# Lake Sharpe Substation Addition

# Transmission System Study

## June 24, 2021

Prepared by:

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# Table of Contents

# 1. Scope

East River Electric Power Cooperative (East River) received an e-mail request on May 21, 2021, from Oahe Electric Cooperative (Oahe) to improve their load serving capability in the area southeast of the existing Pocket Substation. The request included a request for a new distribution substation to accommodate new unplanned load growth and support existing load in the area. East River studied Oahe's request and the impact to the East River transmission system, and developed expansion options for serving the requested substation and other future needs in the area. East River has tentatively named the new substation the Lake Sharpe Substation because the proposed substation is located near Lake Sharpe, South Dakota, on the Missouri River.

# 2. Oahe Electric Request

In its e-mail, Oahe detailed the circumstances that resulted in their request to improve their load serving capability in the area. The distribution system in the southeast portion of Hughes County is currently served by East River's 69/24.9-kV Pocket Substation. Due to the residential and irrigation load growth and concerns with the load-serving capability Oahe's system, Oahe requested an additional substation in the southeast part of Hughes County, SD with an in-service date of summer of 2023.

An overview of the area is shown in Figure 1.

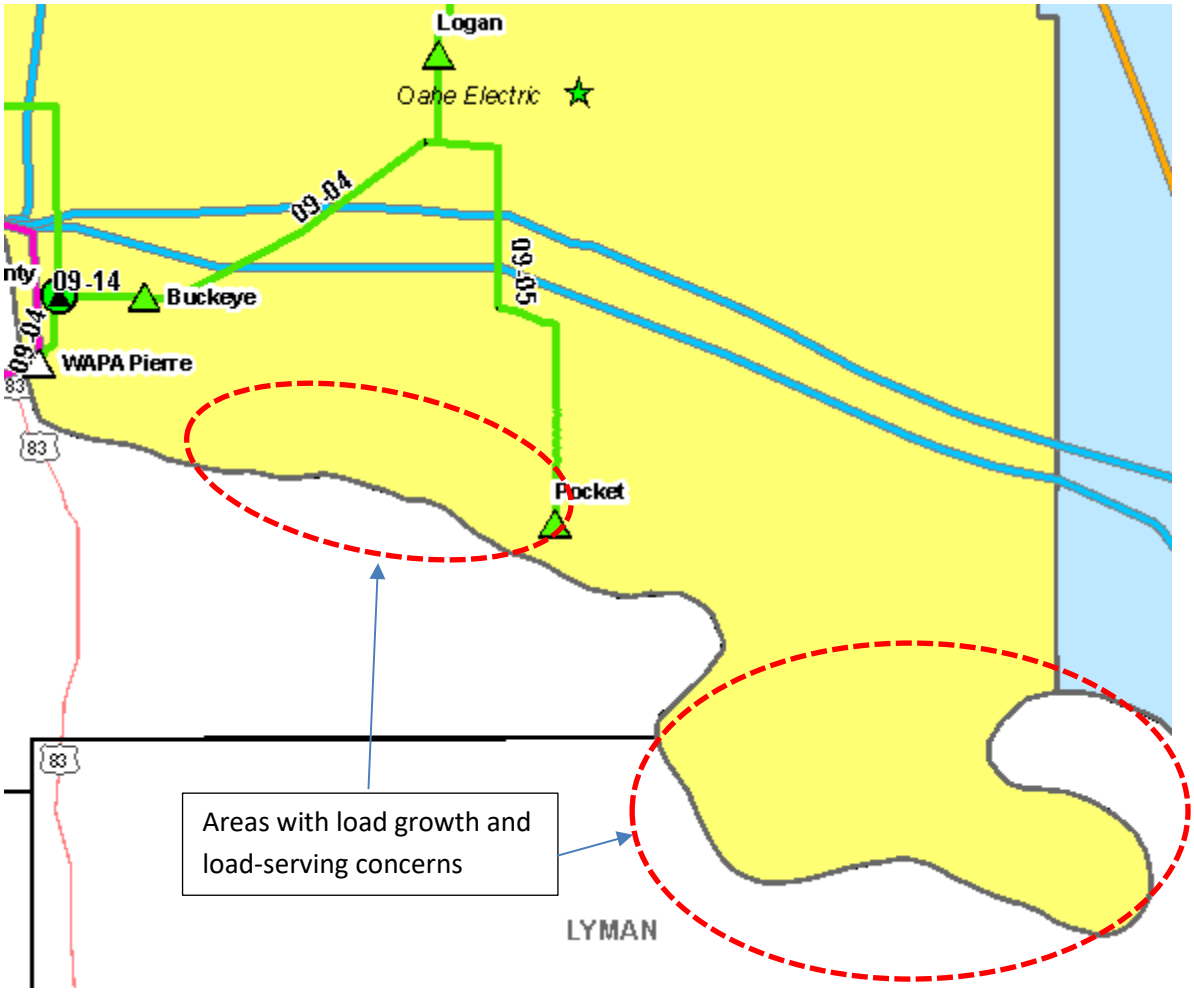


*Figure 1: Lake Sharpe Area*

Oahe requested the new Lake Sharpe Substation be located at the intersection of South Dakota Highway 34 and 316th Avenue, approximately seven miles east and sixteen miles south of Blunt, South Dakota. This location is located 8.5 miles east of East River's Pocket Substation.

