



Artificial Island Proposal Window

PJM TEAC

Artificial Island Recommendation

6/16/2014

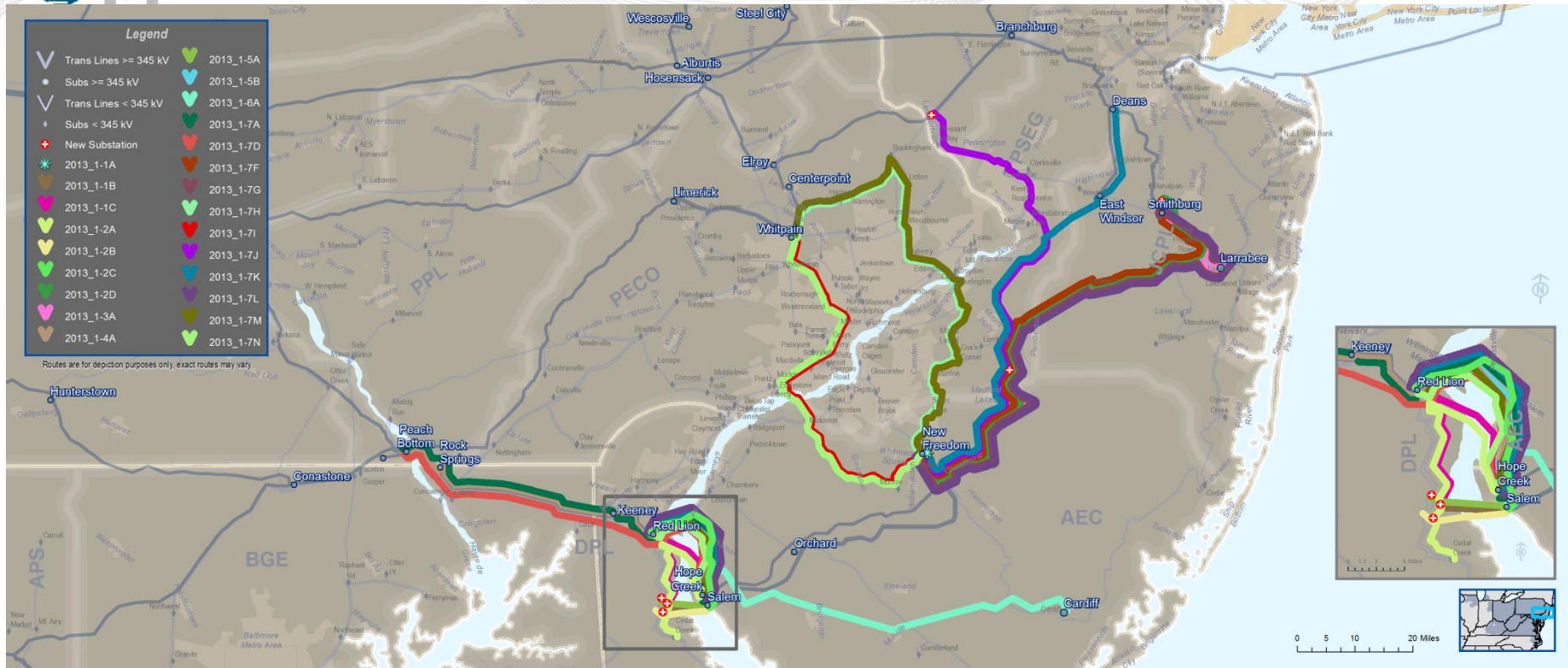
Artificial Island Timeline

- 9/13/2012 – PJM discusses the trending Artificial Island operational issues with PJM Stakeholders
- March 2013 - TEAC Previewed conceptual timeline and next steps for an Artificial Island Proposal Window
- 4/29/2013 – Artificial Island Proposal Window Opened
- 6/28/2013 – Artificial Island Proposal Window Closed
- July 2013 through April 2014 – PJM discusses the details of project performance, cost and constructability

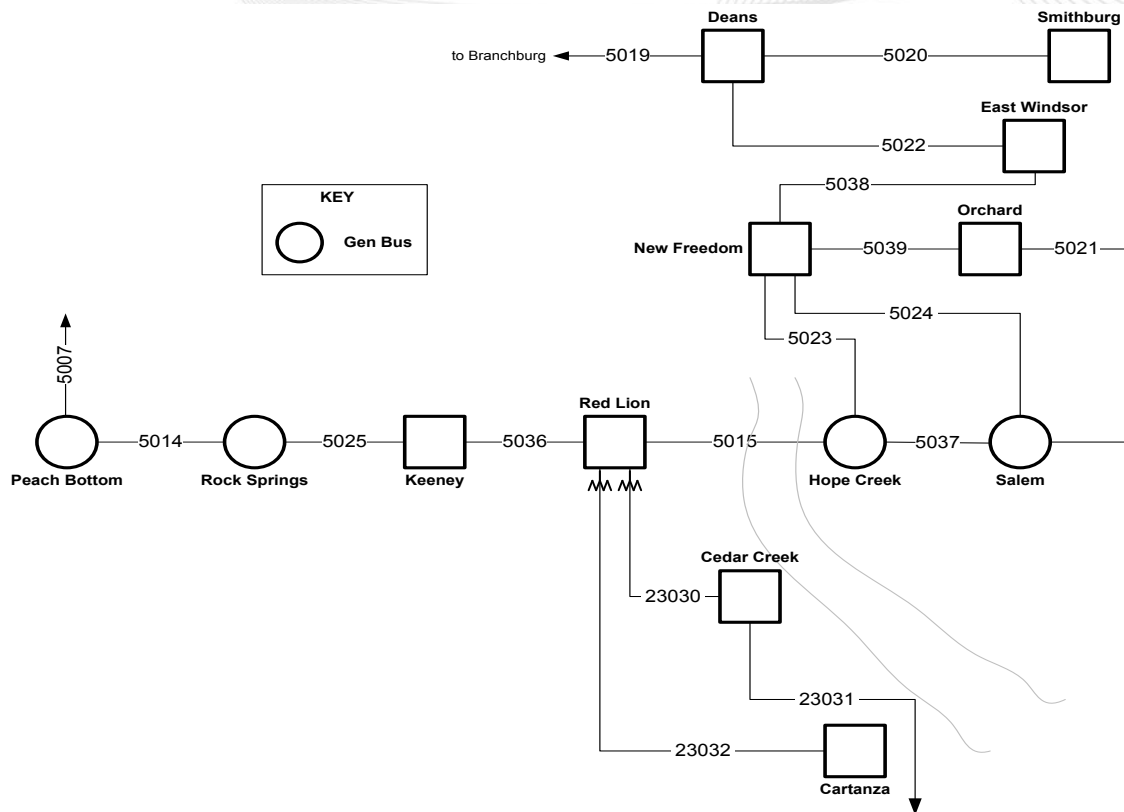
- Monday, May 19th TEAC
 - 3 hour stakeholder technical meeting
 - In-person at PJM CTC
- Monday, June 2nd – Due date for stakeholder comment/feedback (14 day comment period)
- June 5th TEAC
- Monday, June 16th – PJM review of stakeholder comment/feedback and final decision meeting
 - Special TEAC Webex / Teleconference
- Comment Period to the PJM Board (36 days for comment period)
- July 10th TEAC
- Tuesday, July 22nd – PJM Board meeting
 - Artificial Island solution recommendation to the PJM Board

Project ID	TO	Cost (\$)	Major Components	Supporting info
P2013_1-1A	Virginia Electric and Power Comj	\$	133 500 MVAR SVC near New Freedom	Two (2) Thyristor Controlled Series Compensation (TCSC) Devices near New Freedom
P2013_1-1B	Virginia Electric and Power Comj	\$	126 New 500 kV from Salem - a new station in Delaware	New 500/230 kV station in Delaware that taps existing Cedar Creek - Red Lion 230kV and Catanza - Red Lion 230kV
P2013_1-1C	Virginia Electric and Power Comj	\$	202 New 500 kV from Hope Creek - a new Station in Delaware	Install a new 500kV line from Hope Creek - Red Lion; New Salem - Hope Creek 500 kV line
P2013_1-2A	Transource	\$213 - \$269	Salem - Cedar Creek 230 kV	Two (2) 500/230 Transformers near Salem; Loop in Red Lion - Cartanza 230 to Cedar Creek
P2013_1-2B	Transource	\$165 - \$208	Salem - North Cedar Creek (new) 230 kV	Two (2) 500/230 transformers near Salem and loop in Red Lion - Cartanza 230 and Red Lion - Cedar Creek 230 kV
P2013_1-2C	Transource	\$123 - \$156	Salem - Red Lion 500 kV	
P2013_1-2D	Transource	\$788 - \$994	New Freedom - Lumberton - North Smithburg (New) 500 kV line	New Salem - Hope Creek 500 kV line and new 500/230 station east of Lumberton
P2013_1-3A	First Energy	\$410.7 (Only FirstEnergy portion)	New Freedom-Smithburg 500 kV line with a loop into Larrabee	Hope Creek - Red Lion 500 kV line
P2013_1-4A	PHI Exelon	\$	475 Peach Bottom - Keeney - Red Lion - Salem 500 kV	Remove Keeney - Red Lion 230 kV; Reconfigure 230 around Hay Road; Reconductor Harmony-Chapel St 138 kV
P2013_1-5A	LS Power	\$116.3M - \$148.3M	Salem - Silver Run (new) 230 kV; Salem 500/230 kV Transformer	New 230 kV station that taps existing Cedar Creek - Red Lion 230kV and Catanza - Red Lion 230kV
P2013_1-5B	LS Power	\$	170 Salem - Red Lion 500 kV	
P2013_1-6A	Atlantic Wind	\$	1,012 320 kV HVDC Salem/Hope Creek - Cardiff	SVC at Salem/Hope Creek; New HVDC Stations at Cardiff and Salem
P2013_1-7A	PSE&G	\$	1,371 Salem-Hope Creek to Peach Bottom 500 kV	Existing ROW
P2013_1-7B	PSE&G	\$	1,372 Salem-Hope Creek to Peach Bottom 500 kV	Same as 7A with Loop into Keeney
P2013_1-7C	PSE&G	\$	1,372 Salem-Hope Creek to Peach Bottom 500 kV	Same as 7A with Loop into Red Lion
P2013_1-7D	PSE&G	\$	831 Salem-Hope Creek to Peach Bottom 500 kV	Same as 7A with New ROW
P2013_1-7E	PSE&G	\$	692 New Freedom - Deans 500 & Salem - Hope Creek 500 kV lines	
P2013_1-7F	PSE&G	\$	879 New Freedom - Smithburg and Salem-Hope Creek 500 kV lines	Existing ROW
P2013_1-7G	PSE&G	\$	1,034 New Freedom - Smithburg and Salem-Hope Creek 500 kV lines	Same as 7F with a Loop into a new Larrabee 500 kV station
P2013_1-7H	PSE&G	\$	1,177 New Freedom - Whitpain and Salem - Hope Creek 500 kV lines	Northern Route
P2013_1-7I	PSE&G	\$	1,353 New Freedom - Whitpain and Salem - Hope Creek 500 kV lines	Same as 7H with the Southern Route
P2013_1-7J	PSE&G	\$	915 New Freedom - New Station on Branchburg-Elroy 500 kV line ("5017 Junction") and Salem - Hope Creek 500 kV line	Existing ROW
P2013_1-7K	PSE&G	\$	1,066 New Freedom - Deans & Salem - Hope Creek - Red Lion 500 kV lines w/ Hope Creek - Red Lion (new);	Same as 7E with Hope Creek - Red Lion
P2013_1-7L	PSE&G	\$	1,250 New Freedom - Smithburg & Salem - Hope Creek - Red Lion 500 kV lines w/ Hope Creek - Red Lion (new);	Same as 7F with Hope Creek - Red Lion
P2013_1-7M	PSE&G	\$	1,548 New Freedom - Whitpain (North) & Salem - Hope Creek - Red Lion 500 kV lines w/ Hope Creek - Red Lion (new);	Same as 7H with Hope Creek - Red Lion
P2013_1-7N	PSE&G	\$	1,289 New Freedom - a new Station on the Branchburg-Elroy 500 kV line ("5017 Junction") & Salem-Hope Creek - Red Lion 500 kV lines w/ Hope Creek - Red Lion (new);	

Artificial Island Proposals



Artificial Island Area Network



Artificial Island Feedback Received from 5/19/2014 Technical Review

Comments submitted by:

- Delaware PSC
- Dominion Virginia Power
- LS Power
- New Jersey BPU
- Atlantic Wind Connection
- PHI Exelon
- PSE&G
- PSE&G Nuclear
- State of Delaware Public Advocate
- Transource

Topics Raised by Commenters

- Alternative proposed which included a neutral reactor and a 500kV CB
- Benefits of TCSC to resolve operational performance issues
- Right of way acquisition: Impact of LDV ownership, private land vs non-private and new versus expansion
- PJM cost estimates: Incorporation of EoC estimates and missing cost components
- Constructability concerns: Submarine cable installation, salt spray, modifications to existing transmission facilities

Topics Raised by Commenters

- Environmental impact and permitting concerns: Supawna Meadows NWR, environmental management areas, Reedy Island dike, Sunken Ship Cove (NRHP), essential fish habitats and wetlands impacts
- Concerns with Delaware river crossing permitting
- Concerns with NRC review of FACTS devices impacting cost and schedule
- Concerns with cost allocation for the 230 kV solutions
- Non-incumbent ability to build transmission facilities in New Jersey and Delaware

- PHI/Exelon: Eliminate the need (and cost) for an SVC by:
 - Alternative # 1 - Install a 2% reactor in the neutral of the 500kV (wye grounded) side of the two Salem generator-step-up transformers (GSU) or Install a 1% neutral reactor to the 500kV side of the two Salem and the Hope Creek GSUs
 - Alternative # 2 - Employ a back-to-back circuit breaker scheme to interconnect the PHI/Exelon proposed 500kV line to the Salem Substation.
- PJM determined that the suggested modifications would only address phase to ground faults and there are three phase faults that would still be unstable and not improved by the back-to-back breakers or neutral reactors
- Reactors also have additional negative impacts that would need be considered

- Feedback at the 5/19/2014 AI Technical Review regarding the potential Hope Creek – Red Lion proposal
 - Transource was concerned that the potential Hope Creek – Red Lion transmission solution would not solve all stability requirements
 - Resolution: PJM worked with Transource to update their technical assumptions and this concern was found to not be an issue

Artificial Island Recommendation

- Performed extensive technical analysis
 - Stability, thermal, voltage, short circuit, market efficiency
 - Studied all solutions as is and with modifications

Initial analysis showed only two of the highest cost solutions worked as submitted

- Engaged outside engineers to perform constructability review
 - *focus on physical, cost, schedule, RoW, siting, permitting*
- Met with all proposers for clarification as needed
- Met with AI nuclear plant representatives
- PJM Operations review
- PJM independent cost evaluation
- Met with equipment manufacturers



Evaluation Considerations

- Primary Considerations
 - Technical Analysis
 - Thermal
 - Stability
 - Short-circuit
 - Voltage
 - NERC Cat-D Contingencies
- Secondary Considerations
 - Schedule
 - Permitting
 - Construction
 - Long lead time equipment
 - Project Complexity
 - Line crossings
 - Outage requirements
 - Modifications to other transmission facilities
 - Modification to Artificial Island substations
 - Modifications to Red Lion substation
- Cost Factors
 - Cost effectiveness
 - Market efficiency
 - PJM estimated costs
- Right of Way and Land Acquisition
 - No eminent domain in Delaware
 - New right of way required
 - Substation land required
- Siting and Permitting
 - Wetlands impact
 - Public opposition risk
 - Delaware river crossing
 - Land permitting
 - Historic and scenic highway
- Operational Impact
 - Artificial island facility requirements
 - Ongoing maintenance
 - Blackstart
 - Route diversity
 - Performance

- Overall, there were 26 proposals
 - 2 projects passed the initial analytical screen without modification
 - Through evaluation of the various proposals, PJM staff found that many of the proposals could be made more effective and efficient with some modification and the addition of other components
 - Screened proposals (with the PJM modifications) based on performance and cost

- PJM focused on a short list of evaluations that included several projects in each of these four categories:
 - Southern Crossing – Submarine
 - Southern Crossing – Overhead
 - Salem to Red Lion 500 kV
 - Hope Creek to Red Lion 500 kV

- Primary Considerations
 - Technical Analysis
 - Cost Factors
 - Project Schedule

- All projects on the short list, with PJM modifications included, satisfied the required criteria including:
 - Stability: Angle swing (including with AI generation at unity power factor)
 - Load flow, short circuit, voltage, NERC cat-D contingencies
- Additional analysis
 - Market efficiency
 - Additional reliability benefits

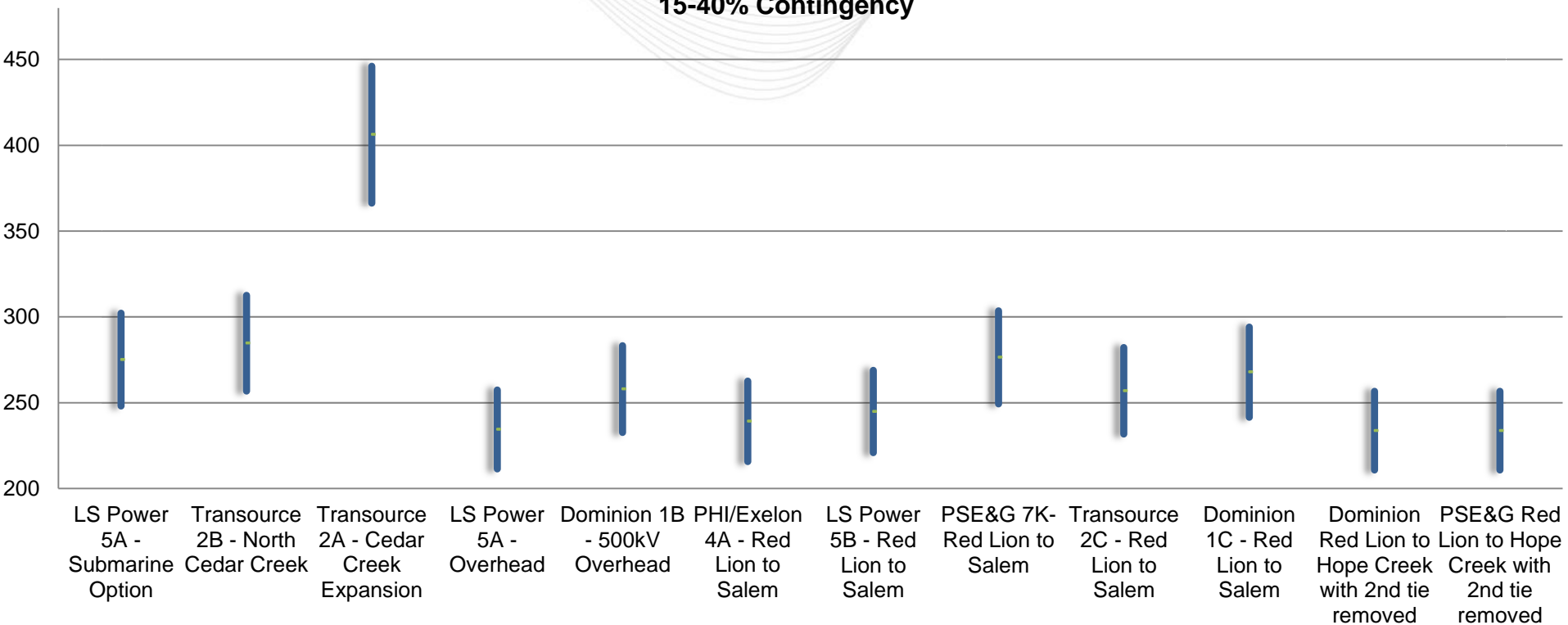


PJM Cost Estimates

PJM Estimated Project Costs

15-40% Contingency

Millions of Dollars



Projects Under Consideration

Note: Estimated costs do not include the SVC cost estimate

- **Permitting**
 - Delaware River Crossing
 - Represents the greatest component of schedule risk for all projects
 - Land Permitting
 - All projects will face challenges
 - Red Lion to Artificial Island
 - » Supawna Meadows National Wildlife Refuge
 - » State wildlife management areas
 - Southern crossing lines
 - » State wildlife management areas
 - Public opposition can be expected with all of the alternatives
- Siting and permitting for a new river crossing will be a major component in the project schedule for all projects under consideration

- Evaluation of risks to cost and schedule
 - Project complexity
 - Modifications to Artificial Island
 - Line Crossings
 - Outage Requirements

- Modification of Artificial Island substations
 - Salem
 - Constrained with limited space for expansion. Proposed alternatives out of Salem would need to ensure continued maintenance access to station aux transformers
 - All protection and control equipment located inside the secure area of the generating station. There is limited spare conduit from the substation into the station for control wiring.
 - Hope Creek
 - Available land for expansion to the north
 - Protection and control equipment located in a separate control building in the substation.
- A new line from Hope Creek without impacts to Salem is considered more constructible

- Line Crossings

- All 500kV projects interconnecting at Salem substation included a line crossing
- Line crossings create operational complexity and the potential for a multiple facility trip event
 - Referenced in NRC Regulations, General Design Criteria-17

- Solutions with no line crossings are preferable

- Outage Requirements
 - All projects require outages to support construction
 - Artificial Island to Red Lion solutions would require outages to the 5015 line
 - 5015 line outages are challenging to schedule
 - All projects would require coordination of 500kV and 230kV facility outages
 - PJM operational analysis to manage impact to system configuration to support any outage required to support construction
 - Reactive devices
 - AI SPS
 - Coordination with planned generation and transmission outages
- A solution that minimizes outage requirements during construction is preferred

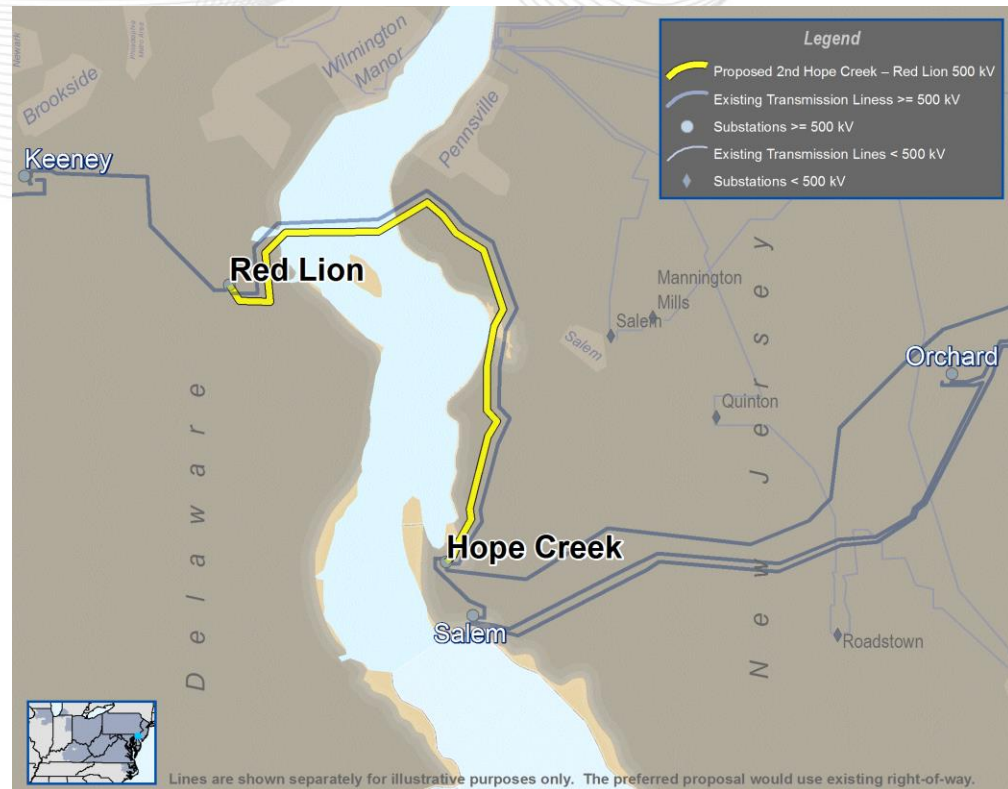
Project Class		Southern Crossing 230kV Lines (Submarine)			Southern Crossing Lines (Overhead)		Red Lion to Salem 500kV Lines			Red Lion to Hope Creek 500kV Lines			
Criteria	Proposal	LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - 230kV Overhead	Dominion 1B - 500kV Overhead	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion Red Lion to Hope Creek w/ 2nd tie removed	PSE&G Red Lion to Hope Creek w/ 2nd tie removed
	Sub-Criteria												
Risks to Cost and Schedule													
Project Complexity	Line Crossings												
	Outage Requirements												
	Modification of AI Subs												

Additional Factors in Project Selection

- Artificial Island to Red Lion 500kV solutions are more robust and provide greater power transmission capacity as compared to the 230kV southern crossing solutions
 - Under normal system conditions, southern crossing solutions would provide little system support
 - Artificial Island to Red Lion 500kV solutions improve voltage drop for loss of 500kV facilities
- An Artificial Island to Red Lion 500 kV line is a more robust solution than a southern crossing line

[illegible]

- In consideration of all factors PJM staff will recommend for inclusion in the RTEP:
 - A new 500kV circuit from Hope Creek to Red Lion



Project Designation Differentiating Factor

- PSE&G and Dominion proposed solutions that included a new 500kV line from Red Lion to Hope Creek. FirstEnergy proposed a Red Lion to Hope Creek facility but declined construction designation.
- Right of Way Acquisition
 - The LDV agreement provides for usage of existing right of way along the recommended project path
 - PSE&G is a party to the LDV agreement
 - 8.5 miles of the right of way in New Jersey would need be expanded
 - Dominion will need to acquire right of way for the entire route of the line

- Assign designation of the Hope Creek – Red Lion 500 kV transmission line to PSE&G
- Assign the necessary connection facilities to accommodate the new transmission facility:
 - Red Lion 500kV station upgrade to PHI
 - Hope Creek 500kV station upgrade to PSE&G

- An SVC is a required component to achieve the necessary project performance
 - Locations at Artificial Island, Orchard and New Freedom were studied and all achieved the required performance
- New Freedom and Orchard locations have the lowest estimated cost and would not require construction at Artificial Island

- PSE&G New Freedom switching station has available property to accommodate the SVC
- New Freedom has stronger system ties to both the PJM 500kV and 230kV systems as compared to the Orchard location

- Construct an SVC at New Freedom 500 kV substation
 - Facilities design will determine the technical parameters
- Designate SVC upgrade at New Freedom to PSE&G

- At the Tuesday, July 22nd PJM Board meeting, PJM staff will recommend for inclusion in the RTEP:
 - Hope Creek to Red Lion 500 kV transmission line designated to PSE&G
 - Associated substation work at Hope Creek designated to PSE&G
 - Associated substation work at Red Lion designated to PHI
 - SVC at New Freedom 500 kV designated to PSE&G

- Detailed facility design
- Finalize review and recommendations on the protection issues raised around current directional carrier blocking scheme (DCB)

Note: Please supply any written comments to the PJM Board through RTEP@PJM.com

Appendix from Previous 5/19 Meeting

- Generate maximum power from the AI under both the baseline (N-0) and maintenance (N-1) assumptions
 - Satisfy applicable planning criteria
- <http://pjm.com/~media/planning/rtep-dev/expan-plan-process/ferc-order-1000/rtep-proposal-windows/redacted-artificial-island-problem-statement.ashx>

Artificial Island Proposal Window Timeline

Announcement

- Announce window and potential timeline
- Request CEII/NDA submittals from anticipated participants
- Request Designated Entity Pre-Qualification

PSS/E v32 Case Development

Initial PSS/E v32 case created

- Benchmarking in Progress
- Develop and benchmark critical system condition cases

Window Opened

(4/29/2013 - 60 Day Duration)

- Open the "Artificial Island" RTEP Proposal Window
- Complete problem statement available
- Analytical files available

