TRANSCO.ENERGY

Round Mountain Area Dynamic Reactive Power Support Project

Project Coordination Study
Final Study Report

Prepared for
PROJECT COORDINATION REVIEW GROUP

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EXECUTIVE SUMMARY

In early 2020, LS Power Grid California, LLC (Project Sponsor) was selected by the California Independent System Operator (CAISO) to procure, install, maintain, and operate +/-500 MVar of Dynamic Reactive power Support (DRS) on PG&E's Round Mountain to Table Mountain 500 kV lines for reliability purposes. The Project Sponsor proposed to install two (2) +/-264.5 MVar Static Synchronous Compensator (STATCOM) blocks approximately eleven (11) miles south of PG&E's Round Mountain Substation. The new Round Mountain Area DRS will be interconnected to the Round Mountain to Table Mountain #1 and #2 500 kV lines via a new 6-position breaker and half (BAAH) switchyard. The new 500 kV STATCOM and associated BAAH switchyard will be known as Fern Road Substation (Project).

In January 2021, the Project Sponsor informed the Western Electricity Coordination Council's (WECC) Reliability Assessment Committee (RAC) and Studies Subcommittee (StS) of the Project and requested a waiver of the Project Coordination Process under Section 4 (Waiver of "Significant Impact" Status) of the WECC Project Coordination, Path Rating and Progress Report Processes. The WECC RAC and StS received letters in opposition to the Waiver of "Significant Impact" Status for the Project from Modesto Irrigation District (MID), Turlock Irrigation District (TID), Western Area Power Administration Sierra Nevada Region (WASN), and Transmission Agency of Northern California (TANC). The basis for the opposition to the Waiver was that these entities were Self-Identified Affected Systems of the Project with PG&E (the Transmission Planner of the Round Mountain -Table Mountain 500 kV lines) with a common concern related to the impacts to COI caused by the Project. As a result of this opposition, the Project Sponsor initiated a WECC Project Coordination Process for the Project.

On July 19, 2021, WECC announced that the Project will be entering into the Project Coordination Process. As part of the notice, an open invitation was provided for interested parties to join the WECC Project Coordination Review Group (PCRG). A Study Plan that outlines the objectives, scope, and methodology for the Project Coordination Study (PCS) for the Project was approved by the PCRG on November 16, 2021.

The PCS was performed with study cases approved by the PRG and which were based on the CAISO Transmission Planning Process (TPP) base cases (PG&E Bulk 2024 Heavy Summer and PG&E Bulk 2025 Spring Off-peak power flow models) as the starting base cases. In the summer operating conditions the DRS was modeled to maintain a 1.06 per unit voltage at the Fern Road 500 kV bus while in the spring off-peak conditions the operating voltage at Fern Road was set at 1.069 per unit. Power flow, transient stability and post-transient voltage stability analyses were conducted to determine any adverse impacts caused by the Project to the regional transmission system and/or on the import capability of the California Oregon Interface (COI) transmission path. In all, six different operating scenarios in both summer peak and spring off-peak were evaluated.

The objective of the PCS was to evaluate the impacts of the Round Mountain DRS Project to the regional transmission systems and address the concerns of Affected Systems. The study included power flow, voltage stability, and transient stability analysis. The study cases used in the PCS represented stressed conditions and various scenarios that included the following:

- Three scenarios with COI S-N flows at 3,675 MW

- Three scenarios with COI N-S flows at 4,800 MW
- Two sensitivity scenarios with COI N-S flows exceeding 4800 MW

The results of the study indicated the following:

<u>COI S-N Scenarios</u>

- The studies did not indicate that the Project would cause adverse thermal, voltage, or stability impacts to the regional transmission system during COI S-N scenarios
- The studies did not indicate that the Project would adversely impact COI S-N transfer capability.

<u>COI N-S Scenarios and Sensitivities</u>

- The studies did not indicate that the Project would cause adverse voltage or stability impacts to the regional transmission system during COI N-S scenarios
- The studies indicated that the Project would cause an overload on the remaining Round Mountain -Fern 500 kV #1 or #2 line under a single line contingency of the other Round Mountain -Fern 500 kV #1 or #2 line.
- The studies indicate that the PG&E proposed Round Mountain -Table Mountain 500 KV RAS project (PG&E RAS Project) will effectively mitigate the post-project overload on the Round Mountain -Fern 500 kV #1 or #2 line following a single line contingency of the other Round Mountain -Fern 500 kV #1 or #2 line. This is with the understanding that the PG&E RAS Project will bypass the series caps on the remaining Round Mountain -Fern 500 kV line at Round Mountain and the series caps on the Fern -Table Mountain 500 kV Lines #1 and #2 at Table Mountain.
- COI N-S transfer capability will be impacted by the Project if the PG&E RAS Project is not operational prior to the Fern 500 kV substation ties into the Round Mountain -Table Mountain 500 kV Lines #1 and #2. Without the PG&E RAS Project, the thermal impacts created by the Project will exacerbate the existing operational constraint for COI N-S transfers. However, if the PG&E RAS Project is operational, the studies indicate that the Project will not adversely impact COI N-S transfer capability.
- The purpose of the PG&E RAS Project is to improve COI N-S transfer capability. The study indicated that the Round Mountain DRS Project will not reduce the additional COI N-S transfer capability gained by the PG&E RAS Project for the conditions represented in the Sensitivity study cases.

Based on the study results, the Project will not cause any adverse impacts to the WECC system or COI operation if the proposed PG&E RAS Project is operational. This is with the understanding that the PG&E RAS Project will include the automatic operation for an outage of the Round Mountain - Fern 500 kV lines #1 or #2 and consist of bypassing the series capacitors on the remaining Round Mountain -Fern 500 kV line at Round Mountain and the series capacitors on the Fern -Table Mountain 500 kV Lines #1 and #2 at Table Mountain.

The conclusion of this study is dependent on the proposed PG&E RAS Project being operational before the Project's Fern 500 kV substation ties into the Round Mountain -Table Mountain 500 KV lines #1 and #2. Since the PG&E RAS Project is not a part of the Round Mountain DRS Project, it is noted that the PG&E RAS Project schedule and final scope are subject to change based on the needs of that project. PG&E has initiated a WECC Path Rating process to study the increased Path Rating on COI caused by the RAS Project. Project Sponsor will continue to monitor the progress of the RAS Project through the WECC Path Rating process and other communications with PG&E. If there are changes to the RAS Project scope or schedule that could impact the conclusion of this study, Project Sponsor will notify the PCRG to reevaluate the Round Mountain DRS Project impacts and associated mitigation.

INTRODUCTION

The California ISO's 2018-2019 Transmission Planning Process (TPP) identified a need for +/-500 MVar Dynamic Reactive power Support (DRS) in the area of PG&E's Round Mountain Substation for reliability purposes. The CAISO governing board approved the DRS project in March 2019.

In early 2020, LS Power Grid California, LLC (LSPGC or Project Sponsor) was selected by the CAISO through a competitive bidding process to procure, install and operate two (2) +/-264.5 MVar Static Synchronous Compensator (STATCOM) blocks approximately eleven (11) miles south of PG&E's Round Mountain Substation. The new Round Mountain Area DRS will be interconnected to the Round Mountain to Table Mountain #1 and #2 500 kV lines via a new 6-position breaker and half (BAAH) switchyard. The new 500 kV STATCOM and associated switchyard will be known as Fern Road Substation (Project).

The Project is proposed to resolve high voltages that occur frequently at the Round Mountain 500 kV bus in real-time operation under non-peak conditions. High voltage issues have resulted in limited clearance opportunities to undertake system maintenance.

Project Background

In early 2020, the Project Sponsor was selected by the CAISO to procure, install, maintain, and operate the Round Mountain DRS Project.

In January 2021, the Project Sponsor informed the Western Electricity Coordination Council's (WECC) Reliability Assessment Committee (RAC) and Studies Subcommittee (StS) of the Project. The Project Sponsor requested a waiver of the Project Coordination Process under Section 4 (Waiver of "Significant Impact" Status) of the WECC Project Coordination, Path Rating and Progress Report Processes.

The WECC RAC and StS received letters in opposition to the waiver request from Modesto Irrigation District (MID), Turlock Irrigation District (TID), Western Area Power Administration Sierra Nevada Region (WASN), and Transmission Agency of Northern California (TANC). The basis for the opposition to the Waiver was that these entities were Identified Affected Systems of the Project with PG&E (the Transmission Planner of the Round Mountain -Table Mountain 500 kV lines) with a common concern related to the impacts to COI caused by the Project.

The WECC RAC and StS announced that the Project's waiver request was denied in April 2021. The determination was based on the necessary transmission studies not being completed for the Project. Specifically, the Project has not been studied through a coordinated transmission planning forum that addressed concerns of Affected Systems or impacts to other WECC member systems.

Consequently, the Project Sponsor initiated the WECC Project Coordination Process for the Project. On July 19, 2021, WECC announced that the Project will be entering into the Project Coordination Process. As part of the notice, an open invitation was provided for interested parties to join the WECC Project Coordination Review Group (PCRG). Appendix A includes the list of

PCRG members who participated in this study. The first PCRG meeting to kick off this study was held on July 22, 2021, via a web-conference.