Figure 2 shows the approximate location of a new substation in southeast Hughes County.

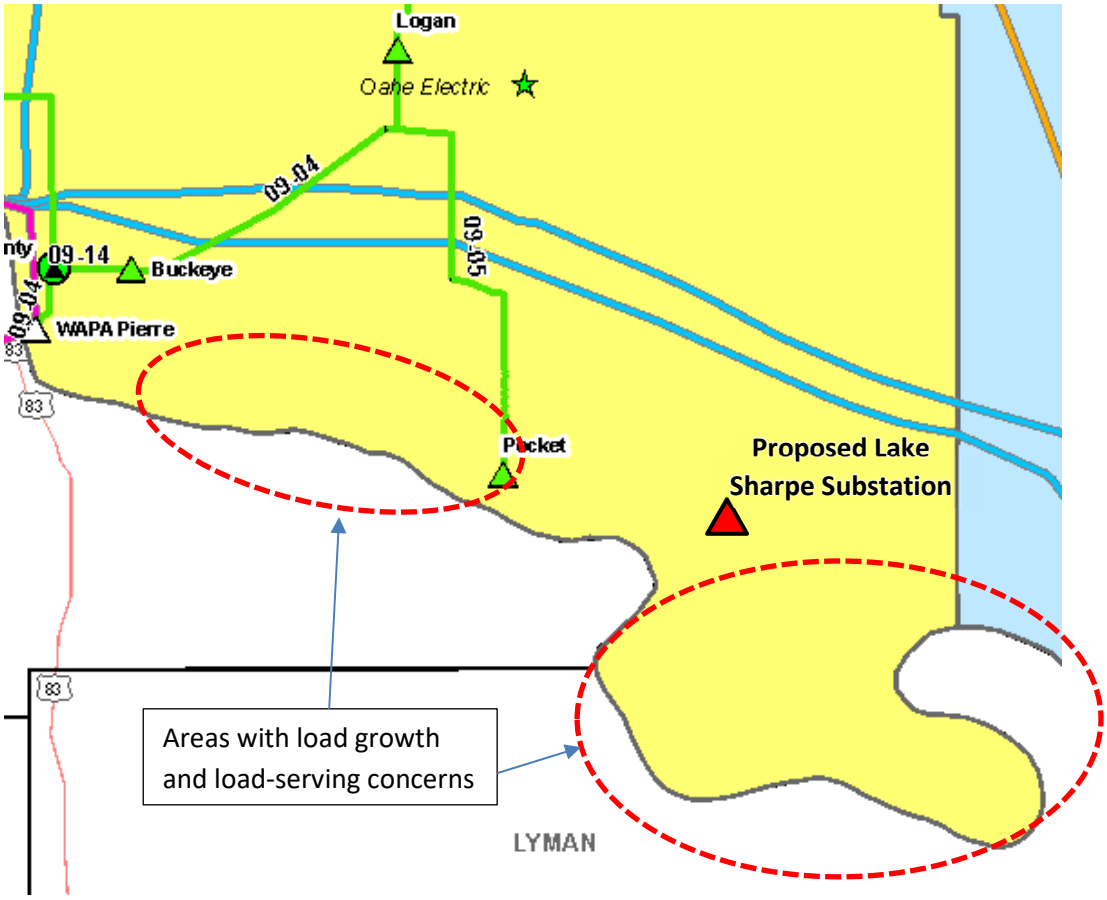


*Figure 2: Proposed Substation Location*

## 3. Area Review

The distribution substations in the area (Pocket and Buckeye) are supplied from East River's Hughes County Substation. For outages of Hughes County, the back-up would normally be provided through the Onida circuit from East River's Sully Buttes Substation.

East River's area substation capacity and loading is shown in Table 1. The substation capacities reflect the rating for the transformers at a 55 degree C rise used under East River's planning procedures. The historical peak load assumes normal system configuration for the transmission system. The Hughes County Substation has not been placed into service as of the date of this report, but it replaces the WAPA Pierre substation which should have the same loading.

*Table 1: Substation Capacity and Loading – Oahe Electric*

| Substation | Operating Voltages (kV) | Capacity (MVA) | Historical Peak Load (MVA) |
|---|---|---|---|
| Sully Buttes * | 230/69 | 50.0 | 26.8 |
| Hughes County * | 115/69 | 53.6 | 13.7 |
| Buckeye | 69/24.9 | 18.75 | 8.4 |
| Pocket | 69/24.9 | 16.67 | 6.3 |
| Onida | 69/24.9 | 33.3 | 11.5 |
| Lake Sharpe | 69/24.9 | N/A | 6.0** |

*transmission substation **predicted peak

Figure 3 provides the one-line representation of the substations and lines in the study area.