Coordinate with Window Participants and Receive Solution Proposals

- Coordination VIA www.pjm.com
- Data, Information
- Questions & Answers

Proposal Window Closed on 6/28/2013

PJM Evaluates Solution Proposals

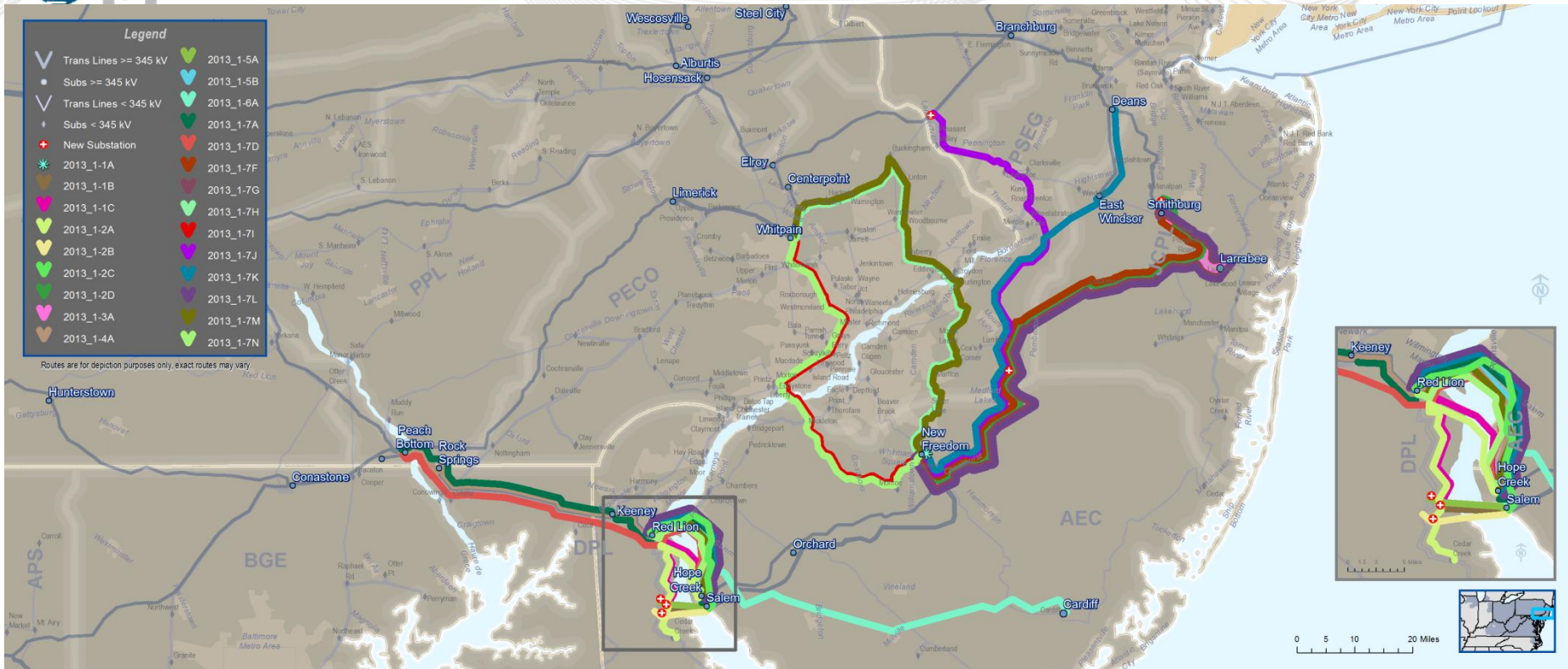
- 9/13/2012 – PJM discusses the Artificial Island with PJM Stakeholders
- March 2013 - TEAC Previewed conceptual timeline and next steps for an Artificial Island Proposal Window
- 4/29/2013 – Artificial Island Proposal Window Opened
- 6/28/2013 – Artificial Island Proposal Window Closed
- July 2013 through April 2014 – PJM discusses the details of project performance, cost and constructability

- 26 Proposals received from 7 individual entities
- **Cost Estimates:** Approximate range of \$100 M to \$1.5 B
- **Technology:** Static Var Compensator (SVC), Thyristor Controlled Series Compensation (TCSC), High Voltage Direct Current (HVDC) transmission line, (AC) transformers, (AC) overhead transmission line, underground/underwater cable transmission line, circuit breakers and associated protection equipment
- **Voltages:** 230 and 500kV
- **Station Connections:** Broad diversity of proposed methods to connect to existing stations or construct new stations as needed
- **Routing:** Wide variety of proposed methods to route new transmission over/under existing rights of way (ROW) or through new ROW

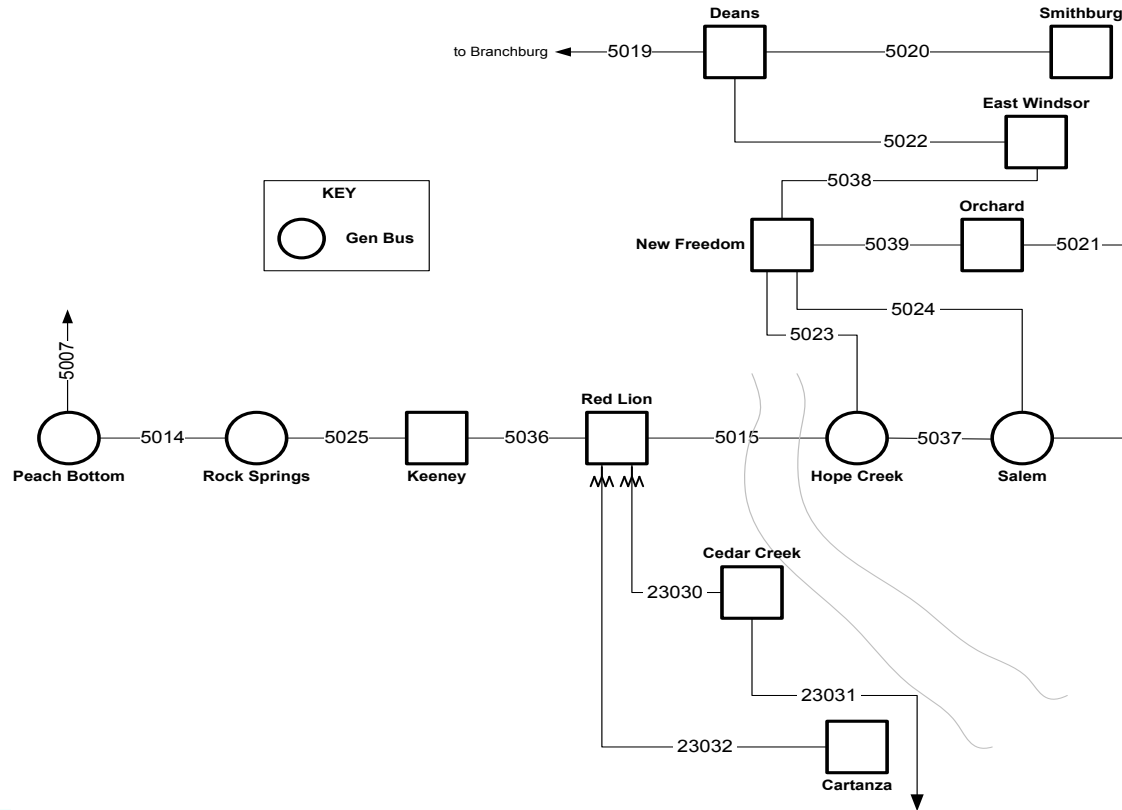
Artificial Island Project Proposal Overviews

Project ID	TO	Cost (\$)	Major Components	Supporting info
P2013_1-1A	Virginia Electric and Power Com	\$ 133	500 MVAR SVC near New Freedom	Two (2) Thyristor Controlled Series Compensation (TCSC) Devices near New Freedom
P2013_1-1B	Virginia Electric and Power Com	\$ 126	New 500 kV from Salem - a new station in Delaware	New 500/230 kV station in Delaware that taps existing Cedar Creek - Red Lion 230kV and Catanza - Red Lion 230kV
P2013_1-1C	Virginia Electric and Power Com	\$ 202	New 500 kV from Hope Creek - a new Station in Delaware	Install a new 500kV line from Hope Creek - Red Lion; New Salem - Hope Creek 500 kV line
P2013_1-2A	Transource	\$213 - \$269	Salem - Cedar Creek 230 kV	Two (2) 500/230 Transformers near Salem; Loop in Red Lion - Catanza 230 to Cedar Creek
P2013_1-2B	Transource	\$165 - \$208	Salem - North Cedar Creek (new) 230 kV	Two (2) 500/230 transformers near Salem and loop in Red Lion - Catanza 230 and Red Lion - Cedar Creek 230 kV
P2013_1-2C	Transource	\$123 - \$156	Salem - Red Lion 500 kV	
P2013_1-2D	Transource	\$788 - \$994	New Freedom - Lumberton - North Smithburg (New) 500 kV line	New Salem - Hope Creek 500 kV line and new 500/230 station east of Lumberton
P2013_1-3A	First Energy	\$410.7 (Only FirstEnergy portion)	New Freedom-Smithburg 500 kV line with a loop into Larrabee	Hope Creek - Red Lion 500 kV line
P2013_1-4A	PHI Exelon	\$ 475	Peach Bottom - Keeney - Red Lion - Salem 500 kV	Remove Keeney - Red Lion 230 kV; Reconfigure 230 around Hay Road; Reconnector Harmony-Chapel St 138 kV
P2013_1-5A	LS Power	\$116.3M - \$148.3M	Salem - Silver Run (new) 230 kV; Salem 500/230 kV Transformer	New 230 kV station that taps existing Cedar Creek - Red Lion 230kV and Catanza - Red Lion 230kV
P2013_1-5B	LS Power	\$ 170	Salem - Red Lion 500 kV	
P2013_1-6A	Atlantic Wind	\$ 1,012	320 kV HVDC Salem/Hope Creek - Cardiff	SVC at Salem/Hope Creek; New HVDC Stations at Cardiff and Salem
P2013_1-7A	PSE&G	\$ 1,371	Salem-Hope Creek to Peach Bottom 500 kV	Existing ROW
P2013_1-7B	PSE&G	\$ 1,372	Salem-Hope Creek to Peach Bottom 500 kV	Same as 7A with Loop into Keeney
P2013_1-7C	PSE&G	\$ 1,372	Salem-Hope Creek to Peach Bottom 500 kV	Same as 7A with Loop into Red Lion
P2013_1-7D	PSE&G	\$ 831	Salem-Hope Creek to Peach Bottom 500 kV	Same as 7A with New ROW
P2013_1-7E	PSE&G	\$ 692	New Freedom - Deans 500 & Salem - Hope Creek 500 kV lines	
P2013_1-7F	PSE&G	\$ 879	New Freedom - Smithburg and Salem-Hope Creek 500 kV lines	Existing ROW
P2013_1-7G	PSE&G	\$ 1,034	New Freedom - Smithburg and Salem-Hope Creek 500 kV lines	Same as 7F with a Loop into a new Larrabee 500 kV station
P2013_1-7H	PSE&G	\$ 1,177	New Freedom - Whitpain and Salem - Hope Creek 500 kV lines	Northern Route
P2013_1-7I	PSE&G	\$ 1,353	New Freedom - Whitpain and Salem - Hope Creek 500 kV lines	Same as 7H with the Southern Route
P2013_1-7J	PSE&G	\$ 915	New Freedom - New Station on Branchburg-Elroy 500 kV line ("5017 Junction") and Salem - Hope Creek 500 kV line	Existing ROW
P2013_1-7K	PSE&G	\$ 1,066	New Freedom - Deans & Salem - Hope Creek - Red Lion 500 kV lines w/ Hope Creek - Red Lion (new);	Same as 7E with Hope Creek - Red Lion
P2013_1-7L	PSE&G	\$ 1,250	New Freedom - Smithburg & Salem - Hope Creek - Red Lion 500 kV lines w/ Hope Creek - Red Lion (new);	Same as 7F with Hope Creek - Red Lion
P2013_1-7M	PSE&G	\$ 1,548	New Freedom - Whitpain (North) & Salem - Hope Creek - Red Lion 500 kV lines w/ Hope Creek - Red Lion (new);	Same as 7H with Hope Creek - Red Lion
P2013_1-7N	PSE&G	\$ 1,289	New Freedom - a new Station on the Branchburg-Elroy 500 kV line ("5017 Junction") & Salem-Hope Creek - Red Lion 500 kV lines w/ Hope Creek - Red Lion (new);	

Artificial Island Proposals



Artificial Island Area Network



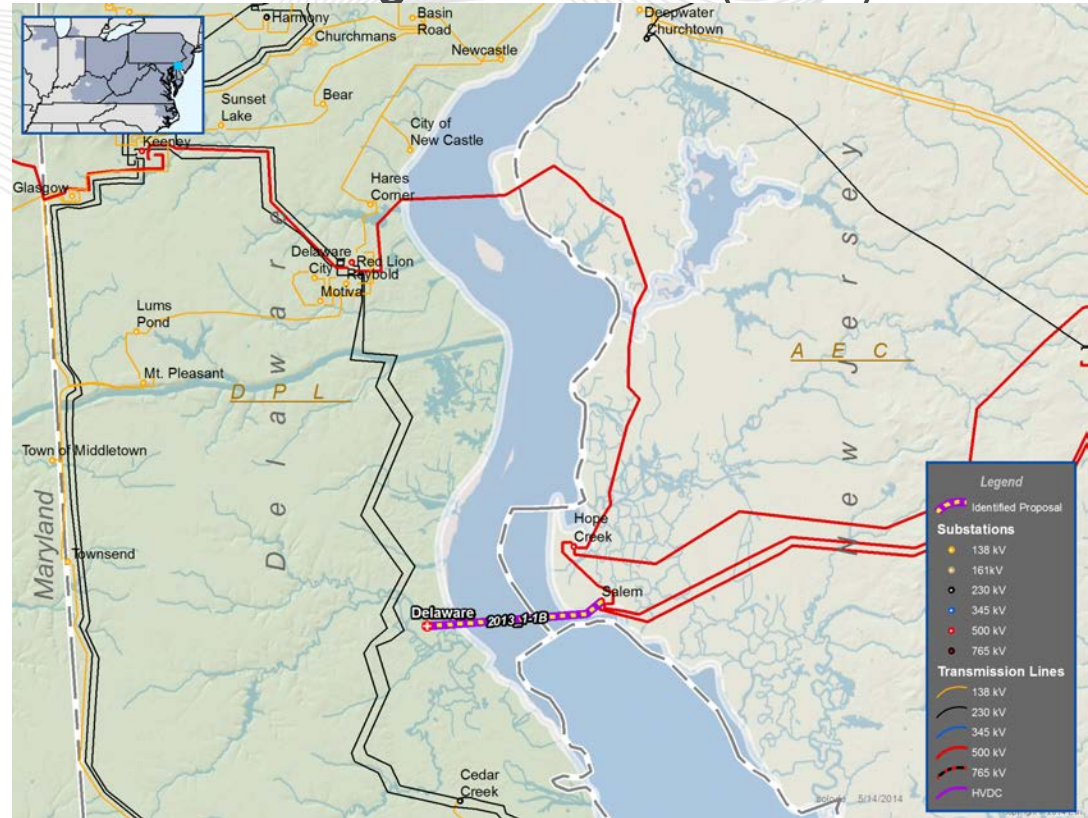
Dominion Virginia Power (DVP) 1A

- New switching station cutting the 5023 and 5024 lines near New Freedom substation that includes
 - a 500kV SVC (+500 to -300 MVar)
 - Two Thyristor Controlled Series Compensation (TCSC) devices
- Proposed Cost Estimate: \$130MM



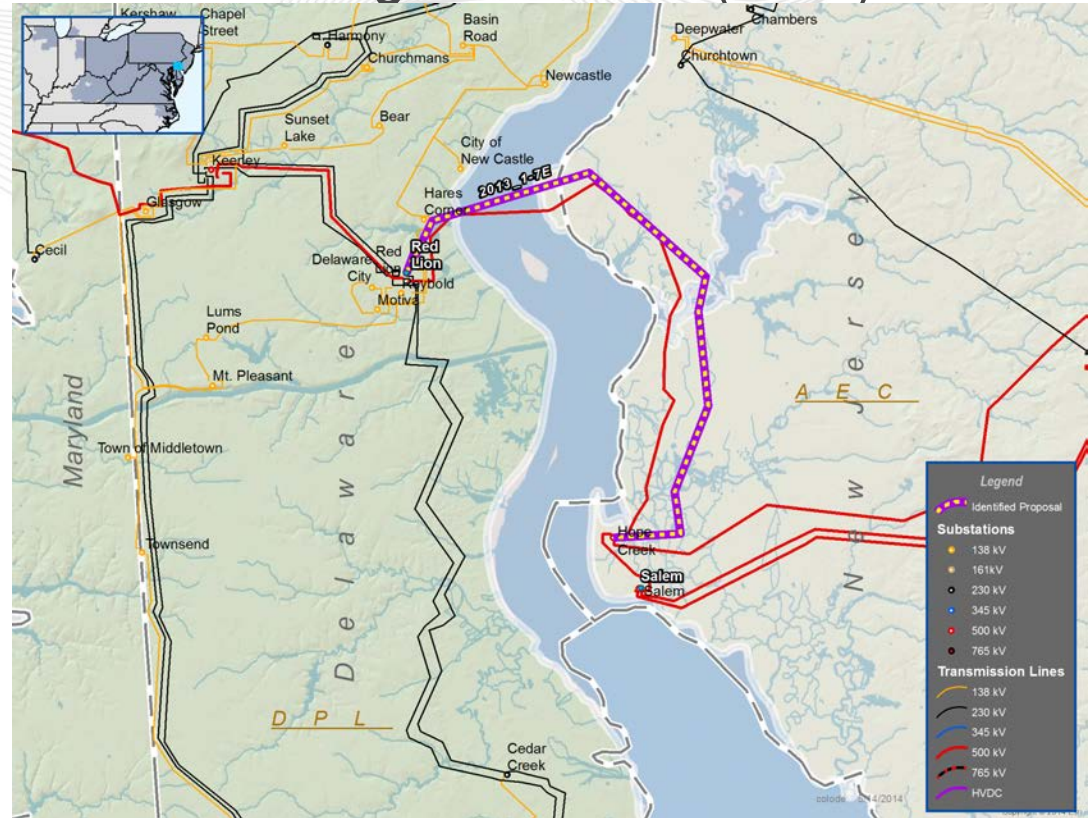
Dominion Virginia Power (DVP) 1B

- Install a new 500kV line from Salem 500kV to a new station in Delaware
- Aerial crossing of the Delaware river
- New substation in Delaware that taps the existing Red Lion to Cartanza 230kV and Red Lion to Cedar Creek 230kV lines
- Proposed Cost Estimate: \$133MM



- Expansion of Hope Creek substation
- 17 mile 500kV line from Hope Creek to Red Lion
 - Parallels existing 5015 Red Lion to Hope Creek 500 kV line
- Second Hope Creek to Salem tie line
- Reconfiguration of Red Lion substation into a breaker and a half scheme
- Proposed Cost Estimate: \$199MM

Dominion Virginia Power (DVP) 1C

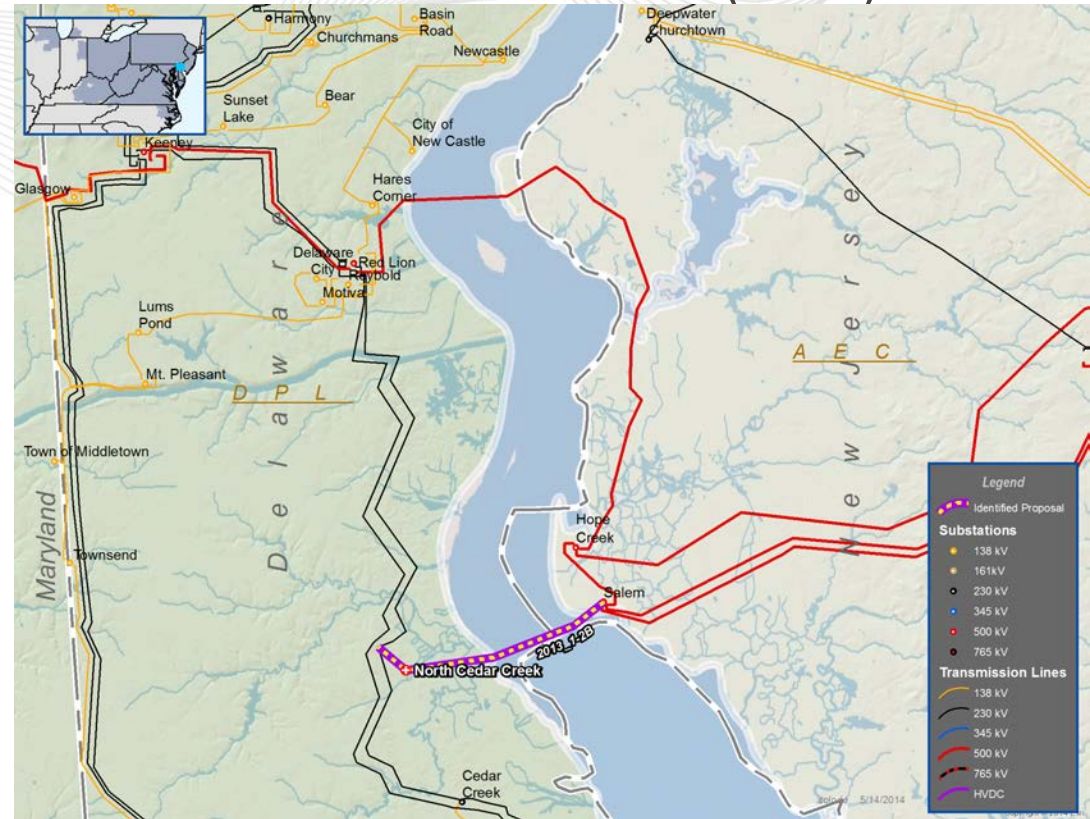


- Expansion of the Salem substation
- New substation near Artificial Island with two 500/230 kV autotransformers
- Submarine line under the Delaware river
- Expand existing Cedar Creek substation to accept the new line and to loop in the Red Lion – Cartanza 230kV line
- Proposed Cost Estimate: \$213-\$269MM

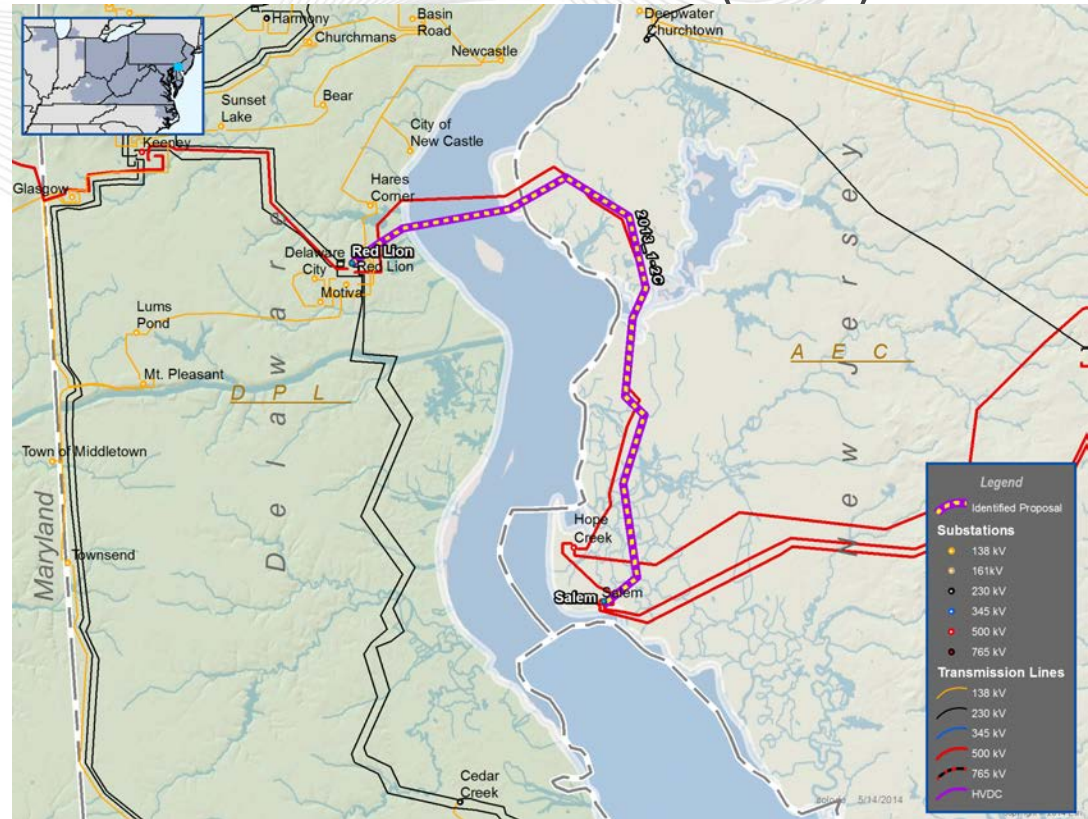
Transource (AEP) 2A



- Expansion of the Salem substation
- New substation near Artificial Island with two 500/230 kV autotransformers
- Submarine line under the Delaware river
- New substation in Delaware that taps the existing Red Lion to Cartanza 230 kV and Red Lion to Cedar Creek 230 kV lines
- Proposed Cost Estimate: \$165-\$208MM



- Expansion of Salem substation
- Move 5024 and 5021 line bays within Salem substation
- 17 mile 500kV line from Red Lion to Salem
 - Parallels existing 5015 Red Lion to Hope Creek 500 kV line
- Reconfiguration of Red Lion substation into a breaker and a half scheme
- Proposed Cost Estimate: \$123-\$156MM



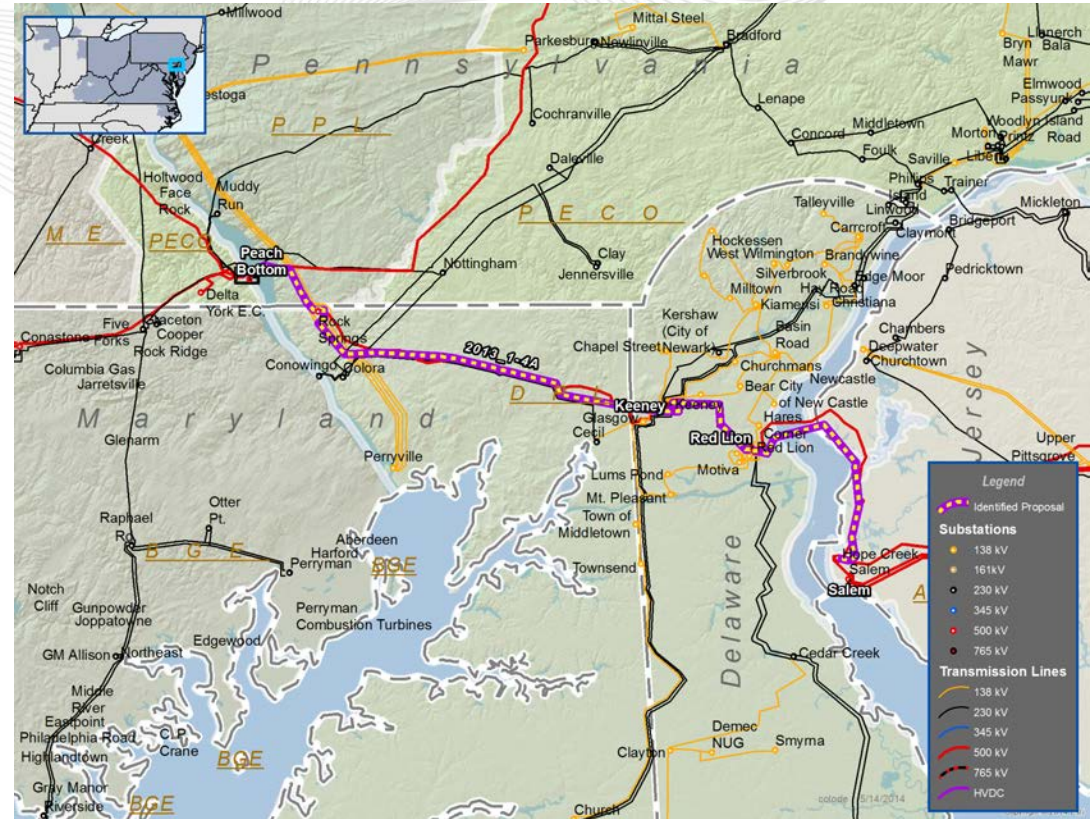
Transource (AEP) 2D

- Install a new 500kV line from New Freedom to Lumberton to North Smithburg
- New 500/230 substation east of Lumberton
- Second Hope Creek to Salem 500kV tie line
- Proposed Cost Estimate: \$788-\$994MM