The Project Sponsor with technical support from TransCo.Energy, LLC (TRANSCO) developed a Study Plan providing outlines for the objectives, scope and methodology for the required study that needs to be completed for the Project. After several iterations of reviews, comments and discussions in web-conferences, the PCRG approved the Study Plan on November 16, 2021.

Study Objective and Scope

The main objective of this Project Coordination study is to evaluate the impact of the Round Mountain area DRS Project on Affected Systems. This Study is performed in accordance with the guidelines specified in the WECC Project Coordination Process.
The scope of this work is to identify any adverse impacts caused by the Project to the regional transmission system and/or on the import capability of the California Oregon Interface (COI), also known as the WECC Path 66. This study is performed in coordination with the WECC PCRG members. The technical analysis is performed in accordance with the North American Electric Reliability Corporation (NERC) reliability standards and WECC System Performance criteria.

Project Description and Plan of Service

The Project will be comprised of two +/- 264.5 MVar STATCOM blocks and a new 6-position Breaker and Half (BAAH) 500 kV switchyard, collectively referred to as the Fern Road Substation (Fern Road or Project). Fern Road will be constructed at a location approximately 11 miles south of Round Mountain 500 kV substation. Fern Road will loop into the existing Round Mountain – Table Mountain 500 kV #1 & #2 lines.

The Project's plan of service is detailed below:

- Construct new 500 kV Switchyard
- Loop in existing Round Mountain – Table Mountain 500 kV lines #1 and 2
- Install two +/-264.5 STATCOM Blocks
- Install two 264.5 MVA, 500/60.9 kV transformers

A conceptual one-line diagram for the Project is depicted in Figure 1.

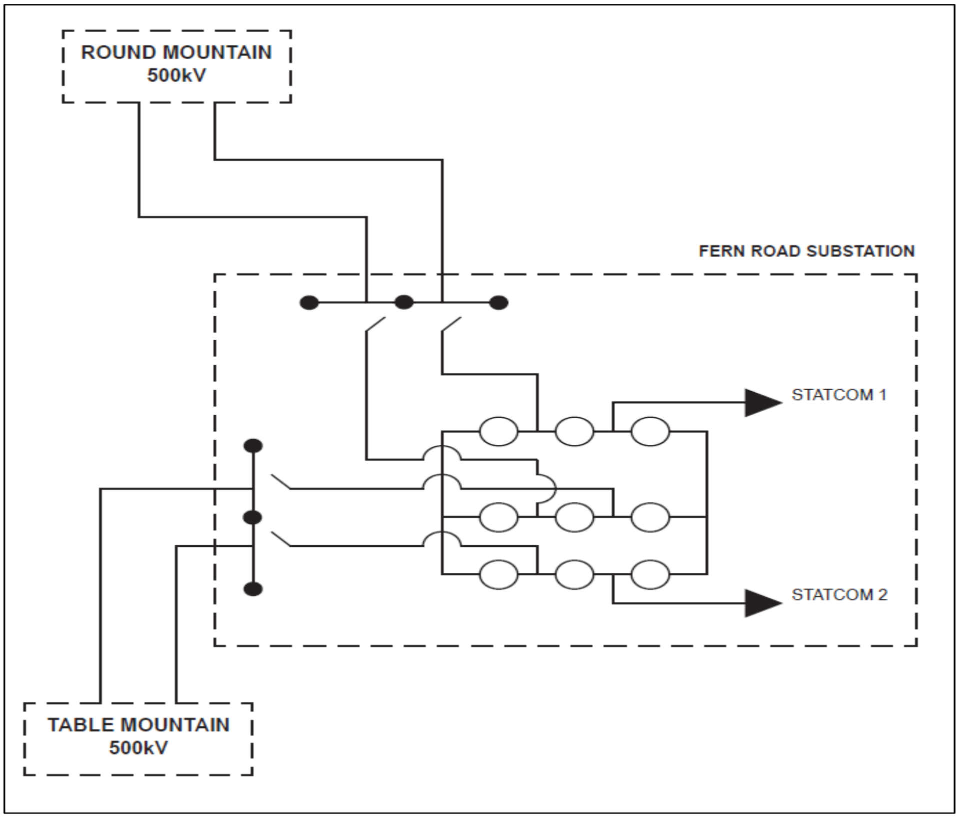

Figure 1: Simplified Representation of Round Mountain DRS Project

STUDY DESCRIPTION AND METHODOLOGY

The analysis is conducted using the CAISO TPP base cases (PG&E Bulk 2024 Heavy Summer and PG&E Bulk 2025 Spring Off-peak power flow models) as the starting base cases for the study. Both starting base cases had 800 MVar Gates DRS and 500 MVar Round Mountain DRS modeled and online. The 500 MVar Round Mountain DRS was initially removed from service in developing the benchmark or pre-Project base cases. System conditions regarding load and generation assumptions in PG&E (Area 30) service territory, Diablo Canyon Nuclear Power Plant (DCPP) status and Helms Units in the starting base cases are summarized in Table 1. The load assumption, DCPP and Helm Units statuses were not altered in developing the pre-Project base cases.

TABLE 1: LOAD AND GENERATION ASSUMPTIONS

CASE	PG&E LOAD	PG&E GENERATION	DCPP STATUS	HELMS STATUS
2024 Heavy Summer (HS)	29,542 MW	26, 740 MW	2 Units online	3 Units- Generating
2025 Spring Off Peak (SOP)	13,695 MW	13,69 MW	1 Unit online	3 Units - Pumping

To assess any adverse impacts of the Project on the COI import transfer capability and to identify steps that would be required to mitigate them, six (6) pre-Project base cases were developed from the starting base cases per the recommendation of the PCRG. In developing the pre-Project cases, either a COI flow level and direction, or NCH level is set by the PCRG, and the other attribute is allowed to float. For example, if the COI flow level in the north to south direction is set at 4500 MW, the Study determines the limiting NCH level to achieve a reliable operating condition or vice versa. The six (6) pre-Project base cases and their attributes are summarized in Table 2. The NCH level in each case is dispatched following the WECC Operations Study Subcommittee (OSS) dispatch pattern.

Post-Project study base cases were developed from the pre-Project base cases by modeling the Project in accordance with its current plan of service. The bus voltage at the Fern Road 500 kV Switchyard (which is controlled by the Round Mountain DRS) is set between 1.06 -1.07 per unit. The COI flow and NCH levels in each pre-Project case were not altered in developing the corresponding post-Project case.

TABLE 2: STUDY BASE CASES

CASE #	CASE NAME	CASE DESCRIPTION
1	Pre-2024HS_HiNCH_COI-NS	Pre-project base case developed from the 2024 PG&E Bulk HS case. NCH level is modeled at 97.74%. Maximum COI N-S flow (<=4800 MW) is determined to be 4,553 MW
2	Pre-2024HS_LoNCH_COI-NS	Pre-project base case developed from the 2024 PG&E Bulk HS case. NCH is modeled at 10.0%. Maximum COI N-S flow (<=4800 MW) is determined to be 4800 MW
3	Pre-2024HS_HiCOI-NS_NCH	Pre-project base case developed from the 2024 PG&E Bulk HS case. COI N-S flow is modeled at 4800 MW. NCH (>50%) is determined to be 69.53%
4	Pre-2025SOP_HiCOI-SN_NCH	Pre-project base case developed from the 2025 Spring off peak case. COI S-N flow is modeled at 3675 MW. NCH is determined to be 48.23%
5	Pre-2025SOP_loNCH_COI-SN	Pre-project base case developed from the 2025 Spring off peak case. NCH is modeled at 10%, Maximum COI S-N flow (<=3675 MW) is determined to be 3675 MW
6	Pre-2025SOP_HiNCH_COI-SN	Pre-project base case developed from the 2025 Spring off-peak case. NCH is modeled at approximately 55%. Maximum COI S-N flow (<=3675 MW) is determined to be 2100 MW
1a	Post-2024HS_HiNCH_COI-NS	Post-project base case developed from Case #1 and models Round Mountain DRS. Fern 500 kV bus voltage set at 1.06 per unit.
2a	Post-2024HS_LoNCH_COI-NS	Post-project base case developed from Case #2 and models Round Mountain DRS. Fern 500 kV bus voltage set at 1.06 per unit.
3a	Post-2024HS_HiCOI-NS_NCH	Post-project base case developed from Case #3 and models Round Mountain DRS. Fern 500 kV bus voltage set at 1.06 per unit.
4a	Post-2025SOP_HiCOI-SN_NCH	Post-project base case developed from Case #4 and models Round Mountain DRS. Fern 500 kV bus voltage set at 1.069 per unit.
5a	Post-2025SOP_LoNCH_COI-SN	Post-project base case developed from Case #5 and models Round Mountain DRS. Fern 500 kV bus voltage set at 1.069 per unit.
6a	Post-2025SOP_HiNCH_COI-SN	Post-project base case developed from Case #6 and models Round Mountain DRS. Fern 500 kV bus voltage set at 1.069 per unit.