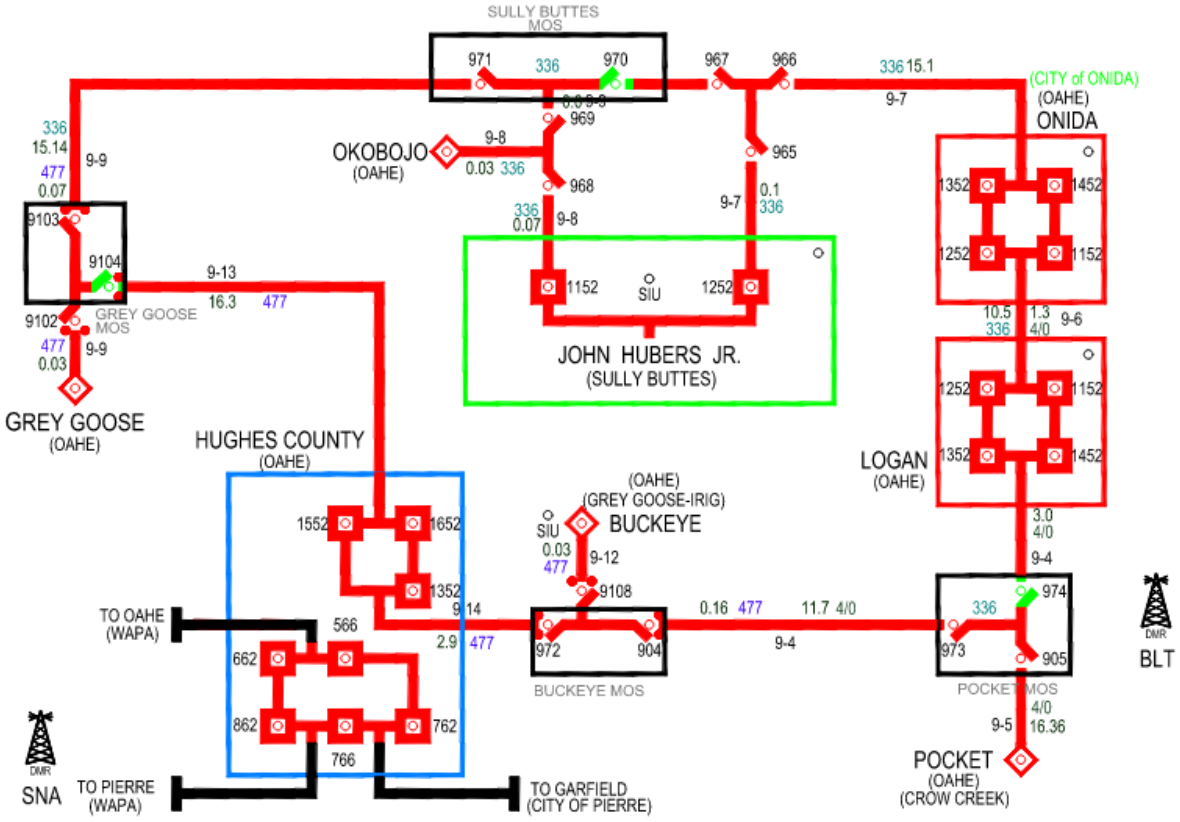


*Figure 3: Oahe Area One-Line Diagram*

The Hughes County 115/69-kV Substation will include three 69-kV breakers. Breakers 1352 and 1552 provide the primary source for the southeastern portion of Hughes County, serving the Buckeye and Pocket Substations. This line has approximately 31 miles of total line exposure with Pocket Substation having the most exposure and highest outage risk.

The East River 69-kV transmission lines in the area, the associated conductor type, year constructed, and summer ratings are shown in Table 2. The lines appear to have adequate capacity for the anticipated load serving needs.

*Table 2: Area Transmission Line Data*

| Transmission Line | Conductor | Year Constructed | Summer Rating (MVA) |
|---|---|---|---|
| 09-14 – Pierre to Buckeye Tie | 477 ACSR | 2019 | 84 |
| 09-04 – Logan Tap (Buckeye to Pocket MOS) | 4/0 ACSR | 1965 | 35 |
| 09-04 – Logan Tap (Pocket MOS to Logan) | 4/0 ACSR | 1965 | 35 |
| 09-05 – Pocket Tap | 4/0 ACSR | 1976 | 45 |
| 09-06 – Onida to Logan Tie | 336 ACSR | 1977 | 67 |

The East River transmission system in the Pocket area has summer voltages of 115 volts unregulated (0.958 per unit), approaching the minimum voltage criteria. Adding more load in this area will exacerbate this low voltage condition. Conversely, during off-peak times of the year, the unregulated voltages in the Pocket area can be as high as 131 volts (1.092 per unit). At a minimum, Oahe will need to improve the power factor of their substations during off-peak to accommodate the new substation addition. The power factor for the load at the new Lake Sharpe Substation will also need to be maintained at or above 0.90 leading. Correcting the power factor reduces the system voltage and stress on equipment but can also lead to low voltages during certain loading conditions. In other words, fixing the power factors, while prudent practice, may drive additional system improvements.