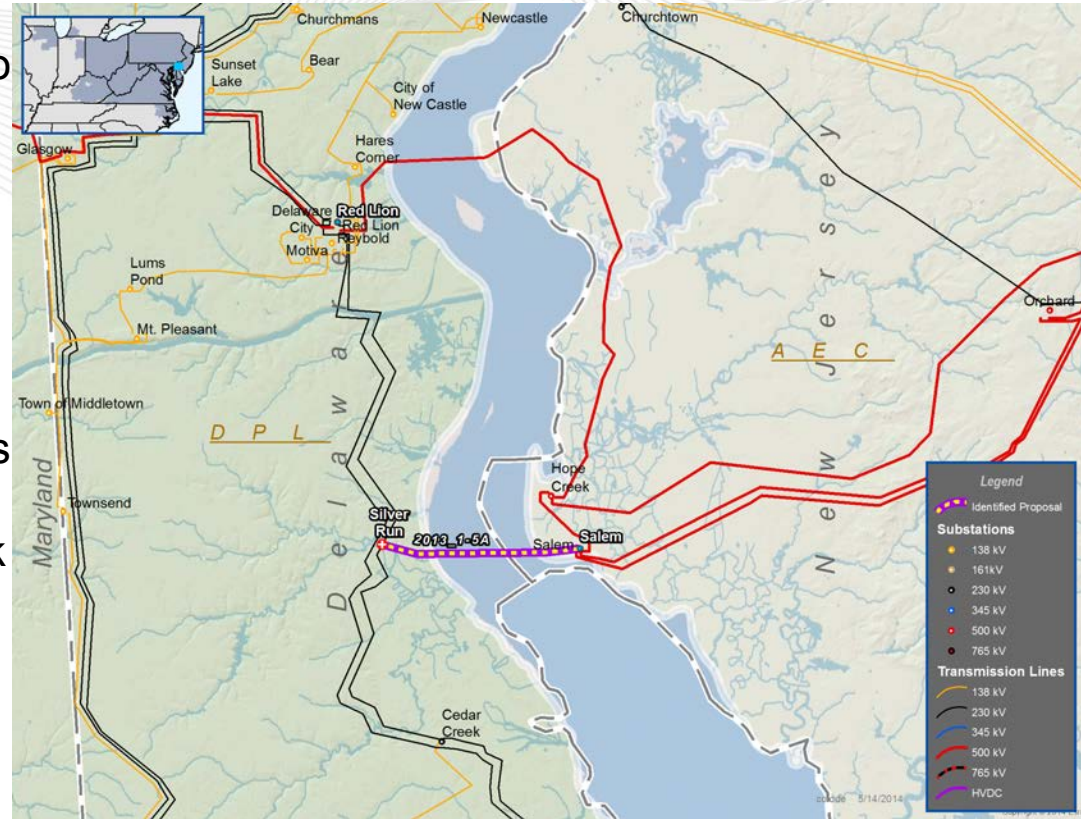


-

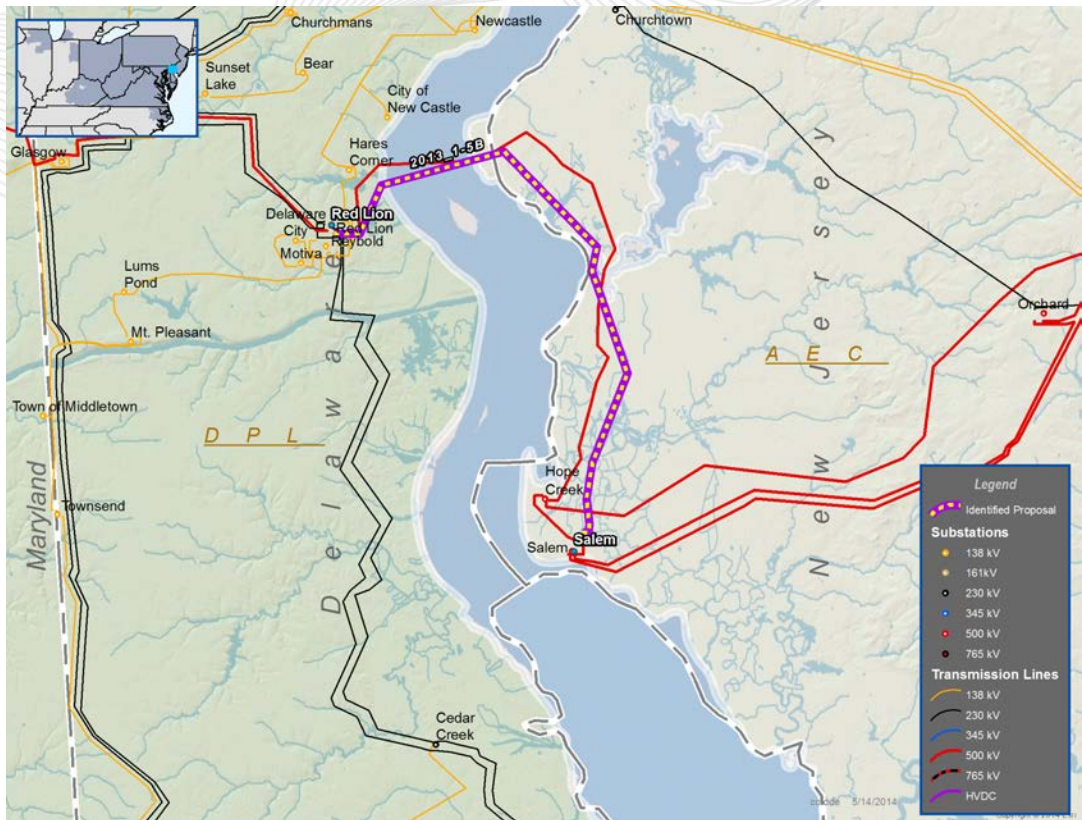
- Install a new Peach Bottom to Keeney to Red Lion to Salem 500kV line
- Remove existing Keeney to Red Lion 230 kV circuit
- Reconfigure the existing 230 kV line from Hay Road to Red Lion to terminate at Keeney instead of Red Lion
- Re-conductor the Harmony to Chapel Street 138 kV line
- Proposed Cost Estimate: \$475MM



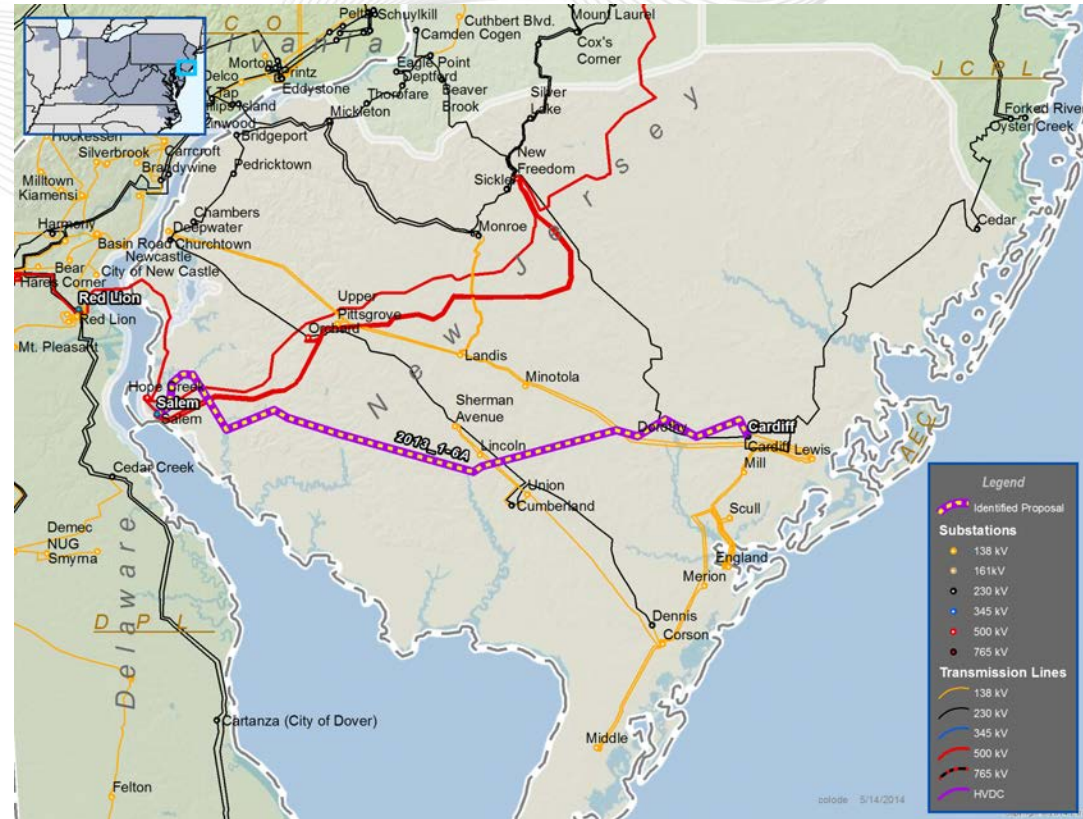
- Expansion of the Salem substation to the south to include a new 500/230kV auto-transformer
- Submarine or aerial line over the Delaware
- New substation in Delaware that taps the existing Red Lion to Cartanza 230 kV and Red Lion to Cedar Creek 230 kV lines
- Proposed Cost Estimate: \$116 - \$148MM



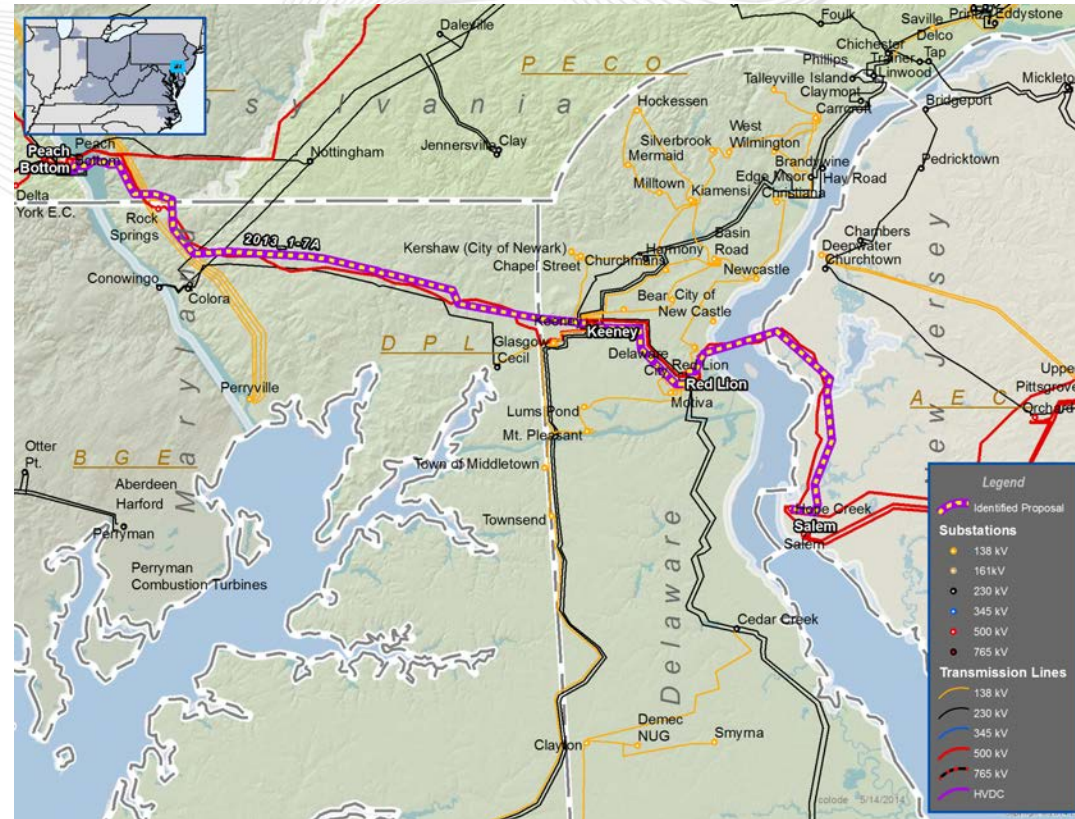
- Expansion of Salem substation
- 17 mile 500kV line from Red Lion to Salem
 - Parallels existing 5015 Red Lion to Hope Creek 500 kV line
- Expansion of Red Lion substation ring-bus
- Proposed Cost Estimate: \$170MM



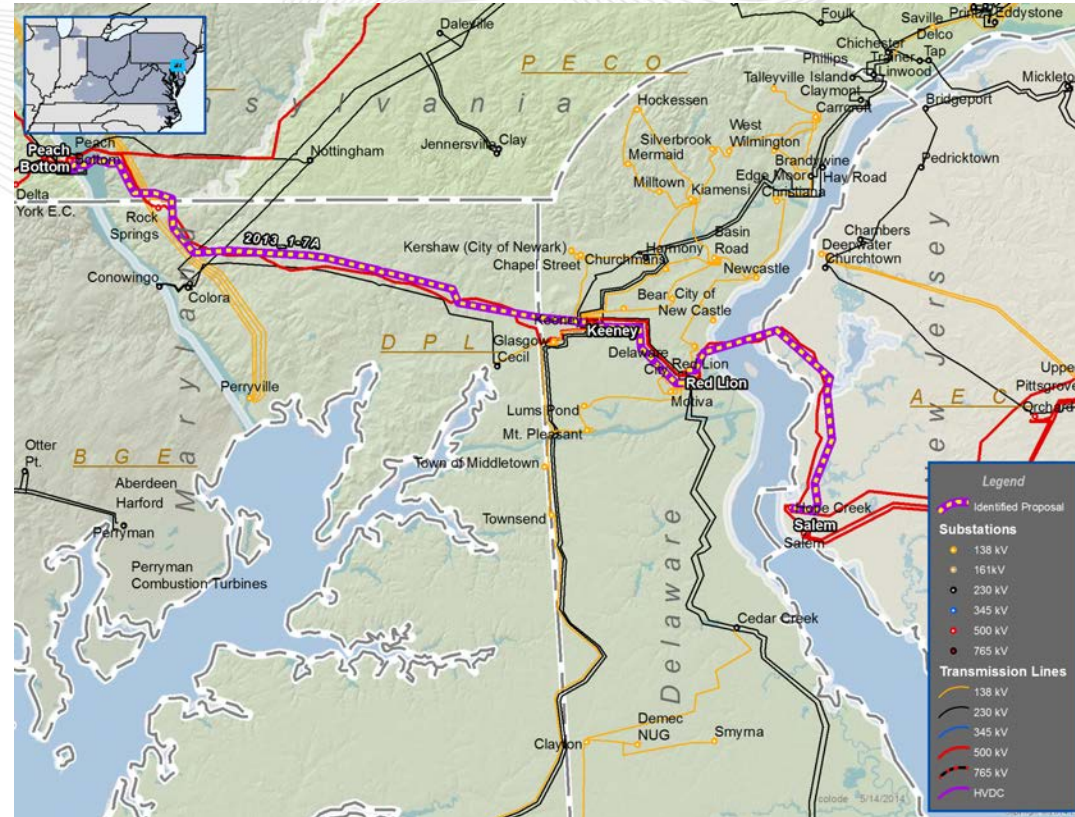
- Install a HVDC converter station near the Artificial Island
 - Install a SVC at the new Artificial Island HVDC station
- Install a HVDC converter station near the existing Cardiff 230 kV
- Install a 320kV HVDC line from the new Artificial Island HVDC station and the new HVDC station near Cardiff 230kV
- Proposed Cost Estimate : \$1,012MM



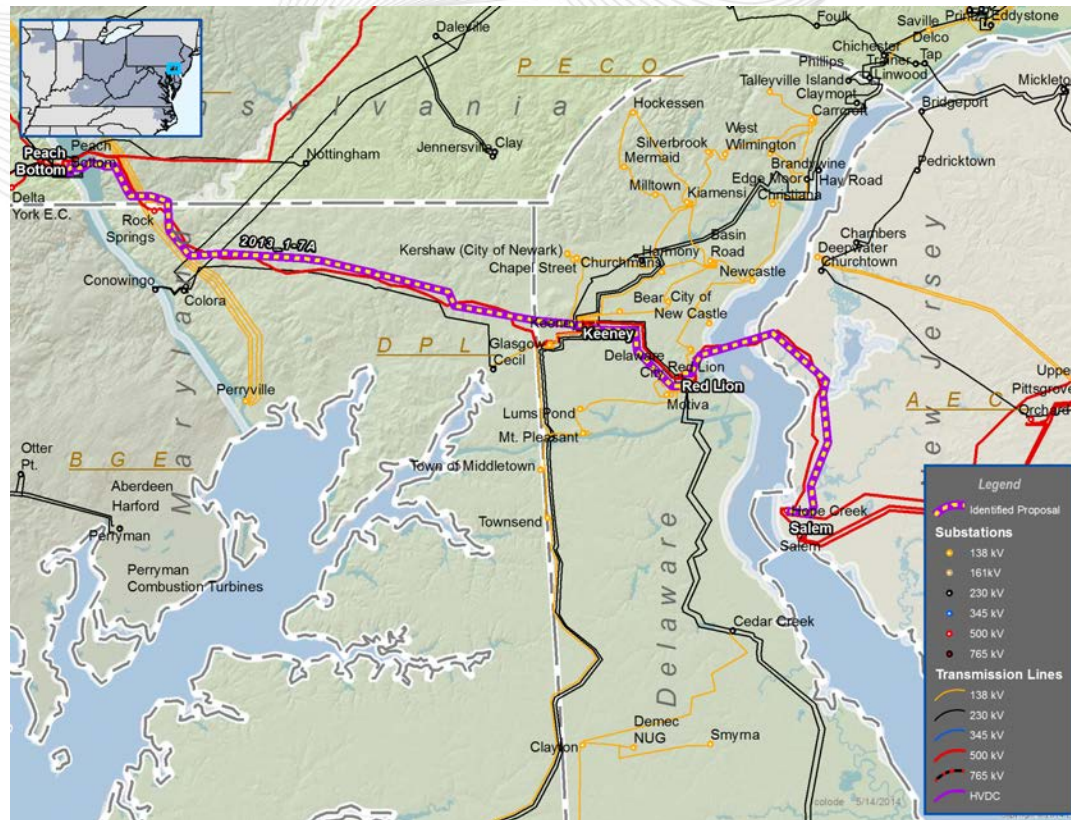
- Second Salem to Hope Creek tie line
- Install a new Hope Creek to Peach Bottom 500 kV line on existing right of way
- Proposed Cost Estimate: \$1,371MM



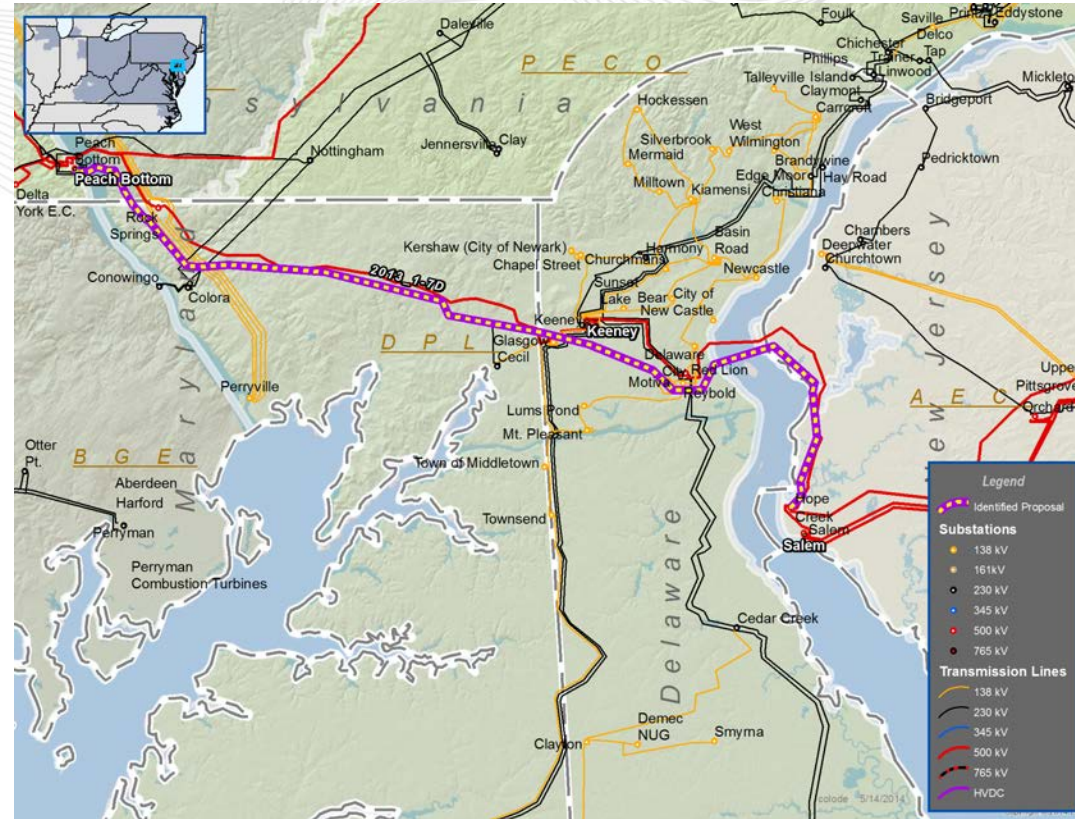
- Second Salem to Hope Creek tie line
- Install a new Hope Creek to Keeney to Peach Bottom 500 kV line on existing right of way
- Tie 5036 and 5025 lines together to open a bay position at Keeney substation
- Proposed Cost Estimate: \$1,372MM



- Second Salem to Hope Creek tie line
- Install a new Hope Creek to Red Lion to Peach Bottom 500 kV line on existing right of way
- Tie 5036 and 5015 lines together to open a bay position at Red Lion substation
- Proposed Cost Estimate: \$1,372MM



- Second Salem to Hope Creek tie line
- Install a new Hope Creek to Peach Bottom 500 kV line on new right of way
- Proposed Cost Estimate: \$831MM



- Second Salem to Hope Creek tie line
- Install a new 500kV line Deans to New Freedom
- Proposed Cost Estimate: \$692MM



- Second Salem to Hope Creek tie line
- Install a new Smithburg to New Freedom 500kV line
- Proposed Cost Estimate: \$879MM



- Second Salem to Hope Creek tie line
- Install a new Smithburg to Larrabee to New Freedom 500kV line
- Expand Larrabee substation to accept the new 500kV connection
- Proposed Cost Estimate: \$1,034MM



- Second Salem to Hope Creek tie line
- Install a new Whitpain to New Freedom 500kV line using a northern route
- Proposed Cost Estimate: \$1,177MM



-
- The map displays the proposed high-voltage transmission lines and substations for the New Jersey and Pennsylvania region. The map includes labels for various towns and cities, as well as major roads and water bodies. A legend in the bottom right corner identifies the symbols for substations and transmission lines. An inset map in the top left corner shows the location of the study area within the larger context of the Northeast United States.
- Legend**
- Identified Proposal
 - Substations
 - 138 kV
 - 161kV
 - 230 kV
 - 345 kV
 - 500 kV
 - 765 kV
 - Transmission Lines
 - 138 kV
 - 230 kV
 - 345 kV
 - 500 kV
 - 765 kV
 - HVDC

- Second Salem to Hope Creek tie line
- New substation at the 5017 junction site cutting the 5017 Elroy to Branchburg line
- Install a new 5017 Junction to New Freedom 500kV line
- Proposed Cost Estimate: \$915MM



- Second Salem to Hope Creek tie line
- 17 mile 500kV line from Hope Creek to Red Lion
 - Parallels existing 5015 Red Lion to Hope Creek 500 kV line
- Install a new Deans to New Freedom 500kV line
- Proposed Cost Estimate: \$1,066MM



- Second Salem to Hope Creek tie line
- 17 mile 500kV line from Hope Creek to Red Lion
 - Parallels existing 5015 Red Lion to Hope Creek 500 kV line
- Install a new Smithburg to New Freedom 500kV line
- Proposed Cost Estimate: \$1,250MM



- Second Salem to Hope Creek tie line
- 17 mile 500kV line from Hope Creek to Red Lion
 - Parallels existing 5015 Red Lion to Hope Creek 500 kV line
- Install a new Whitpain to New Freedom 500kV line using a northern route
- Proposed Cost Estimate: \$1,548MM



- Second Salem to Hope Creek tie line
- 17 mile 500kV line from Hope Creek to Red Lion
 - Parallels existing 5015 Red Lion to Hope Creek 500 kV line
- New substation at the 5017 junction site cutting the 5017 Elroy to Branchburg line
- Install a new 5017 Junction to New Freedom 500kV line
- Proposed Cost Estimate: \$1,289MM



Artificial Island Project Evaluation

Objectives

- ✓ Achieve desired system performance
- ✓ Minimize initial project cost
- ✓ Assess risk factors to minimize impact to cost and schedule
- ✓ Minimize impact to transmission operations
- ✓ No adverse impact to nuclear licensing

Evaluation of Proposals – PJM Approach

- Performed extensive technical analysis
 - Stability, thermal, voltage, short circuit, market efficiency
 - Studied all solutions as is and with modifications

Initial analysis showed only two of the highest cost solutions worked as submitted

- Engage outside engineers to perform constructability review
 - *focus on physical, cost, schedule, RoW, siting, permitting*
- Met with all proposers for clarification as needed
- Met with AI nuclear plant representatives
- PJM Operations review
- PJM independent cost evaluation
- Met with equipment manufacturers



Artificial Island Evaluation Considerations

- Primary Considerations
 - Technical Analysis
 - Thermal
 - Stability
 - Short-circuit
 - Voltage
 - NERC Cat-D Contingencies
 - Cost Factors
 - Cost effectiveness
 - Market efficiency
 - PJM estimated costs
- Secondary Considerations
 - Schedule
 - Permitting
 - Construction
 - Long lead time equipment
 - Project Complexity
 - Line crossings
 - Outage requirements
 - Modifications to other transmission facilities
 - Modification to Artificial Island substations
 - Modifications to Red Lion substation
 - Right of Way and Land Acquisition
 - No eminent domain in Delaware
 - New right of way required
 - Substation land required
 - Siting and Permitting
 - Wetlands impact
 - Public opposition risk
 - Delaware river crossing
 - Land permitting
 - Historic and scenic highway
 - Operational Impact
 - Artificial island facility requirements
 - Ongoing maintenance
 - Blackstart
 - Route diversity

Project Modifications

- Identified and implemented by PJM
- Modification Examples to Improve Performance
 - Move connection point to eliminate a critical fault
 - Add SVC to improve stability performance
- Modification Examples to reduce cost and improve constructability
 - Remove proposed new breakers that aren't needed to pass applicable criteria testing
 - Remove proposed transmission that isn't needed to pass applicable criteria testing

		Southern Crossing Lines (Submarine)			Southern Crossing Lines (Overhead)		Red Lion to Artificial Island Lines						
							From Salem			From Hope Creek			
		LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - Overhead	Dominion 1B - 500kV Overhead	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion 1C - Red Lion to Hope Creek (Remove RL - HK)	PSE&G 7K- Red Lion to Hope Creek (Remove RL - HK)
Modifications	SVC Additions at Orchard, NF, AI	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓*	✓*
	Moved Connection At Salem or Hope Creek						✓						✓
	Removed proposed breakers					✓				✓		✓	✓
	Removed proposed Transmission										✓	✓	✓

* SVC option at AI is excluded.

PJM Evaluation of Potential Solutions

- New switching station cutting New Freedom to Hope Creek and New Freedom to Salem (5023 and 5024) lines. Two Thyristor Controlled Series Compensation (TCSC) devices at the new station.
- PJM modifications
 - Changed SVC size



- **Stability Performance**

- Failed required performance
 - Failed as proposed by project sponsor. Did not satisfy stability criteria for a three phase fault with normal clearing with AI units at unity power factor under 5038 maintenance outage condition
- Passed required performance when SVC size increased to 750MVAR to achieve acceptable performance.
- Stability performance is not as good as 230kV options + SVC or as good as 500kV options + SVC.
- Anticipate nuclear regulatory concerns in approving this configuration.