Apart from the stated modeling assumptions, the transmission and load assumptions in the starting base cases were not altered in developing the post- Project base cases. Power flow, post-transient and transient stability analyses were performed to ensure that the system performance criteria prescribed in the NERC reliability standards and WECC System Performance Criteria are met. Specific studies conducted, and their evaluation criteria are outlined below:

Power Flow Analysis

Power flow analysis was performed on the pre- and post-Project base cases summarized in Table 2. The Study evaluated the impact of the Round Mountain DRS Project on the existing transmission system during normal operating conditions (Category P0), single event (Category P1) as well as multiple (Category P6-P7) events. All P6/P7 events were initially simulated without RAS action, as the Project Sponsor did not have a valid RAS definition for these outages. Subsequently, this information was obtained from PG&E and the outages were simulated again with appropriate RAS actions. This report includes both sets of results. The outages simulated include:

- P1: Gates- Los Banos 500 kV line
- P1: Tesla – Los Banos 500 kV line
- P1: Moss Landing – Los Banos 500 kV line
- P1: Gates – Midway 500 kV line
- P1: Midway – Los Banos 500 kV line
- P1: Metcalf – Tesla 500 kV line
- P1: Metcalf – Moss Landing 500 kV line
- P1: Captain Jack – Olinda 500 kV line
- P1: Round Mtn – Table Mtn #1 500 kV line (pre-project only)
- P1: Round Mtn – Table Mtn #2 500 kV line (pre-project only)
- P1: Round Mtn – Malin #1 500 kV line
- P1: Round Mtn – Malin #2 500 kV line
- P1: Table Mtn – Tesla #1 500 kV line
- P1: Table Mtn – Vaca Dixon #1 500 kV line
- P1: Round Mountain – Fern #1 500 kV line (post-project only)
- P1: Round Mountain – Fern #2 500 kV line (post-project only)
- P1: Table Mountain – Fern #1 500 kV line (post-project only)
- P1: Table Mountain – Fern #2 500 kV line (post-project only)
- P1: Olinda – Tracy 500 kV line
- P1: Vaca Dixon – Tesla 500 kV line
- P1: Tracy – Tesla 500 kV line
- P1: Tracy – Los Banos 500 kV line
- P1: Round Mtn 500/230 kV transformer
- P1: Olinda 500/230 kV transformer
- P1: Palo Verde G-1
- P1: Diablo G-1
- P6: Round Mtn – Table Mtn #1 &2 500 kV lines (pre-project only)
- P6: Round Mtn – Fern #1 & 2 500 kV lines (post-project only)
- P6: Table Mtn – Fern #1 & 2 500 kV lines (post-project only)
- P6: Round Mtn – Malin #1 &2 500 kV lines
- P6: Tesla – Tracy & Tracy- Los Banos 500 kV lines
- P6: Table Mtn – Tesla & Table Mtn – Vaca Dixon 500 kV lines

- P6: Tesla - Los Banos 500 kV & Tracy – Los Banos 500 kV
- P6: Los Banos - Midway 500 kV & Los Banos – Gates #1 500 kV
- P6: Los Banos - Midway 500 kV & Gates - Midway 500 kV
- P7: Tesla – Los Banos & Tesla -Tracy 500 kV lines
- P7: PDCI Bipole outage
- P7: Palo Verde G-2
- P7: Diablo G-2

The NERC reliability standards and the WECC System Performance Criteria were used to evaluate study results. The following criteria were adhered to in evaluating the power flow results:

- Pre-contingency bus voltage must be between 0.95 per unit and 1.05 per unit unless specific minimum and maximum operating voltage requirements exists. For the post-Project case, the Fern Road 500 kV bus voltage shall be between 1.06 -1.07 per unit.
- Pre-disturbance loading to remain within continuous ratings of all equipment and line conductors.
- Post-disturbance loading to remain within emergency ratings of all equipment and line conductors.
- Post-disturbance bus voltages to remain within applicable criteria:
    - Between 0.9 per unit and 1.10 per unit for Category P1-P7 events unless lower standards have previously been adopted.
- Post-disturbance bus voltage deviation to remain within applicable criteria:
    - Within 8% for Category P1 events, unless lower standards have previously been adopted
- Existing Remedial Action Schemes (RAS) were deployed as part of contingency definition as applicable.

Transient Stability Analysis

Transient stability analysis was conducted on the post-Project study cases summarized in Table 2 with the COI flow in each case increased by 10%. The 10% margin on the COI flow is used in System Operation to account for the high unscheduled flows that commonly occur on COI during real-time operation. The PCRG recommended the 10% margin to identify any impacts to COI operation attributable to the Project. Accordingly, the flow on COI was modeled at 10% higher than the COI flow in each case. Pre-Project analysis was performed as required if criteria violations were identified in post-Project analysis. The dynamic data files developed for use with the pre-Project base cases were updated to include the Round Mountain DRS dynamic model in post-Project cases.

Transient stability runs were simulated for 30 seconds excluding a 1 second pre-outage run to ensure the system is stable and positively damped. Three-phase faults with 4 cycle clearing time were simulated for all the selected planning events.

The following selected critical disturbances were considered as part of the transient stability analysis. For each of the outages below, the fault was applied at the first bus for P1 events, and at the common bus for P6 events.

- P1: Gates- Los Banos 500 kV line
- P1: Tesla – Los Banos 500 kV line
- P1: Moss Landing – Los Banos 500 kV line
- P1: Gates – Midway 500 kV line
- P1: Midway – Los Banos 500 kV line
- P1: Metcalf – Tesla 500 kV line
- P1: Metcalf – Moss Landing 500 kV line
- P1: Captain Jack – Olinda 500 kV line
- P1: Round Mtn – Table Mtn #1 500 kV line (pre-project only)
- P1: Round Mtn – Table Mtn #2 500 kV line (pre-project only)
- P1: Round Mtn – Malin #1 500 kV line
- P1: Round Mtn – Malin #2 500 kV line
- P1: Table Mtn – Tesla #1 500 kV line
- P1: Table Mtn – Vaca Dixon #1 500 kV line
- P1: Round Mountain – Fern #1 500 kV line (post-project only)
- P1: Round Mountain – Fern #2 500 kV line (post-project only)
- P1: Table Mountain – Fern #1 500 kV line (post-project only)
- P1: Table Mountain – Fern #2 500 kV line (post-project only)
- P1: Olinda – Tracy 500 kV line
- P1: Vaca Dixon – Tesla 500 kV line
- P1: Tracy – Tesla 500 kV line
- P1: Tracy – Los Banos 500 kV line
- P1: Round Mtn 500/230 kV transformer
- P1: Olinda 500/230 kV transformer
- P1: Palo Verde G-1
- P1: Diablo G-1
- P6: Round Mtn – Table Mtn #1 &2 500 kV lines (pre-project only)
- P6: Round Mtn – Fern #1 & 2 500 kV lines (post-project only)
- P6: Table Mtn – Fern #1 & 2 500 kV lines (post-project only)
- P6: Round Mtn – Malin #1 &2 500 kV lines
- P6: Tesla – Tracy & Tracy- Los Banos 500 kV lines
- P6: Table Mtn – Tesla & Table Mtn – Vaca Dixon 500 kV lines
- P6: Tesla - Los Banos 500 kV & Tracy – Los Banos 500 kV
- P6: Los Banos - Midway 500 kV & Los Banos – Gates #1 500 kV
- P6: Los Banos - Midway 500 kV & Gates - Midway 500 kV
- P7: Tesla – Los Banos & Tesla -Tracy 500 kV lines
- P7: PDCI Bipole outage
- P7: Palo Verde G-2

- P7: Diablo G-2

The following transient stability evaluation criteria were used to evaluate the impact of the Project on the stability limits of the existing transmission system:

- All machines in the interconnected system shall remain in synchronism as demonstrated by their relative rotor angles.
- System stability was evaluated based on the damping of the relative rotor angles and the damping of the voltage magnitude swings.
- System damping was assessed visually with the aid of stability plots. All oscillations that do not show positive damping within 30-seconds after the start of the studied event was deemed unstable.
- Transient voltage deviation was assessed using the TPL-0100-WECC-CRT-3 transient voltage dip criteria:
    - Following fault clearing, the voltage shall recover to 80% of the pre-contingency voltage within 20 seconds of the initiating event for all P1 through P7 events, for each applicable BES bus serving load.
    - Following fault clearing and voltage recovery above 80%, voltage at each applicable BES bus serving load shall neither dip below 70% of pre-contingency voltage for more than 30 cycles nor remain below 80% of pre-contingency voltage for more than two seconds, for all P1 through P7 events.

Post-Transient Voltage Stability Analysis

Post-transient voltage stability analysis was performed following the addition of Round Mountain DRS. This analysis was performed on the study base cases listed in Table 2. PCRG recommended using 10% margin for COI flow in lieu of the WECC TPL-001-WECC-CRT-3.2 Criterion WR5. The 10% margin is used in System Operation to account for the high unscheduled flows that commonly occur on COI during real-time operation. The PCRG's proposed 10% margin is more stringent than the WECC TPL-001-WECC-CRT-3.2 criterion but was recommended for this study to identify any impacts to COI operation attributable to the Project. Thus, the flow on COI in each case was modeled at 10% higher than flow established in each case.

