI-0814 Modeling of Primary Generation and System Transfers**

| Unit | Output (MW) |
|---|---|
| Fort Peck | 90 |
| Tiber Plant | 7.5 |
| Canyon Ferry Plant | 58 |
| Great Falls Plant | 281 |
| Glacier Wind 1 | 104 MW |
| Glacier Wind 2 | 100 |
| Miles DC Tie | 200 East-West |
| Crossover Phase Shifter | 77 North-South |

## Appendix A.3 Miscellaneous Updates and Corrections

Updates and corrections made to the GI-0822 power flow cases are listed in Table A-3.

### Table A-3: Model Updates and Corrections

| Response File | Description | 2010 LA | 2019 HS |
|---|---|---|---|
| NWMT-46 & 89.idv | Prior Queued Project | | x |
| NWMT-32.idv | Prior Queued Project | | x |
| NWMT-33.idv | Prior Queued Project | | x |
| NWMT-49.idv | Prior Queued Project | | x |
| NWMT-53.idv | Prior Queued Project | | x |
| NWMT-44-73-78-87-95.idv | Prior Queued Project | | x |
| nwmt 47.idv | Prior Queued Project | | x |
| nwmt 62.idv | Prior Queued Project | | x |
| NWMT 81 AND 62040.idv | Prior Queued Project | | x |
| Prior Q Sink.idv | Sink Prior Queued | | x |
| Rating_Updates.idv | Rating updates | x | x |
| GF-GFCityT1_1.idv | Topology updates | x | x |
| HT-BV2_1.idv | Add Second line | x | x |
| JG23_100_1.idv | Topology updates | x | x |
| JG-JGT-HT_1.idv | Topology updates | x | x |
| MD-TD_1.idv | Topology updates | x | x |
| East helena -Three rivers-Gt Falls 230 kV.idv | Add 230 kV line | | x |
| Broadvu-Harlowtn 100kV line.idv | Add 100 kV line | | x |
| Conrad-gtfalls 230 kV_ver31.idv | Add new 230 kV line | x | x |
| GI0822 offline.idv | GI-0822 offline | x | x |
| TURN ON GI-0814.idv | Turn on GI-0814 | x | |
| Switch on 62095 at 187.5 MW.idv | Turn on existing prior queued project | | x |
| Sinking Exisin project.idv | Sinking existing prior queued project | | x |

# Appendix B: Powerflow One Line Diagrams

## (CEII)

# Appendix C: Steady State Detailed Analysis

**Available Upon Request**