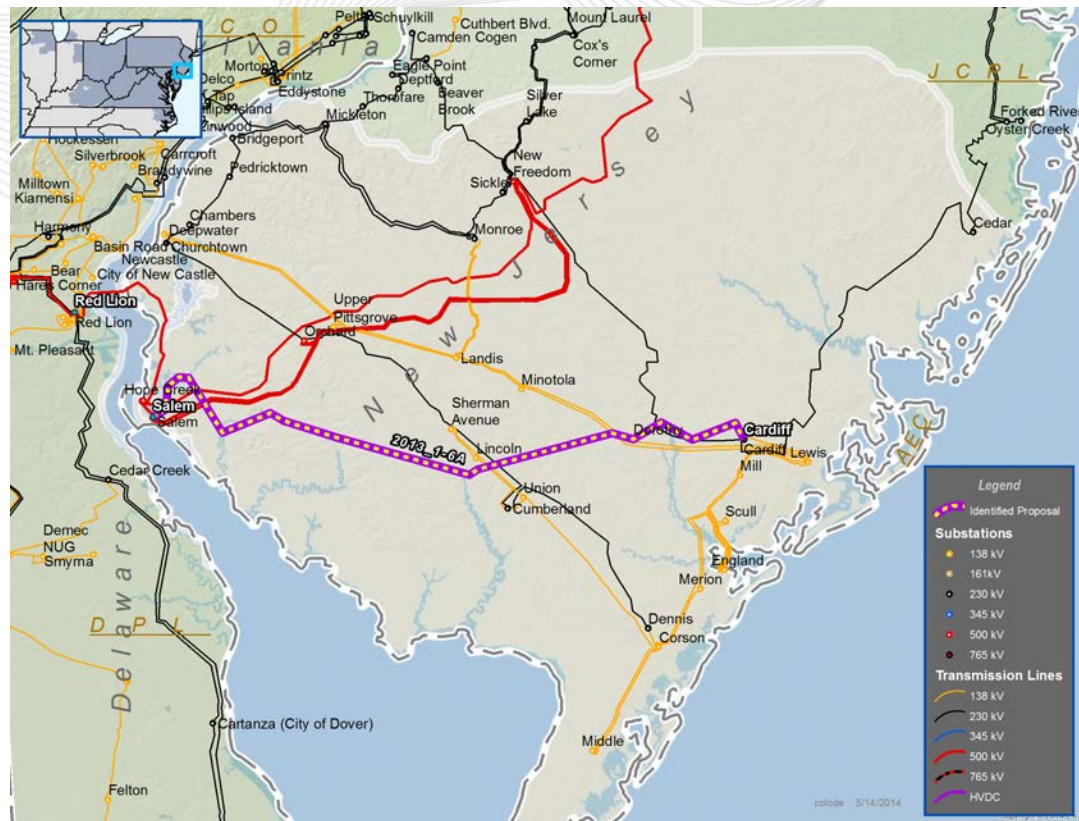
- Lines between:
 - New Freedom to Lumberton
 - Lumberton to North Smithburg
 - Hope Creek to Salem tie
- Estimated costs higher than other proposals



- Lines between:
 - Smithburg to Larrabee
 - Larrabee to New Freedom
 - Hope Creek to Red Lion
- Estimated costs higher than other proposals



- HVDC line between Artificial Island and Cardiff
- SVC at Artificial Island converter station
- Estimated costs higher than other proposals

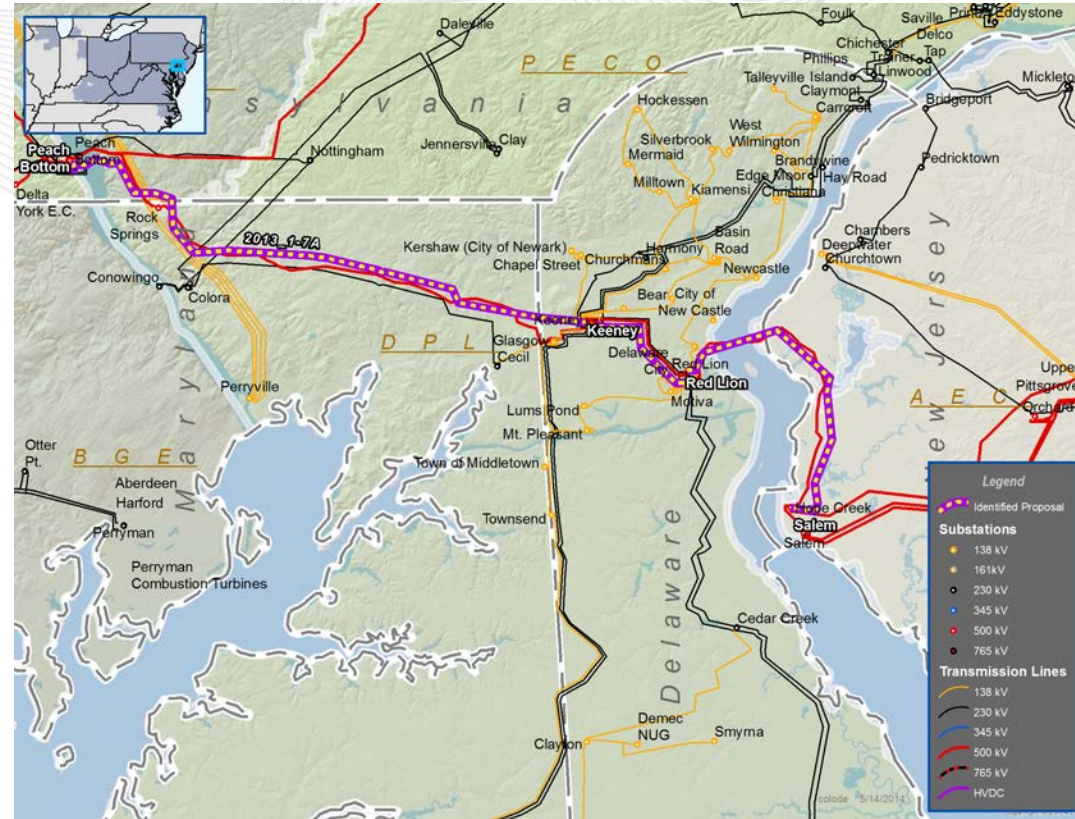


- **Stability Performance**

- Failed required performance

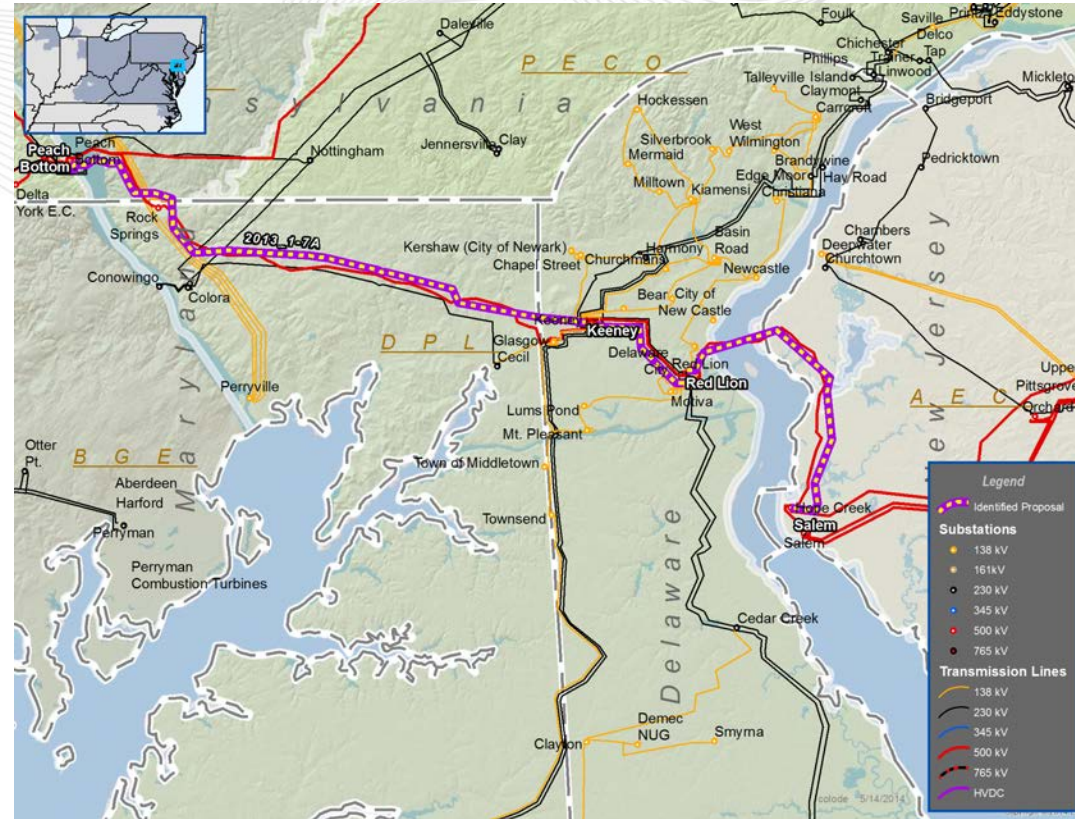
- Failed as proposed by project sponsor.
 - Did not satisfy stability criteria for a SLG fault with stuck breaker with AI units at unity power factor under 5015 maintenance outage condition without significant MW flow on the proposed HVDC facility from the AI to Cardiff.

- Lines between:
 - Salem to Hope Creek tie
 - Hope Creek to Peach Bottom (existing right of way)
- Estimated costs higher than other proposals



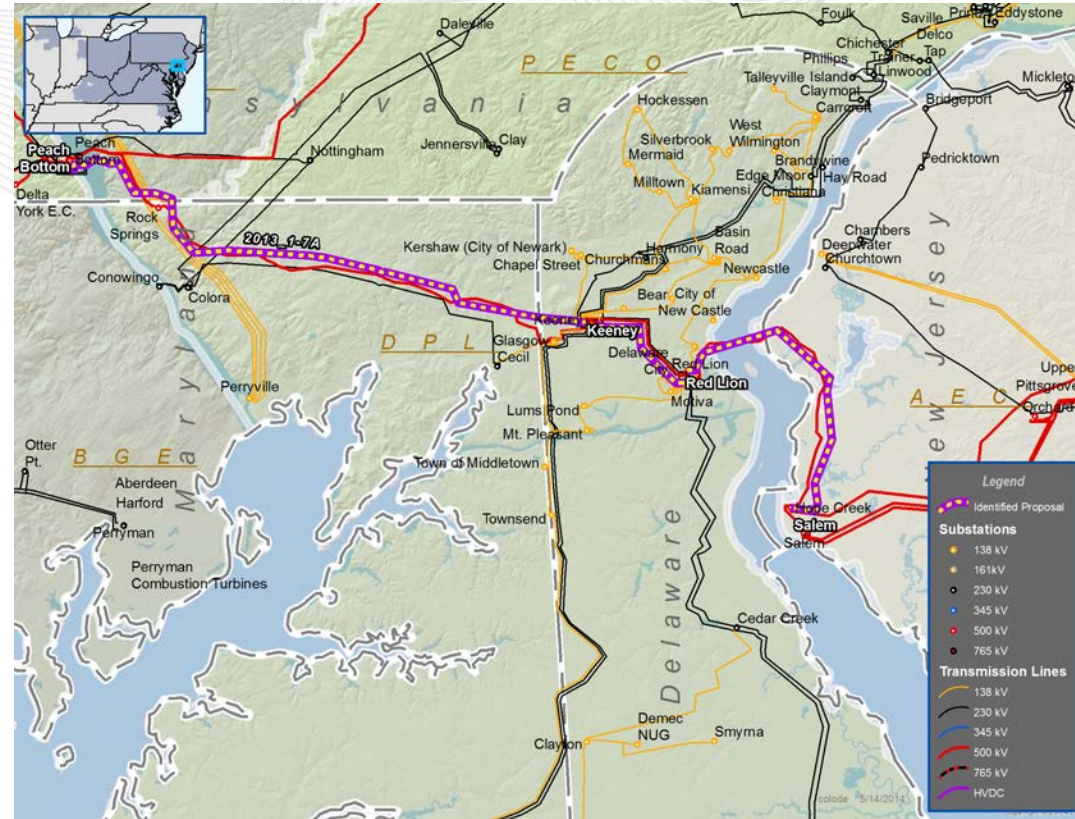
- Lines between:
 - Salem to Hope Creek tie
 - Hope Creek to Keeney
 - Keeney to Peach Bottom
 - Remove Keeney from existing Rock Springs to Keeney to Red Lion lines (5025 and 5036)

- Estimated costs higher than other proposals

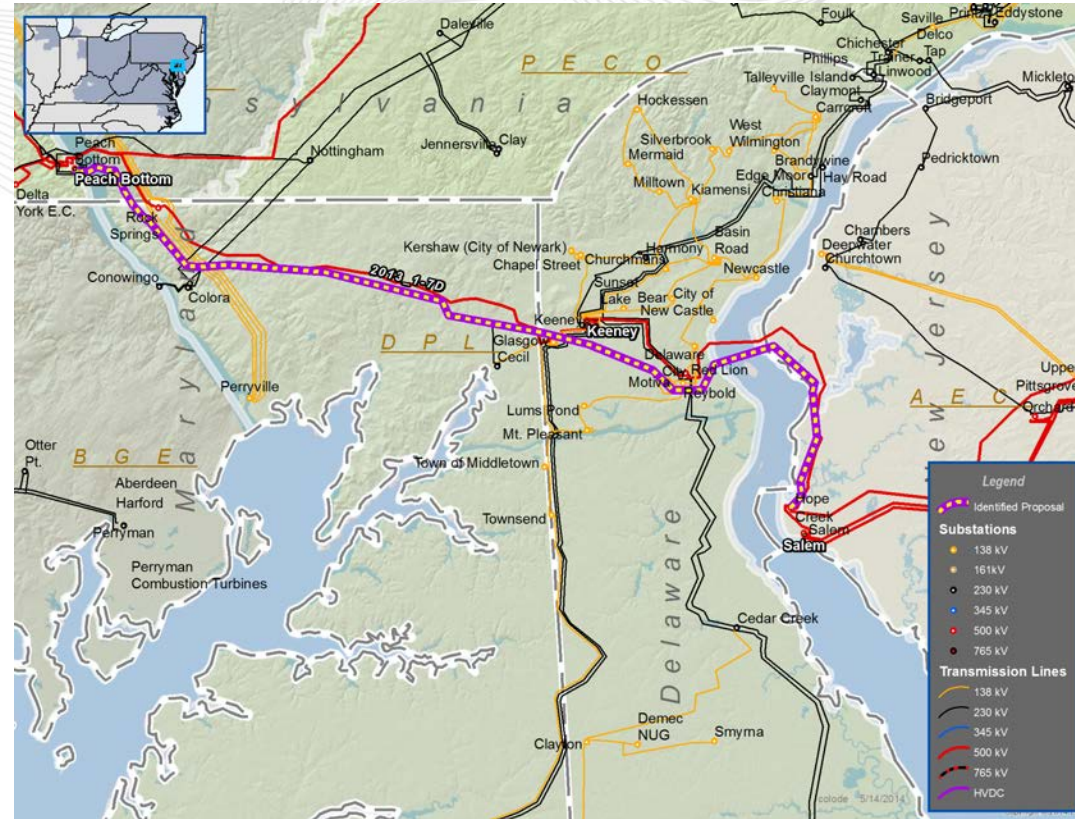


- Lines between:
 - Salem to Hope Creek tie
 - Hope Creek to Red Lion
 - Red Lion to Peach Bottom
 - Remove Red Lion from existing Keeney to Red Lion to Hope Creek lines (5036 and 5015)

- Estimated costs higher than other proposals



- Lines between:
 - Salem to Hope Creek tie
 - Hope Creek to Peach Bottom (new right of way)
- Estimated costs higher than other proposals



- Lines between:
 - Salem to Hope Creek tie
 - Deans to New Freedom
- Estimated costs higher than other proposals



- Lines between:
 - Salem to Hope Creek tie
 - Smithburg to New Freedom
- Estimated costs higher than other proposals



- Lines between:
 - Salem to Hope Creek tie
 - Smithburg to Larrabee
 - Larrabee to New Freedom
- Estimated costs higher than other proposals



- Lines between:
 - Salem to Hope Creek tie
 - Whippen to New Freedom (northern route)
- Estimated costs higher than other proposals



- Lines between:
 - Salem to Hope Creek tie
 - Whippen to New Freedom (northern route)
- Estimated costs higher than other proposals



- Lines between:
 - Salem to Hope Creek tie
 - Whippain to New Freedom (southern route)
- Estimated costs higher than other proposals



- Lines between:
 - Salem to Hope Creek tie
 - 5017 Junction (cutting the 5017 Elroy to Branchburg line) to New Freedom
- Estimated costs higher than other proposals



- Lines between:
 - Salem to Hope Creek tie
 - Hope Creek to Red Lion
 - New Smithburg to New Freedom
- Estimated costs higher than other proposals



-
- Legend**
- Identified Proposal**
- 138 kV
 - 161 kV
 - 230 kV
 - 345 kV
 - 500 kV
 - 765 kV
 - HVDC
- Transmission Lines**
- 138 kV
 - 230 kV
 - 345 kV
 - 500 kV
 - 765 kV
 - HVDC

- Lines between:
 - Salem to Hope Creek tie
 - Hope Creek to Red Lion
 - 5017 Junction (cutting the 5017 Elroy to Branchburg line) to New Freedom
- Estimated costs higher than other proposals

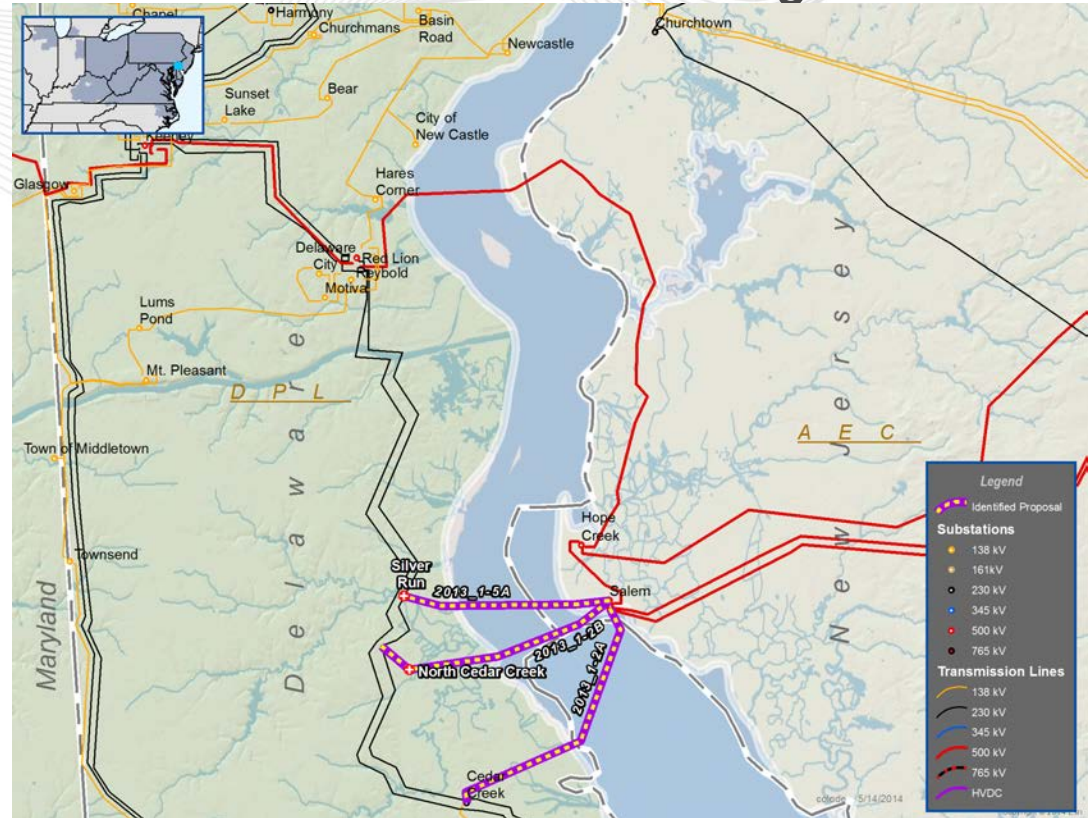


Submarine Southern Delaware Crossing Lines

- Expansion of the Salem substation to the south
- Submarine line under the Delaware river
- New or expansion of existing substation in Delaware
- Proposing Entities:

Transource

LS Power



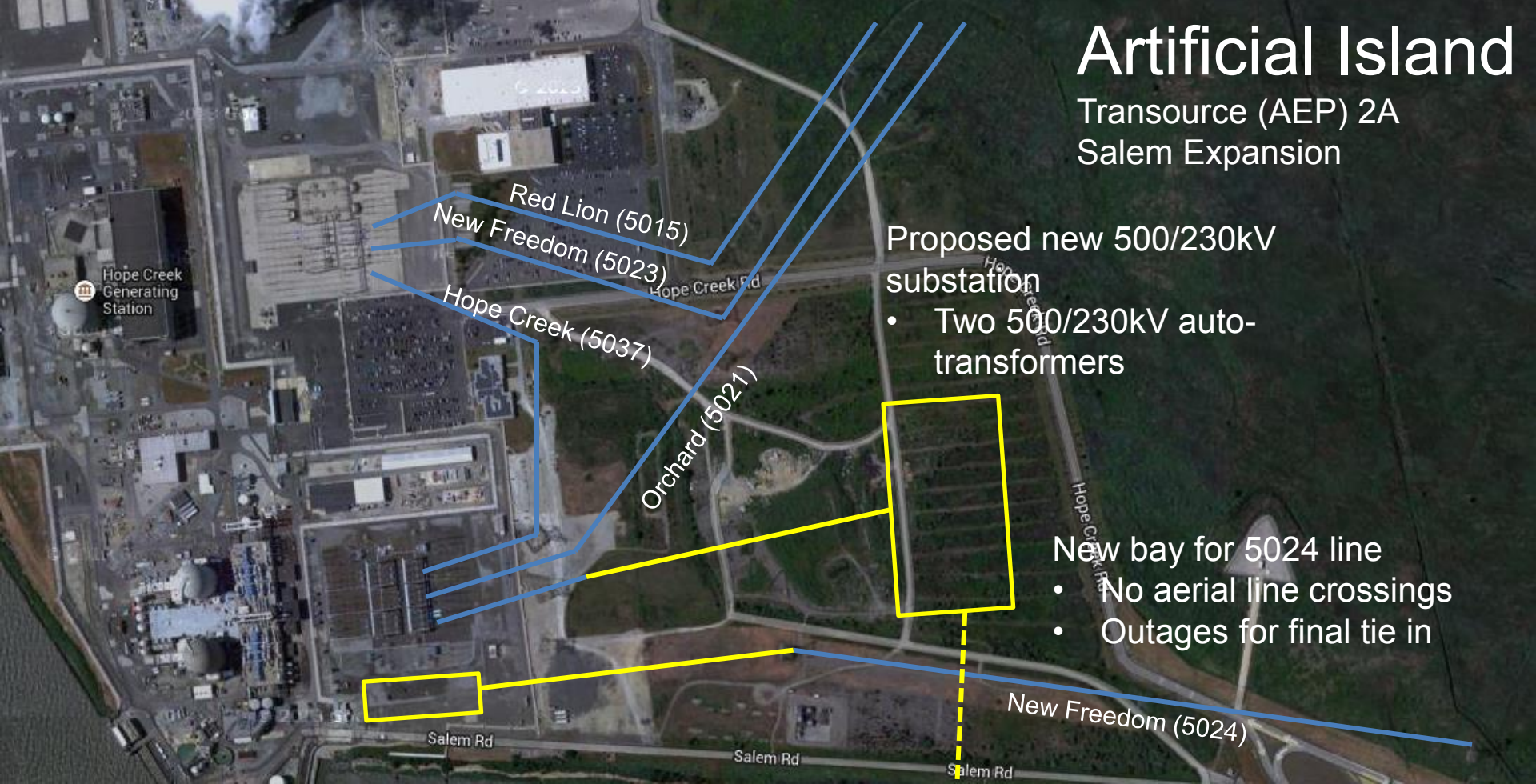
- Line between new substation near Artificial Island and Cedar Creek substation
- Submarine under the Delaware river
- PJM modifications
 - Technical:
 - Added SVC
 - Constructability:
 - Spare submarine cable added
 - New Salem connection as a full bay



- **Stability Performance**
 - Failed required performance
 - Failed as proposed by project sponsor
 - Did not satisfy stability criteria for a single line to ground fault with stuck breaker with AI units at unity power factor under 5015 maintenance outage condition.
 - Passed required performance
 - Passed when modified with the addition of an SVC at Orchard, New Freedom or Artificial Island

Artificial Island

Transource (AEP) 2A
Salem Expansion

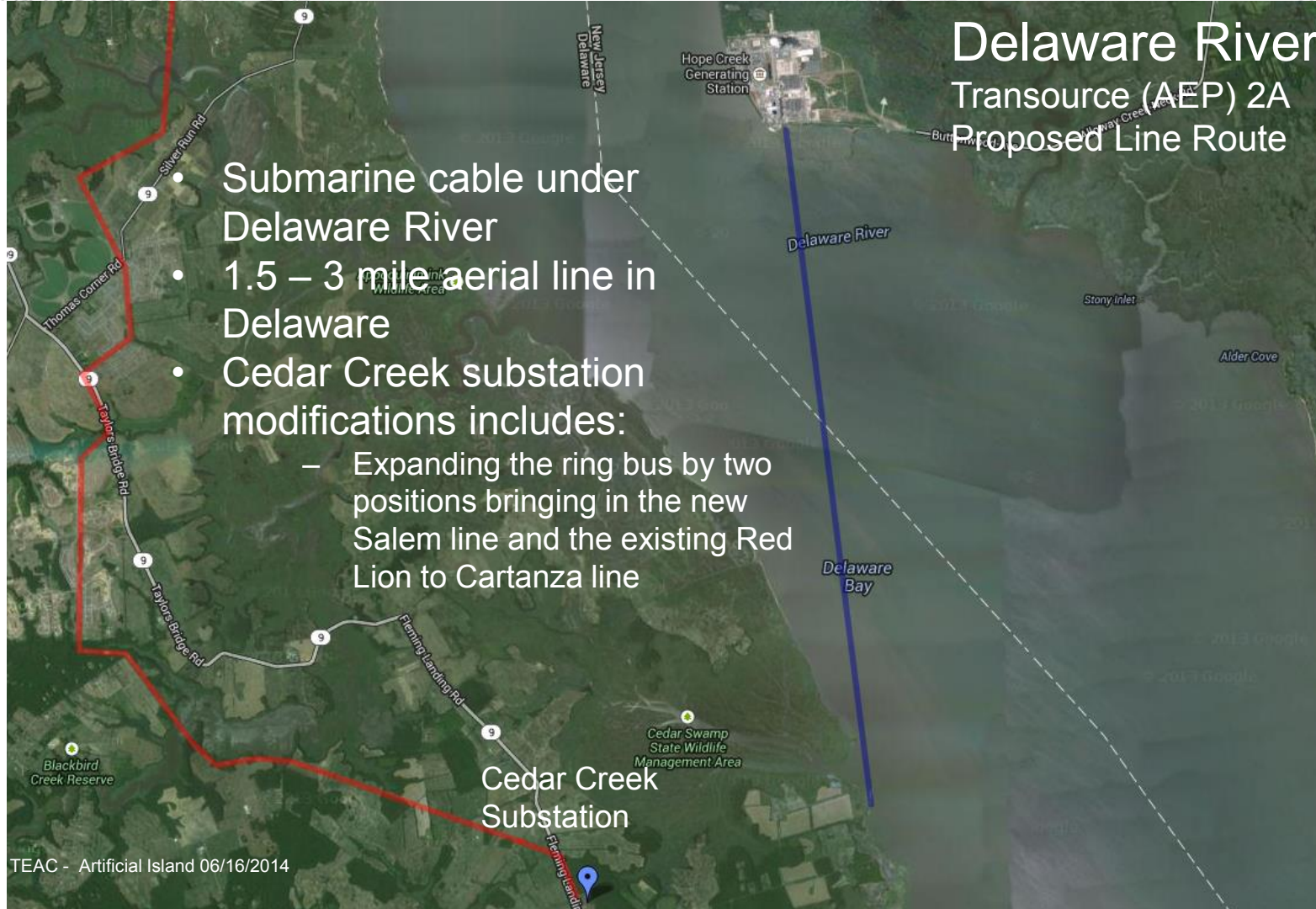


Delaware River

Transource (AEP) 2A

Proposed Line Route

- Submarine cable under Delaware River
- 1.5 – 3 mile aerial line in Delaware
- Cedar Creek substation modifications includes:
 - Expanding the ring bus by two positions bringing in the new Salem line and the existing Red Lion to Cartanza line