The only other transmission facilities in the area are WAPA's double circuit 230-kV line that runs between WAPA's Oahe and Fort Thompson Substations. WAPA recently notified East River of a new 230-kV North Bend Switching Station that will be installed in western Hyde County in 2023. This new 230-kV switching station was considered in the options developed for the Oahe request. This new switching station could also provide benefits for serving existing and new loads in Hyde County.

# 4. Option Development

Options were developed to address the Oahe request while maintaining or improving the reliability of service for the area. Three separate options were considered for serving the new substation in southeastern Hughes County. New facilities were based on East River design standards with the new substation likely using the standard radial distribution substation design.

**Option 1- Install New 3-Way Switch on Pocket Tap and Build New Lake Sharpe Tap**

Description: A new distribution substation with a 69-kV/24.9-kV, 7.5/10/12.5 MVA (55°C rise) transformer was located east of the existing Pocket Substation at the location requested by Oahe. A new 3-way switch was installed on line 09-05 at structure 249 outside the Pocket Substation. A new 69-kV line was constructed from the new 3-way switch to Lake Sharpe Substation. This option requires Oahe to improve the power factor to 0.90 leading or better at the Pocket Substation and maintain a power factor of 0.90 leading or better at the Lake Sharpe Substation. Option 1 is shown in Figure 4 below.

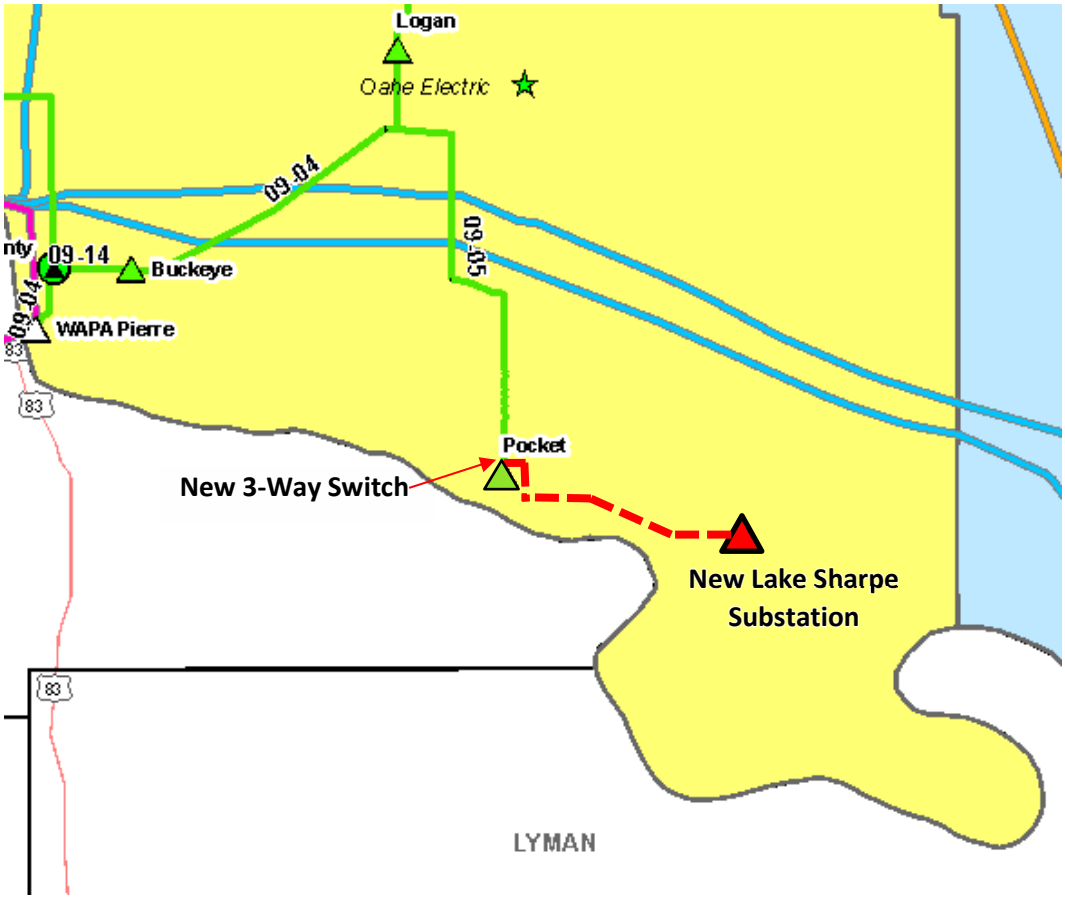


*Figure 4: Option 1 – Install New 3-Way Switch on Pocket Tap and Build New Lake Sharpe Tap*

