



# Reliability Analysis Update

Transmission Expansion Advisory  
Committee

April 13, 2017





# Baseline and Supplemental Upgrade Summary 2014 – 2016



# 2016 RTEP Proposal Window Data

2016 RTEP Proposal Windows	2016 RTEP Proposal Window 1	2016 RTEP Proposal Window 2	2016 RTEP Proposal Window 3	2016 RTEP Proposal Window 3 Addendum 1	2016/17 RTEP Long Term Proposal Window
Window Open	2/16/2016	6/29/2016	9/30/2016	11/28/2016	11/1/2016
Window Close	3/17/2016	7/29/2016	10/31/2016	12/13/2016	2/28/2017
Objective	Generator Deliverability and Common Mode Outage Violations related to Carson-Rogers Rd 500 kV and Chesterfield-Messer Rd-Charles City Rd 230 kV and Dominion Local TO Criterion for End of	N-1 Thermal and Voltage; Gen Deliv and Common Mode Outage, Load Deliv Thermal and Voltage; N-1-1	Winter Reliability, Light Load Reliability, Short Circuit	Winter Reliability	Market Efficiency Congestion, 15 Year Reliability Analysis
Flowagtes	13	137	25	10	4
Proposals	25	87	29	6	96
Entities	7	13	7	3	19
Cost Range	\$7.7M - \$111.5M	\$0.03M - \$224M	\$0.01 - \$69.3	\$3.2 - \$62.8	\$1 - \$371.3
Proposals approved by PJM Board	2	14	6	N/A	N/A
Board Dates	Aug-16	Dec-16; Feb-17	Feb-17	N/A	N/A
Approved Greenfield Projects	0	0	0	N/A	N/A
Approved Upgrade Projects	2	14	6	N/A	N/A

- Implemented 1/1/2016
- Proposal Fee Structure:
  - No fee (\$0) for any proposed projects (upgrade and greenfield) below \$20M estimated in service year cost
  - \$5,000 fee for any proposed projects (upgrade and greenfield) between \$20M and \$100M estimated in service year cost
  - \$30,000 fee for any proposed projects (upgrade and greenfield) above \$100M estimated in service year cost

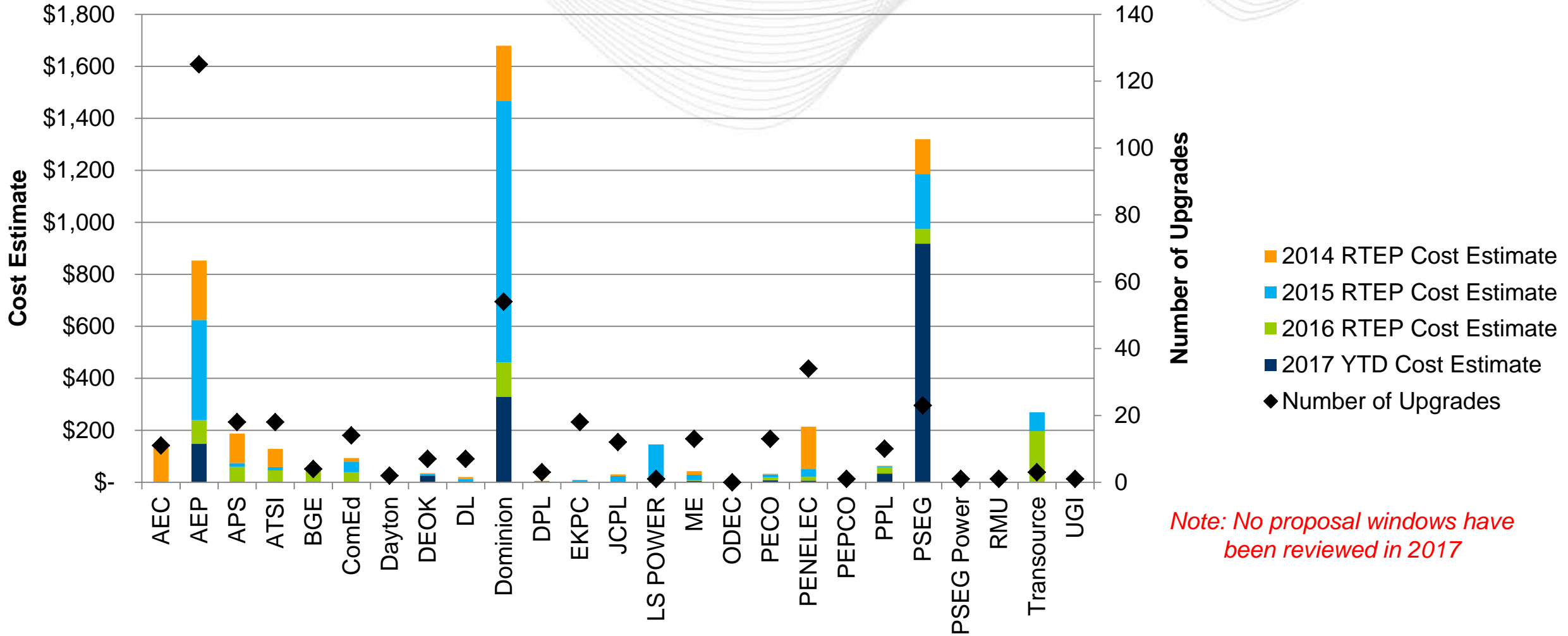


# 2016 RTEP Proposal Window Financials

- Requirement to review fees received after 2 years
- 7.8% Net Surplus

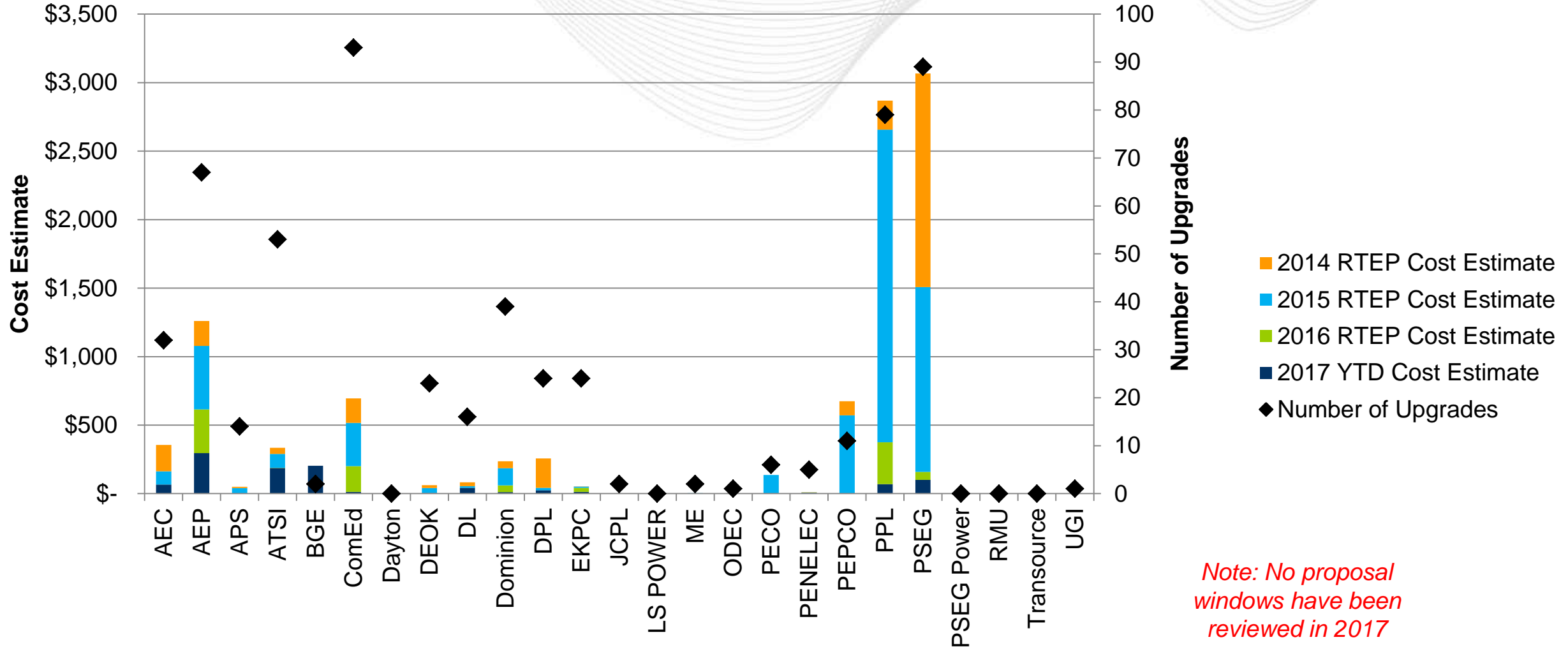
<b>2016 RTEP Window Revenue and Cost</b>	<b><u>2016 Common Proposal Window Work</u></b>	<b><u>2016 Proposal Window 1</u></b>	<b><u>2016 Proposal Window 2</u></b>	<b><u>2016 Proposal Window 3 (incl addendum)</u></b>	<b><u>Total</u></b>
Revenue (Proposal Fees received)		\$ 165,000	\$ 270,000	\$ 55,000	\$ 490,000
Cost (Labor + Consultanats)	\$ 79,834	\$ 39,919	\$ 219,341	\$ 112,516	\$ 451,610
Net Surplus					\$ 38,390