Transsource (AEP) 2A - Cost Factors

PJM Estimated Cost: \$366-\$446 (million)

- 5.7 circuit miles of submarine cable (two cables per phase plus one spare cable)
- Six 500/230kV auto-transformers

Proposed Cost Estimate: \$213-269 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
 - New path from the AI to Delaware (on the Cedar Creek - Catanza / Red Lion – Catanza path)
- Results:
 - Approximate benefit to cost ratio of 0.25
 - Approximately \$92 million over 15 years

Outage Cost

- 230kV outage during substation cut-in



Transsource (AEP) 2A - Project Schedule

Proposed Schedule 42 months (items run concurrent)

- Permitting: 24 months
- RoW acquisition: 12 months

Schedule Criteria

- Permitting
 - CPCNs in two states and Army Corps of Engineers
- Long Lead Time Materials
 - Auto-transformers and submarine cable
- Construction
 - Specialized equipment needed for submarine cable installation
 - Could be impacted by restrictions due to endangered species and shipping traffic

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
 - Approximately 3 miles of right of way needs to be acquired in Delaware
- New Right of Way Required
 - Approximately 3 miles of right of way needs to be acquired in Delaware
- Substation Land Required
 - Land in New Jersey will need to be acquired for the new substations

Siting and Permitting Criteria

- Wetlands Impact
 - Permits required to cross the Delaware state lands on the river coast
 - Impacts approximately 10 acres of forested wetlands
- Public Opposition Risk
 - Submarine crossing of the Delaware river does not incur any new view-shed impact
 - Some opposition to any river crossing is expected
- Historic and Scenic Highway
 - Not applicable
- Delaware River Crossing
 - Numerous approvals and permits required: (a few major permits are listed below)
 - Delaware River Basin Commission approval required
 - Delaware and New Jersey CPCNs required
 - US Army Corps of Engineers Section 404 and 10 authorizations
 - Multiple US Fish and Wildlife permits required
 - National Marine Fisheries Service



Transource (AEP) 2A - Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements

- PJM Operations Review
 - Request to minimize impact to existing transmission facilities
- Salem/Hope Creek Facility Owner Feedback
 - Request to minimize outage and physical impacts to existing transmission facilities
 - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
 - Salem control house is a part of plant facilities and access is constrained

- Blackstart

- 230kV connection may provide additional benefit

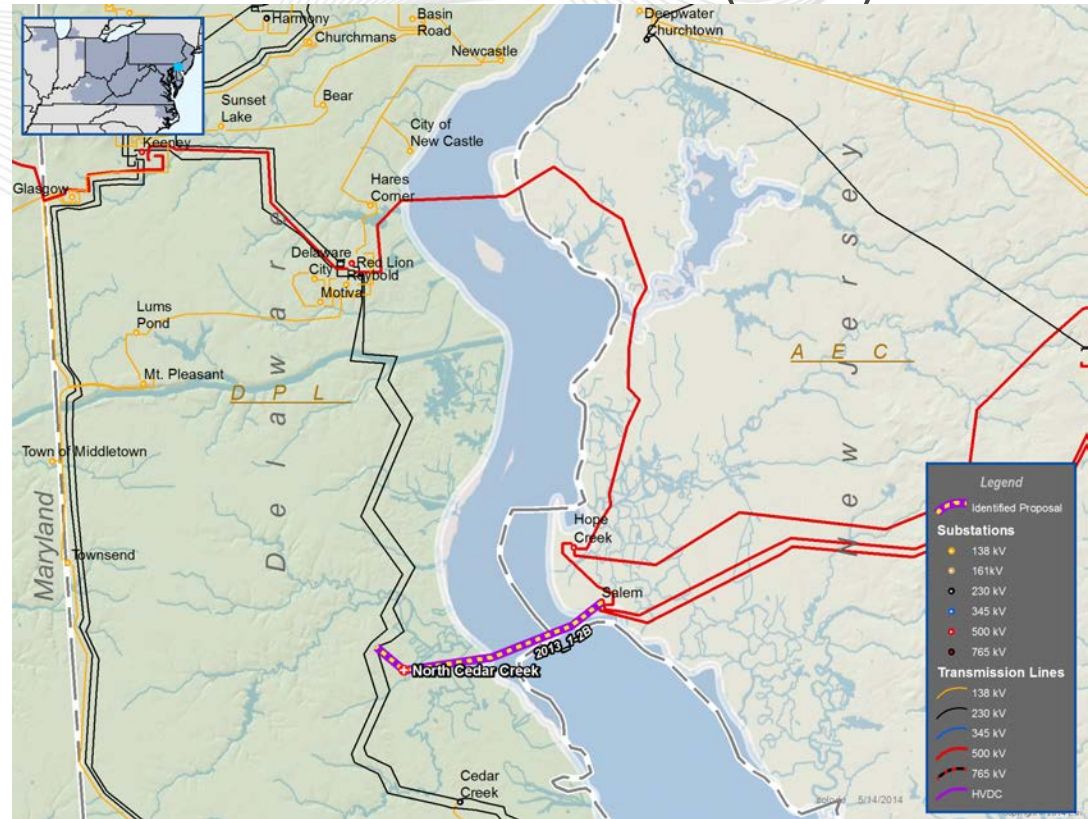
- Route Diversity

- Project route is new and does not parallel an existing line

- Ongoing Maintenance

- Auto-transformers as line component may increase outage frequency
- Salt spray concern with proximity to Delaware river

- Line between new substation near Artificial Island and new substation in Delaware
- Submarine under the Delaware river
- PJM modifications
 - Technical:
 - Added SVC
 - Constructability:
 - Spare submarine cable added
 - New Salem connection as a full bay



- **Stability Performance**

- **Failed required performance**

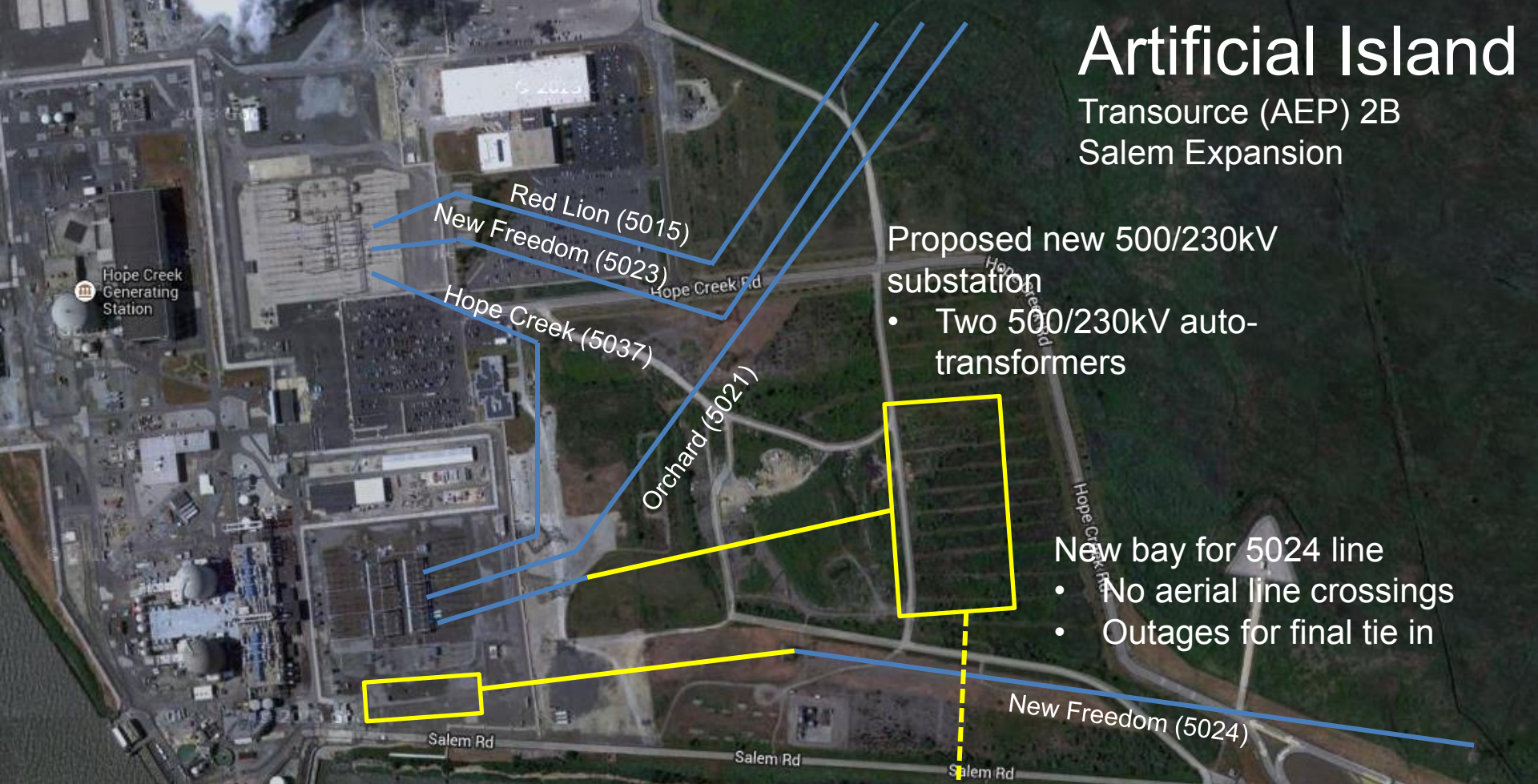
- Failed as proposed by project sponsor.
 - Did not satisfy stability criteria for a single line to ground fault with stuck breaker with AI units at unity power factor under 5015 maintenance outage condition.

- **Passed required performance**

- Passed as proposed with the addition of an SVC at Orchard, New Freedom or Artificial Island

Artificial Island

Transource (AEP) 2B
Salem Expansion



Delaware River

Transource (AEP) 2B

Proposed Line Route

Artificial Island

Hope Creek
Generating
Station

= 230kV
Corridor

Route 9

Silver Run Rd

Upper Break

Delaware
River

New Jersey
Delaware

Appoquinimink
Wildlife Area

- Approximately 3 mile submarine cable under Delaware River
- 1.5 – 3 mile aerial line in Delaware
- New substation in Delaware cut in two existing 230kV lines



Transsource (AEP) 2B - Cost Factors

PJM Estimated Cost: \$257-\$313 (million)

- Approximately 3 miles of submarine cable (two cables per phase plus one spare cable)
- Six 500/230kV auto-transformers

Proposed Cost Estimate: \$165-\$208 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
 - New path from the AI to Delaware (on the Cedar Creek - Catanza / Red Lion – Catanza path)
- Results:
 - Approximate benefit to cost ratio of 0.25
 - Approximately \$92 million over 15 years

Outage Cost

- 230kV outage during substation cut-in



Transsource (AEP) 2B - Project Schedule

Proposed Schedule 42 months (items run concurrent)

- Permitting: 30 months
- RoW acquisition: 9 months

Schedule Criteria

- Permitting
 - CPCNs in two states and Army Corps of Engineers
- Long Lead Time Materials
 - Auto-transformers and submarine cable
- Construction
 - Specialized equipment needed for submarine cable installation
 - Could be impacted by restrictions due to endangered species and shipping traffic



Transource (AEP) 2B - RoW and Land Acquisition

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
 - 1.5 to 3 miles of right of way needs to be acquired in Delaware
- New Right of Way Required
 - 1.5 to 3 miles of right of way needs to be acquired in Delaware
- Substation Land Required
 - Land in Delaware and New Jersey will need to be acquired for the new substations

Siting and Permitting Criteria

- Wetlands Impact
 - Permits required to cross the Delaware state lands on the river coast
 - New route will allow flexibility
- Public Opposition Risk
 - Submarine crossing of the Delaware river does not incur any new view-shed impact
 - Some opposition to any river crossing is expected
- Historic and Scenic Highway
 - Proposed line route crosses Delaware state route 9, which is classified as a 'Scenic and Historic' highway which may impact permitting
- Delaware River Crossing
 - Numerous approvals and permits required:
(a few major permits are listed below)
 - Delaware River Basin Commission approval required
 - Delaware and New Jersey CPCNs required
 - US Army Corps of Engineers Section 404 and 10 authorizations
 - Multiple US Fish and Wildlife permits required
 - National Marine Fisheries Service



Transsource (AEP) 2B - Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements

- PJM Operations Review
 - Request to minimize impact to existing transmission facilities
- Salem/Hope Creek Facility Owner Feedback
 - Request to minimize outage and physical impacts to existing transmission facilities
 - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
 - Salem control house is a part of plant facilities and access is constrained

- Blackstart

- 230kV connection may provide additional benefit

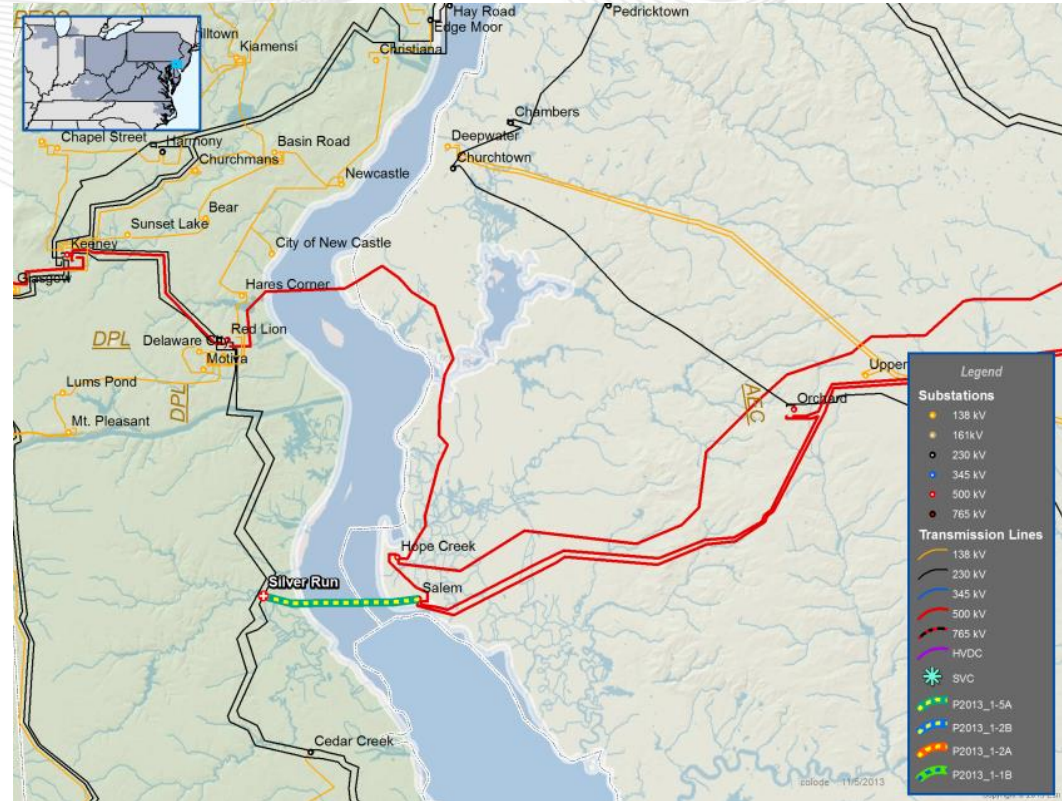
- Route Diversity

- Project route is new and does not parallel an existing line

- Ongoing Maintenance

- Auto-transformers as line component may increase outage frequency
- Salt spray concern with proximity to Delaware river

- Line between Salem and new substation in Delaware
- Submarine under the Delaware river
- PJM modifications
 - Technical:
 - Added SVC
 - Constructability:
 - Spare transformer phase added
 - Spare submarine cable added



- **Stability Performance**

- Failed required performance

- Failed as proposed by project sponsor.
 - Did not satisfy stability criteria for a three phase fault with AI units at unity power factor under 5015 maintenance outage condition.

- Passed required performance

- Passed as proposed with the addition of an SVC at Orchard, New Freedom or Artificial Island

Artificial Island

LS Power – Proposal 5A
Salem Expansion

New 500kV bay and 500/230kV autotransformer in Salem substation

- No aerial line crossings
- Outages for final tie in



Salem Substation

LS Power – Proposal 5A
Salem Expansion

Salem Unit 2

Hope Creek (5037)

Orchard (5021)

New Freedom (5024)

Salem Unit 1

Delaware River

LS Power (Submarine) 5A

Proposed Line Route

Artificial
Island

Hope Creek
Generating
Station

= 230kV
Corridor

Route 9

Silver Run Rd

Upper Break

Silver Run Rd

440

Thomas Corner Rd

Taylor's Bridge Rd

Appoquinimink
Wildlife Area

PJM TEAC - Artificial Island 06/16/2014

- Approximately 3 mile submarine cable under Delaware River
- 1.5 – 3 mile aerial line in Delaware
- New substation in Delaware cut in two existing 230kV lines



LS Power 5A (Submarine) - Cost Factors

PJM Estimated Cost: \$248 - \$311 (million)

- 3.3 circuit miles of submarine cable (two cables per phase plus one spare cable)
- Four 500/230kV auto-transformers

Proposed Cost Estimate: \$148 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
 - New path from the AI to Delaware (on the Cedar Creek - Catanza / Red Lion – Catanza path)
- Results:
 - Approximate benefit to cost ratio of 0.25
 - Approximately \$92 million over 15 years

Outage Cost

- 230kV outage during substation cut-in



LS Power 5A (Submarine) - Project Schedule

Proposed Schedule 42 months (items run concurrent)

- Permitting: 30 months
- RoW acquisition: 9 months

Schedule Criteria

- Permitting
 - CPCNs in two states and Army Corps of Engineers
- Long Lead Time Materials
 - Auto-transformers and submarine cable
- Construction
 - Specialized equipment needed for submarine cable installation
 - Could be impacted by restrictions due to endangered species and shipping traffic



LS Power 5A (Submarine) - RoW and Land Acquisition

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
 - 1.5 to 3 miles of right of way needs to be acquired in Delaware
- New Right of Way Required
 - 1.5 to 3 miles of right of way needs to be acquired in Delaware
- Substation Land Required
 - Has acquired an option on a site for the proposed new switching station in Delaware

Siting and Permitting Criteria

- Wetlands Impact
 - Permits required to cross the Delaware state lands on the river coast
 - New route will allow flexibility
- Public Opposition Risk
 - Submarine crossing of the Delaware river does not incur any new view-shed impact
 - Some opposition to any river crossing is expected
- Historic and Scenic Highway
 - Proposed line route parallels Delaware state route 9, which is classified as a 'Scenic and Historic' highway which may impact permitting
- Delaware River Crossing
 - Numerous approvals and permits required:
(a few major permits are listed below)
 - Delaware River Basin Commission approval required
 - Delaware and New Jersey CPCNs required
 - US Army Corps of Engineers Section 404 and 10 authorizations
 - Multiple US Fish and Wildlife permits required
 - National Marine Fisheries Service

Operational Impact Criteria

- Artificial Island Facility Requirements

- PJM Operations Review
 - Request to minimize impact to existing transmission facilities
- Salem/Hope Creek Facility Owner Feedback
 - Request to minimize outage and physical impacts to existing transmission facilities
 - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
 - Salem control house is a part of plant facilities and access is constrained

- Blackstart

- 230kV connection may provide additional benefit

- Route Diversity

- Project route is new and does not parallel an existing line

- Ongoing Maintenance

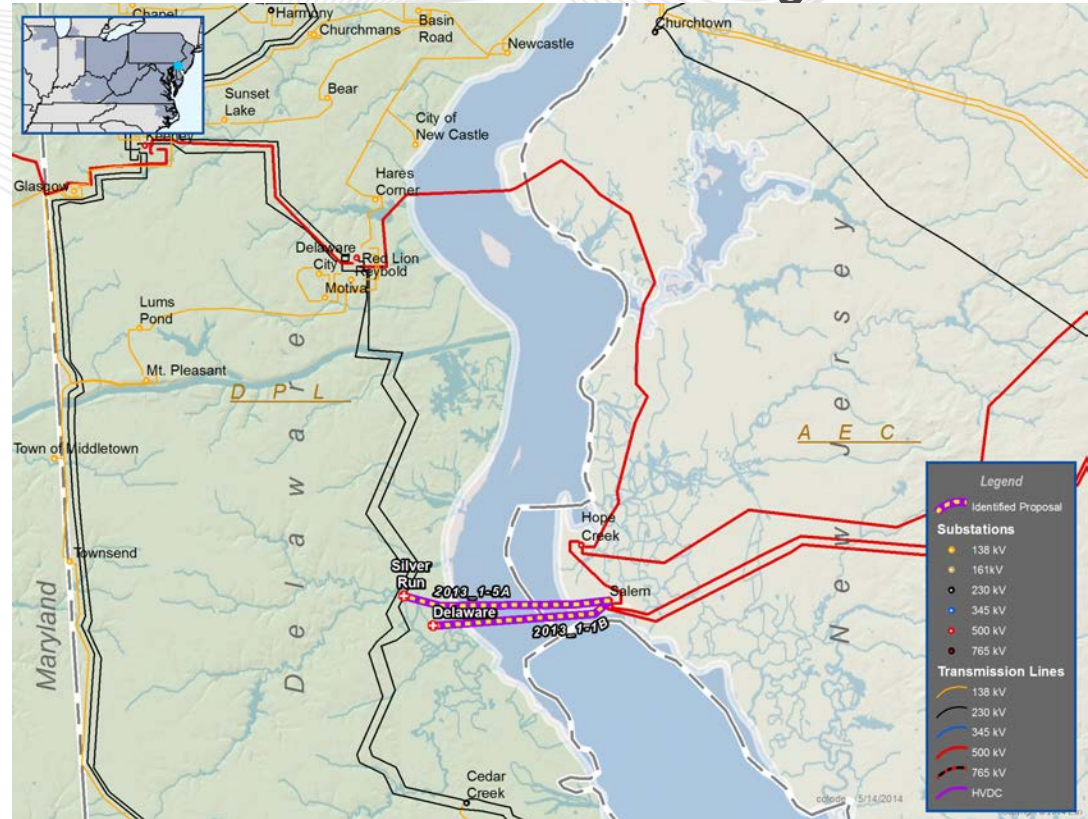
- Auto-transformers as line component may increase outage frequency
- Salt spray concern with proximity to Delaware river

Overhead Southern Delaware Crossing Lines

- Expansion of the Salem substation to the south
- Aerial line over the Delaware river
- New substation in Delaware
- Proposing Entities:

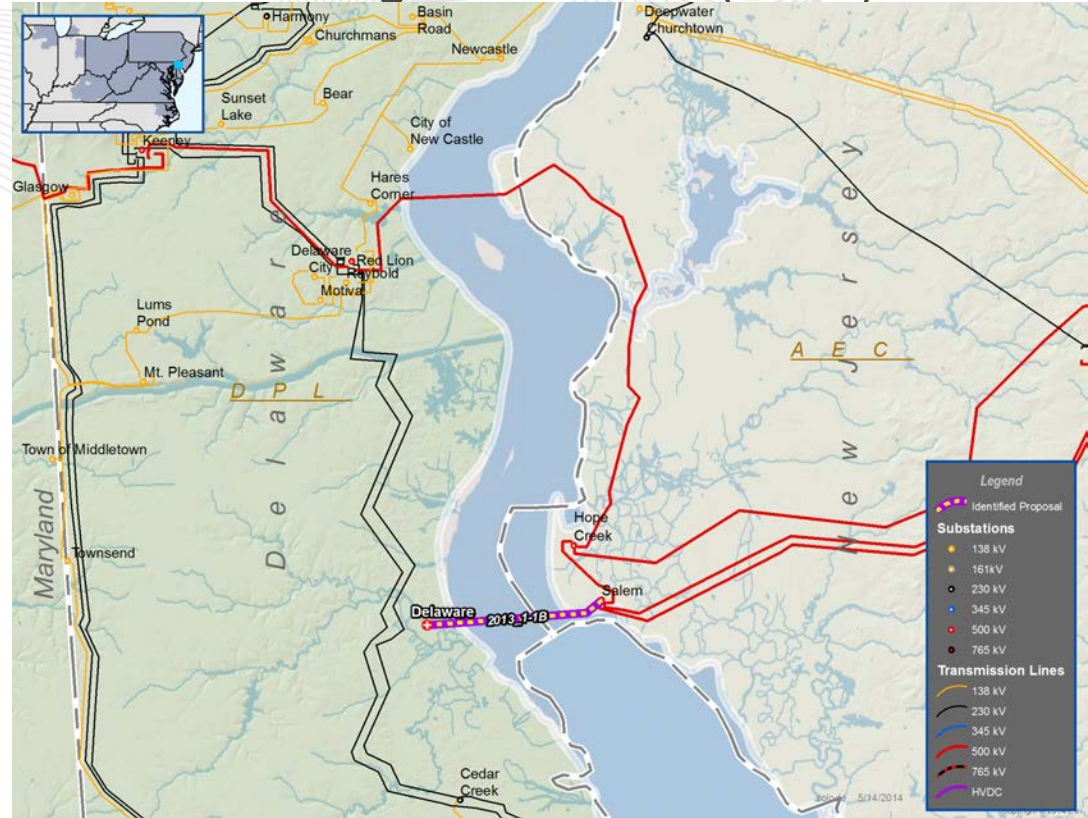
Dominion

LS Power



Dominion Virginia Power (DVP) 1B

- Line between Salem and new substation in Delaware
- Aerial crossing of the Delaware river
- PJM modifications
 - Technical:
 - Added SVC
 - Constructability:





Dominion Virginia Power (DVP) 1B – Technical Analysis

- **Stability Performance**

- **Failed required performance**

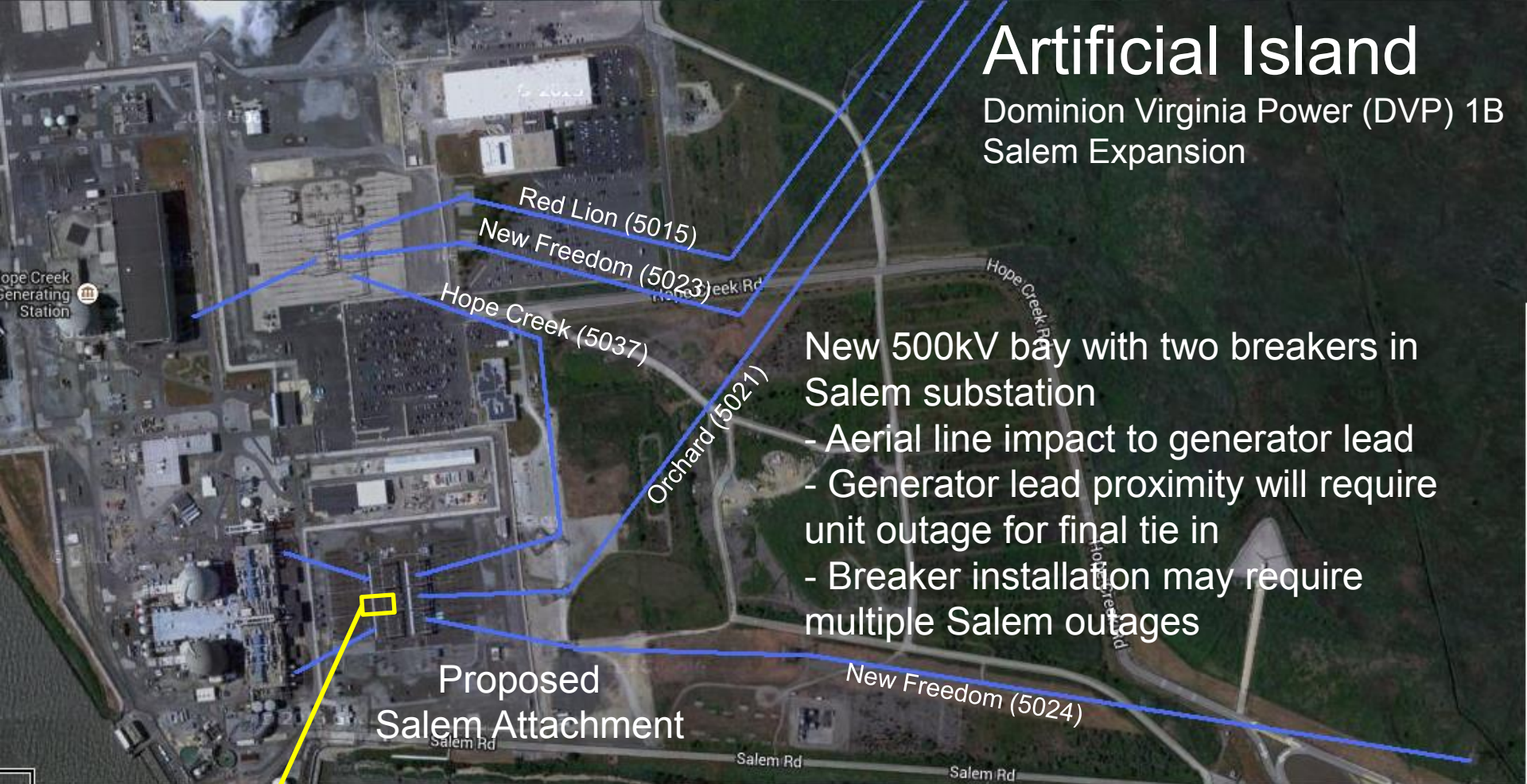
- Failed as proposed by project sponsor.
 - Failed with modification to remove proposed breakers.
 - Did not satisfy stability criteria for a three phase fault with AI units at unity power factor under 5015 maintenance outage condition.
 - Did not satisfy stability criteria for a three phase fault with AI units at unity power factor under 5015 maintenance outage condition with modification to remove proposed breakers.