**Option 2 – New WAPA North Bend 230-kV Terminal, New 230/69-kV Substation, and New 69-kV Lake Sharpe Tap**

Description: A new distribution substation with a 69-kV/24.9-kV, 7.5/10/12.5 MVA (55°C rise) transformer was located west of the new WAPA North Bend Substation at the location requested by Oahe. A new 230-kV terminal was added at WAPA's North Bend Switching Station and a new 230/69-kV substation was constructed adjacent to WAPA's switching station. A new 69-kV line was constructed from the 230/69-kV substation to the Lake Sharpe Substation. This option requires Oahe to maintain a power factor of 0.90 leading or better at the Lake Sharpe Substation. Option 2 is shown in Figure 5 below.

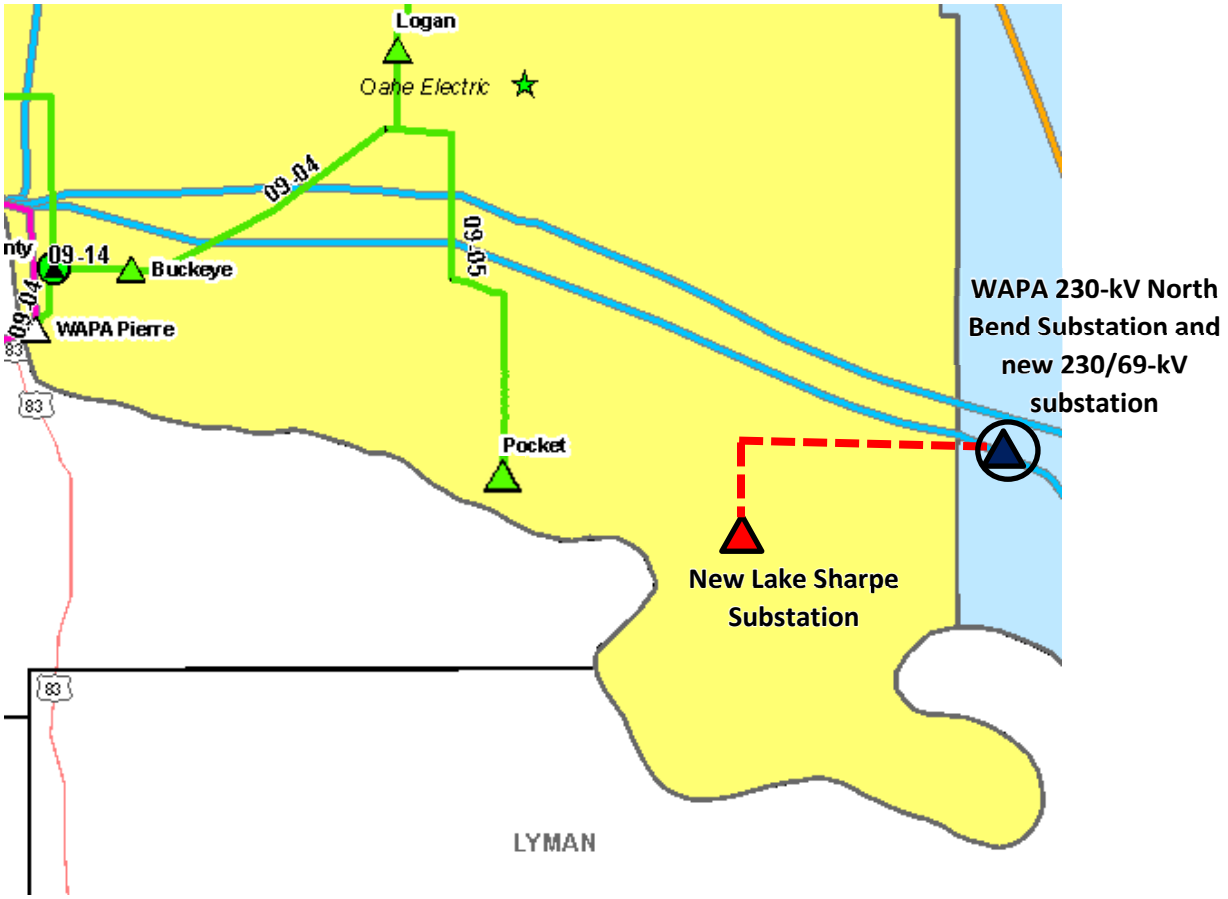


*Figure 5: Option 2 – New WAPA North Bend Terminal, 230/69-kV Substation, and 69-kV Lake Sharpe Tap*

**Option 3 – New 3-Way Switch on Pocket Tap, WAPA North Bend 230-kV Terminal, 230/69-kV Substation, and 69-kV Line from Pocket to the 230/69-kV Substation**

Description: A new distribution substation with a 69-kV/24.9-kV, 7.5/10/12.5 MVA (55°C rise) transformer was located east of the existing Pocket Substation at the location requested by Oahe. A new 230-kV terminal was added at WAPA's North Bend Switching Station. A new 230/69-kV substation was constructed adjacent to the WAPA's switching station, and a new 69-kV line was constructed from the 230/69-kV substation to Lake Sharpe Substation. A new line was also built from the Lake Sharpe Substation to a new 3-way switch outside of the existing Pocket Substation. This option requires Oahe to improve or maintain the power factor to 0.90 leading or better at the Pocket and Lake Sharpe Substations. Option 3 is shown in Figure 6 below.