The outage list for the post-transient stability analysis is follows:

- P1: Gates- Los Banos 500 kV line
- P1: Tesla – Los Banos 500 kV line
- P1: Moss Landing – Los Banos 500 kV line
- P1: Gates – Midway 500 kV line
- P1: Midway – Los Banos 500 kV line
- P1: Metcalf – Tesla 500 kV line
- P1: Metcalf – Moss Landing 500 kV line
- P1: Captain Jack – Olinda 500 kV line
- P1: Round Mtn – Table Mtn #1 500 kV line (pre-project only)
- P1: Round Mtn – Table Mtn #2 500 kV line (pre-project only)

- P1: Round Mtn – Malin #1 500 kV line
- P1: Round Mtn – Malin #2 500 kV line
- P1: Table Mtn – Tesla #1 500 kV line
- P1: Table Mtn – Vaca Dixon #1 500 kV line
- P1: Round Mountain – Fern #1 500 kV line (post-project only)
- P1: Round Mountain – Fern #2 500 kV line (post-project only)
- P1: Table Mountain – Fern #1 500 kV line (post-project only)
- P1: Table Mountain – Fern #2 500 kV line (post-project only)
- P1: Olinda – Tracy 500 kV line
- P1: Vaca Dixon – Tesla 500 kV line
- P1: Tracy – Tesla 500 kV line
- P1: Tracy – Los Banos 500 kV line
- P1: Round Mtn 500/230 kV transformer
- P1: Olinda 500/230 kV transformer
- P1: Palo Verde G-1
- P1: Diablo G-1
- P6: Round Mtn – Table Mtn #1 &2 500 kV lines (pre-project only)
- P6: Round Mtn – Fern #1 & 2 500 kV lines (post-project only)
- P6: Table Mtn – Fern #1 & 2 500 kV lines (post-project only)
- P6: Round Mtn – Malin #1 &2 500 kV lines
- P6: Tesla – Tracy & Tracy- Los Banos 500 kV lines
- P6: Table Mtn – Tesla & Table Mtn – Vaca Dixon 500 kV lines

To achieve post-transient voltage stability, positive reactive power margins must be recorded for each outage.

Sensitivity Analysis

After the completion of study, the PCRG requested additional sensitivity analysis to assess the impacts of the Project with the PG&E proposed RAS at COI flow levels more than its current Accepted Rating of 4,800 MW. The sensitivity analysis is performed using the study Cases 1 and 3 described in Table 1 as the starting cases. A summary of sensitivity cases is provided in Table 3.

TABLE 3: SENSITIVITY CASES

CASE #	CASE NAME	CASE DESCRIPTION
1-S	Pre_2024HS_HiNCH_COI_NS_sen	Sensitivity Case 1-S is developed from Case 1 by increasing the COI north to south flow till a critical facility limit is achieved (N-0 or N-1 limit). This limit assumes that PG&E proposed RAS that bypasses the series capacitors on either of the Round Mountain -Table Mountain 500 kV lines for an outage of the other line is in-service. This allows the COI path to be operated at a higher flow than its Accepted Rating of 4800 MW.
3-S	Pre-2024HS_HiCOI-NS_NCH_sen	Sensitivity Case 3-S is developed from Case 3 by increasing the COI north to south flow till a critical facility limit is achieved (N-0 or N-1 limit). This limit assumes that PG&E proposed

TABLE 3: SENSITIVITY CASES

		RAS that bypasses the series capacitors on either of the Round Mountain -Table Mountain 500 kV lines for an outage of the other line is in-service. This allows the COI path to be operated at a higher flow than its Accepted Rating of 4800 MW.
1A-S	Post-2024HS_HiNCH_COI-NS_sen	This post-Project sensitivity case was developed from the Case 1-S by adding the Round Mountain DRS and associated Fern 500 kV switchyard. No system adjustments were made.
3A-S	Post-2024HS_HiCOI-NS_NCH_sen	This post-Project sensitivity case was developed from Case 3-S by adding the Round Mountain DRS and associated Fern 500 kV switchyard. No system adjustments were made.

In this sensitivity analysis, only power flow and transient analyses were performed. The transient analysis was performed on the sensitivity cases 1A-S and 3A-S. For both power flow and transient stability analyses the following P1 outages were simulated.

- P1: Gates- Los Banos 500 kV line
- P1: Tesla – Los Banos 500 kV line
- P1: Moss Landing – Los Banos 500 kV line
- P1: Gates – Midway 500 kV line
- P1: Midway – Los Banos 500 kV line
- P1: Metcalf – Tesla 500 kV line
- P1: Metcalf – Moss Landing 500 kV line
- P1: Captain Jack – Olinda 500 kV line
- P1: Round Mtn – Table Mtn #1 500 kV line (pre-project only)
- P1: Round Mtn – Table Mtn #2 500 kV line (pre-project only)
- P1: Round Mtn – Malin #1 500 kV line
- P1: Round Mtn – Malin #2 500 kV line
- P1: Table Mtn – Tesla #1 500 kV line
- P1: Table Mtn – Vaca Dixon #1 500 kV line
- P1: Round Mountain – Fern #1 500 kV line (post-project only)
- P1: Round Mountain – Fern #2 500 kV line (post-project only)
- P1: Table Mountain – Fern #1 500 kV line (post-project only)
- P1: Table Mountain – Fern #2 500 kV line (post-project only)
- P1: Olinda – Tracy 500 kV line
- P1: Tracy – Tesla 500 kV line
- P1: Tracy – Los Banos 500 kV line
- P1: Round Mtn 500/230 kV transformer
- P1: Olinda 500/230 kV transformer

STUDY RESULTS

This section details the key findings of the power flow, post-transient voltage stability and transient stability analyses. NERC reliability standards and WECC System Performance Criteria were used to assess the adequacy of the system performance based on the study results.

Base Case Summary

A summary of selected base case transmission line / path flows, NCH level modeled, and status of the Round Mountain DRS for both pre- and post-Project study base cases with all transmission lines in service is provided in Table 4. Selected 500 kV bus voltages in the pre- and post-Project base cases with all transmission lines in service are provided in Table 5.

TABLE 4: SUMMARY OF BASE CASE TRANSMISSION LINE / PATH FLOWS

BASE CASE	CASE DESCRIPTION	NCH	TRANSMISSION LINE / PATH FLOWS (MW)			
			COI[1]	PATH 15	PATH 26	PDCI
Pre-2024HS_HiNCH_COI-NS (Case 1)	Pre-Project	97.74%	4,553	(417)	1,540	3,220
Post-2024HS_HiNCH_COI-NS (Case 1a)	Post-Project	97.74%	4,554	(429)	1,550	3,220
Pre-2024HS_LoNCH_COI-NS (Case 2)	Pre-Project	10.06%	4,800	2,254	(1,151)	3,220
Post-2024HS_LoNCH_COI-NS (Case 2a)	Post-Project	10.06%	4,800	2,252	(1,149)	3,220
Pre-2024HS_HiCOI-NS_NCH (Case 3)	Pre-Project	69.53%	4,800	68	1,058	3,220
Post-2024HS_HiCOI-NS_NCH (Case 3a)	Post-Project	69.53%	4,800	59	1,067	3,220
Pre-2025SOP_HiCOI-SN_NCH (Case 4)	Pre-Project	48.23%	(3,675)	(360)	2,974	(997)
Post-2025SOP_HiCOI-SN_NCH (Case 4a)	Post-Project	48.23%	(3,675)	(369)	2,993	(997)
Pre-2025SOP_loNCH_COI-SN (Case 5)	Pre-Project	10.47%	(3,675)	890	1,716	(997)
Post-2025SOP_loNCH_COI-SN (Case 5a)	Post-Project	10.47%	(3,675)	877	1,730	(997)
Pre-2025SOP_HiNCH_COI-SN (Case 6)	Pre-Project	55.55%	(2,100)	(1,468)	3,354	(997)
Post-2025SOP_HiNCH_COI-SN (Case 6a)	Post-Project	55.55%	(2,100)	(1,475)	3,362	(997)

[1] Higher COI flows (>4,800 MW) are studied as part of a sensitivity analysis described later in this report. Table 10 and 11 include the sensitivity study results.

TABLE 5: 500 KV BUS VOLTAGES

BASE CASE	CASE DESCRIPTION	BUS VOLTAGES (PU)				
		FERN	ROUND MT	TABLE MT	METCALF	TESLA
Pre-2024HS_HiNCH_COI-NS (Case 1)	Pre-Project	N/A	1.051	1.046	1.052	1.050
Post-2024HS_HiNCH_COI-NS (Case 1a)	Post-Project	1.060	1.081	1.058	1,550	3,220
Pre-2024HS_LoNCH_COI-NS (Case 2)	Pre-Project	N/A	1.064	1.063	1.059	1.066
Post-2024HS_LoNCH_COI-NS (Case 2a)	Post-Project	1.060	1.083	1.066	1.060	1.067
Pre-2024HS_HiCOI-NS_NCH (Case 3)	Pre-Project	N/A	1.054	1.052	1.056	1.057
Post-2024HS_HiCOI-NS_NCH (Case 3a)	Post-Project	1.060	1.082	1.063	1,.059	1.062
Pre-2025SOP_HiCOI-SN_NCH (Case 4)	Pre-Project	N/A	1.087	1.096	1.098	1.088
Post-2025SOP_HiCOI-SN_NCH (Case 4a)	Post-Project	1.069	1.070	1.083	1.095	1.083
Pre-2025SOP_loNCH_COI-SN (Case 5)	Pre-Project	N/A	1.090	1.100	1.097	1.089
Post-2025SOP_loNCH_COI-SN (Case 5a)	Post-Project	1.069	1.070	1.084	1.092	1.082
Pre-2025SOP_HiNCH_COI-SN (Case 6)	Pre-Project	N/A	1.093	1.102	1.107	1.094
Post-2025SOP_HiNCH_COI-SN (Case 6a)	Post-Project	1.069	1.070	1.070	1.099	1.085

Power Flow Analysis Findings

Case 1/1a: 2024 HS-High NCH & High COI N-S

Cases 1 & 1a were used to evaluate the impact of the Project during heavy summer operation with high NCH level (97.74%). For a no critical facility (500 kV) thermal overloads under P0/P1 planning events, COI north-south flow in the pre-Project base case (Case 1) was determined to be 4,553 MW. Post-Project base case (Case 1a) was developed from Case 1 by adding the Round Mountain DRS while maintaining the COI flow at pre-Project level. The Round Mountain DRS was modeled to control the Fern 500 kV bus at 1.06 per unit.