# Baseline Upgrades by Transmission Owner



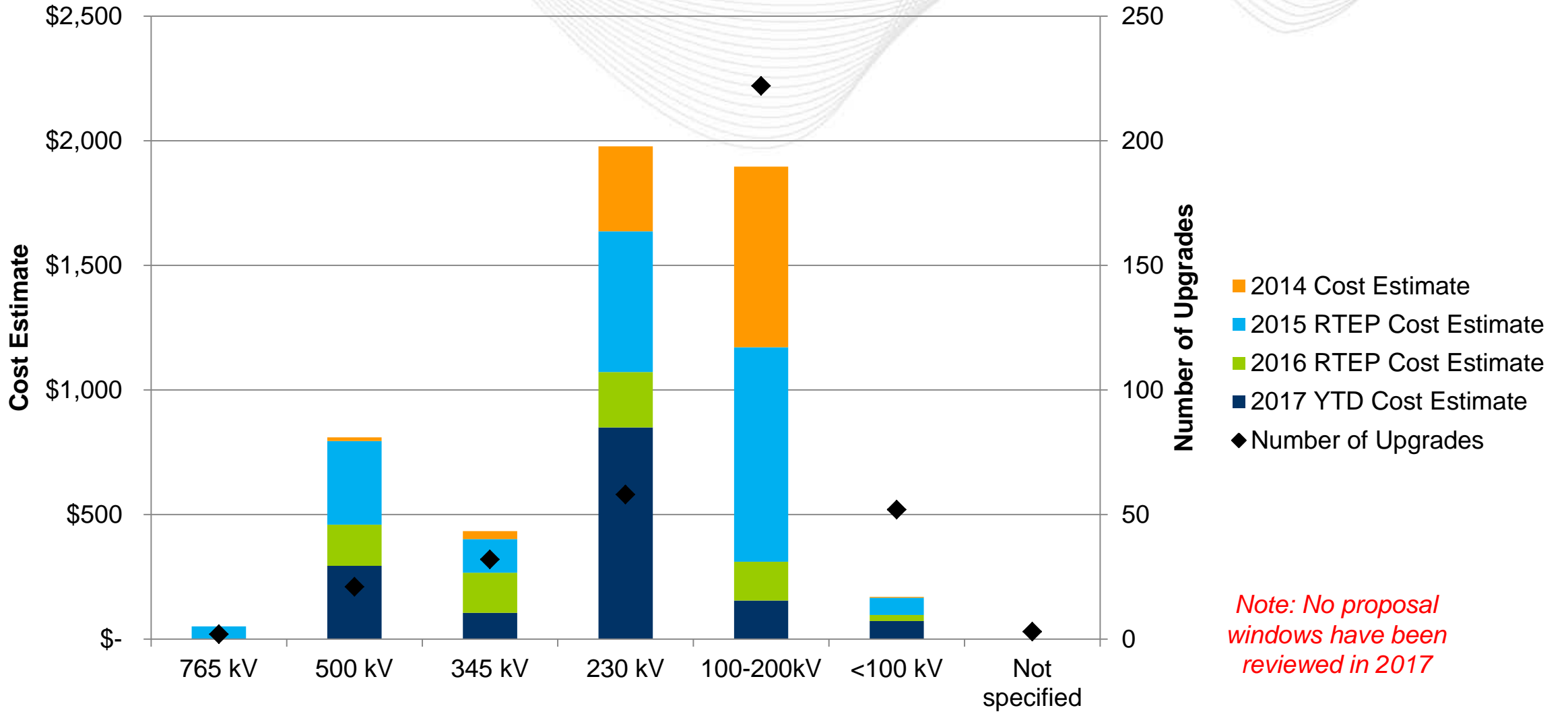
*Note: No proposal windows have been reviewed in 2017*