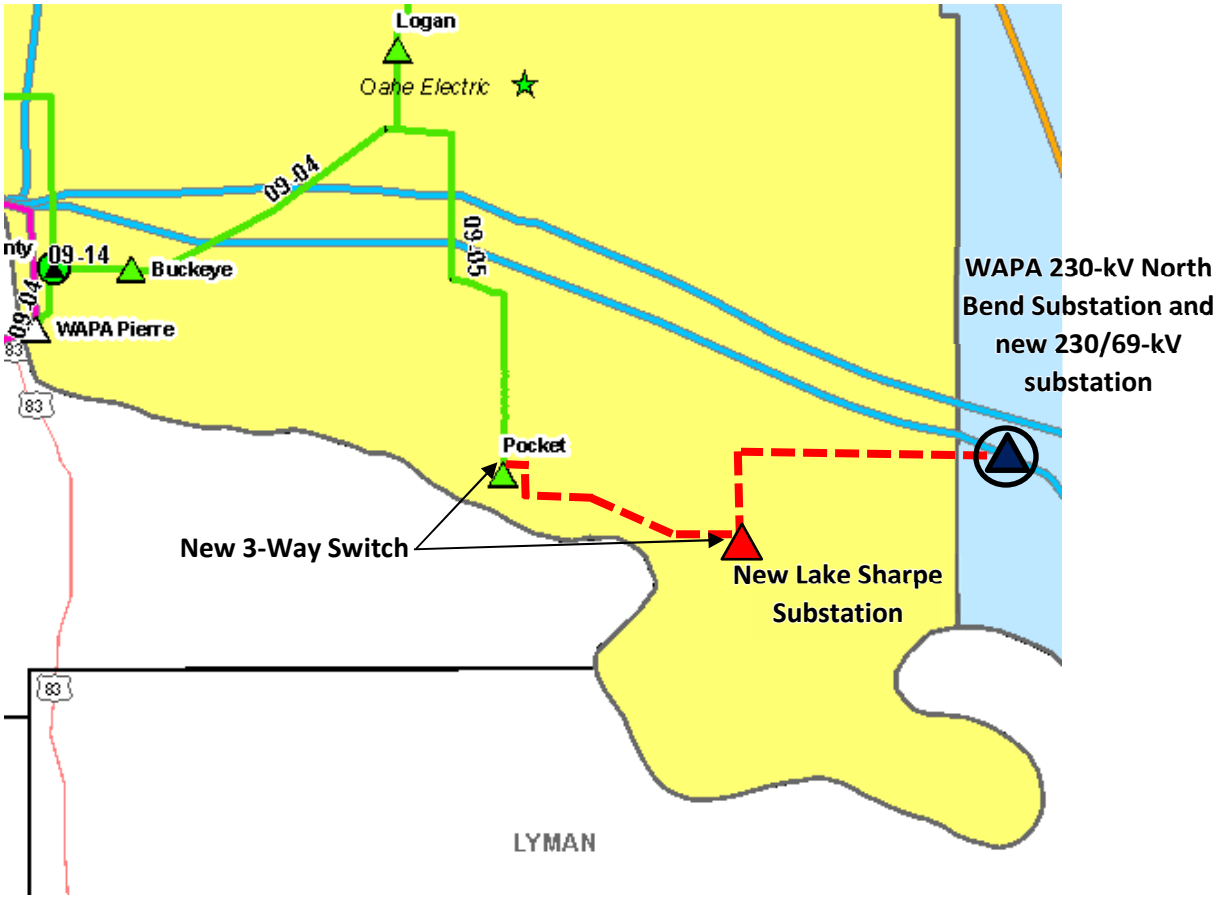


*Figure 6: Option 3 – Install New 3-Way Switch on Pocket Tap, New WAPA 230-kV Terminal, New 230/69-kV Substation and New 69-kV line from Pocket to the 230/69-kV Substation*

# 5. Option Evaluation

An evaluation was completed for each option to determine its performance and impact on reliability. The options were evaluated using SPP planning models, and East River and SPP system planning criteria.

The planning criteria include voltage and thermal limits as well as load-at-risk and line exposure limits. There were no line exposure or thermal overloads identified in the Lake Sharpe area for the options evaluated. The studies were completed assuming power factors in the area are 0.90 leading or better during off-peak conditions and 0.95 lagging or better during peak conditions.