Power flow solutions were obtained for all P1 outage events simulated. Summary of the power flow results can be found in Appendix B, Table B-1.

Provided below are key findings from the power flow analysis using Case 1 & Case 1a:

- **Two (2) New Transmission facility overloads Identified**

The post-Project case shows two (2) transmission facility overloads following P1 outage events during heavy summer operating conditions with high NCH level (97.74%) and north-south COI flow of approximately 4550 MW. The 2 transmission facility overloads are:

- Round Mountain – Fern #1 500 kV line (109%) following the outage of Round Mountain – Fern #2 500 kV line
- Round Mountain – Fern #2 500 kV line (109%) following the outage of Round Mountain – Fern #1 500 kV line

The equivalent outage in the pre-project case resulted in the thermal loading of the remaining 500 kV line between Round Mountain and Table Mountain of approximately 99%. A RAS project is currently being proposed by PG&E to improve COI N-S transfer capability with an expected in-service date in the second quarter of 2024. Further analysis was performed with the proposed PG&E RAS and the results show the RAS effectively mitigates the identified overloads. Table 6 summarizes the results of the power flow analysis with and without the proposed RAS.

TABLE 6: POWER FLOW RESULTS -- CASE 1/1A

Outage Element (s)	Overloaded Facility	Applicable Rating	Loading (%)			Comments
			Case 1	Case 1A	Case 1A w/ RAS	
Category P1 Contingencies						
Round MT– Fern #2 500 kV line (For Case 1: Round MT – Table MT #2 500 kV line)	Round MT – Fern #1 500 kV line (For Case 1: Round MT – Table MT #1 500 kV line)	3,280 A	99.8	109.4	82.1	Proposed PG&E RAS to bypass the 3 remaining series capacitors on the Round MT – Fern - Table MT 500 kV lines under this outage is successful in mitigating the overload
Round MT – Fern #1 500 kV line (For Case 1: Round MT – Table MT #1 500 kV line)	Round MT – Fern #2 500 kV line (For Case 1: Round MT – Table MT #2 500 kV line)	3,280 A	99.9	109.4	82.1	Proposed PG&E RAS to bypass the 3 remaining series capacitors on the Round MT – Fern - Table MT 500 kV lines under this outage is successful in mitigating the overload

- **Existing P1 Transmission facility overload persisted with the Project**

Two (2) existing P1 outage event thermal overloads persisted following the addition of the Project as shown in Table 7.

TABLE 7: POWER FLOW RESULTS -- CASE 1/1A EXISTING THERMAL OVERLOADS

Outage Element (s)	Overloaded Facility	Applicable Rating	Loading (%)	
			Case 1	Case 1A
Category P1 Contingencies				
Olinda – Tracy 500 kV line	Delevan – Cortina 230 kV line	954 A	104.0	103.1
Olinda – Captain Jack 500 kV line	Olinda– KE South 230 kV line	810 A	103.9	103.5

•No Power Flow Solution for P6/P7 Planning Events without RAS

The following P6/P7 planning events did not yield power flow solutions without the existing RAS (PACI) using the pre-Project and/or post-Project cases. These P6/P7 planning events are:

- Table MT – Vaca Dixon & Table MT – Tesla 500 kV lines (pre-Project case)
- Table MT – Round MT #1 & 2 500 kV lines (pre-Project case)
- Round MT – Malin #1 &2 500 kV lines (pre-& post-Project cases)
- Table MT – Fern #1 & 2 500 kV lines (post-Project case)
- Round MT – Fern #1 & 2 500 kV lines (post-Project case)

These outages solve without any thermal overloads with the existing RAS associated with each outage deployed.

•No voltage criteria violation identified

No voltage criteria violation identified for the planning outages simulated.

Case 2/2a: 2024 HS-Low NCH & High COI N-S

Cases 2 & 2a were used to evaluate the impact of the Project during heavy summer operation with low NCH level of 10%. A maximum achievable COI north-south flow of 4800 MW was modeled without any P0/P1 outage event's thermal limitations. Summary of the power flow results can be found in Appendix B, Table B-2.

Provided below are key findings from the power flow analysis using Cases 2 & Case 2a:

•No New Transmission facility overload attributable to Project

The addition of the Round Mountain DRS did not cause any transmission facility overloads under normal and following selected P1 outage events during heavy summer operating conditions with low NCH level (10.06%) and high north-south COI flow (4,800 MW).

•Existing P6/P7 Transmission facility overload persisted with the Project

Existing P6/P7 outage event thermal overloads without RAS persisted following the addition of the Round Mountain DRS. Appendix B, Table B-2 summarizes the pre- and post-Project power flow results. No thermal overload was recorded with existing RAS associated with each outage deployed.

•No voltage criteria violation identified

No voltage criteria violation identified for the planning outages simulated.

Case 3/3a: 2024 HS-High COI & Moderate NCH

Cases 3 & 3a were used to evaluate the impact of the Project during heavy summer operation with high COI north-south flow (4,800 MW). A moderate NCH level of 69.53% was modeled to not cause any critical facility overload under P0/P1 outage events. Power flow solutions were obtained for all P1 outages simulated. Summary of the power flow results can be found in Appendix B, Table B-3.

Provided below are key findings from the power flow analysis using Case 3 & Case 3a:

•Two (2) New Transmission facility overload Identified

The post-Project case shows two (2) transmission facility overloads following P1 outage event during heavy summer operating conditions with high northern high north-south COI flow (4,800 MW). The 2 transmission facility overloads are:

- Round Mountain – Fern #1 500 kV line (109%) following the outage of Round Mountain – Fern #2 500 kV line
- Round Mountain – Fern #2 500 kV line (109%) following the outage of Round Mountain – Fern #1 500 kV line

As previously stated for Case 1/1a results, these thermal overloads are mitigated by the proposed PG&E RAS which bypasses the series capacitors on each line following the P1 critical outage. Table 8 summarizes the results of the power flow analysis with and without the proposed RAS.

TABLE 8: POWER FLOW RESULTS -- CASE 3/3A

Outage Element (s)	Overloaded Facility	Applicable Rating	Loading (%)			Comments
			Case 3	Case 3A	Case 3A w/ RAS	
Category P1 Contingencies						
Round MT– Fern #2 500 kV line (For Case 3: Round MT – Table MT #2 500 kV line)	Round MT – Fern #1 500 kV line (For Case 3: Round MT – Table MT #1 500 kV line)	3,280 A	99.3	108.9	81.7	Proposed PG&E RAS to bypass the 3 remaining series capacitors on the Round MT – Fern – Table MT 500 kV lines under this outage is successful in mitigating the overload
Round MT – Fern #1 500 kV line (For Case 3: Round MT – Table MT #1 500 kV line)	Round MT – Fern #2 500 kV line (For Case 3: Round MT – Table MT #2 500 kV line)	3,280 A	99.4	108.9	81.7	Proposed PG&E RAS to bypass the 3 remaining series capacitors on the Round MT – Fern – Table MT 500 kV lines under this outage is successful in mitigating the overload

•Existing P6/P7 Transmission facility overload persisted with the Project

Existing P6/P7 outage event thermal overloads without RAS persisted following the addition of the Round Mountain DRS. Appendix B, Table B-2 summarizes the pre- and post-Project power flow results. No thermal overload was recorded with existing RAS associated with each outage deployed.

- **No voltage criteria violation identified**

No voltage criteria violation identified for the planning outages simulated.

Case 4/4a: 2025 SOP-High COI S-N & Moderate NCH

Cases 4 & 4a were used to evaluate the impact of the Round Mountain DRS during Spring off-peak operation with rated COI south-north (S-N) flow. For a thermal limitation under P0/P1 outage to be reached, NCH level was modeled at 48% in developing Case 4. Case 4a was developed from Case 4 by adding the Project while maintaining the COI S-N flow of 3675 MW. The Round Mountain DRS was modeled to control the Fern 500 kV bus at 1.069 per unit.

Power flow solutions were obtained for all outages (P1/P7) simulated. Summary of the power flow results can be found in Appendix B, Table B-4.