# Supplemental Upgrades by Transmission Owner



*Note: No proposal windows have been reviewed in 2017*

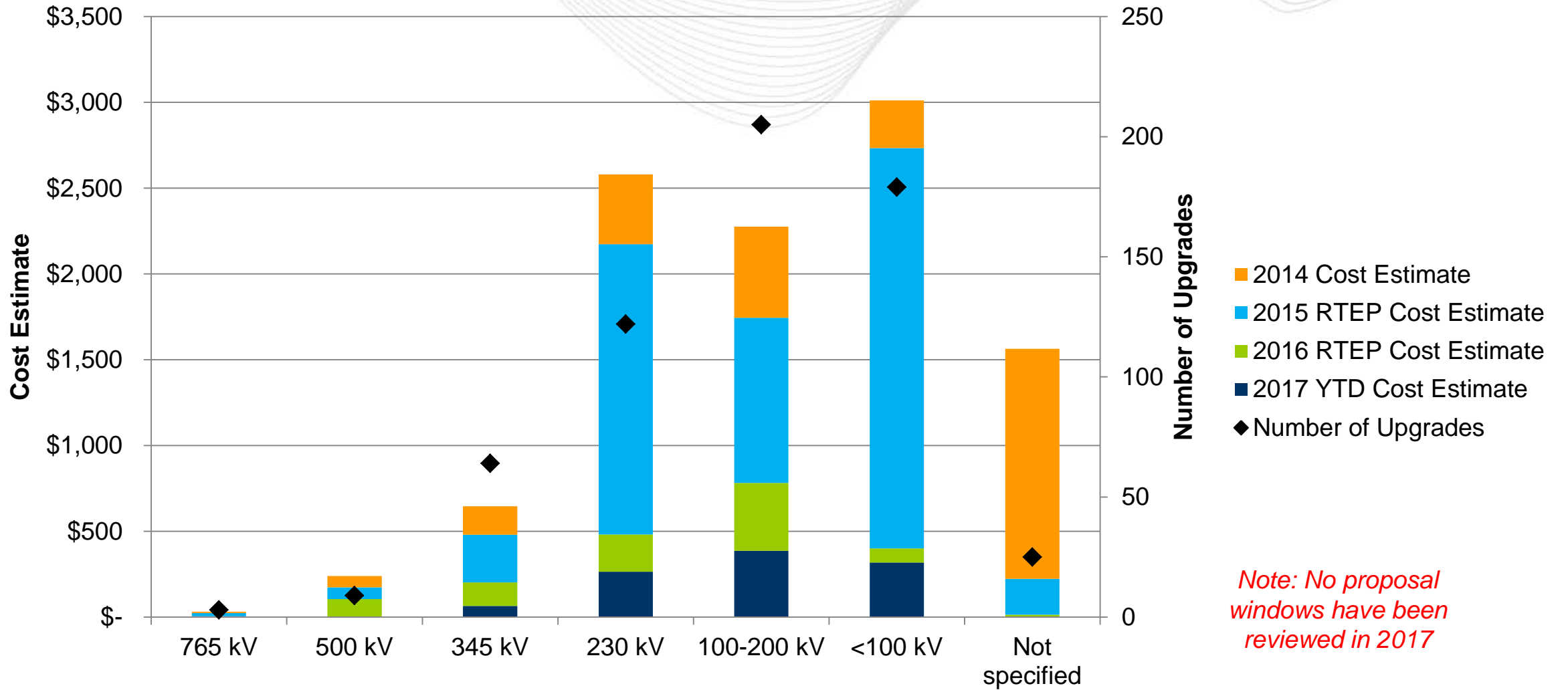
# Baseline Upgrades by Voltage



*Note: No proposal windows have been reviewed in 2017*



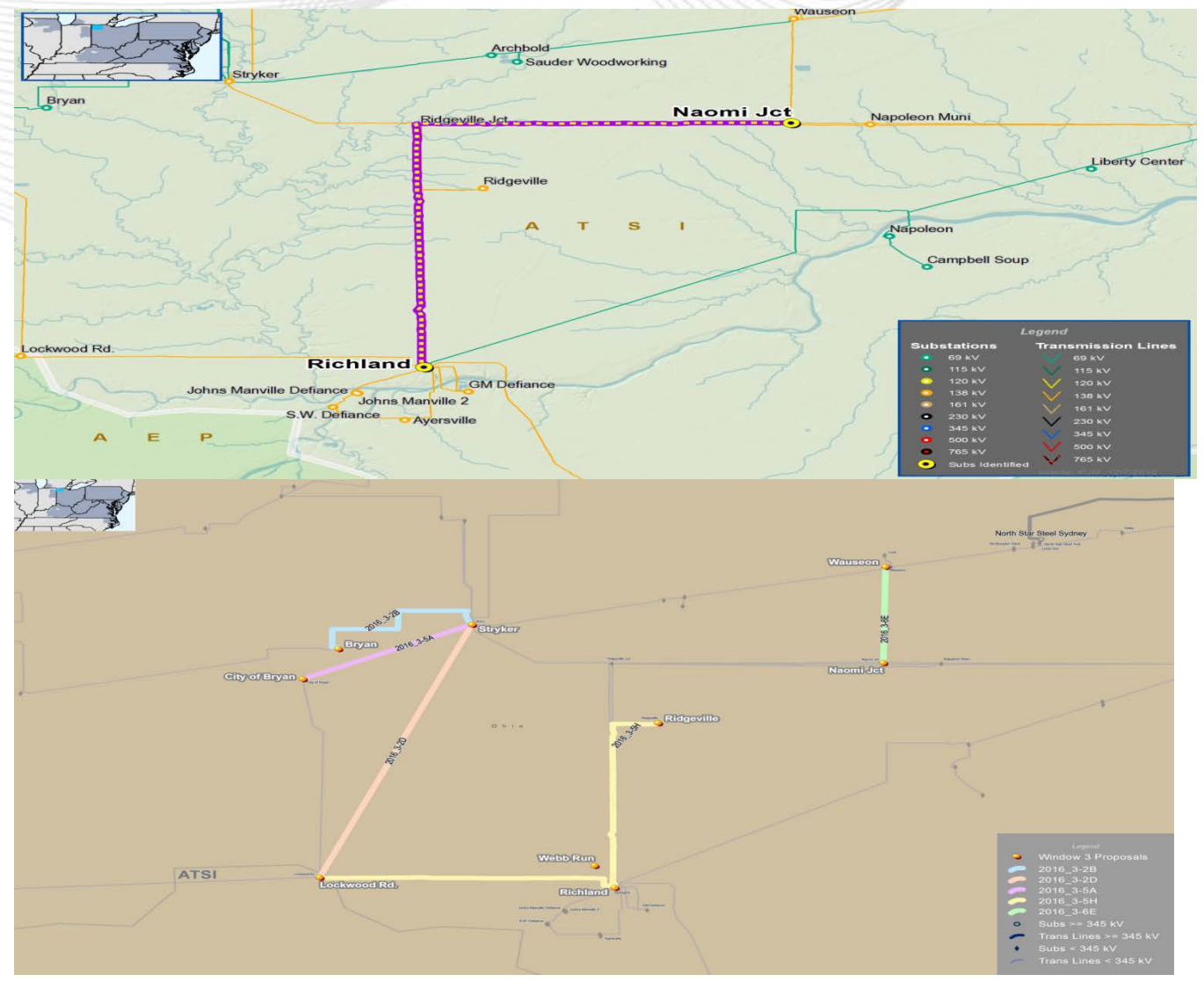
# Supplemental Upgrades by Voltage



*Note: No proposal windows have been reviewed in 2017*

# 2016 RTEP Proposal Window #3 Update

- Common Mode Outage (FG# 1, 2, and 3):
- Richland to Naomi Junction 138 kV circuit is overloaded for multiple bus and line fault stuck breaker contingencies.
- **Alternatives considered:**
  - 2016\_3-2B (\$ 8.3 M)
  - 2016\_3-2D (\$ 17.2 M)
  - 2016\_3-5A (\$ 8.5 M)
  - 2016\_3-5H (\$ 6.1 M)
  - 2016\_3-6E (\$ 9.1 M)



## Summary of Project Alternatives

Project ID	Project Description	Proposing Entity	Cost Estimate (\$M)	Advantages	Disadvantages
2016_3-2B	Construct a new single circuit 138 kV line between Bryan Station and Stryker Station.	Transource (Greenfield)	8.3	Solves all identified flowgates	Requires a new ROW (~7 miles); relative high cost
2016_3-2D	Construct approximately 14 miles of new 138 kV line establishing a Lockwood Road – Stryker 138 kV Circuit.	Transource (Greenfield)	17.2	Solves all identified flowgates	Requires a new ROW (~14 miles); relative very high cost
2016_3-5A	Build a 138 kV line from the existing 138 kV City of Bryan substation to the existing 138 kV Stryker substation	NTD (Greenfield)	8.5	Solves all identified flowgates	Requires a new ROW (~7 miles); relative high cost
2016_3-5H	Build a 138 kV switching station ("Webb Run") interconnecting the Richland to Lockwood Road 138 kV line and the Richland LJ to Ridgeville 138 kV line	NTD (Greenfield)	6.1	Solves all identified flowgates	Building a new sub next to the existing substation to achieve the "reconfiguration of an existing substation"; Risk of substation site: if the location needs to move farther away from Richland substation it will probably increase the length of the 4 138kV lines ;
2016_3-6E	Eliminate three terminal line at Naomi Junction by constructing a double circuit line towards Wauseon substation. Wauseon substation will need to incorporate a new 138kV line exit by adding a 138kV breaker and relaying.	First Energy (Upgrade)	9.1	Solves all identified flowgates; Creates a third resource into Wauseon 69KV area where a potential reliability concern exists and eliminate the need for the pre-contingency switching of the Wauseon 138/69kV transformer under certain N-1 contingencies; Eliminate the three terminal lines and improve system protection and coordination.	Small margin (95.8% loading); relative high cost
PJM Solution	Relocate the Richland to Ridgeville 138KV line from Richland J bus to K, extend the K bus and install a new breaker.	PJM (Upgrade)	1.7	Solves all identified flowgates; lowest estimated cost	None

\* PJM reviewed the proposed cost estimates and found the estimates were reasonable (within \$1~2M difference)

\* 2D will be cost allocated to both AEP and ATSI; and the rest of the proposals will be 100% allocated to FE



**Preliminary Recommendation:**

PJM Proposed Solution: Relocate the Richland to Ridgeville 138KV line from Richland J bus to K, extend the K bus and install a new breaker.

**Designated Entity:** FE

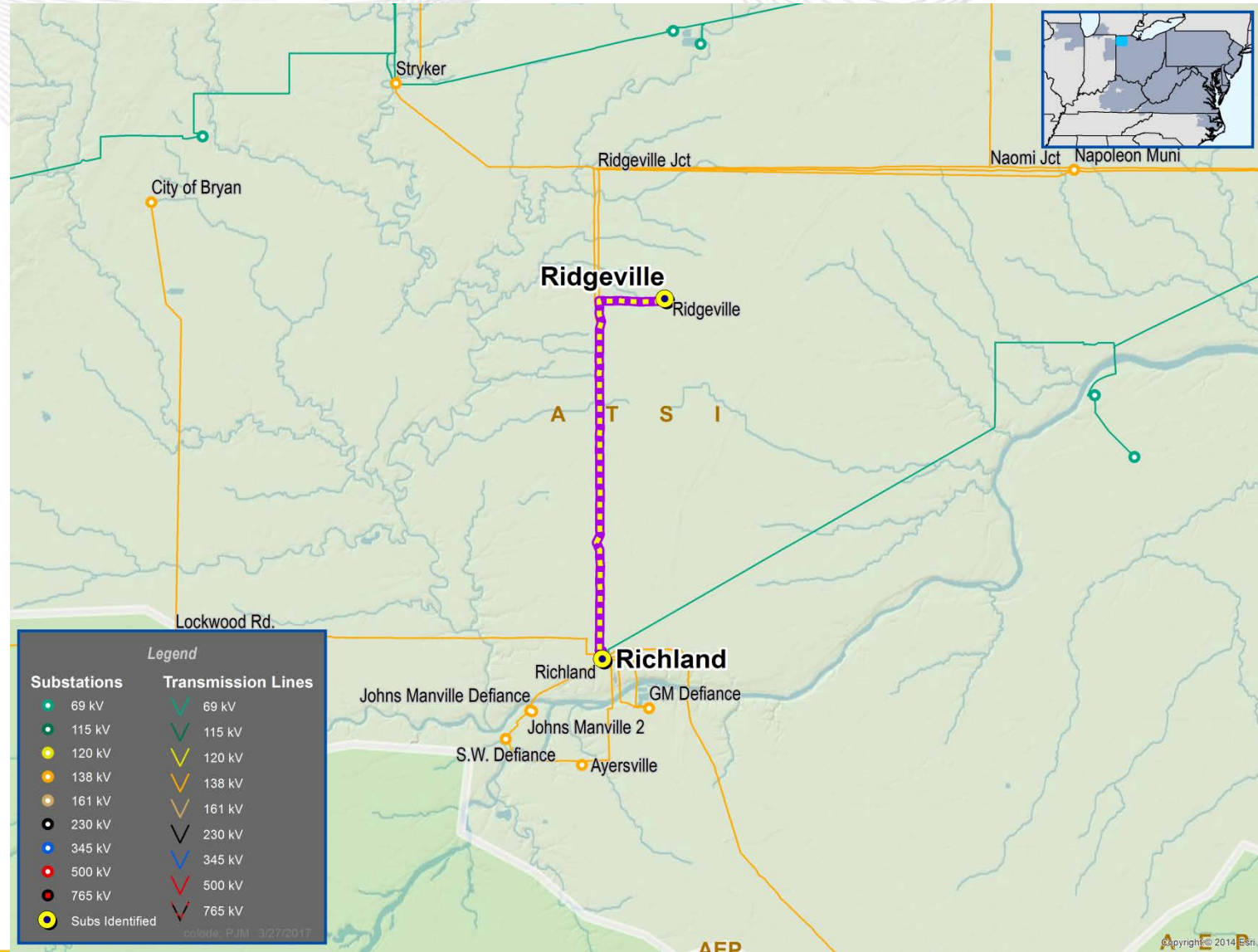
**Estimated Project Cost:** \$1.7M

**Required IS Date:** 6/1/2019

**Cancel B2558:** Close normally open switch A 13404 to create a Richland J Bus - Richland K Bus 138 kV line.

**Estimated Cost:** \$0.02M

**Required IS Date:** 6/1/2019



# Dominion Reliability Analysis Update



## Existing b2624 Scope Change (2<sup>nd</sup> Rev.)

- End of Life Criteria - 115kV Lines #18 and #145 Possum Point to Smoketown DP are approximately 8.35 miles long and were constructed on double-circuit, 3-pole wood H-frame structures in the timeframe between 1948 and 1954.
- These lines serve as the normal and alternate feeds to NOVEC's Country Club, Bethel/Garber, and Smoketown DP's. A total of 11,360 NOVEC customers are served by both lines.
- Rebuilding Lines #18 and #145 to current 230kV standards (with continued operation at 115kV) would be consistent with the Company's practice of containing or converting 115kV load in the Northern Virginia area.