Voltage limits apply for both system intact and single contingency outages. For typical back-up system configurations, the contingency voltage criteria apply. Voltages outside these ranges would require upgrades to mitigate the violations.

| Voltage Criteria | System Intact | Contingency (N-1) |
|---|---|---|
| | 0.95 to 1.05 per unit | 0.90 to 1.10 per unit |

A power flow study was performed on each option to identify voltage and thermal violations. System models used for the power flow study were the SPP 2022ITP models with the worst cases occurring in the 2032 Summer cases. The 2023 Light Load case was also studied, but only the worst-case scenario results are provided.

**Option 1- New 3-Way Switch on Pocket Tap and New Lake Sharpe Tap**

For Option 1, the voltages for the Base Case analysis were compared to the system intact and the worst-case contingency for the Lake Sharpe area. Due to the Pocket Tap being an approximately 16-mile radial line, an outage on the Pocket Tap results in the inability for Oahe to serve load. In this option, adequate back-up exists if the contingency occurs between Pocket MOS and Hughes County. The results are shown in Table 3.

*Table 3: Option 1 System Voltages (2032 Summer)*

| Bus Monitored | Voltage (Per Unit) | | | |
|---|---|---|---|---|
| | Base Case | Option 1 System Intact | Option 1 Backup Source* | Option 1 Backup Source** |
| Sully Buttes | 1.011 | 1.011 | 0.995 | 1.011 |
| Hughes County | 1.012 | 0.999 | 1.016 | 1.018 |
| Onida | 1.002 | 1.002 | 0.969 | 1.002 |
| Logan | 1.000 | 1.000 | 0.947 | 1.000 |
| Pocket | 0.993 | 0.954 | 0.915 | 0.000 |
| Buckeye | 1.008 | 0.992 | 1.013 | 1.015 |
| Lake Sharpe | N/A | 0.949 | 0.911 | 0.000 |

*Pocket MOS to Hughes County contingency ** Pocket Tap contingency

Benefits:

- Fulfills Oahe's request for a new Lake Sharpe Substation
- Least cost option

Drawbacks:

- Does not improve the voltage issues in the area
- Pocket and Lake Sharpe Substations are on the same long radial tap

The associated costs for Option 1 are shown in Table 4.

*Table 4: Option 1 Costs*

| Facility | Quantity /Miles | Cost |
|---|---|---|
| New Lake Sharpe distribution substation* | 1 | $2.0 million |
| New Lake Sharpe Tap with 3-way Switch | 8.6 | $2.4 million |
| **Total** | | $4.4 million |

Conclusion: Option 1 is the least cost option but does not fix the voltage issues or back-up capability issues that presently exist with the radially fed Pocket Substation.

**Option 2 – New WAPA North Bend Terminal, 230/69-kV Substation and 69-kV Lake Sharpe Tap**

For Option 2, the voltages for the Base Case analysis were compared to the system intact and the worst-case contingency for the Lake Sharpe area. Due to the Pocket Tap being an approximately 16-mile radial line, an outage on the Pocket Tap results in the inability for Oahe to serve load. Thus, bringing another source to the area would provide significant benefit. The results are shown in Table 5.

*Table 5: Option 2 System Voltages (2032 Summer)*

| Bus Monitored | Voltage (Per Unit) | | |
|---|---|---|---|
| | Base Case | Option 2 System Intact | Option 2 Backup Source* |
| North Bend | N/A | 1.023 | 1.025 |
| Hughes County | 1.012 | 1.012 | 1.012 |
| Onida | 1.002 | 1.002 | 1.002 |
| Logan | 1.000 | 1.000 | 1.000 |
| Pocket | 0.993 | 0.993 | 0.993 |
| Buckeye | 1.008 | 1.008 | 1.008 |
| Lake Sharpe | N/A | 1.014 | 0.000 |

*Lake Sharpe to North Bend Tie Contingency

Benefits:

- Fulfills Oahe's request for a new Lake Sharpe Substation
- Brings another reliable source to the area
- Improves voltage issues in the area

Drawbacks:

- Pocket and Lake Sharpe Substations are on separate long radial taps
- Higher cost than Option 1
- Relies on WAPA's timely construction of the North Bend Switching Station to meet the requested in-service date

The associated costs for Option 2 are shown below in Table 6.

*Table 6: Option 2 Costs*

| Facility | Quantity /Miles | Cost |
|---|---|---|
| New Lake Sharpe distribution substation* | 1 | $2.0 million |
| New Lake Sharpe Tap with 3-way Switch | 13.5 | $3.8 million |
| WAPA North Bend Terminal Position | 1 | $2.4 million |
| 230/69-kV Substation | 1 | $3.5 million |
| **Total** | | $11.7 million |

Conclusion: Option 2 provides an increase in the level of reliability for the area by adding another source. The voltage issues are resolved for system intact scenarios. However, Option 2 relies on distribution back-up for N-1 contingencies in the area and adds another substation on a long radial line.