Provided below are key findings from the power flow analysis using Case 4 & Case 4a:

- **No New Transmission facility overload attributable to Project Identified**

The interconnection of the Round Mountain DRS did not cause any new transmission facility overloads under P0/P1 planning event. The NCH level modeled in the pre- Project base case (Case 4) was limited to 48% because of thermal limitation on the Table Mountain 500/230 kV transformer (99.6%) following the outage of the Round Mountain 500/230 kV transformer. Following the addition of the Round Mountain DRS, the loading on the Table Mountain 500/230 kV transformer (limiting element) was marginally decreased to 98.5% following the outage of the Round Mountain 500/230 kV transformer while maintaining the NCH level at 48%.

- **Existing P6/P7 Transmission facility overload persisted with the Project**

Existing P6/P7 outage event thermal overloads without RAS persisted following the addition of the Round Mountain DRS. Appendix B, Table B-4 summarizes the pre- and post-Project power flow results. No thermal overload was recorded with existing RAS associated with each outage deployed.

- **No voltage criteria violation identified**

No voltage criteria violation identified.

Case 5/5a: 2025 SOP-Low NCH & High COI S-N

Cases 5 & 5a were used to evaluate the impact of the Round Mountain DRS during Spring off-peak operation with low NCH level. For a low NCH level of 10.47%, no transmission facility thermal limitation was identified for a rated COI south-north flow of 3675 MW under P0/P1 outage conditions. The Round Mountain DRS was modeled to control the Fern 500 kV bus at 1.069 per unit.

Power flow solutions were obtained for all outages (P1/P7) simulated. Summary of the power flow results can be found in Appendix B, Table B-5.

Provided below are key findings from the power flow analysis using Case 5 & Case 5a:

- **No New Transmission facility overload attributable to Project Identified**

  The interconnection of the Round Mountain DRS did not cause any new transmission facility thermal overloads under P0/P1 planning event.

- **Existing P6/P7 Transmission facility overload persisted with the Project**

  Existing P6/P7 outage event thermal overloads without RAS persisted following the addition of the Round Mountain DRS. Appendix B, Table B-5 summarizes the pre- and post-Project power flow results. No thermal overload was recorded with existing RAS associated with each outage deployed.

- **No voltage criteria violation identified**

  No voltage criteria violation identified.

Case 6/6a: 2025 SOP-High NCH & Moderate COI S-N

A high NCH level (55.55%) was modeled in the pre-Project case 6 to evaluate the impact of the Round Mountain DRS during Spring off-peak operation. With NCH of 55.55%, a P0/P1 outage thermal limitation was reached when COI south-north flow reached 2,100 MW. The limiting facility was found to be Table Mountain 500/230 kV transformer (99.7%) following the outage of Round Mountain 500/230 kV transformer. Case 6a was developed from Case 6 by adding the Project while maintaining the COI S-N flow of 2,100 MW. The Round Mountain DRS was modeled to control the Fern 500 kV bus at 1.069 per unit.

Power flow solutions were obtained for all outages (P1/P7) simulated. Summary of the power flow results can be found in Appendix B, Table B-6.

Provided below are key findings from the power flow analysis using Case 6 & Case 6a:

•No New Transmission facility overload attributable to Project Identified

The interconnection of the Project did not cause any new transmission facility overloads under P0/P7 planning events.

•Existing P6/P7 Transmission facility overload persisted with the Project

Existing P6/P7 outage event thermal overloads without RAS persisted following the addition of the Round Mountain DRS. Appendix B, Table B-6 summarizes the pre- and post-Project power flow results. No thermal overload was recorded with existing RAS associated with each outage deployed.

•No voltage criteria violation identified

No voltage criteria violation identified.

Transient Stability Analysis Findings

Transient stability analysis was performed on all the post-Project base cases. For each case a 10% flow margin on COI was modeled.

Key findings from the stability analysis include:

- All outages simulated including P6/P7 Planning Events resulted in stable system performance with positive damping. Stability plots for 2024 heavy summer and 2025 spring off-peak post-Project base cases can be found at Attachment A and B respectively.
- TPL-0100-WECC-CRT-3 transient voltage dip criteria were met for all outages simulated

Post Transient Voltage Stability Analysis Findings

Post-transient voltage stability analysis was performed on all the post-Project base cases. For each case a 10% flow margin on COI was modeled. Table 9 provides a summary of the results of the post-transient voltage stability analysis.

As summarized in Table 9, power flow solutions were achieved for all outages simulated. Therefore, positive reactive margins were obtained for all outages simulated. Thus, the addition of Round Mountain DRS did not impact the post-transient voltage stability limits of the interconnected transmission system.

TABLE 9: SUMMARY OF POST-TRANSIENT VOLTAGE STABILITY ANALYSIS

OUTAGE SIMULATED	POST-TRANSIENT VOLTAGE STABILITY CRITERIA MET?					
	CASE 1A	CASE 2A	CASE 3A	CASE 4A	CASE 5A	CASE 6A
Gates – Los Banos 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Tesla – Los Banos 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Moss Landing – Los Banos 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Gates – Midway 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Midway – Los Banos 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Metcalf – Tesla 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Metcalf – Moss Landing 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Captain Jack – Olinda 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Round Mtn – Malin #1 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Round Mtn – Mail #2 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Table Mtn – Tesla #1 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Table Mtn – Vaca Dixon #1 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Round Mtn – Fern #1 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Round Mtn – Fern #2 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Table Mtn – Fern #1 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Table Mtn – Fern #2 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Olinda – Tracy 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Vaca Dixon – Tesla 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Tracy – Tesla 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Tracy – Los Banos 500 kV line	Yes	Yes	Yes	Yes	Yes	Yes
Round Mtn 500/230 kV transformer	Yes	Yes	Yes	Yes	Yes	Yes
Olinda 500/230 kV transformer	Yes	Yes	Yes	Yes	Yes	Yes
Palo Verde G-1	Yes	Yes	Yes	Yes	Yes	Yes
Diablo g-1	Yes	Yes	Yes	Yes	Yes	Yes
Round Mtn – Fern #1 &2 500 kV lines (w/ RAS)	Yes	Yes	Yes	Yes	Yes	Yes
Table Mtn – Fern #1 & 2 500 kV lines (w/ RAS)	Yes	Yes	Yes	Yes	Yes	Yes
Round Mtn – Malin #1 & 2 500 kV lines (w/ RAS)	Yes	Yes	Yes	Yes	Yes	Yes
Tesla – Tracy & Tracy – Los Banos 500 kV lines	Yes	Yes	Yes	Yes	Yes	Yes
Table Mtn – Tesla & Table Mtn – Vaca Dixon 500 kV lines (w/ RAS)	Yes	Yes	Yes	Yes	Yes	Yes

Sensitivity Analysis Findings

The sensitivity analysis assessed the impacts of the Project with the PG&E proposed RAS at higher COI flow levels. Provided below are the key findings from sensitivity study:

<u>Case 1-S/1A-S: 2024 HS-High NCH & High COI N-S Sensitivity</u>

Using Case 1 as the starting base case, the sensitivity Case 1-S was developed by increasing the COI north to south flow till a critical facility limit is achieved (N-0 or N-1 limit). This limit assumes that PG&E proposed RAS that bypasses the series capacitors on either of the Round Mountain -Table

Mountain 500 kV lines for an outage of the other line is in-service. This allows the COI path to be operated at a higher flow than its Accepted Rating of 4800 MW. In this case, the COI flow was found to be 5,371 MW, limited by the normal rating of the series capacitor on the Table Mountain – Vaca Dixon 500 kV line.

Post-Project sensitivity Case 1A-S was developed from the Case 1-S by adding the Round Mountain DRS and associated Fern 500 kV switchyard. No system adjustments were made. The study results using the Case 1A-S show that COI flow did not change from the pre-Project levels of 5,371 MW. However, the loading on the limiting element is marginally reduced and therefore the COI flow could have been increased further, were system adjustments be allowed. Table 10 summarizes the power flow study results.

TABLE 10: POWER FLOW RESULTS - SENSITIVITY ANALYSIS: CASE 1-S/1A-S

Outage Element (s)	Overloaded Facility	Applicable Rating	Loading (%)		Comments
			Case 1-S COI=5,371 MW	Case 1A-S COI=5,371 MW	
NA	Table Mountain - Vaca Dixon 500 kV line	2,478 A	99.8	98.9	COI flow limited by normal rating of the series capacitor on the Table Mountain - Vaca Dixon 500 kV line. Flow is marginally reduced in the post-Project case.
Round MT– Fern #2 500 kV line (For Case 1-S: Round MT – Table MT #2 500 kV line)	Round MT – Fern #1 500 kV line (For Case 1-S: Round MT – Table MT #1 500 kV line)	3,280 A	73.8	94.2	Proposed PG&E RAS bypasses the 3 remaining series capacitors on the Round MT – Fern – Table MT 500 kV lines under this outage
Round MT – Fern #1 500 kV line (For Case 1-S: Round MT – Table MT #1 500 kV line)	Round MT – Fern #2 500 kV line (For Case 1-S: Round MT – Table MT #2 500 kV line)	3,280 A	73.8	94.2	Proposed PG&E RAS bypasses the 3 remaining series capacitors on the Round MT – Fern – Table MT 500 kV lines under this outage

Transient stability analysis was performed for all P1 events listed for the original study. Simulations were performed using post-Project sensitivity Case 1A-S. Key findings from the transient analysis include:

- All P1 planning events resulted in stable system performance with positive damping. Stability plots for Case 1A-S can be found at Attachment C.
- TPL-0100-WECC-CRT-3 transient voltage dip criteria were met for all outages simulated

Case 3-S/3A-S: 2024 HS-High COI & Moderate NCH Sensitivity

The pre-Project Sensitivity Case 3-S was developed from the Case 3 by increasing the COI north to south flow till a critical facility limit is achieved (N-0 or N-1 limit). This limit assumes that PG&E proposed RAS that bypasses the series capacitors on either of the Round Mountain -Table Mountain 500 kV lines for an outage of the other line is in-service.