## Previous Scope:

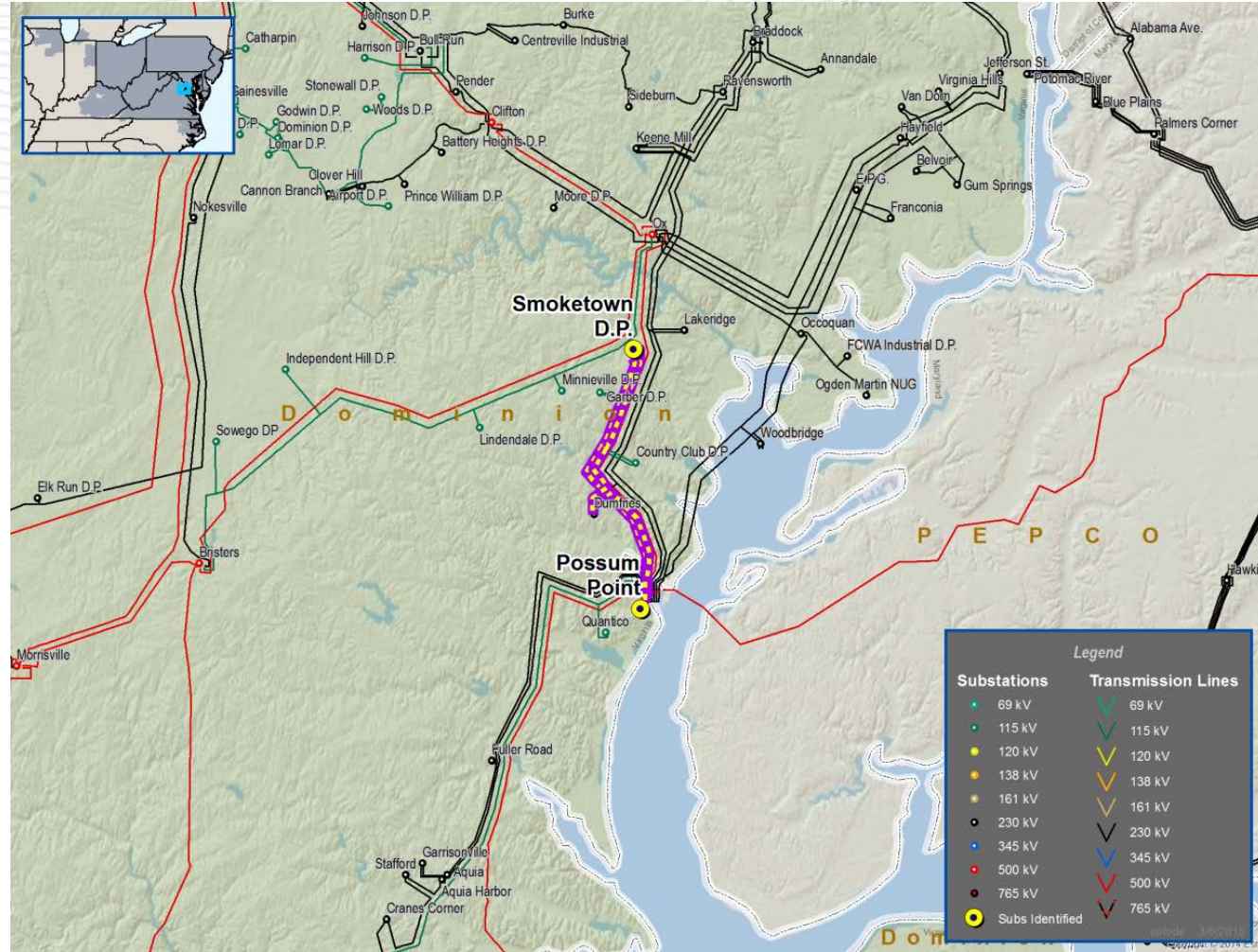
- Rebuild 115kV Lines #18 and #145 between Possum Point Generating Station and NOVEC's Smoketown DP (approx. 8.35 miles) to current 115kV standards with a normal continuous summer rating of 353 MVA.

## New Scope:

- Rebuild Lines #18 and #145 between Possum Point Generating Station and NOVEC's Smoketown DP (approx. 8.35 miles) to current 230kV standards with a normal continuous summer rating of 524 MVA at 115kV (1047 MVA at 230kV).

**Estimated Project Cost:** \$24.7 M

**Projected IS Date:** 12/31/2019



Continued from previous slide...

- b2624 historical information
  - **Original TEAC date:** 03/09/15 – Initial
  - **Estimated cost:** \$24.7 M
  - **Proposed Solution:** Rebuild 115kV Lines #18 and #145 between Possum Point Generating Station and NOVEC's Smoketown DP (approx. 8.35 miles) to current 230kV standards with a normal continuous summer rating of 524 MVA at 115kV (1047 MVA at 230kV) (b2624)
  - **Projected IS Date:** 12/31/2016
  
  - **Latest TEAC date:** 02/04/16 – 1<sup>st</sup> Revision
  - **Estimated cost:** \$24.7 M
  - **Proposed Solution:** Rebuild 115kV Lines #18 and #145 between Possum Point Generating Station and NOVEC's Smoketown DP (approx. 8.35 miles) to current 115kV standards with a normal continuous summer rating of 353 MVA (b2624)
  - **Projected IS Date:** 12/31/2016



## Problem Statement: DOM “End of Life Criteria”

- Line #247 Swamp to Suffolk was constructed mostly on wood H frames in 1968 (~49 years).
- This line needs to be rebuilt to current standards based on Dominion’s “End of Life” criteria.
  - Wood structure life is 35-55 years
  - Conductor & connectors are 40-60 years
  - Porcelain insulators are 50 years
- Permanent MW load loss for removal of this line is 21 MW.

## Proposed Solution:

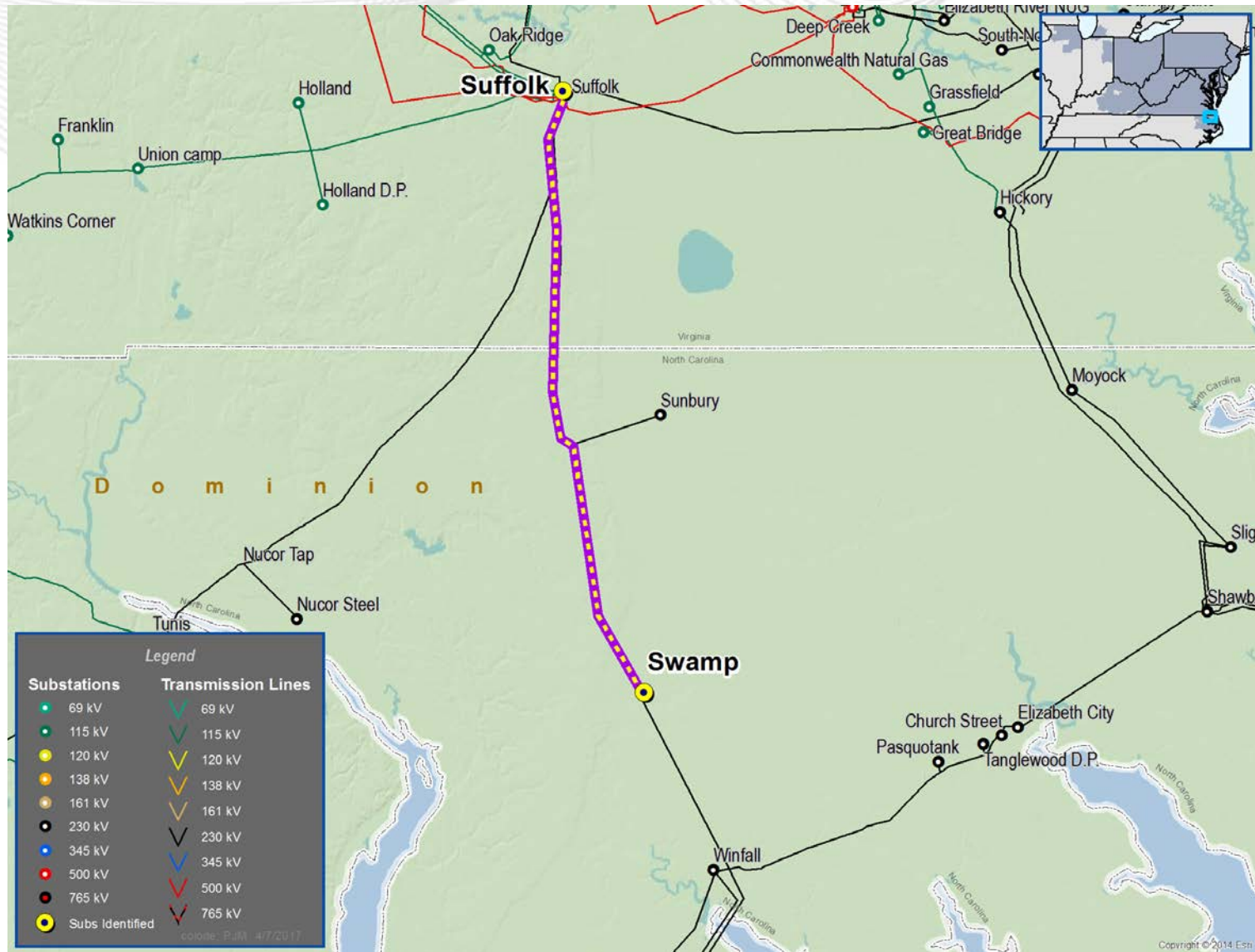
- Rebuild 230kV line #247 from Swamp to Suffolk (31 miles) to current standards with a summer emergency rating of 1047 MVA at 230kV. **(b2871)**

**Alternatives:** None

**Estimated Project Cost:** \$31 M

**Projected IS Date:** 12/30/2022

**Project Status:** Conceptual



# Supplemental Projects





## Supplemental Project: Amos - 345kV CB J2 Replacement

### Problem Statement/Driver:

Amos J2 345KV breaker is a 1970's air blast, PK type breaker. Air breakers are being replaced across the AEP system due to safety concerns regarding their catastrophic and violent failures. Air blast breakers tend to expel sharp pieces of porcelain from their bushings with failures which are a safety hazard. Additionally most of the PK's are near or at their life expectancy. Given they are being replaced across AEP, spare parts are becoming more difficult to find for break and fix scenarios. Breaker J2 has also suffered 17 fault operations that exceeds the manufacturer life expectancy on this category (10 operations).