- **Passed required performance**

- Passed as modified with the addition of an SVC at Orchard, New Freedom or Artificial Island.

Artificial Island

Dominion Virginia Power (DVP) 1B
Salem Expansion



New 500kV bay with two breakers in
Salem substation

- Aerial line impact to generator lead
- Generator lead proximity will require unit outage for final tie in
- Breaker installation may require multiple Salem outages

Delaware River

Dominion Virginia Power
(DVP) 1B

Proposed Line Route

Artificial
Island

Hope Creek
Generating
Station

= 230kV
Corridor

Route 9

Silver Run Rd

Upper Break

Silver Run Rd

440

Thomas Corner Rd

Taylor's Bridge Rd

PJM TEAC - Artificial Island 06/16/2014

- Approximately 3 mile aerial line over the Delaware River
- 1.5 – 3 mile aerial line in Delaware
- New substation in Delaware cut in two existing 230kV lines

Appoquinimink
Wildlife Area



Dominion Virginia Power (DVP) 1B- Cost Factors

PJM Estimated Cost: \$233 - \$283 (million)

- Six 500/230kV auto-transformers
- Aerial crossing of the Delaware River

Proposed Cost Estimate: \$133 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
 - New path from the AI to Delaware (on the Cedar Creek - Catanza / Red Lion – Catanza path)
- Results:
 - Approximate benefit to cost ratio of 0.25
 - Approximately \$92 million over 15 years

Outage Cost

- 230kV outage during substation cut-in



Dominion Virginia Power (DVP) 1B - Project Schedule

Proposed Schedule 93 months (items run concurrent)

- Permitting: 50 months
- RoW acquisition: 56 months

Schedule Criteria

- Permitting
 - CPCNs in two states and Army Corps of Engineers
- Construction
 - Could be impacted by restrictions due to endangered species and shipping traffic
- Long Lead Time Materials
 - Auto-transformers

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
 - 1.5 to 3 miles of right of way needs to be acquired in Delaware
- New Right of Way Required
 - 1.5 to 3 miles of right of way needs to be acquired in Delaware
- Substation Land Required
 - Land in Delaware will need to be acquired for the new substation



Dominion Virginia Power (DVP) 1B - Siting and Permitting

Siting and Permitting Criteria

- Wetlands Impact
 - Permits required to cross the Delaware state lands on the river coast
 - New route will allow flexibility
- Public Opposition Risk
 - Aerial crossing of the Delaware river would create a new view-shed impact
 - Some opposition to any river crossing is expected
- Historic and Scenic Highway
 - Proposed line route parallels Delaware state route 9, which is classified as a 'Scenic and Historic' highway which may impact permitting
- Delaware River Crossing
 - Numerous approvals and permits required:
(a few major permits are listed below)
 - Delaware River Basin Commission approval required
 - Delaware and New Jersey CPCNs required
 - US Army Corps of Engineers Section 404 and 10 authorizations
 - Multiple US Fish and Wildlife permits required
 - National Marine Fisheries Service



Dominion Virginia Power (DVP) 1B - Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements

- PJM Operations Review
 - Request to minimize impact to existing transmission facilities
- Salem/Hope Creek Facility Owner Feedback
 - Request to minimize outage and physical impacts to existing transmission facilities
 - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
 - Salem control house is a part of plant facilities and access is constrained

- Blackstart

- 500kV connection may provide additional benefit

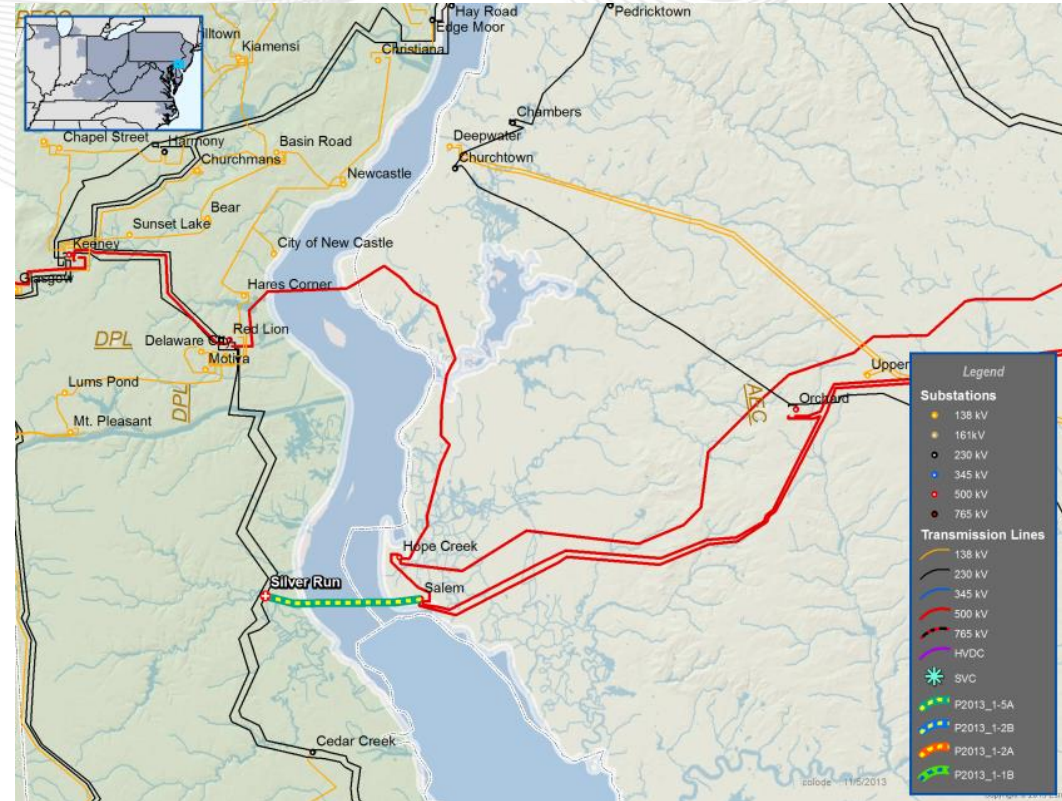
- Route Diversity

- Project route is new and does not parallel an existing line

- Ongoing Maintenance

- Auto-transformers as line component may increase outage frequency

- Line between Salem and new substation in Delaware
- Aerial crossing of the Delaware river
- PJM modifications
 - Technical:
 - Added SVC
 - Constructability:
 - Spare transformer phase added



- **Stability Performance**

- Failed required performance

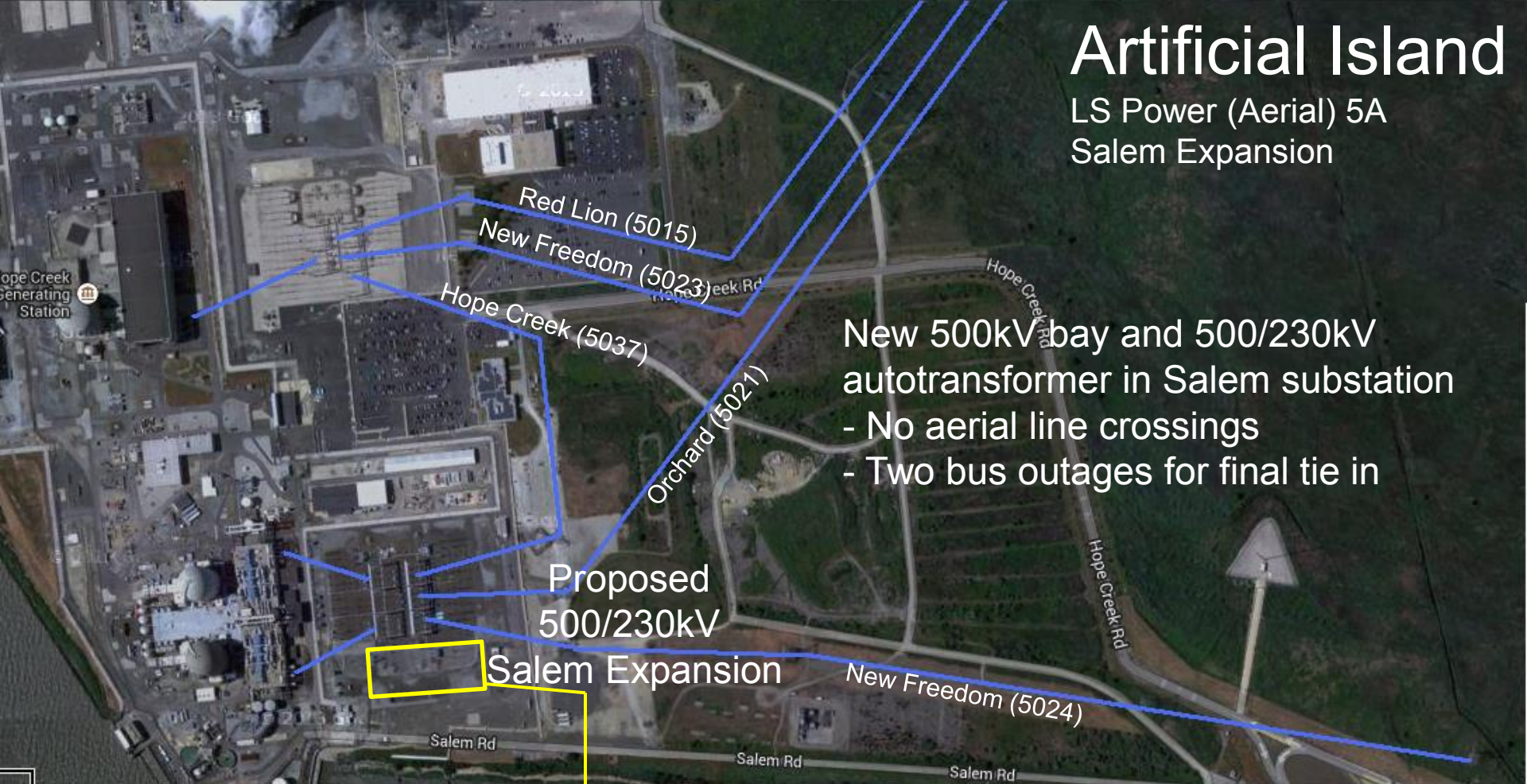
- Failed as proposed by project sponsor.
 - Did not satisfy stability criteria for a three phase fault with AI units at unity power factor under 5015 maintenance outage condition.

- Passed required performance

- Passed as proposed with the addition of an SVC at Orchard, New Freedom or Artificial Island.

Artificial Island

LS Power (Aerial) 5A
Salem Expansion



New 500kV bay and 500/230kV autotransformer in Salem substation

- No aerial line crossings
- Two bus outages for final tie in

Proposed
500/230kV
Salem Expansion

Salem Substation

Salem Unit 2

Hope Creek (5037)

LS Power (Aerial) 5A
Salem Expansion

Orchard (5021)

New Freedom (5024)

Salem Unit 1

Delaware River

LS Power (Aerial) 5A
Proposed Line Route

Artificial
Island

Hope Creek
Generating
Station

New Jersey
Delaware

Delaware
River

Upper Break

Appoquinimink
Wildlife Area

Route 9

Silver Run Rd

Silver Run
Wildlife Area

= 230kV
Corridor

Silver Run Rd

440

Thomas Corner Rd
Taylors Bridge Rd

PJM TEAC - Artificial Island 06/16/2014

- Approximately 3 mile aerial line over the Delaware River
- 1.5 – 3 mile aerial line in Delaware
- New substation in Delaware cut in two existing 230kV lines



LS Power 5A (Aerial) - Cost Factors

PJM Estimated Cost: \$211 - \$257 (million)

- Four 500/230kV auto-transformers
- Aerial Delaware river crossing

Proposed Cost Estimate: \$116 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
 - New path from the AI to Delaware (on the Cedar Creek - Catanza / Red Lion – Catanza path)
- Results:
 - Approximate benefit to cost ratio of 0.25
 - Approximately \$92 million over 15 years

Outage Cost

- 230kV outage during substation cut-in



LS Power 5A (Aerial) - Project Schedule

Proposed Schedule 42 months (items run concurrent)

- Permitting: 30 months
- RoW acquisition: 9 months

Schedule Criteria

- Permitting
 - CPCNs in two states and Army Corps of Engineers
- Construction
 - Could be impacted by restrictions due to endangered species and shipping traffic
- Long Lead Time Materials
 - Auto-transformers

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
 - Has acquired an option on a site for the proposed new switching station in Delaware
 - 1.5 to 3 miles of right of way needs to be acquired in Delaware
- New Right of Way Required
 - 1.5 to 3 miles of right of way needs to be acquired in Delaware
- Substation Land Required
 - Has acquired an option on a site for the proposed new switching station in Delaware

Siting and Permitting Criteria

- Wetlands Impact
 - Permits required to cross the Delaware state lands on the river coast
 - New route will allow flexibility
- Public Opposition Risk
 - Aerial crossing of the Delaware river would create a new view-shed impact
 - Some opposition to any river crossing is expected
- Historic and Scenic Highway
 - Proposed line route parallels Delaware state route 9, which is classified as a 'Scenic and Historic' highway which may impact permitting
- Delaware River Crossing
 - Numerous approvals and permits required:
(a few major permits are listed below)
 - Delaware River Basin Commission approval required
 - Delaware and New Jersey CPCNs required
 - US Army Corps of Engineers Section 404 and 10 authorizations
 - Multiple US Fish and Wildlife permits required
 - National Marine Fisheries Service



LS Power 5A (Aerial) - Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements

- PJM Operations Review
 - Request to minimize impact to existing transmission facilities
- Salem/Hope Creek Facility Owner Feedback
 - Request to minimize outage and physical impacts to existing transmission facilities
 - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
 - Salem control house is a part of plant facilities and access is constrained

- Blackstart

- 230kV connection may provide additional benefit

- Route Diversity

- Project route is new and does not parallel an existing line

- Ongoing Maintenance

- Auto-transformers as line component may increase outage frequency
- Salt spray concern with proximity to Delaware river

Salem to Red Lion Lines

- Expansion of Salem substation
- 17 mile 500kV line
- Parallels 5015 (Existing Red Lion – Hope Creek 500 kV)
- Proposing Entities:

PHI/Exelon

LS Power

Transource



- New 500kV Line between Salem and Red Lion substations
- PJM modifications
 - Technical:
 - Analysis based on building only the Salem to Red Lion segment of proposed Salem to Peach Bottom proposal
 - Added SVC
 - Constructability:
 - Dead-end towers added around line crossing
 - New Salem connection as a full bay



- **Stability Performance**

- Failed required performance

- Failed as proposed by project sponsor.
 - Failed with modification to change connection point at Salem to bus bar #1 from #2.
 - Did not satisfy stability criteria for a single line to ground fault with stuck breaker with AI units at unity power factor under 5015 maintenance outage condition.
 - Did not satisfy stability criteria for a single line to ground fault with stuck breaker with AI units at unity power factor under 5015 maintenance outage condition with modification to change connection point at Salem to bus bar #1 from #2.

- Passed required performance

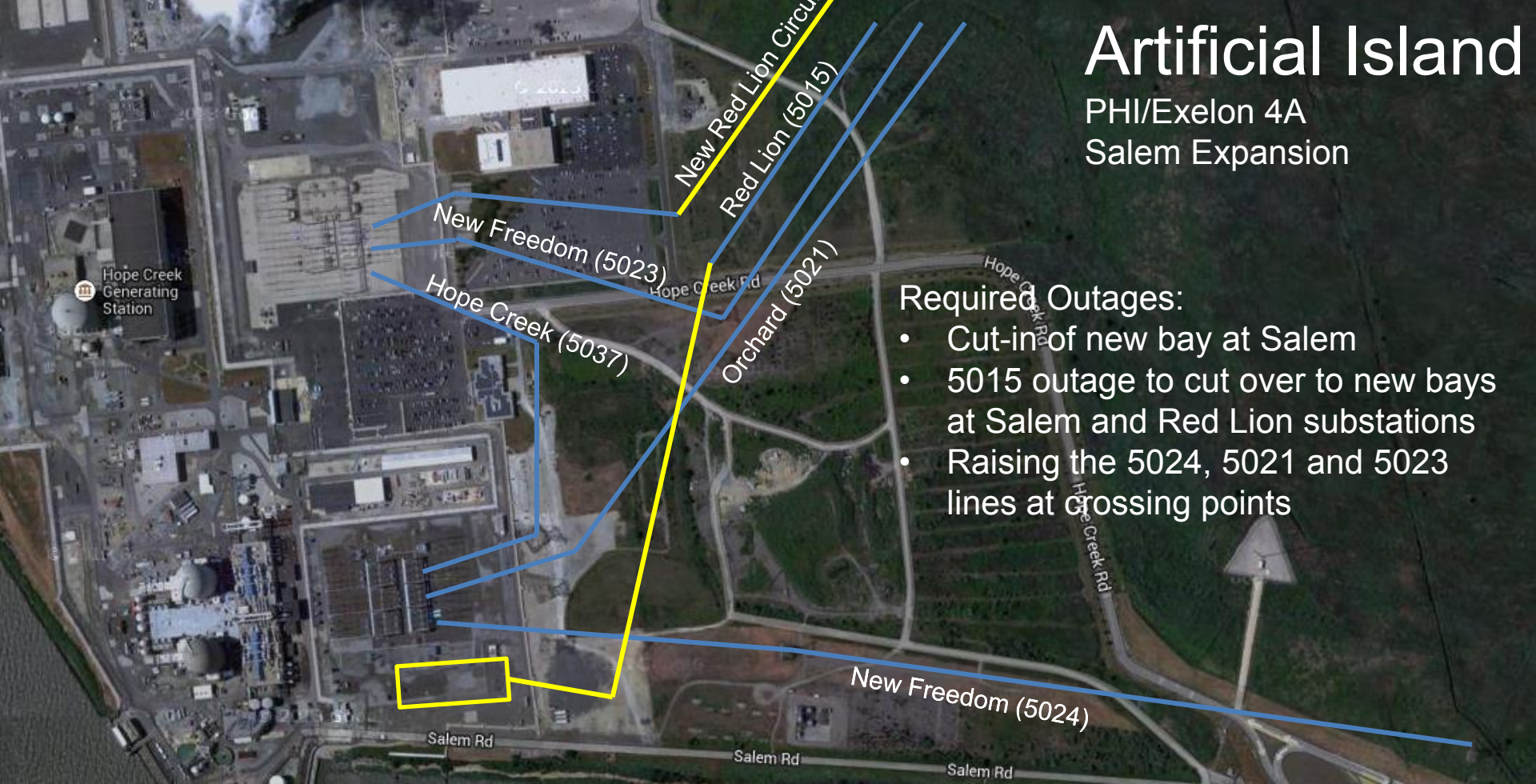
- Passed as modified with the addition of an SVC at Orchard, New Freedom or Artificial Island.

Artificial Island

PHI/Exelon 4A
Salem Expansion

Required Outages:

- Cut-in of new bay at Salem
- 5015 outage to cut over to new bays at Salem and Red Lion substations
- Raising the 5024, 5021 and 5023 lines at crossing points



Red Lion Substation

PHI/Exelon 4A

New Salem Circuit

Hope Creek (5015) Circuit

Relocate 5015 to a new
500kV line terminal
and add double breaker
between lines



PHI / Exelon 4A - Cost Factors

PJM Estimated Cost: \$216-\$263 (million)

- New 17 mile 500kV line
- Aerial Delaware river crossing

Proposed Cost Estimate: \$181 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
 - New 500 kV path from the AI to Red Lion
- Results:
 - Approximate benefit to cost ratio of 0.15
 - Approximately \$57 million over 15 years

Outage Cost

- 5015 outage estimated at 30 days

Proposed Schedule 60 months (items run concurrent)

- Permitting: 34 months
- Design and Construction: 50 months
- Property Acquisition: 0 months

Schedule Criteria

- Permitting
 - CPCNs in two states and Army Corps of Engineers
- Construction
 - Could be impacted by restrictions due to endangered species and shipping traffic
- Long Lead Time Materials
 - No significant long lead time equipment required

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
 - All project have approximately 0.5 miles of right of way to either expand or acquire in Delaware
 - Land is coastal and under state jurisdiction
 - Red Lion substation expansion is on land currently owned by PHI
- New Right of Way Required
 - As participants in the LDV agreement, party has a right of way agreement for the new line
- Substation Land Required
 - Red Lion substation expansion will be done on land currently owned by PHI.

Siting and Permitting Criteria

- Wetlands Impact
 - Permits required to cross the Delaware state lands on the river coast
 - Impacts approximately 350 acres of forested wetland
- Public Opposition Risk
 - View-shed impacts minimal as this is adjacent to the existing 5015
 - Some opposition to any river crossing is expected
- Historic and Scenic Highway
 - No impact
- Land Permitting
 - USFWS right of way permit to cross Supawna National Wildlife Refuge required
- Delaware River Crossing
 - Numerous approvals and permits required: (a few major permits are listed below)
 - Delaware River Basin Commission approval required
 - Delaware and New Jersey CPCNs required
 - US Army Corps of Engineers Section 404 and 10 authorizations
 - Multiple US Fish and Wildlife permits required
 - National Marine Fisheries Service

Operational Impact Criteria

- Artificial Island Facility Requirements

- PJM Operations Review
 - Request to minimize impact to existing transmission facilities
- Salem/Hope Creek Facility Owner Feedback
 - Request to minimize outage and physical impacts to existing transmission facilities
 - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
 - Salem control house is a part of plant facilities and access is constrained

- Blackstart

- No blackstart advantage

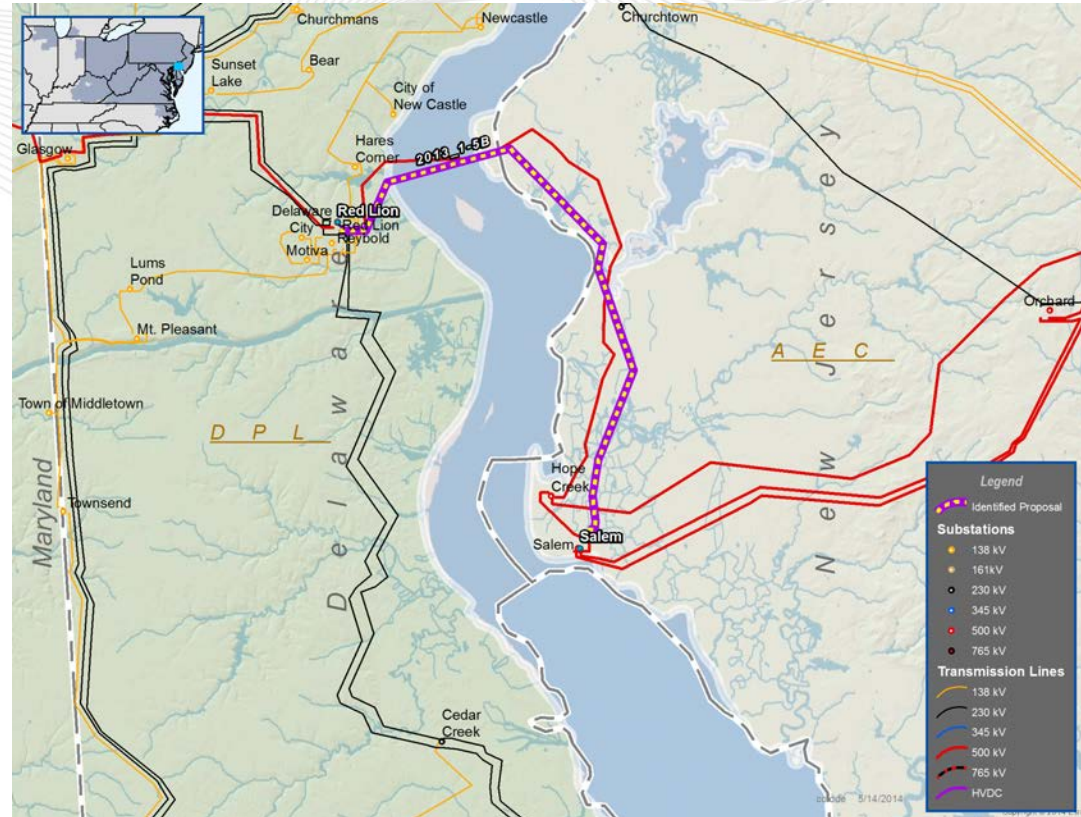
- Route Diversity

- Project route is parallels the existing 5015 line

- Ongoing Maintenance

- Salt spray concern with proximity to Delaware river

- New 500kV Line between Salem and Red Lion substations
- PJM modifications
 - Technical:
 - Added SVC
 - Constructability:
 - Dead-end towers added around line crossing
 - New Salem connection as a full bay

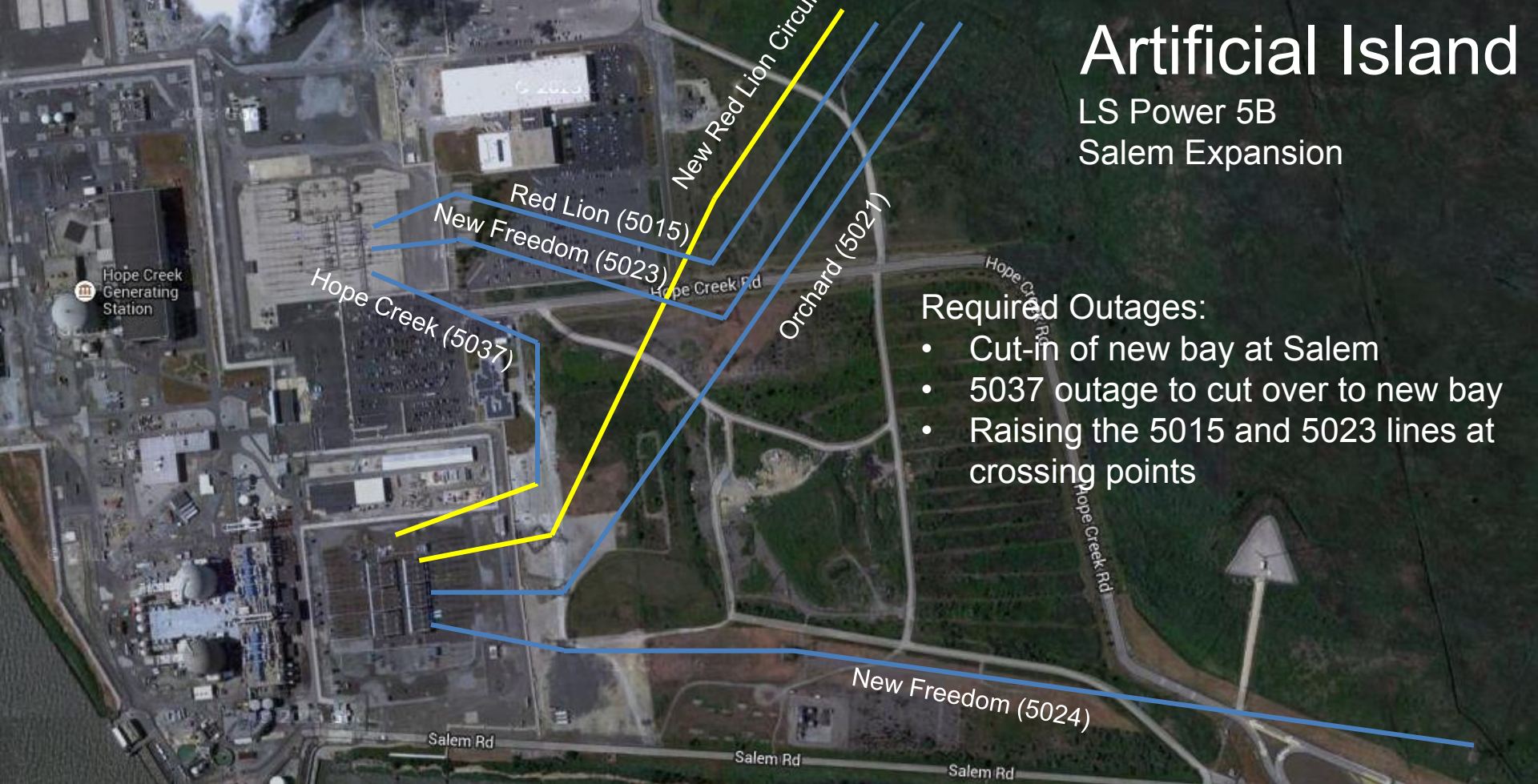


- **Stability Performance**
 - Failed required performance
 - Failed as proposed by project sponsor.
 - Did not satisfy stability criteria for a three phase fault with AI units at unity power factor under 5015 maintenance outage condition.
 - Passed required performance
 - Passed as proposed with the addition of an SVC at Orchard, New Freedom or Artificial Island.