**Option 3 – New 3-Way Switch on Pocket Tap, WAPA North Bend 230-kV Terminal, 230/69-kV Substation, and 69-kV Line from Pocket to 230/69-kV Substation**

For Option 3, the voltages for the Base Case analysis were compared to the system intact and the worst-case contingency for the Lake Sharpe area. Due to the Pocket and Lake Sharpe Taps both being long radial lines in Option 1 and 2, an outage on either tap greatly reduces the reliability in the area. Tying North Bend and Pocket will result in significant improvement in the area for all N-1 contingencies. The results are shown in Table 7.

*Table 7: Option 3 System Voltages (2032 Summer)*

| Bus Monitored | Voltage (Per Unit) | | |
|---|---|---|---|
| | Base Case | Option 3 System Intact | Option 3 Backup Source* |
| North Bend | N/A | 1.023 | N/A |
| Hughes County | 1.012 | 1.012 | 0.999 |
| Onida | 1.002 | 1.002 | 1.002 |
| Logan | 1.000 | 1.000 | 1.000 |
| Pocket | 0.993 | 0.993 | 0.954 |
| Buckeye | 1.008 | 1.008 | 0.992 |
| Lake Sharpe | N/A | 1.014 | 0.949 |

*Lake Sharpe to North Bend Tie Contingency

Benefits:

- Fulfills Oahe's request for a new Lake Sharpe Substation
- Brings another reliable source to the area
- Resolves all voltage issues in the area
- Provides adequate backup for N-1 contingencies
- Eliminates two long radial transmission lines (Pocket Tap and Lake Sharpe Tap)

Drawbacks:

- Highest cost option
- Relies on WAPA's timely construction of the North Bend Switching Station to meet the requested in-service date

The associated costs for Option 3 are shown in Table 8.

*Table 8: Option 3 Costs*

| Facility | Quantity /Miles | Cost |
|---|---|---|
| New Lake Sharpe distribution substation* | 1 | $2.0 million |
| New Pocket to Lake Sharpe to North Bend Tie | 22.1 | $6.2 million |
| WAPA North Bend 230-kV Terminal | 1 | $2.4 million |
| 230/69-kV Substation | 1 | $3.5 million |
| **Total** | | $14.1 million |

Conclusion: Option 3 provides the most robust solution but is the highest cost. Having the flexibility of tying three sources together significantly improves the voltage and reliability issues in the area.

# 6. Conclusion

East River performed a transmission system study to evaluate the request from Oahe to build a new distribution substation near Lake Sharpe. Three options were evaluated:

Option 1 – New 3-Way Switch on Pocket Tap and New Lake Sharpe Tap

Option 2 – New WAPA North Bend 230-kV Terminal, 230/69-kV Substation and Lake Sharpe Tap

Option 3 – New 3-Way Switch on Pocket Tap, WAPA North Bend 230-kV Terminal, 230/69-kV Substation and 69-kV Line from Pocket to 230/69-kV Substation

Of the options considered, several conclusions could be made regarding the transmission system in the Lake Sharpe area:

- The East River transmission system in the Lake Sharpe area is weak during peak irrigation season
- Oahe is unable to the support load in the area with the loss of East River's Pocket Tap
- Building the Lake Sharpe Substation impacts the performance of the East River transmission system by degrading the voltage profile in the area
- The voltages in the area can be supported with an expansion of WAPA's North Bend Switching Station to include a new 230/69-kV substation and 69-kV line to the new Lake Sharpe Substation.
- As load growth continues in the area, additional tie lines may be required to provide adequate transmission backup for the area.

Option 1 is the lowest cost but would not be recommended as a solution since it does not resolve the voltage issues in the area during summer peak and increases the length of a long radial tap.

Option 2 provides an increase in level of service compared to today's system. This is because another source provides voltage support for the area. Option 2 is recommended initially for the addition of the new substation and load. However, the backup capabilities are only slightly improved, and another long radial line is added to the system. Additional load growth in the area may require upgrades.

From a planning perspective, Option 3 provides the best system performance, increases reliability, mitigates all load-at-risk issues and addresses the need to improve the voltage issues in the entire area. The downside of Option 3 is the cost and timing to implement the system upgrades.

Options 2 and 3 include the development of another reliable source at North Bend to support Oahe's load in western Hughes County but will be beneficial for improving East River's ability to serve its members' needs in Hyde, Buffalo and Hand Counties. Today, the only source in Hyde, Buffalo and Hand Counties is the WAPA Fort Thompson Substation. Loss of that source severely impairs East River's ability to provide electric service to two members in that area (Dakota Energy and Central Electric), and to provide outlet capability for a large wind project. The North Bend expansion provides the opportunity to dramatically improve the back-up capability for East River's transmission system in the area.