### Potential Solution:

Replace Amos 345KV circuit breaker J2, 50kA CB with new 63 kA CB to match the rest of the breakers.

### Alternatives:

No cost effective alternatives were identified.

Cost Estimate: \$0.83M

Projected IS date: 3/31/2017

Status: Construction





## Supplemental Project: Hayden – 345 kV CB C1 and C2 Replacement

### Problem Statement/Driver:

Breakers in this project to be replaced are all I.T.E. SF6 breakers that were both manufactured in 1974. AEP has been replacing this breaker type for several years now due to multiple bushing failures. There are only 7 breakers of this type left in the entire AEP system, including these. Breakers C1 and C2 have the following documented conditions: age and spare parts availability.

### Potential Solution:

Replace 345 kV 40 kA circuit breakers C1 and C2 with new 63 kA units at Hayden station to match the other breaker ratings at the Hayden 345kV station.

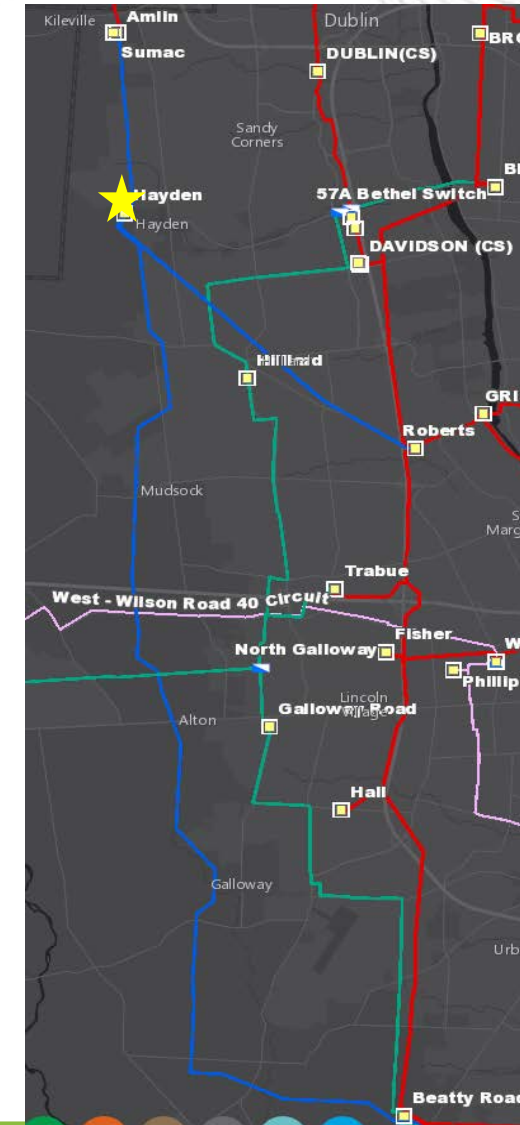
### Alternatives:

No cost effective alternatives were identified.

Cost Estimate: \$2.255M

Projected IS date: 8/31/2017

Status: Construction





## Supplemental Project: Hyatt Breaker Replacements

### Problem Statement/Driver:

Breakers in this project to be replaced are all I.T.E. SF6 breakers that were manufactured in 1974. AEP has been replacing this breaker type for several years now due to multiple bushing failures. There are only 7 breakers of this type left in the entire AEP system, including these. Breakers 302N, 302C and 302S have the following documented conditions: age and repair parts availability.

### Potential Solution:

Replace Hyatt 345 kV 50 kA circuit breakers 302N, 302C and 302S with new 5000 A 63 kA units

### Alternatives:

No cost effective alternatives were identified.

Cost Estimate: \$3.13M

Projected IS date: 11/22/2017

Status: Construction





## Supplemental Project: Dumont 765/345kV Transformer Replacement

### Problem Statement/Driver:

Dumont 765/345kV transformer T1 was manufactured in 1977. It has the following documented conditions: age, bushing maintenance issues, dielectric breakdown, oil quality, partial discharge readings and insulation breakdown. To avoid neutral current imbalances, all three single phase transformers will be replaced.

### Potential Solution:

At Dumont station, replace the existing 765/345kV 500MVA transformer T1 with new 765/345kV/34.5 750MVA transformer T3 and a spare T3SP 765/345kV/34.5 750MVA transformer along with associated equipment and protection.

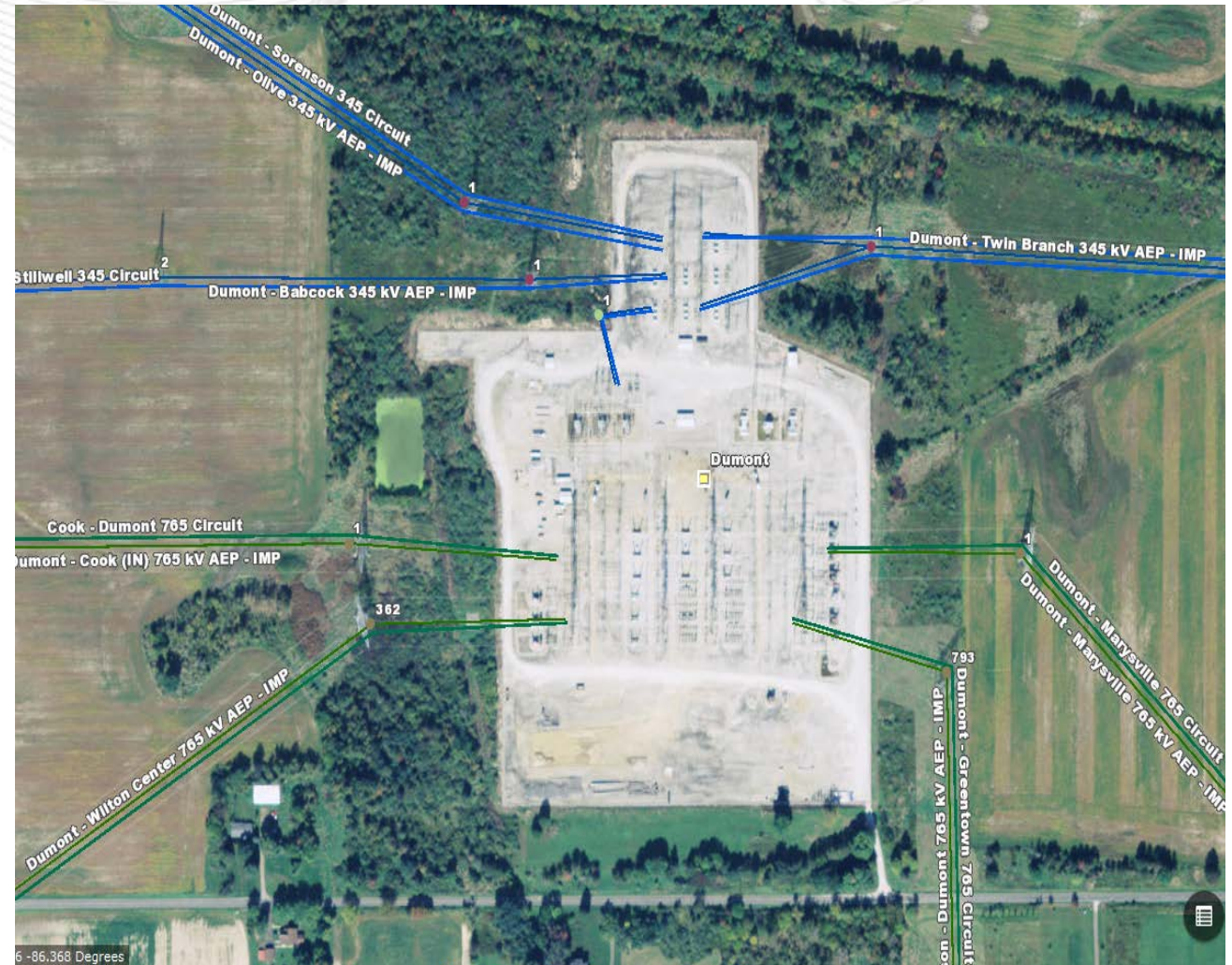
### Alternatives:

No additional cost effective alternatives were identified.