Artificial Island

LS Power 5B

Salem Expansion



Required Outages:

- Cut-in of new bay at Salem
- 5037 outage to cut over to new bay
- Raising the 5015 and 5023 lines at crossing points

Red Lion Substation

LS Power 5B

Hope Creek (5015)

New Salem Circuit

Relocate 5015 to a new
500kV line terminal
and add double breaker
between lines



LS Power 5B - Cost Factors

PJM Estimated Cost: \$221-\$269 (million)

- New 17 mile 500kV line
- Aerial Delaware river crossing

Proposed Cost Estimate: \$171 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
 - New 500 kV path from the AI to Red Lion
- Results:
 - Approximate benefit to cost ratio of 0.15
 - Approximately \$57 million over 15 years

Outage Cost

- 5015 outage estimated at 30 days

Proposed Schedule 60 months (items run concurrent)

- Permitting: 27 months
- Design and Construction: 60 months
- Property Acquisition: 18 months

Schedule Criteria

- Permitting
 - CPCNs in two states and Army Corps of Engineers
- Construction
 - Could be impacted by restrictions due to endangered species and shipping traffic
- Long Lead Time Materials
 - No significant long lead time equipment required

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
 - All project have approximately 0.5 miles of right of way to either expand or acquire in Delaware
 - Land is coastal and under state jurisdiction
 - Red Lion substation expansion is on land currently owned by PHI
- New Right of Way Required
 - Will need to either negotiate with the LDV parties or negotiate with individual land owners and public entities
- Substation Land Required
 - Red Lion substation expansion will be done on land currently owned by PHI.

Siting and Permitting Criteria

- Wetlands Impact
 - Permits required to cross the Delaware state lands on the river coast
 - Impacts approximately 350 acres of forested wetland
- Public Opposition Risk
 - View-shed impacts minimal as this is adjacent to the existing 5015
 - Some opposition to any river crossing is expected
- Historic and Scenic Highway
 - No impact
- Land Permitting
 - USFWS right of way permit to cross Supawna National Wildlife Refuge required
- Delaware River Crossing
 - Numerous approvals and permits required:
(a few major permits are listed below)
 - Delaware River Basin Commission approval required
 - Delaware and New Jersey CPCNs required
 - US Army Corps of Engineers Section 404 and 10 authorizations
 - Multiple US Fish and Wildlife permits required
 - National Marine Fisheries Service

Operational Impact Criteria

- Artificial Island Facility Requirements
 - PJM Operations Review
 - Request to minimize impact to existing transmission facilities
 - Salem/Hope Creek Facility Owner Feedback
 - Request to minimize outage and physical impacts to existing transmission facilities
 - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
 - Salem control house is a part of plant facilities and access is constrained
- Blackstart
 - No blackstart advantage
- Route Diversity
 - Project route is parallels the existing 5015 line
- Ongoing Maintenance
 - No impact

- New 500kV Line between Salem and Red Lion substations
- PJM modifications
 - Technical:
 - Added SVC
 - Constructability:
 - Dead-end towers added around line crossing
 - New Salem connection as a full bay



- **Stability Performance**

- Failed required performance

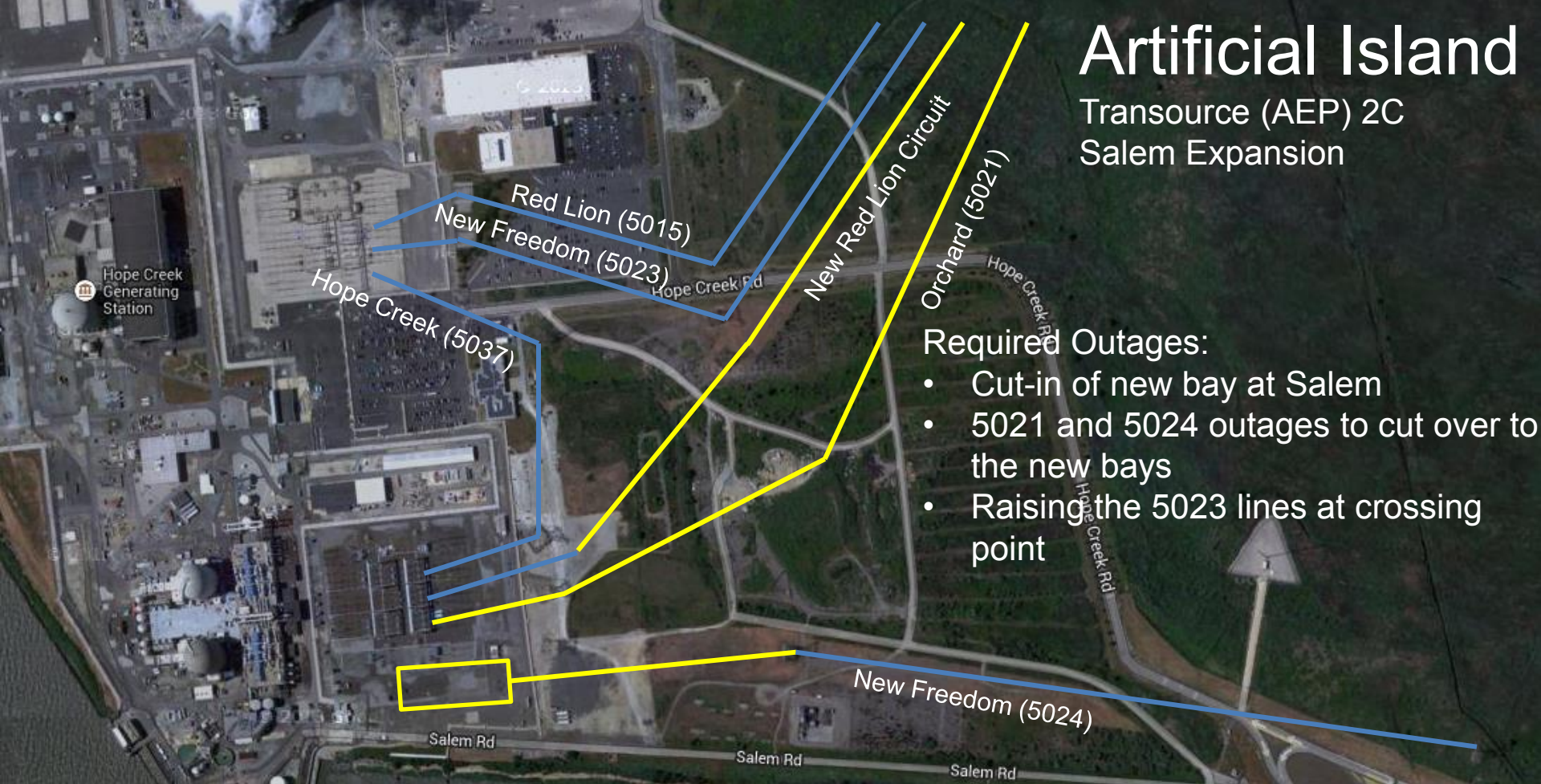
- Failed as proposed by project sponsor.
 - Did not satisfy stability criteria for a single line to ground fault with stuck breaker with AI units at unity power factor under 5015 maintenance outage condition.

- Passed required performance

- Passed as proposed with the addition of an SVC at Orchard, New Freedom or Artificial Island.

Artificial Island

Transsource (AEP) 2C
Salem Expansion

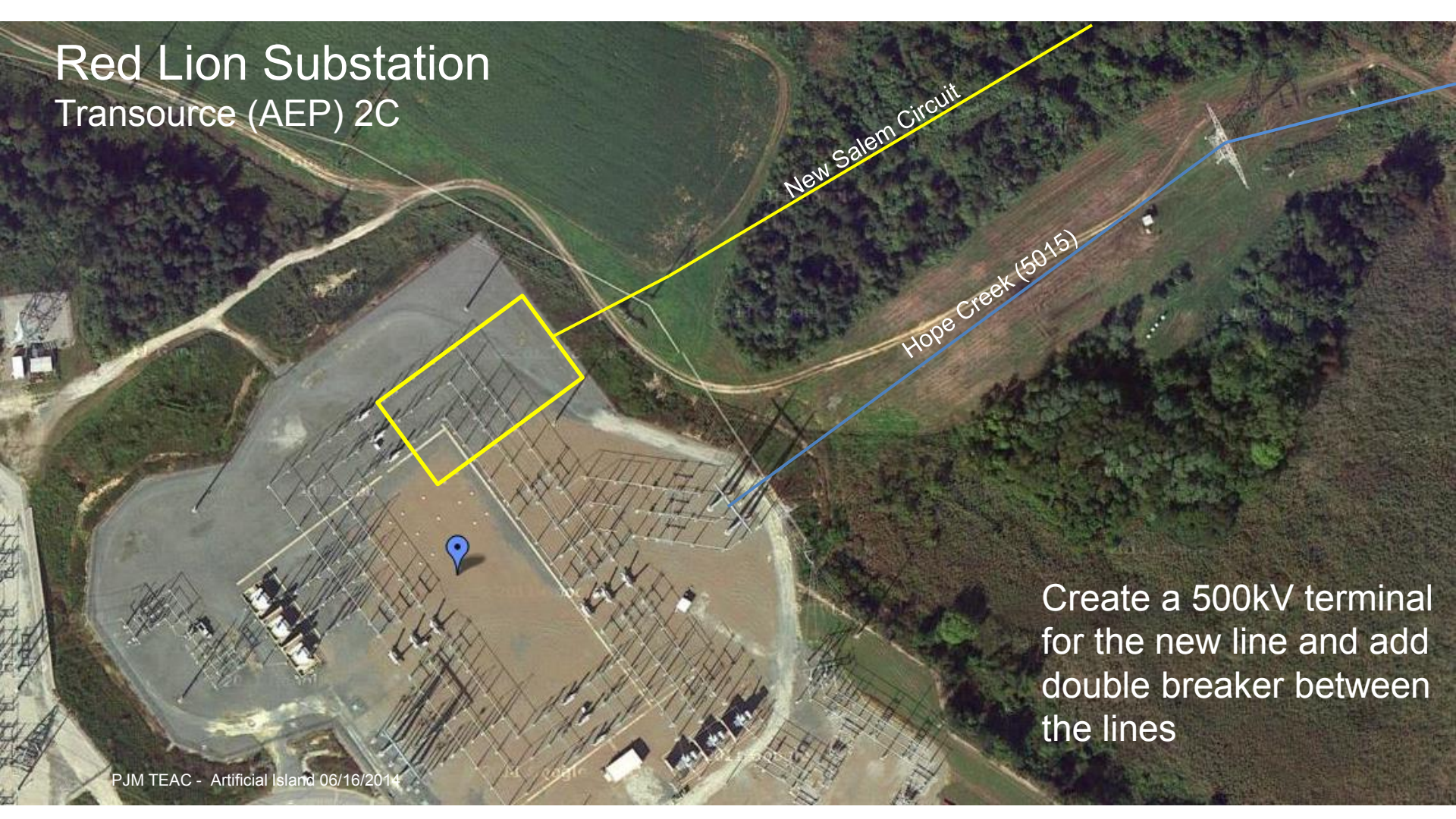


Required Outages:

- Cut-in of new bay at Salem
- 5021 and 5024 outages to cut over to the new bays
- Raising the 5023 lines at crossing point

Red Lion Substation

Transource (AEP) 2C



New Salem Circuit

Hope Creek (5015)

Create a 500kV terminal
for the new line and add
double breaker between
the lines



Transsource (AEP) 2C - Cost Factors

PJM Estimated Cost: \$232-\$282 (million)

- New 17 mile 500kV line
- Aerial Delaware river crossing

Proposed Cost Estimate: \$123-156 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
 - New 500 kV path from the AI to Red Lion
- Results:
 - Approximate benefit to cost ratio of 0.15
 - Approximately \$57 million over 15 years

Outage Cost

- 5015 outage estimated at 14 days

Proposed Schedule 48 months (items run concurrent)

- Permitting: 27 months
- Design and Construction: 30 months
- Property Acquisition: 15 months

Schedule Criteria

- Permitting
 - CPCNs in two states and Army Corps of Engineers
- Construction
 - Could be impacted by restrictions due to endangered species and shipping traffic
- Long Lead Time Materials
 - No significant long lead time equipment required

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
 - All project have approximately 0.5 miles of right of way to either expand or acquire in Delaware
 - Land is coastal and under state jurisdiction
 - Red Lion substation expansion is on land currently owned by PHI
- New Right of Way Required
 - Will need to either negotiate with the LDV parties or negotiate with individual land owners and public entities
- Substation Land Required
 - Red Lion substation expansion will be done on land currently owned by PHI.

Siting and Permitting Criteria

- Wetlands Impact
 - Permits required to cross the Delaware state lands on the river coast
 - Impacts approximately 350 acres of forested wetland
- Public Opposition Risk
 - View-shed impacts minimal as this is adjacent to the existing 5015
 - Some opposition to any river crossing is expected
- Historic and Scenic Highway
 - No impact
- Land Permitting
 - USFWS right of way permit to cross Supawna National Wildlife Refuge required
- Delaware River Crossing
 - Numerous approvals and permits required: (a few major permits are listed below)
 - Delaware River Basin Commission approval required
 - Delaware and New Jersey CPCNs required
 - US Army Corps of Engineers Section 404 and 10 authorizations
 - Multiple US Fish and Wildlife permits required
 - National Marine Fisheries Service



Transsource (AEP) 2C - Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements

- PJM Operations Review
 - Request to minimize impact to existing transmission facilities
- Salem/Hope Creek Facility Owner Feedback
 - Request to minimize outage and physical impacts to existing transmission facilities
 - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
 - Salem control house is a part of plant facilities and access is constrained

- Blackstart

- No blackstart advantage

- Route Diversity

- Project route is parallels the existing 5015 line

- Ongoing Maintenance

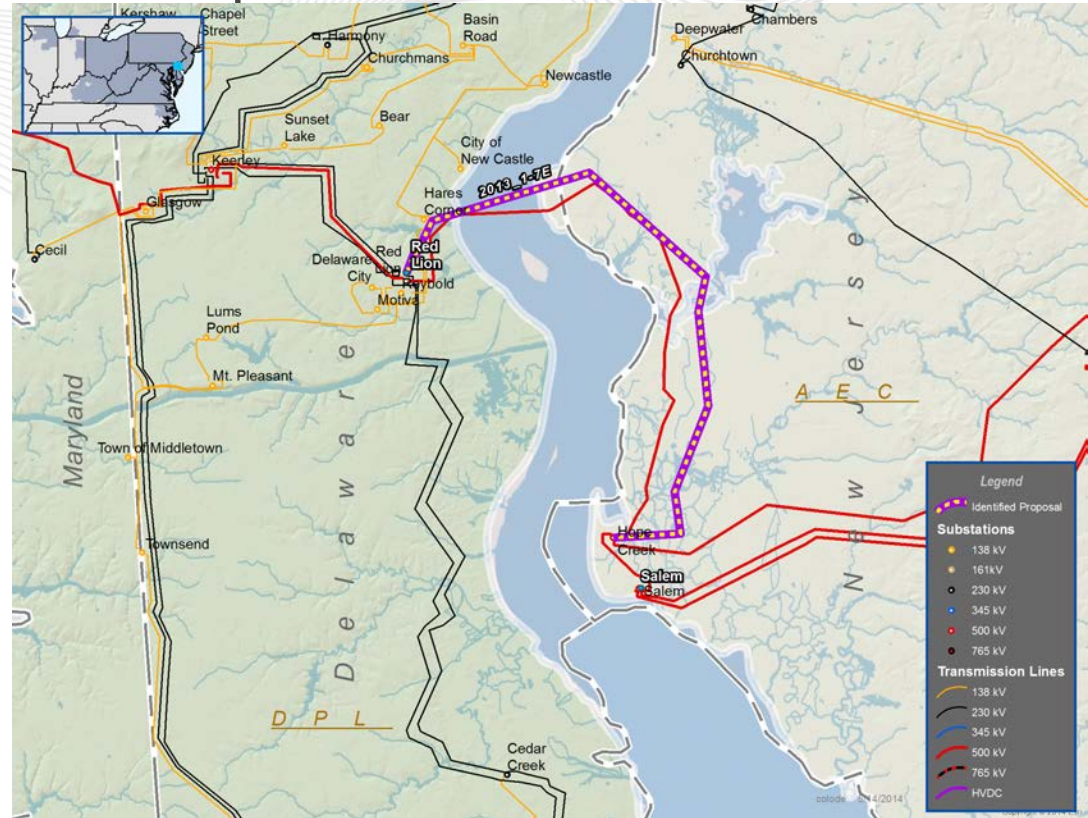
- Salt spray concern with proximity to Delaware river

- Expansion of Hope Creek substation
- 17 mile 500kV line
- Parallels 5015 (Existing Red Lion – Hope Creek 500 kV)
- Proposing Entities:

Dominion

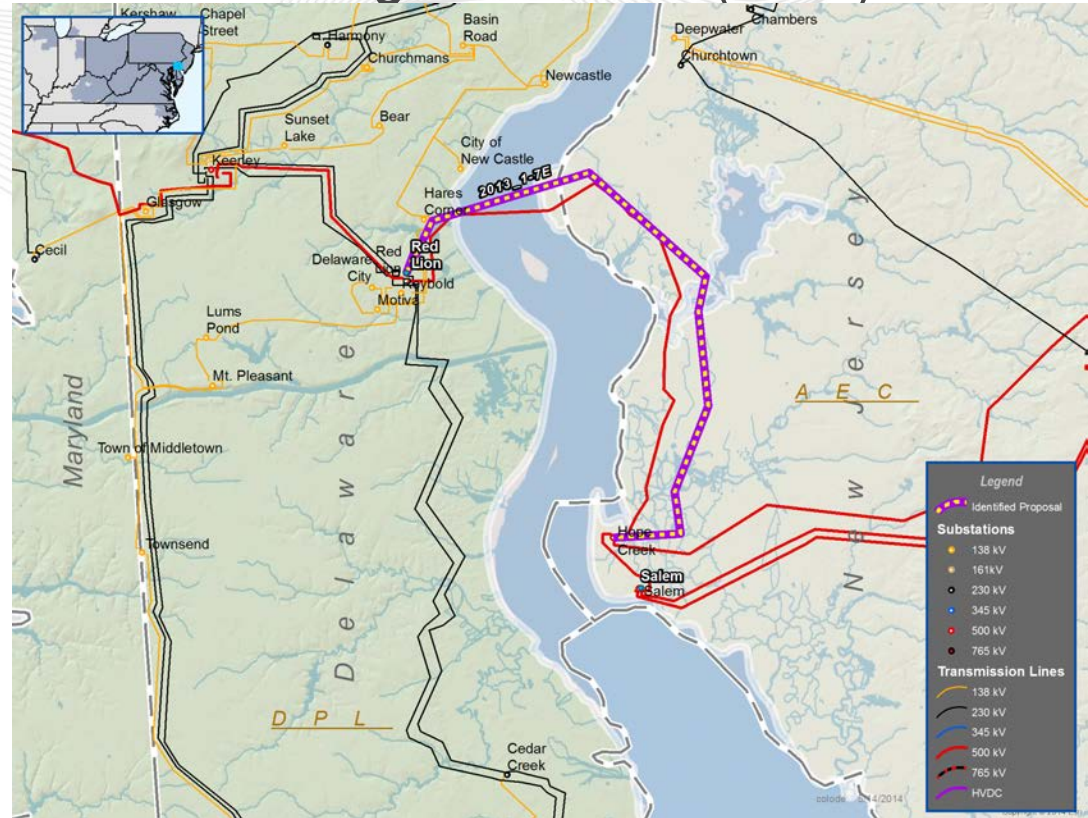
PSE&G

Hope Creek to Red Lion Lines



- New 500kV Line between Hope Creek and Red Lion substations
- New bus tie between Hope Creek and Salem substations
- PJM modifications
 - Technical:
 - Added SVC
 - Constructability:
 - Dead-end towers added around line crossing

Dominion Virginia Power (DVP) 1C





Dominion Virginia Power (DVP) 1C – Technical Analysis

- Stability Performance

- Failed required performance

- Failed as proposed by project sponsor.
 - Failed with modification to remove proposed breakers.
 - Did not satisfy stability criteria for a SLG fault with stuck breaker with AI units at unity power factor under new Hope Creek – Red Lion line maintenance outage condition.
 - Did not satisfy stability criteria for a SLG fault with stuck breaker with AI units at unity power factor under new Hope Creek – Red Lion line maintenance outage condition with modification to remove proposed breakers.

- Passed required performance

- Passed as modified with the addition of an SVC at Orchard, New Freedom or Artificial Island.

Proposed
Hope Creek
Attachment

Artificial Island

Dominion 1C

Artificial Island Expansion

Hope Creek
Generating
Station

Proposed
New Station
Tie Line

Required Outages:

- Cut-in of new bay at Hope Creek
- Installation of tie-line

Red Lion (5015)

New Freedom (5023)

Hope Creek (5037)

Orchard (5021)

New Freedom (5024)

Salem Rd

Salem Rd

Salem Rd

Hope Creek Rd

Red Lion Substation

Dominion 1C

New Hope Creek Circuit

Hope Creek (5015)

- Substation proposed to be rebuilt as a double bus – double breaker scheme
- New line crosses the 5015 line



Dominion Virginia Power (DVP) 1C - Cost Factors

PJM Estimated Cost: \$242-\$294 (million)

- New 17 mile 500kV line
- Aerial Delaware river crossing

Proposed Cost Estimate: \$199 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
 - New 500 kV path from the AI to Red Lion
- Results:
 - Approximate benefit to cost ratio of 0.15
 - Approximately \$57 million over 15 years

Outage Cost

- 5015 outage estimated at 40 days



Dominion Virginia Power (DVP) 1C - Project Schedule

Proposed Schedule 111 months (items run concurrent)

- Permitting: 24 months
- Design and Construction: 38 months
- Property Acquisition: 78 months

Schedule Criteria

- Permitting
 - CPCNs in two states and Army Corps of Engineers
- Construction
 - Could be impacted by restrictions due to endangered species and shipping traffic
- Long Lead Time Materials
 - No significant long lead time equipment required



Dominion Virginia Power (DVP) 1C - RoW and Land Acquisition

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
 - All project have approximately 0.5 miles of right of way to either expand or acquire in Delaware
 - Land is coastal and under state jurisdiction
 - Red Lion substation expansion is on land currently owned by PHI
- New Right of Way Required
 - Will need to either negotiate with the LDV parties or negotiate with individual land owners and public entities
- Substation Land Required
 - Red Lion substation expansion will be done on land currently owned by PHI.



Dominion Virginia Power (DVP) 1C - Siting and Permitting

Siting and Permitting Criteria

- Wetlands Impact
 - Permits required to cross the Delaware state lands on the river coast
 - Impacts approximately 350 acres of forested wetland
- Public Opposition Risk
 - View-shed impacts minimal as this is adjacent to the existing 5015
 - Some opposition to any river crossing is expected
- Historic and Scenic Highway
 - No impact
- Land Permitting
 - USFWS right of way permit to cross Supawna National Wildlife Refuge required
- Delaware River Crossing
 - Numerous approvals and permits required: (a few major permits are listed below)
 - Delaware River Basin Commission approval required
 - Delaware and New Jersey CPCNs required
 - US Army Corps of Engineers Section 404 and 10 authorizations
 - Multiple US Fish and Wildlife permits required
 - National Marine Fisheries Service

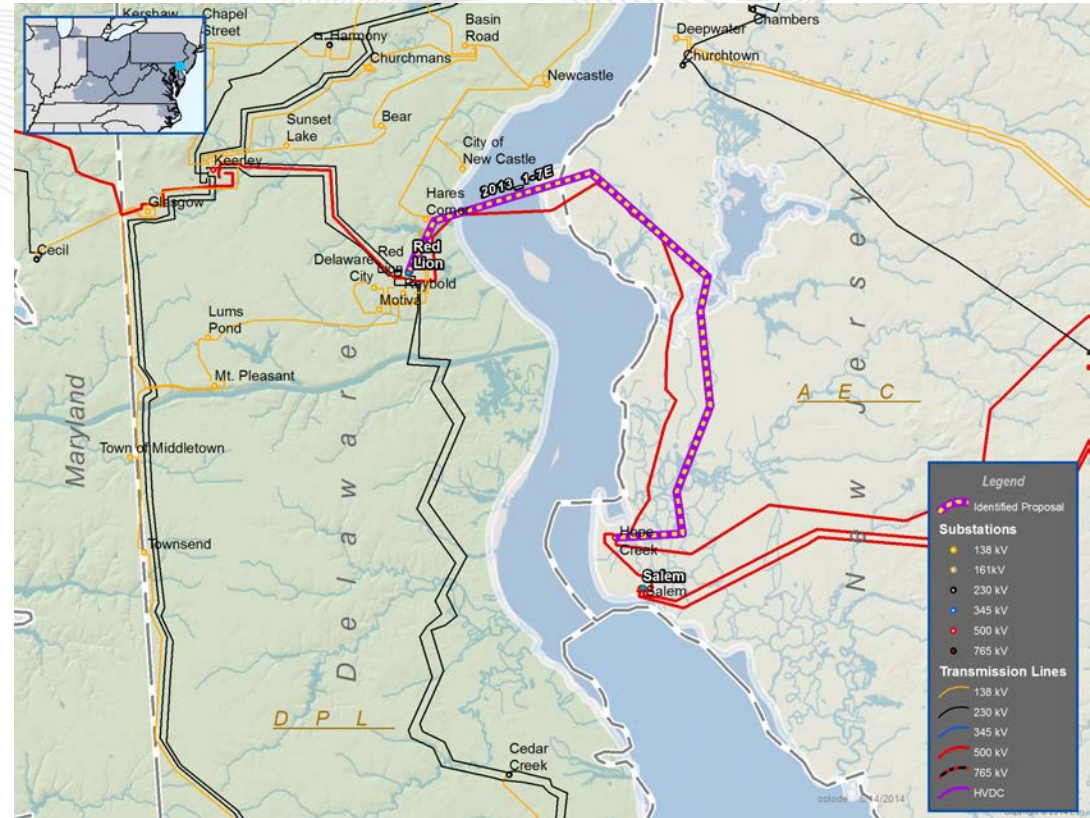


Dominion Virginia Power (DVP) 1C - Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements
 - PJM Operations Review
 - Request to minimize impact to existing transmission facilities
 - Salem/Hope Creek Facility Owner Feedback
 - Request to minimize outage and physical impacts to existing transmission facilities
 - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
 - Salem control house is a part of plant facilities and access is constrained
- Blackstart
 - No blackstart advantage
- Route Diversity
 - Project route parallels the existing 5015 line
- Ongoing Maintenance
 - Limited physical access could lead to maintenance issues on the new tie line between Salem and Hope Creek

- New 500kV Line between Hope Creek and Red Lion substations
- New bus tie between Hope Creek and Salem substations
- PJM modifications
 - Technical:
 - Removed the New Freedom to Deans portion of the project
 - Added SVC
 - Constructability:
 - Dead-end towers added around line crossing



- **Stability Performance**

- Failed required performance

- Failed as proposed by project sponsor.
 - Did not satisfy stability criteria for a single line to ground fault with stuck breaker with AI units at unity power factor under 5037 maintenance outage condition.