In the pre-Project Sensitivity Case 3-S, the maximum COI flow achievable was 5,535 MW. This COI flow was limited by the emergency rating of the Malin – Round Mountain #2 500 kV line conductor following the outage of the Olinda – Captain Jack 500 kV line (with RAS to bypass series capacitor at the Olinda end of the Olinda – Maxwell 500 kV line).
A post-Project Sensitivity Case 3A-S was developed from Case 3-S by adding the Round Mountain DRS and associated Fern 500 kV switchyard. No system adjustments were made. The COI flow in the post-Project Sensitivity Case 3A-S was 5,554 MW, 19 MW more than the pre-Project Sensitivity Case 3-S.
The power flow results show that even though the COI flow increased by 19 MW in the post-Project case, the loading of limiting element is reduced by 1% and thus a further stressing of the COI could have been achieved should system adjustments be allowed. Table 11 provides a summary of the power flow analysis.

TABLE 11: POWER FLOW RESULTS - SENSITIVITY ANALYSIS: CASE 3-S/3A-S

Outage Element (s)	Overloaded Facility	Applicable Rating	Loading (%)		Comments
			Case 3-S COI=5,535 MW	Case 3A-S COI=5,554 MW	
Olinda - Captain Jack 500 kV line (with RAS to bypass series capacitor at Olinda on Olinda - Maxwell 500 kV line)	Malin - Round Mountain #2 500 kV line	3,092 A	99.9	98.9	Pre- Project COI flow limited by N-1 rating of the series capacitor on the Malin - Round Mountain #2 500 kV line. Further stressing can be done to achieve higher post-Project COI flow
Round MT– Fern #2 500 kV line (For Case 1-S: Round MT – Table MT #2 500 kV line)	Round MT – Fern #1 500 kV line (For Case 1-S: Round MT – Table MT #1 500 kV line)	3,280 A	74.0	92.2	Proposed PG&E RAS bypasses the 3 remaining series capacitors on the Round MT – Fern – Table MT 500 kV lines under this outage
Round MT – Fern #1 500 kV line (For Case 1-S: Round MT – Table MT #1 500 kV line)	Round MT – Fern #2 500 kV line (For Case 1-S: Round MT – Table MT #2 500 kV line)	3,280 A	74.0	92.2	Proposed PG&E RAS bypasses the 3 remaining series capacitors on the Round MT – Fern – Table MT 500 kV lines under this outage

Transient stability analysis was performed for all P1 events listed for the original study. Simulations were performed using post-Project sensitivity Case 3A-S. Key findings from the transient analysis include:

- All P1 planning events resulted in stable system performance with positive damping. Stability plots for Case 3A-S can be found at Attachment C.
- TPL-0100-WECC-CRT-3 transient voltage dip criteria were met for all outages simulated

CONCLUSION

The objective of this PCS was to evaluate the impacts of the Round Mountain DRS Project to the regional transmission systems and address the concerns of Affected Systems. The study included power flow, voltage stability, and transient stability analysis. The study cases used in the PCS represented stressed conditions and various scenarios that included the following:

- Three scenarios with COI S-N flows at 3,675 MW
- Three scenarios with COI N-S flows at 4,800 MW
- Two sensitivity scenarios with COI N-S flows exceeding 4800 MW

The results of the study indicated the following:

COI S-N Scenarios

- The studies did not indicate that the Project would cause adverse thermal, voltage, or stability impacts to the regional transmission system during COI S-N scenarios
- The studies did not indicate that the Project would adversely impact COI S-N transfer capability.

COI N-S Scenarios and Sensitivities

- The studies did not indicate that the Project would cause adverse voltage or stability impacts to the regional transmission system during COI N-S scenarios
- The studies indicated that the Project would cause an overload on the remaining Round Mountain -Fern 500 kV #1 or #2 line under a single line contingency of the other Round Mountain -Fern 500 kV #1 or #2 line.
- The studies indicate that the PG&E proposed Round Mountain -Table Mountain 500 KV RAS project (PG&E RAS Project) will effectively mitigate the post-project overload on the Round Mountain -Fern 500 kV #1 or #2 line following a single line contingency of the other Round Mountain -Fern 500 kV #1 or #2 line. This is with the understanding that the PG&E RAS Project will bypass the series caps on the remaining Round Mountain -Fern 500 kV line at Round Mountain and the series caps on the Fern -Table Mountain 500 kV Lines #1 and #2 at Table Mountain.
- COI N-S transfer capability will be impacted by the Project if the PG&E RAS Project is not operational prior to the Fern 500 kV substation ties into the Round Mountain -Table Mountain 500 kV Lines #1 and #2. Without the PG&E RAS Project, the thermal impacts created by the Project will exacerbate the existing operational constraint for COI N-S transfers. However, if the PG&E RAS Project is operational, the studies indicate that the Project will not adversely impact COI N-S transfer capability.
- The purpose of the PG&E RAS Project is to improve COI N-S transfer capability. The study indicated that the Round Mountain DRS Project will not reduce the additional COI N-S

transfer capability gained by the PG&E RAS Project for the conditions represented in the Sensitivity study cases.

Based on the study results, the Project will not cause any adverse impacts to the WECC system or COI operation if the proposed PG&E RAS Project is operational. This is with the understanding that the PG&E RAS Project will include the automatic operation for an outage of the Round Mountain - Fern 500 kV lines #1 or #2 and consist of bypassing the series capacitors on the remaining Round Mountain -Fern 500 kV line at Round Mountain and the series capacitors on the Fern -Table Mountain 500 kV Lines #1 and #2 at Table Mountain.

The conclusion of this study is dependent on the proposed PG&E RAS Project being operational before the Project's Fern 500 kV substation ties into the Round Mountain -Table Mountain 500 KV lines #1 and #2. Since the PG&E RAS Project is not a part of the Round Mountain DRS Project, it is noted that the PG&E RAS Project schedule and final scope are subject to change based on the needs of that project. PG&E has initiated a WECC Path Rating process to study the increased Path Rating on COI caused by the RAS Project. Project Sponsor will continue to monitor the progress of the RAS Project through the WECC Path Rating process and other communications with PG&E. If there are changes to the RAS Project scope or schedule that could impact the conclusion of this study, Project Sponsor will notify the PCRG to reevaluate the Round Mountain DRS Project impacts and associated mitigation.

APPENDIX A: PCRG MEMBERS

Table A-1: Study Participants (PCRG Representatives)

Company	Representatives	
	First Name	Last Name
California ISO	Ebrahim	Rahimi
	Binaya	Shrestha
DesertLink LLC	Tim	Cook
	Ramya	Nagrajan
Long Road Energy	Radha	Soorya
Modesto Irrigation District	Martin	Caballero
NV Energy	Jeff	Watkins
Pacific Gas & Electric	Sophie	Xu
	Marco	Rios
	Bill	Wang
	Simrit	Basrai
	Ron	Markham
Pacificorp	Jamie	Austin
Sacramento Municipal Utility District	Patrick	Truong
Transmission Agency of Northern California	Dave	Larsen
	Ellie	Foruzan
	Tim	Schiermeyer
	Amy	Cuellar
Turlock Irrigation District	Brett M.	Bodine
	Danna M.	Anguiano
	Kody J.	Heppner
WAPA - Sierra Nevada Region	Patrick	Montplaisir
	Bryan	Griess
	Page	Andrews
	Chris	Mensah-Bonsu
	Gary	Farmer
	Chris	Effiong
WECC Staff	Doug	Tucker
LS Power Grid California (Project Sponsor)	Sandeep	Arora
	Mark	Milburn
	Diwakar	Tewari
Transco Energy (Consultant for Project Sponsor)	John	Kyei

APPENDIX B: SUMMARY OF POWER FLOW RESULTS

Table B-1: Summary of Power Flow Results—Cases 1/1A

Outage Element (s)	Overloaded Facility	Applicable Rating	Loading (%)	
			Case 1	Case 1A
Category P0—Normal Overloads				
None/(P0)	None	N/A	N/A	N/A
Category P1 Contingencies				
Round MT– Fern #2 500 kV line / (no RAS)	Round MT – Fern #1 500 kV line	3,280 A	99.8*	109.4
Round MT – Fern #1 500 kV line / (no RAS)	Round MT – Fern #2 500 kV line	3,280 A	99.9*	109.4
Round MT– Fern #2 500 kV line / (RAS)	Round MT – Fern #1 500 kV line	3,280 A	Not Simulated	82.2
Round MT – Fern #1 500 kV line / (RAS)	Round MT – Fern #2 500 kV line	3,280 A	Not Simulated	82.2
Olinda – Tracy 500 kV line	Delevan – Cortina 230 kV line	954 A	104.0	103.1
Olinda – Captain Jack 500 kV line	Olinda– KE South 230 kV line	810 A	103.9	103.5
Category P6-P7 Contingencies				
Table MT – Vaca Dix & Table MT – Tesla 500 kV lines/ (no RAS)	RIO OSO – Brighton 230 kV line	937 A	Non-Solve	102.1
	Olinda – Maxwell #1 &2 500 kV lines	4,300 A		102.2
	Delevan – Cortina 230 kV line	954 A		126.9
	COTWD_E – Round MT 230 kV line	745 A		129.8
	Table MT D – RIO OSO 230 kV line	1,517 A		106.7
	Round MT – COTWD_E2 #2 230 kV line	845 A		118.2
Table MT – Vaca Dix & Table MT – Tesla 500 kV lines/ (RAS)	None	N/A	N/A	N/A
Table MT – Round MT #1 & 2 500 kV lines/ (RAS)	None	N/A	N/A	N/A
Round MT – Fern #1 &2 500 kV lines / (no RAS)	None	N/A	N/A	N/A
Table MT – Fern #1 & 2 500 kV lines / (no RAS)	None	N/A	N/A	N/A
Round MT – Malin #1 & 2 500 kV lines (RAS)	None	N/A	N/A	N/A

* represents loadings of equivalent elements under equivalent outages in the pre-Project configuration.