Cost Estimate: \$43.743M

Projected IS date: 12/29/2017

Status: Engineering





## Supplemental Project: Olive-Bosserman 138 kV

### Problem Statement/Driver:

The LaPorte Junction - New Carlisle 34.5 kV circuit has a vintage from 1930s and is wood pole construction. Between 2010-2015, ~2 million customer minutes of interruption (CMI) were recorded at Silver Lakes station. There are 183 open conditions, 95 of which are category A conditions on the ~20 mile long line.

Indiana and Michigan Power Company has requested to convert Silver Lake and Springville to 138 kV operation.

This project would also resolve congestion on the Olive-Bosserman 138 kV identified during MISO-PJM JOA market efficiency studies in addition to addressing the a potential overload identified on this facility during the PJM 2021 RTEP. It was submitted (without the new distribution station additions) to the PJM reliability and market efficiency windows.

### Potential Solution:

Construct two 138/12 kV distribution stations, Bootjack and Marquette, to replace Silver Lake 34.5 kV and Springville 69 kV stations.

Cut the existing Olive – Bosserman line into New Carlisle station.

Rebuild sections of the LaPorte Junction-New Carlisle/New Buffalo 34.5 kV line to 138 kV to establish Bootjack-Olive 138 kV circuit.

Install a three way phase over phase switch, called Kuchar, near Liquid Carbonics station and construct a new 138 kV line between Bootjack and Kuchar.

Construct a 138 kV extension to Marquette station by tapping the Bosserman-Liquid Carbonics 138 kV line.

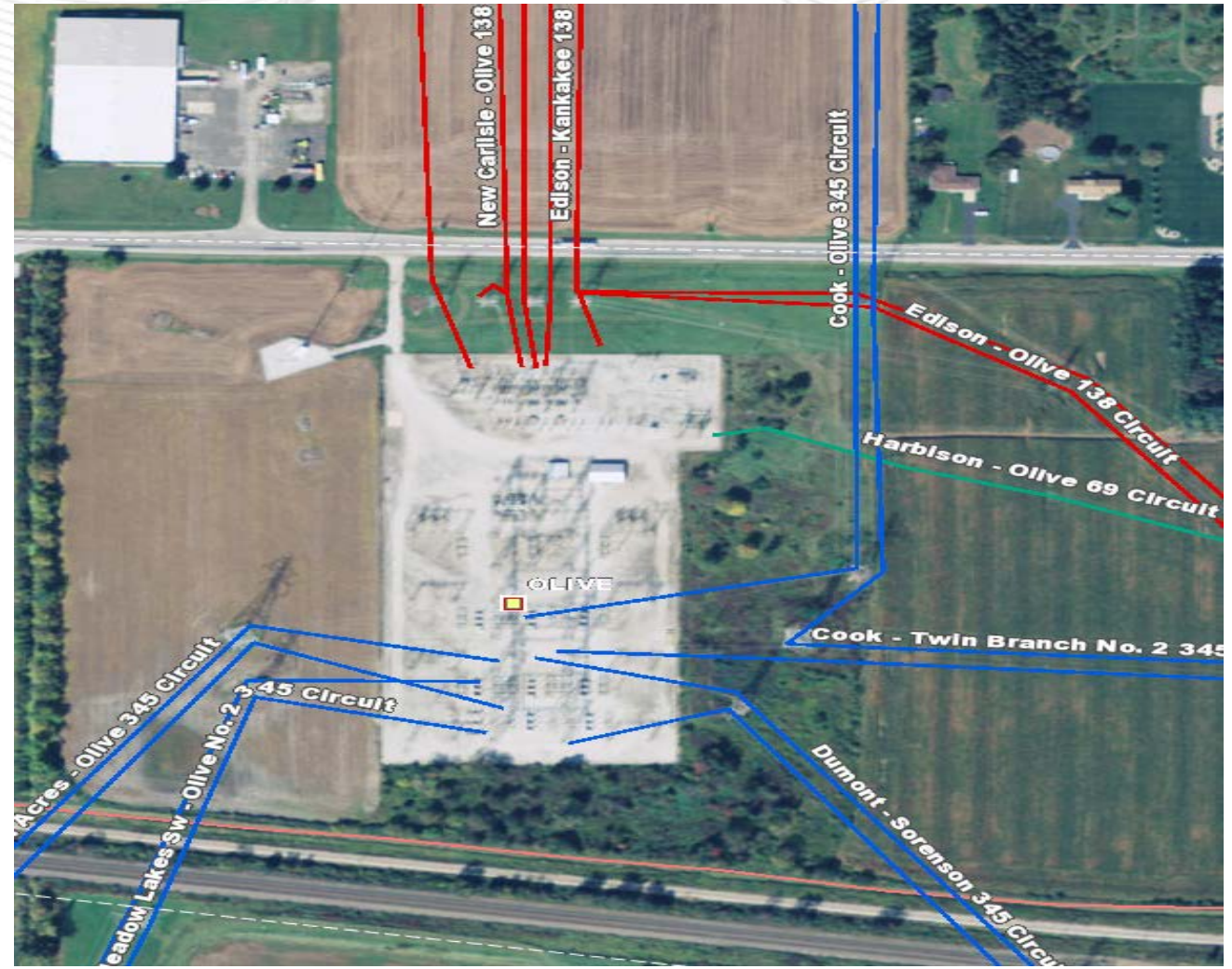
### Alternatives:

Rebuild ~20 mile long New Carlisle – LaPorte Junction 34.5 kV utilizing existing line ROW corridor. This alternative was not selected because it did not provide the operational flexibility & efficiency and customer service benefits provided by the preferred option. Estimated cost: ~\$32M

Cost Estimate: \$36.786M

Projected IS date: 12/1/2019

Status: Scoping







# DEOK Transmission Zone

## Supplemental Project: - Remove Beckjord U6 Feeder

### Problem Statement/Driver:

Beckjord Unit 6 was retired October 2014. The GSU has been removed. The connecting 345kV feeder from the GSU to Pierce substation is no longer in use and crosses over a state highway. The single support tower and the feeder are over fifty years old and in declining condition. Need to remove the risk of the feeder falling onto the highway.

### Potential Solution:

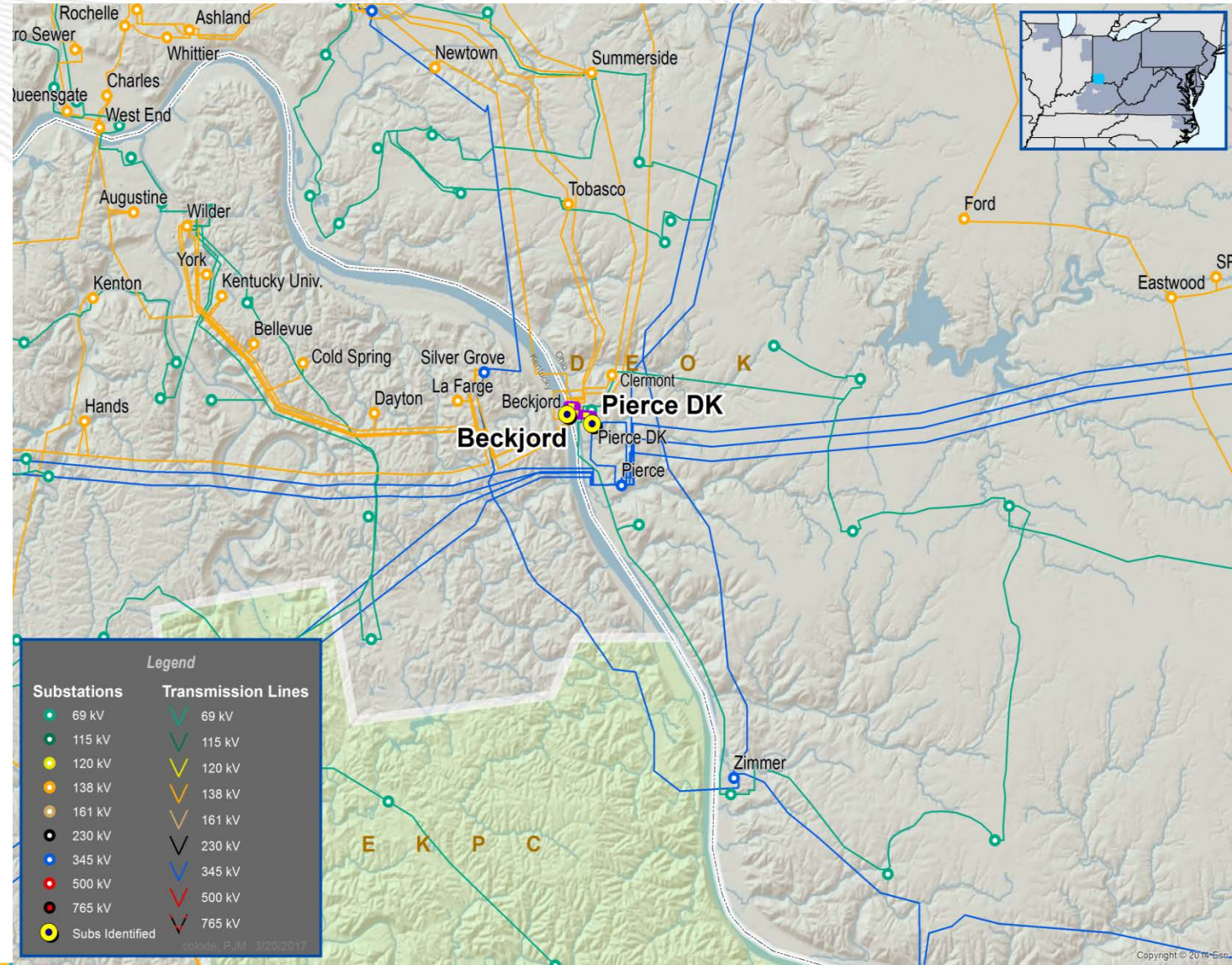
Remove 345kV feeder and support tower.

Alternatives: No alternatives.

Cost Estimate: \$0.121M

Projected IS date: 12/31/2017

Status: Planning





## Supplemental Project: Poolesville Station

### Problem Statement: Operational Performance

- On Jan 26, 2017 a ground fault occurred when closing the 21416 switch at Poolesville substation to energize the Poolesville to Winchester section of the 214 Line.
- In depth field inspection found the switch to be in good working condition.
- On February 11, 2017, while returning the 21416 switch to service, a large arc formed across the switch contacts. Had weather events been different (ex: stronger wind), another fault could have occurred. See photo at bottom of slide.
- Initial engineering studies and analyses indicate that heavy mutual coupling from other transmission lines is the root cause. Heavy mutual coupling results in an increased voltage difference between the open contacts of the switches, greater than the capability of the switches

### Potential Solution:

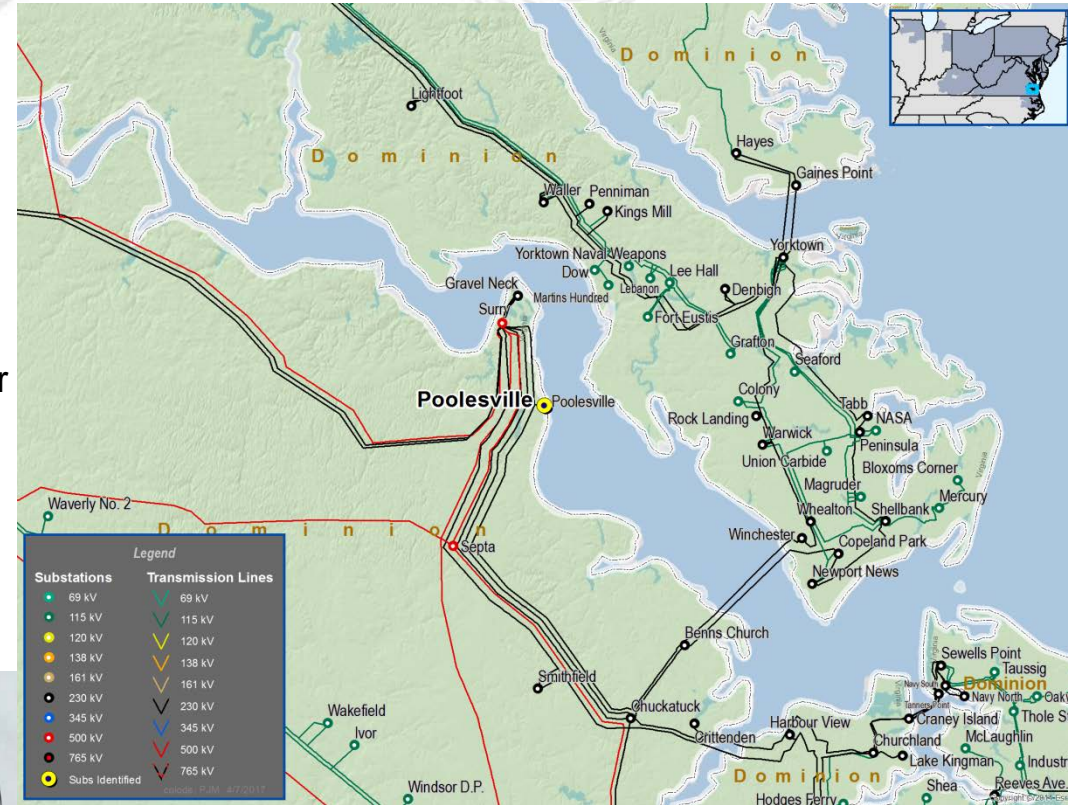
- Install a Circuit Switcher in series with line switch 21416 at Poolesville to enable line switching and address this operational performance problem

Alternatives: None

Estimated Project Cost: \$410 K

Possible IS Date: 04/13/2017

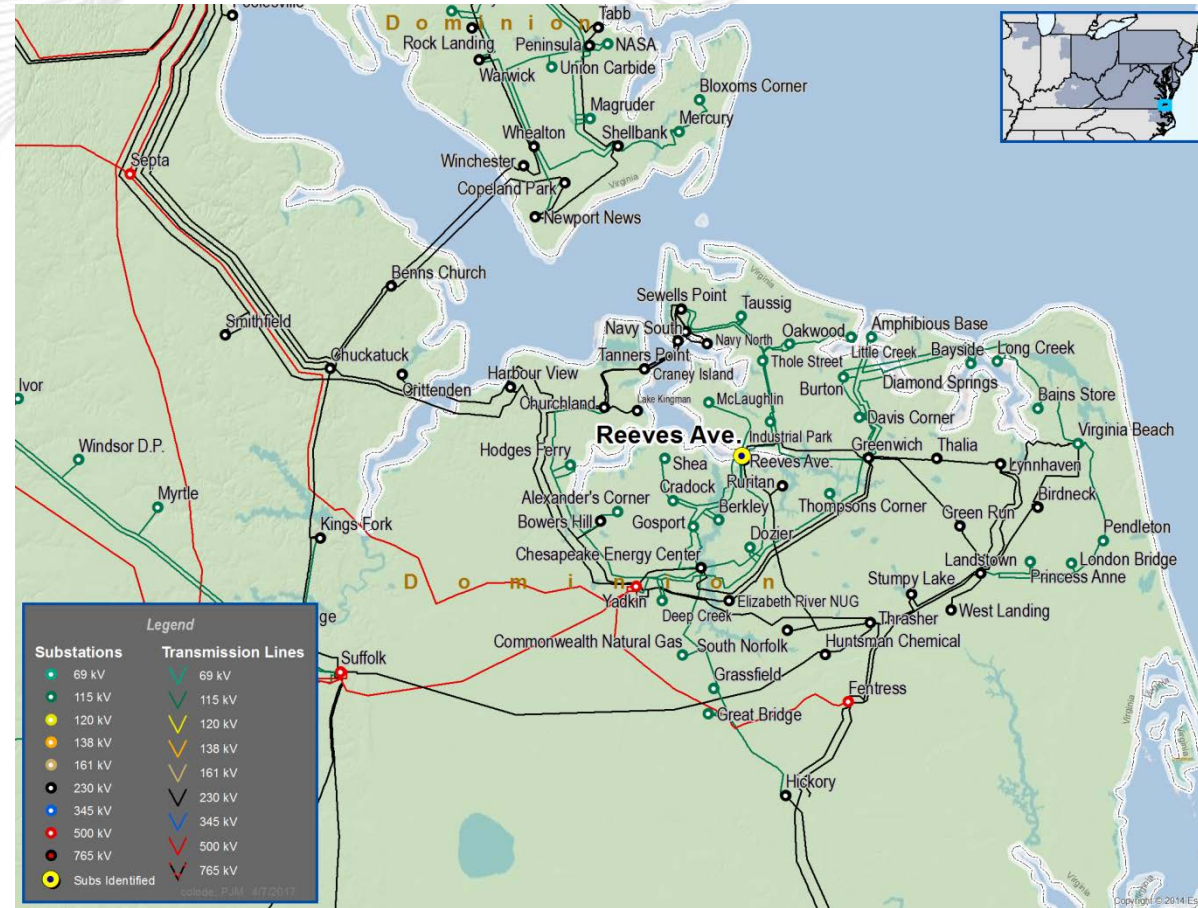
Project Status: Under Construction



## Supplemental Project: Reeves Ave Station

### Problem Statement: Operational Performance

- Reeves Ave 230kV configuration: 230/115kV transformers #4 and #5 are hung off 230kV line #279 and #2038 respectively with sectionalizing schemes
  - Fault on the 230kV lines remove network transformer, and fault on transformers trip corresponding line, interrupting the network and any tapped load.
  - Breaker maintenance on the 230kV tie breaker opens the 230kV network.
- Reeves Ave 115kV configuration: 115/34.5kV transformer #6 is hung off 115kV line #94 with sectionalizing scheme, 115/34.5kV transformer #2 and #3 connect to 115kV bus #2 and #1 respectively with sectionalizing schemes, multiple 115kV lines connect to corresponding bus with breakers.
  - Fault on line #94 removes transformer #6 affecting about 3000 customers, fault on transformer #6 trips line #94, interrupting the network.
  - Fault on transformer #2 or #3 will trip all 115kV lines associated with corresponding bus, interrupting the network.