Table B-2: Summary of Power Flow Results—Cases 2/2A

Outage Element (s)	Overloaded Facility	Applicable Rating	Loading (%)	
			Case 2	Case 2A
Category P0—Normal Overloads				
None/(P0)	None	N/A	N/A	N/A
Category P1 Contingencies				
None	None	N/A	N/A	N/A
Category P6-P7 Contingencies				
Table MT – Vaca Dix & Table MT – Tesla 500 kV lines/ (no RAS)	Table MT 500/230 kV transformer	1,122 MVA	108.0	108.4
Table MT – Round MT #1 & 2 500 kV lines/ (no RAS)	Round MT 500/230 kV transformer	1,122 MVA	107.2	Outage N/A
	COTWD_E – Round MT 230 kV line	745 A	137.6	Outage N/A
	Round MT – COTWDWAP 230 kV line	974 A	106.6	Outage N/A
	Round MT – COTWD_E2 #2 230 kV line	845 A	124.3	Outage N/A
Round MT – Fern #1 &2 500 kV lines / (no RAS)	Round MT 500/230 kV transformer	1,122 MVA	Outage N/A	106.0
	COTWD_E – Round MT 230 kV line	745 A	Outage N/A	139.6
	Round MT – COTWDWAP 230 kV line	974 A	Outage N/A	108.1
	Round MT – COTWD_E2 #2 230 kV line	845 A	Outage N/A	126.1
Table MT – Fern #1 & 2 500 kV lines / (no RAS)	Round MT 500/230 kV transformer	1,122 MVA	Outage N/A	110.7
	COTWD_E – Round MT 230 kV line	745 A	Outage N/A	137.5
	Round MT – COTWDWAP 230 kV line	974 A	Outage N/A	106.5
	Round MT – COTWD_E2 #2 230 kV line	845 A	Outage N/A	124.1
Table MT – Vaca Dix & Table MT – Tesla 500 kV lines/ (RAS)	None	N/A	N/A	N/A
Table MT – Round MT #1 & 2 500 kV lines/ (RAS)	None	N/A	N/A	N/A
Round MT – Fern #1 &2 500 kV lines / (RAS)	None	N/A	N/A	N/A
Table MT – Fern #1 & 2 500 kV lines / (RAS)	None	N/A	N/A	N/A

Round MT – Malin #1 & 2 500 kV lines (RAS)	None	N/A	N/A	N/A

Table B-3: Summary of Power Flow Results—Cases 3/3A

Outage Element (s)	Overloaded Facility	Applicable Rating	Loading (%)	
			Case 3	Case 3A
Category P0—Normal Overloads				
None/(P0)	None	N/A	N/A	N/A
Category P1 Contingencies				
Round MT– Fern #2 500 kV line (no RAS)	Round MT – Fern #1 500 kV line	3,280 A	99.3*	108.9
Round MT – Fern #1 500 kV line (no RAS)	Round MT – Fern #2 500 kV line	3,280 A	99.4*	108.9
Round MT– Fern #2 500 kV line / (RAS)	Round MT – Fern #1 500 kV line	3,280 A	Outage N/A	82.0
Round MT – Fern #1 500 kV line / (RAS)	Round MT – Fern #2 500 kV line	3,280 A	Outage N/A	82.0
Category P6-P7 Contingencies				
Table MT – Vaca Dix & Table MT – Tesla 500 kV lines/ (no RAS)	COTWD_E – Round MT 230 kV line	745 A	127.1	125.9
	Round MT – COTWD_E2 #2 230 kV line	845 A	115.2	114.1
	Delevan – Cortina 230 kV line	954 A	108.6	108.0
Table MT – Vaca Dix & Table MT – Tesla 500 kV lines/ (RAS)	None	N/A	N/A	N/A
Table MT – Round MT #1 & 2 500 kV lines/ (RAS)	None	N/A	N/A	N/A
Round MT – Fern #1 &2 500 kV lines / (RAS)	None	N/A	N/A	N/A
Table MT – Fern #1 & 2 500 kV lines / (RAS)	None	N/A	N/A	N/A
Round MT – Malin #1 & 2 500 kV lines (RAS)	None	N/A	N/A	N/A

* represents loadings of equivalent elements under equivalent outages in the pre-Project configuration.

Table B-4: Summary of Power Flow Results—Cases 4/4A

Outage Element (s)	Overloaded Facility	Applicable Rating	Loading (%)	
			Case 4	Case 4A
Category P0—Normal Overloads				
None/(P0)	None	N/A	N/A	N/A
Category P1 Contingencies				
Round MT 500/230 kV transformer	Table MT 500/230 kV transformer	1,122 MVA	99.6	98.5
Category P6-P7 Contingencies				
Table MT – Vaca Dix & Table MT – Tesla 500 kV lines/ (no RAS)	Table MT 500/230 kV transformer	1,122 MVA	109.9	107.5
Round MT– Fern #1 &2 500 kV lines (no RAS)	Round MT 500/230 kV transformer	1,122 MVA	Outage N/A	123.4
	Summit 1 – Drum 115 kV line	482 A	Outage N/A	108.2
	Summit 2 – Drum 115 kV line	402 A	Outage N/A	100.6
Table MT – Fern #1&2 500 kV lines (no RAS)	Round MT 500/230 kV transformer	1,122 MVA	Outage N/A	122.8
	Summit 1 – Drum 115 kV line	482 A	Outage N/A	108.2
	Summit 2 – Drum 115 kV line	402 A	Outage N/A	100.6
Round MT – Table MT #1 &2 500 kV lines (no RAS)	Round MT 500/230 kV transformer	1,122 MVA	123.0	Outage N/A
	Summit 1 – Drum 115 kV line	482 A	108.1	Outage N/A
	Summit 2 – Drum 115 kV line	402 A	100.5	Outage N/A
Round MT – Malin #1 & 2 500 kV lines (no RAS)	Olinda 500/230 kV transformer	1,041 MVA	109.9	110.3
	Summit 1 – Drum 115 kV line	482 A	122.2	123.1
	Summit 2 – Drum 115 kV line	402 A	119.1	120.3
Table MT – Vaca Dix & Table MT – Tesla 500 kV lines/ (RAS)	None	N/A	N/A	N/A
Table MT – Round MT #1 & 2 500 kV lines/ (RAS)	None	N/A	N/A	N/A
Round MT – Fern #1 &2 500 kV lines / (RAS)	None	N/A	N/A	N/A
Table MT – Fern #1 & 2 500 kV lines / (RAS)	None	N/A	N/A	N/A
Round MT – Malin #1 & 2 500 kV lines (RAS)	None	N/A	N/A	N/A

Table B-5: Summary of Power Flow Results—Cases 5/5A

Outage Element (s)	Overloaded Facility	Applicable Rating	Loading (%)	
			Case 5	Case 5A
Category P0—Normal Overloads				
None/(P0)	None	N/A	N/A	N/A
Category P1 Contingencies				
None	None	N/A	N/A	N/A
Category P6-P7 Contingencies				
Round MT – Malin #1 & 2 500 kV lines (no RAS)	Summit 1 – Drum 115 kV line	482 A	104.3	105.5
Round MT – Malin #1 & 2 500 kV lines (RAS)	None	N/A	N/A	N/A

Table B-6: Summary of Power Flow Results—Cases 6/6A

Outage Element (s)	Overloaded Facility	Applicable Rating	Loading (%)	
			Case 6	Case 6A
Category P0—Normal Overloads				
None/(P0)	None	N/A	N/A	N/A
Category P1 Contingencies				
Round MT 500/230 kV transformer	Table MT 500/230 kV transformer	1,122 MVA	99.7	98.3
Category P2-P7 Contingencies				
Round MT – Malin #1 & 2 500 kV lines (no RAS)	Summit 1 – Drum 115 kV line	482 A	103.0	104.1
	Summit 2 – Drum 115 kV line	402 A	98.9	100.3
Round MT – Malin #1 & 2 500 kV lines (RAS)	None	N/A	N/A	N/A