## Supplemental Project: Reeves Ave Station

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### Potential Solution:

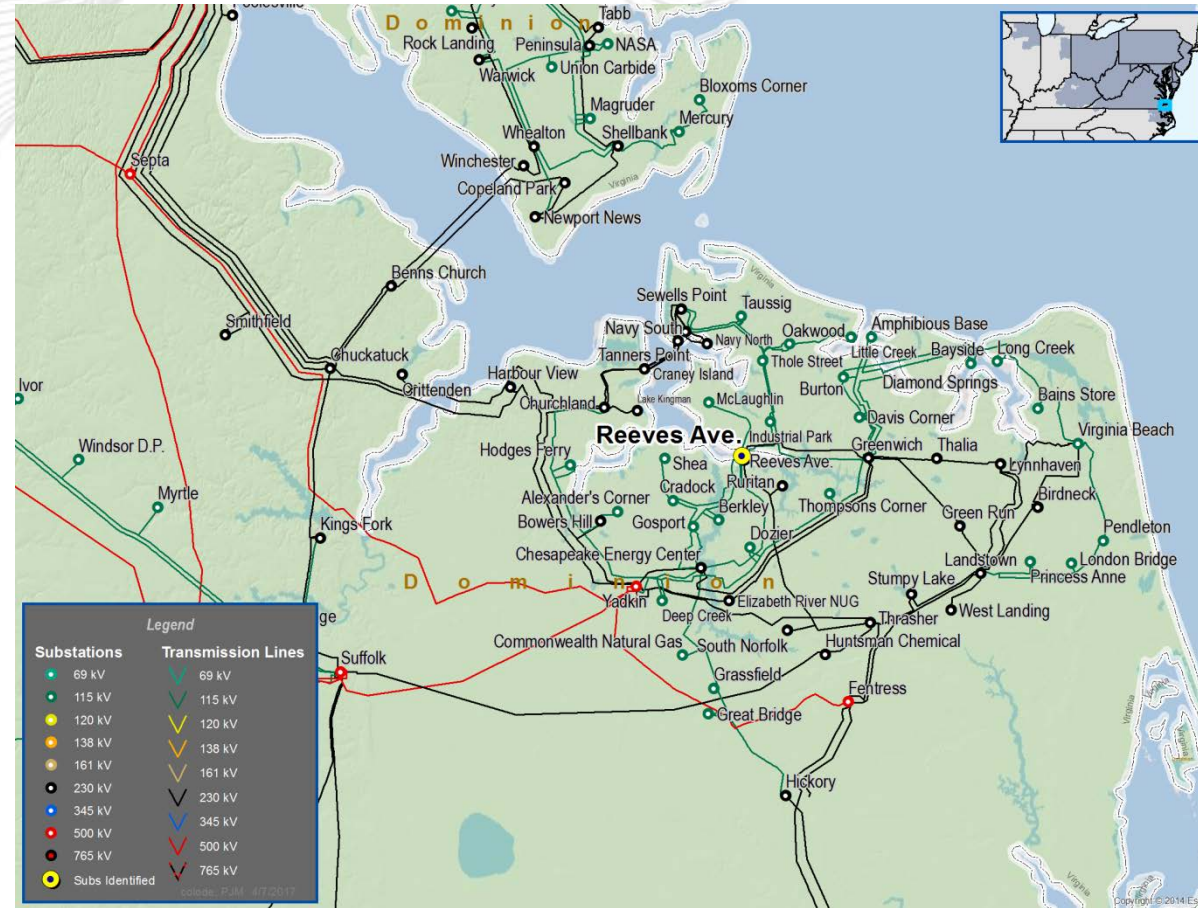
- 230kV configuration: Install three 230kV breakers to form a 4-breaker ring bus. **(s1271.1)**
  - A fault operation on 230kV lines maintains network flow through both transformer #4 and #5. A transformer #4 or #5 fault operation will no longer trip the associated line, maintaining the integrity of the grid and service to the tapped load.
  - Breaker maintenance on any 230kV breaker in the ring does not effect network flows.
- 115kV configuration: Install 115kV breakers on high side of transformer #2, #3, and #6. **(s1271.2)**
  - A fault operation on the line #94 does not affect the transformer #6 load.
  - A transformer #2, #3 or #6 fault operation will no longer trip the associated line or bus, maintaining the integrity of the grid and service to the network and tapped load.

**Alternatives:** None

**Estimated Project Cost:** \$5.2 M

**Possible IS Date:** 12/15/2018

**Project Status:** Engineering





# Dominion Transmission Area

## Supplemental Project: Reeves Ave Transformer

### Problem Statement:

- Reeves Ave TX#4 (nameplate rating 224MVA, installed 1988) and TX#5 (nameplate rating 168MVA, installed 1984) need to be replaced due to age and increased maintenance

### Potential Solution:

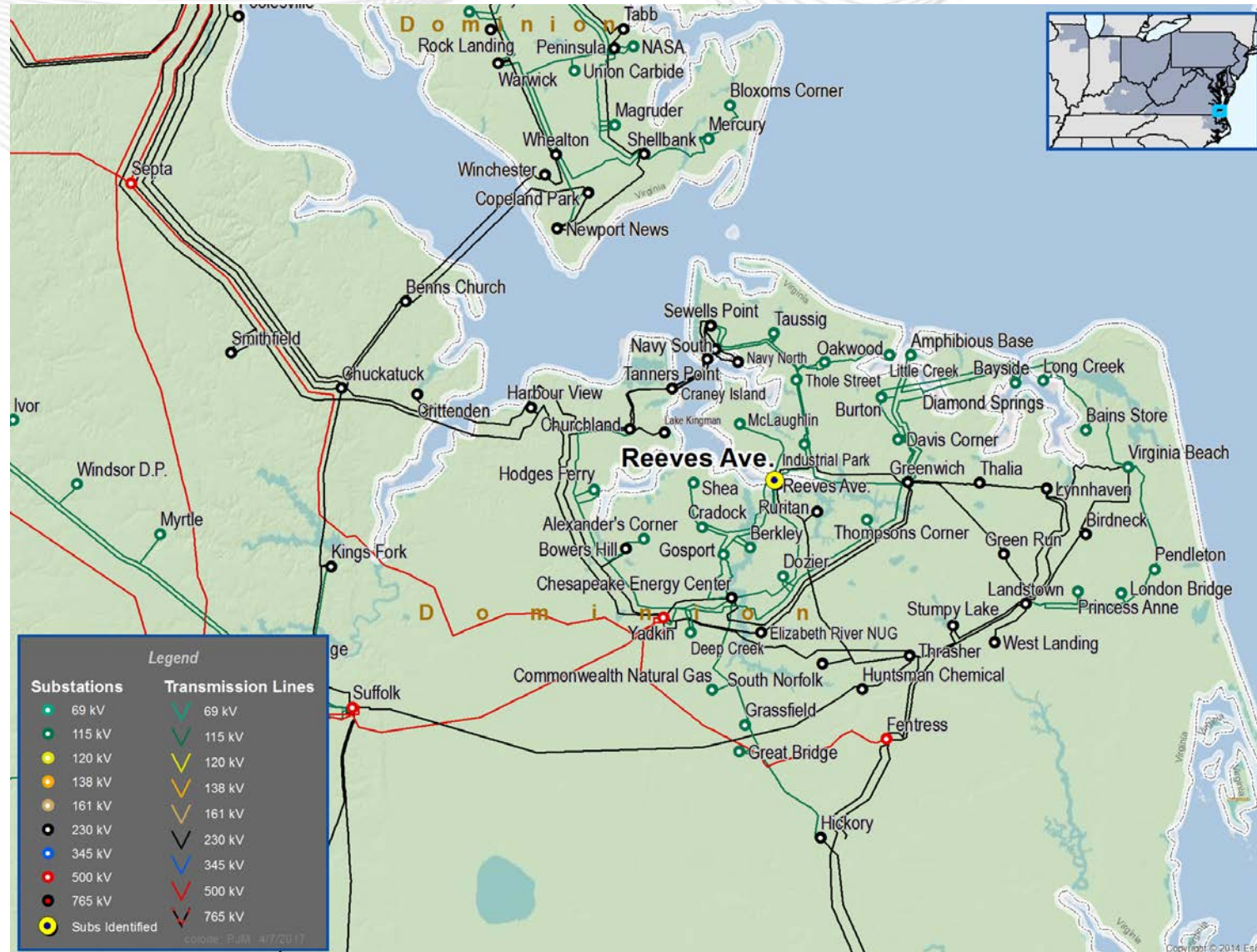
- Replace TX#4 and TX#5 with new 168MVA (nameplate rating) transformers. **(s1272)**
- A study has been performed to verify the ratings are sufficient.

Alternatives: None

Estimated Project Cost: \$8.7M

Possible IS Date: 01/31/2018

Project Status: Engineering





# 2017 RTEP Anticipated Schedule

- Finalize Models
- Analysis
  - 2022 Baseline N-1
  - 2022 Summer Generator Deliverability and Common Mode Outage
  - 2022 Light Load Reliability Analysis
  - 2022 Winter Generator Deliverability and Common Mode Outage
  - 2022 Winter Load Deliverability
  - 2022 Winter N-1-1
  - 2022 Summer Load Deliverability
  - 2022 Summer N-1-1
  - Short Circuit Analysis
  - Annual Stability Assessment
  - Transmission Owner Criteria

# RTEP Next Steps

- Finalize 2017 Models
- Begin 2017 RTEP Analysis
- Lower Voltage Filing to be implemented with first 2017 RTEP Proposal Window
  - PJM will post the violations we expect to not go through a window consistent with filing



# Questions?

Email: [RTEP@pjm.com](mailto:RTEP@pjm.com)

- Revision History
  - V1 – 4/10/2017 – Original Version Posted to PJM.com
  - V2 – 4/12/2017 – Slide #23, correction on the # of open conditions (183 in
  - V3 – 4/13/2017 – Slide #21, Map update