- Passed required performance

- Passed as modified with the addition of an SVC at Orchard, New Freedom or Artificial Island.

Proposed
Hope Creek
Attachment

Artificial Island

PSE&G 7K

Artificial Island Expansion

Hope Creek
Generating
Station

Proposed
New Station
Tie Line

Red Lion (5015)

New Freedom (5023)

Hope Creek (5037)

Orchard (5021)

Required Outages:

- Cut-in of new bay at Hope Creek
- Installation of tie-line

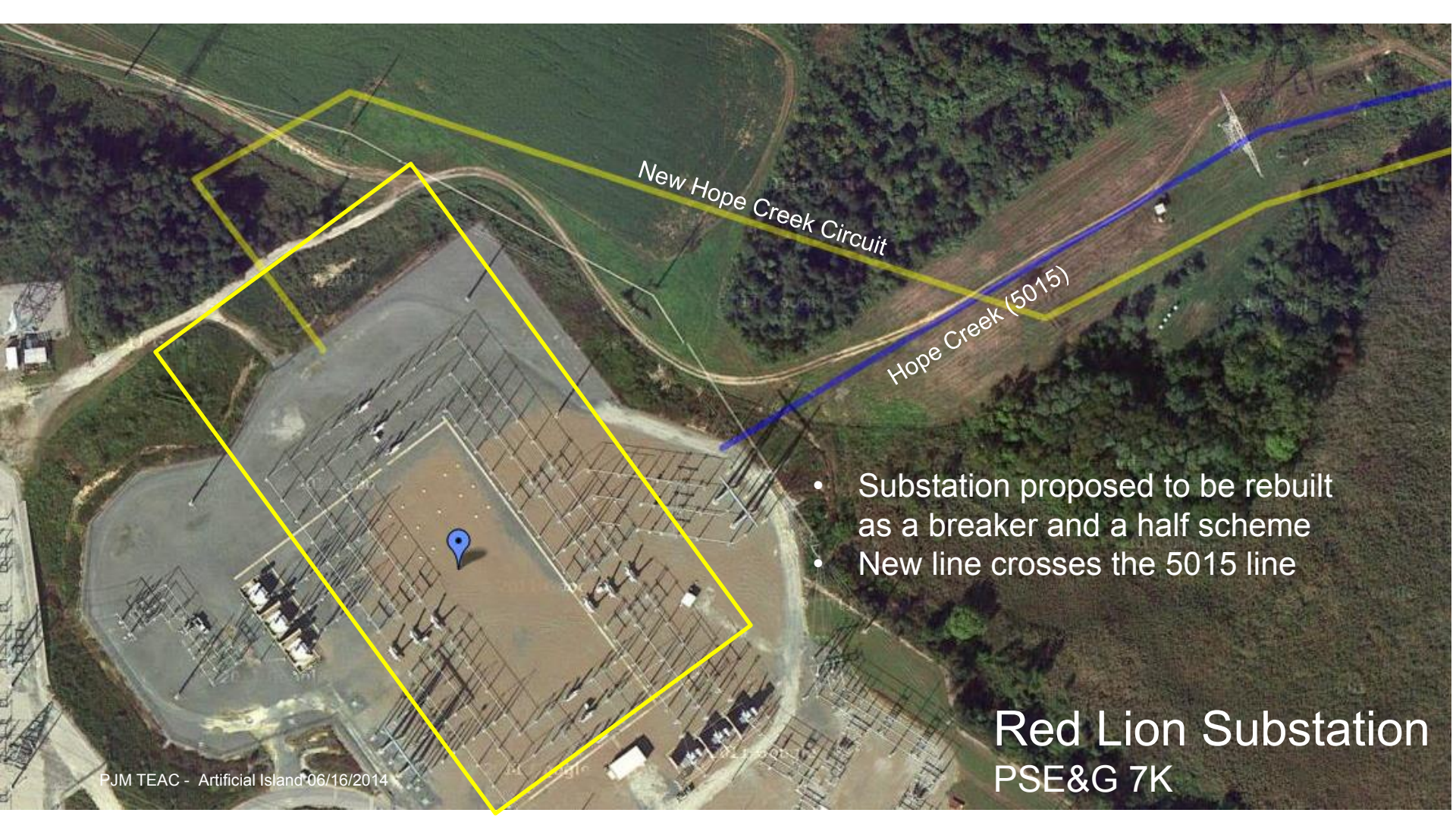
New Freedom (5024)

Salem Rd

Salem Rd

Salem Rd

Hope Creek Rd



New Hope Creek Circuit

Hope Creek (5015)

- Substation proposed to be rebuilt as a breaker and a half scheme
- New line crosses the 5015 line

Red Lion Substation
PSE&G 7K



PSE&G 7K - Cost Factors

PJM Estimated Cost: \$249-\$304 (million)

- New 17 mile 500kV line
- Aerial Delaware river crossing

Proposed Cost Estimate: \$297 (million)

Market Efficiency Analysis Sensitivity Study

- Scenario:
 - New 500 kV path from the AI to Red Lion
- Results:
 - Approximate benefit to cost ratio of 0.15
 - Approximately \$57 million over 15 years

Outage Cost

- 5015 outage estimated at 40 days

Proposed Schedule 51 months (items run concurrent)

- Permitting: 51 months
- Design and Construction: 48 months
- Property Acquisition: 0 months

Schedule Criteria

- Permitting
 - CPCNs in two states and Army Corps of Engineers
- Construction
 - Could be impacted by restrictions due to endangered species and shipping traffic
- Long Lead Time Materials
 - No significant long lead time equipment required

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
 - All project have approximately 0.5 miles of right of way to either expand or acquire in Delaware
 - Land is coastal and under state jurisdiction
 - Red Lion substation expansion is on land currently owned by PHI
- New Right of Way Required
 - As participants in the LDV agreement, party has a right of way agreement for the new line
- Substation Land Required
 - Red Lion substation expansion will be done on land currently owned by PHI.

Siting and Permitting Criteria

- Wetlands Impact
 - Permits required to cross the Delaware state lands on the river coast
 - Impacts approximately 350 acres of forested wetland
- Public Opposition Risk
 - View-shed impacts minimal as this is adjacent to the existing 5015
 - Some opposition to any river crossing is expected
- Historic and Scenic Highway
 - No impact
- Land Permitting
 - USFWS right of way permit to cross Supawna National Wildlife Refuge required
- Delaware River Crossing
 - Numerous approvals and permits required: (a few major permits are listed below)
 - Delaware River Basin Commission approval required
 - Delaware and New Jersey CPCNs required
 - US Army Corps of Engineers Section 404 and 10 authorizations
 - Multiple US Fish and Wildlife permits required
 - National Marine Fisheries Service

Operational Impact Criteria

- Artificial Island Facility Requirements

- PJM Operations Review
 - Request to minimize impact to existing transmission facilities
- Salem/Hope Creek Facility Owner Feedback
 - Request to minimize outage and physical impacts to existing transmission facilities
 - Salem is space constrained so expansion needs to incorporate maintenance access to substation equipment
 - Salem control house is a part of plant facilities and access is constrained

- Blackstart

- No blackstart advantage

- Route Diversity

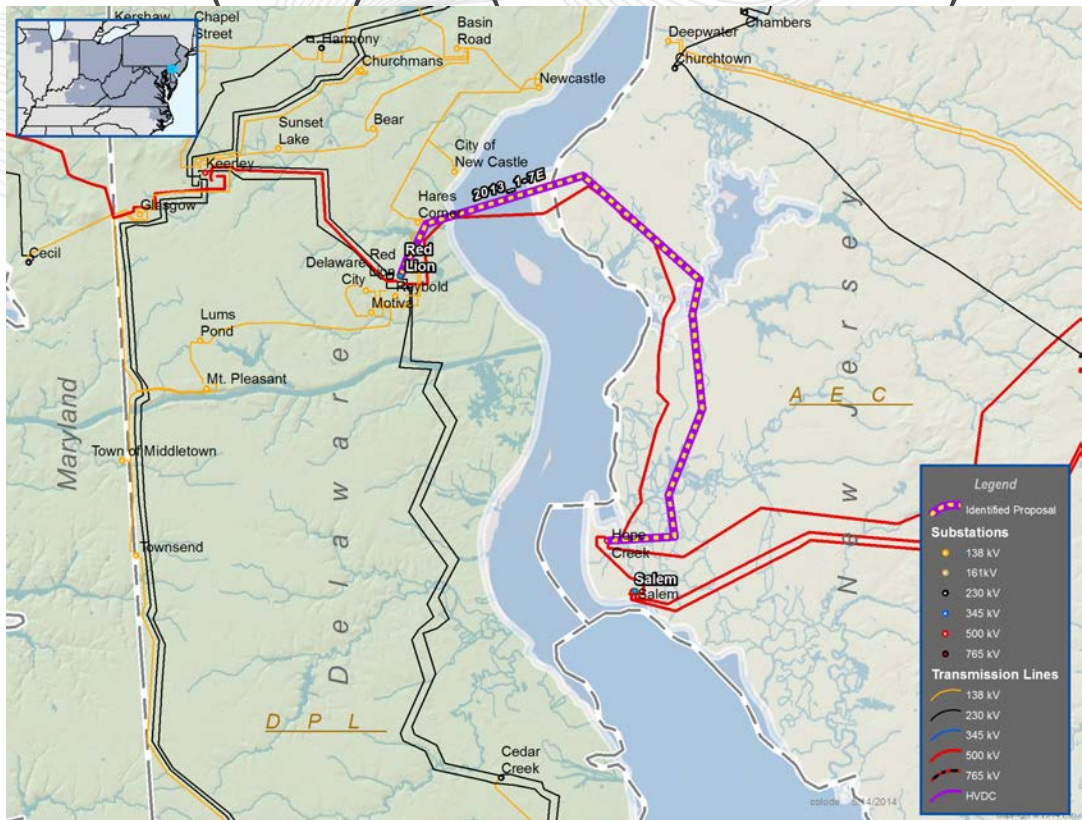
- Project route is parallels the existing 5015 line

- Ongoing Maintenance

- The new gas-insulated bus tie line between Salem and Hope Creek may require more frequent maintenance

Dominion Virginia Power (DVP) 1C (No New Bus Tie)

- New 500kV Line between Hope Creek and Red Lion substations
- PJM modifications
 - Technical:
 - Removed the new tie between Salem and Hope Creek substations
 - Added SVC
 - Constructability:
 - Red Lion expansion changed from a breaker and a half to an expansion of the existing ring-bus



- **Stability Performance**

- Failed required performance

- Failed as proposed by project sponsor.
 - Failed with modification to remove proposed breakers and transmission line.
 - Did not satisfy stability criteria for a SLG fault with stuck breaker with AI units at unity power factor under Hope Creek – Red Lion line maintenance outage condition.
 - Did not satisfy stability criteria for a SLG fault with stuck breaker with AI units at unity power factor under Hope Creek – Red Lion line maintenance outage condition with modification to remove proposed breakers and transmission line.

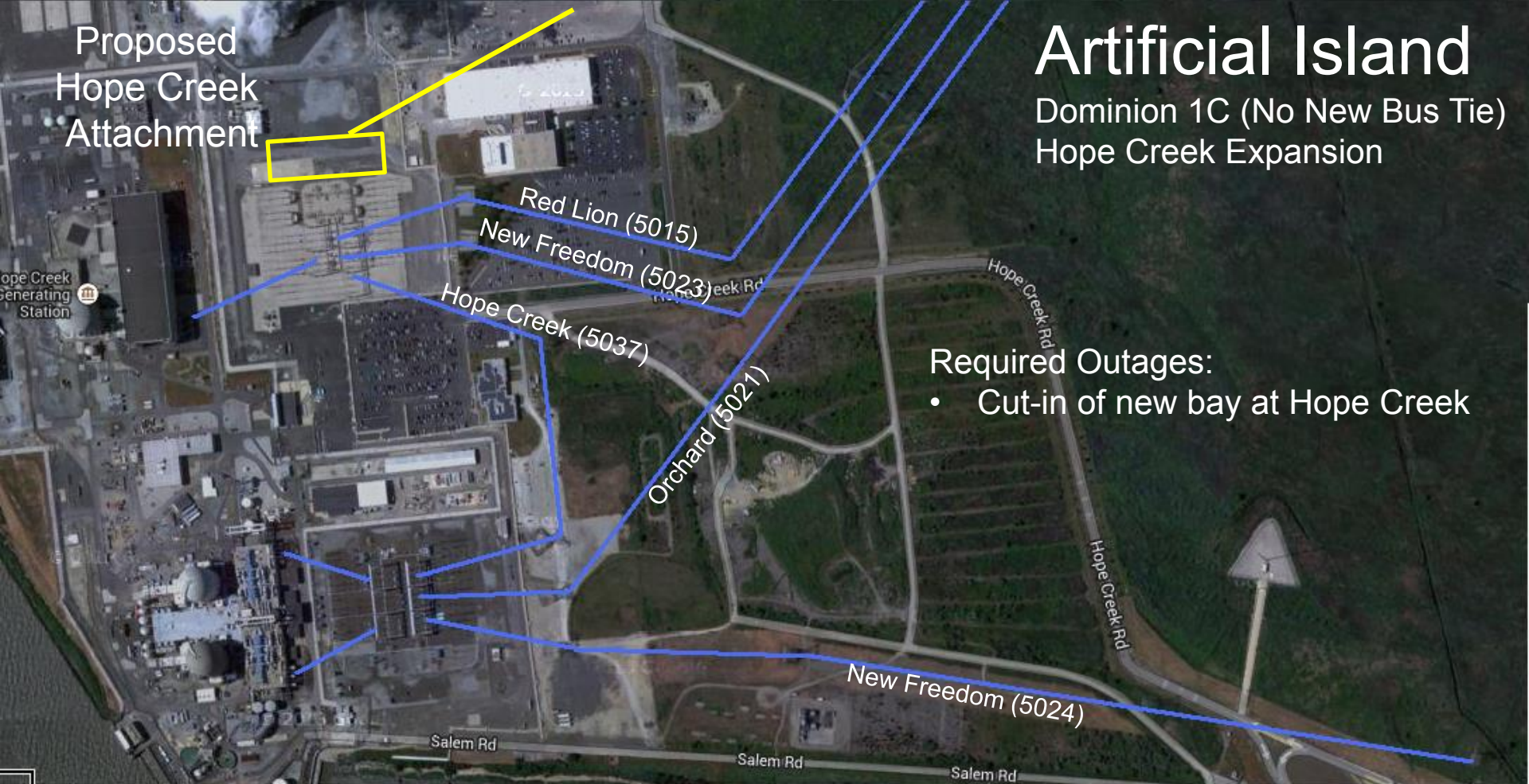
- Passed required performance

- Passed as modified with the addition of an SVC at Orchard or New Freedom.

Proposed
Hope Creek
Attachment

Artificial Island

Dominion 1C (No New Bus Tie)
Hope Creek Expansion



Required Outages:

- Cut-in of new bay at Hope Creek

Red Lion Substation

Dominion 1C (No New Bus Tie)

Hope Creek (5015)

New Hope Creek Circuit

Relocate 5015 to a new
500kV line terminal
and add double breaker
between lines



Dominion Virginia Power (DVP) 1C (No New Bus Tie) Cost Factors

PJM Estimated Cost: \$211-\$257 (million)

- New 17 mile 500kV line
- Aerial Delaware river crossing

Market Efficiency Analysis Sensitivity Study

- Scenario:
 - New 500 kV path from the AI to Red Lion
- Results:
 - Approximate benefit to cost ratio of 0.15
 - Approximately \$57 million over 15 years

Outage Cost

- 5015 outage estimated at 14 days



Dominion Virginia Power (DVP) 1C (No New Bus Tie) Project Schedule

Proposed Schedule 111 months (items run concurrent)

- Permitting: 24 months
- Design and Construction: 38 months
- Property Acquisition: 78 months

Schedule Criteria

- Permitting
 - CPCNs in two states and Army Corps of Engineers
- Construction
 - Could be impacted by restrictions due to endangered species and shipping traffic
- Long Lead Time Materials
 - No significant long lead time equipment required



Dominion Virginia Power (DVP) 1C (No New Bus Tie) RoW and Land Acquisition

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
 - All project have approximately 0.5 miles of right of way to either expand or acquire in Delaware
 - Land is coastal and under state jurisdiction
 - Red Lion substation expansion is on land currently owned by PHI
- New Right of Way Required
 - Will need to either negotiate with the LDV parties or negotiate with individual land owners and public entities
- Substation Land Required
 - Red Lion substation expansion will be done on land currently owned by PHI.



Dominion Virginia Power (DVP) 1C (No New Bus Tie) Siting and Permitting

Siting and Permitting Criteria

- Wetlands Impact
 - Permits required to cross the Delaware state lands on the river coast
 - Impacts approximately 350 acres of forested wetland
- Public Opposition Risk
 - View-shed impacts minimal as this is adjacent to the existing 5015
 - Some opposition to any river crossing is expected
- Historic and Scenic Highway
 - No impact
- Land Permitting
 - USFWS right of way permit to cross Supawna National Wildlife Refuge required
- Delaware River Crossing
 - Numerous approvals and permits required: (a few major permits are listed below)
 - Delaware River Basin Commission approval required
 - Delaware and New Jersey CPCNs required
 - US Army Corps of Engineers Section 404 and 10 authorizations
 - Multiple US Fish and Wildlife permits required
 - National Marine Fisheries Service



Dominion Virginia Power (DVP) 1C (No New Bus Tie)

Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements

- PJM Operations Review
 - Request to minimize impact to existing transmission facilities
- Salem/Hope Creek Facility Owner Feedback
 - Request to minimize outage and physical impacts to existing transmission facilities
 - Hope Creek north has available land for expansion
 - Hope Creek control house has adequate space and access for expansion

- Blackstart

- No blackstart advantage

- Route Diversity

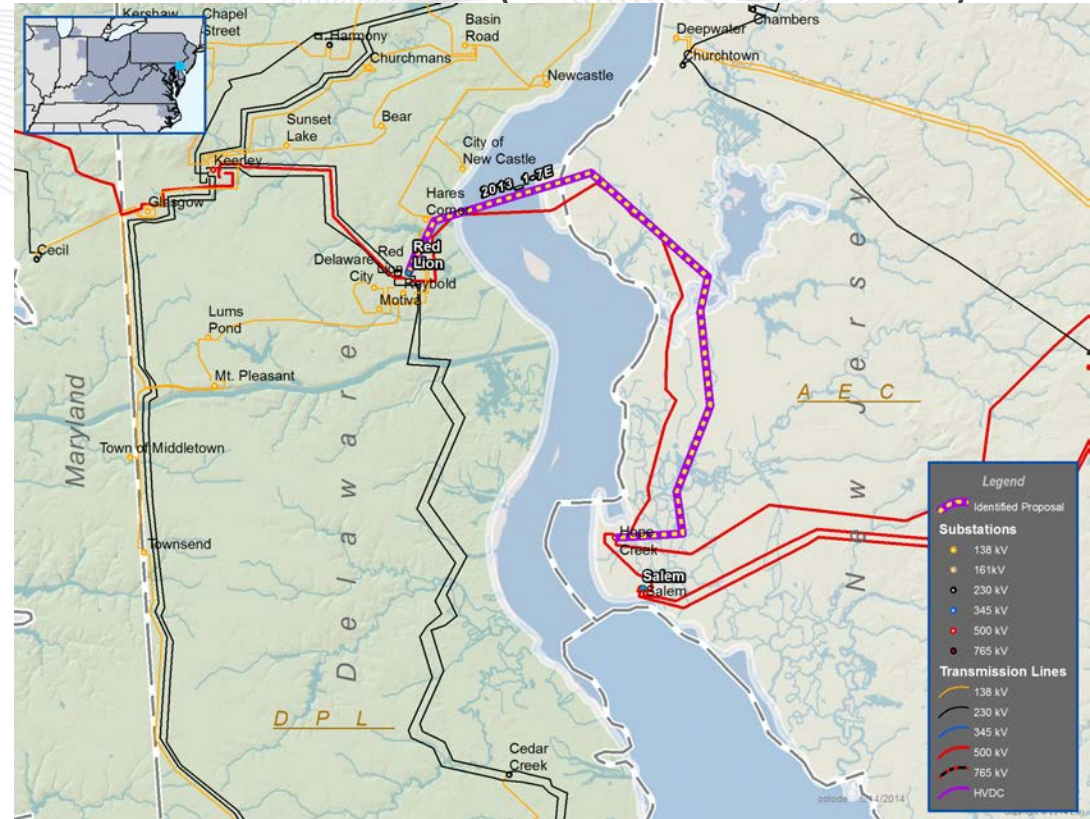
- Project route is parallels the existing 5015 line

- Ongoing Maintenance

- No impact

PSE&G 7K (No New Bus Tie)

- New 500kV Line between Hope Creek and Red Lion substations
- PJM modifications
 - Technical:
 - Removed the New Freedom to Deans portion of the project
 - Removed the new tie between Salem and Hope Creek substations
 - Added SVC
 - Constructability:
 - Red Lion expansion changed from a breaker and a half to an expansion of the existing ring-bus



- **Stability Performance**

- **Failed required performance**

- Failed as proposed by project sponsor.
 - Did not satisfy stability criteria for a single line to ground fault with stuck breaker with AI units at unity power factor under new Hope Creek – Red Lion 500kV line maintenance outage condition with modification to remove Salem – Hope Creek 2nd tie and proposed breakers.

- **Passed required performance**

- Passed as modified with the addition of an SVC at Orchard or New Freedom.

Proposed
Hope Creek
Attachment

Artificial Island

PSE&G 7K (No New Bus Tie)
Hope Creek Expansion



Required Outages:

- Cut-in of new bay at Hope Creek

Red Lion Substation

PSE&G 7K (No New Bus Tie)

Hope Creek (5015)

New Hope Creek Circuit

Relocate 5015 to a new
500kV line terminal
and add double breaker
between lines



PSE&G 7K (No New Bus Tie) - Cost Factors

PJM Estimated Cost: \$211-\$257 (million)

- New 17 mile 500kV line
- Aerial Delaware river crossing

Market Efficiency Analysis Sensitivity Study

- Scenario:
 - New 500 kV path from the AI to Red Lion
- Results:
 - Approximate benefit to cost ratio of 0.15
 - Approximately \$57 million over 15 years

Outage Cost

- 5015 outage estimated at 14 days



PSE&G 7K (No New Bus Tie) - Project Schedule

Proposed Schedule: 51 months (items run concurrent)

- Permitting: 51 months
- Design and Construction: 48 months
- Property Acquisition: 0 months

Schedule Criteria

- Permitting
 - CPCNs in two states and Army Corps of Engineers
- Construction
 - Could be impacted by restrictions due to endangered species and shipping traffic
- Long Lead Time Materials
 - No significant long lead time equipment required



PSE&G 7K (No New Bus Tie) - RoW and Land Acquisition

Right of Way and Land Acquisition Criteria

- No Eminent Domain in Delaware
 - All project have approximately 0.5 miles of right of way to either expand or acquire in Delaware
 - Land is coastal and under state jurisdiction
 - Red Lion substation expansion is on land currently owned by PHI
- New Right of Way Required
 - As participants in the LDV agreement, party has a right of way agreement for the new line
- Substation Land Required
 - Red Lion substation expansion will be done on land currently owned by PHI.

Siting and Permitting Criteria

- Wetlands Impact
 - Permits required to cross the Delaware state lands on the river coast
 - Impacts approximately 350 acres of forested wetland
- Public Opposition Risk
 - View-shed impacts minimal as this is adjacent to the existing 5015
 - Some opposition to any river crossing is expected
- Historic and Scenic Highway
 - No impact
- Land Permitting
 - USFWS right of way permit to cross Supawna National Wildlife Refuge required
- Delaware River Crossing
 - Numerous approvals and permits required:
(a few major permits are listed below)
 - Delaware River Basin Commission approval required
 - Delaware and New Jersey CPCNs required
 - US Army Corps of Engineers Section 404 and 10 authorizations
 - Multiple US Fish and Wildlife permits required
 - National Marine Fisheries Service

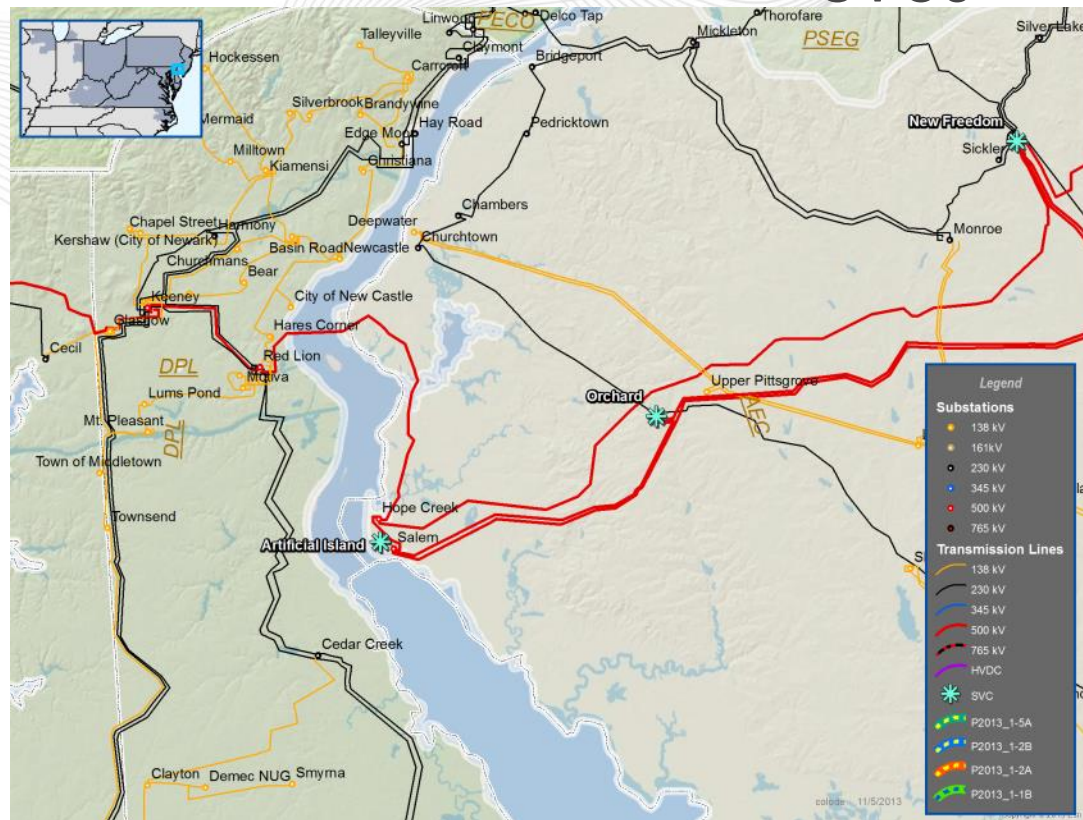


PSE&G 7K (No New Bus Tie) - Operational Impact

Operational Impact Criteria

- Artificial Island Facility Requirements
 - PJM Operations Review
 - Request to minimize impact to existing transmission facilities
 - Salem/Hope Creek Facility Owner Feedback
 - Request to minimize outage and physical impacts to existing transmission facilities
 - Hope Creek north has available land for expansion
 - Hope Creek control house has adequate space and access for expansion
- Blackstart
 - No blackstart advantage
- Route Diversity
 - Project route is parallels the existing 5015 line
- Ongoing Maintenance
 - No impact

- SVC Locations Considered:
 - New Freedom
 - Orchard
 - Artificial Island
- Schedule Estimate 36 months
 - SVC lead time of 24 months
 - Permitting and land acquisition 6 months
- Cost Estimate \$80 million
 - SVC \$60 million





- No determining factor difference between the Orchard or New Freedom SVC
 - Project complexity
 - Expansion of existing substations at either Orchard or New Freedom
 - Land acquisition
 - New land purchase at Orchard
 - PSE&G owns adjacent land at New Freedom
 - Siting and permitting will be similar between the two projects
 - Cost and schedule estimates are the same
- Artificial Island
 - Anticipated nuclear regulatory concerns in approving this device at Artificial Island

Consolidated Summary

Artificial Island Technical Summary

		Southern Crossing Lines (Submarine)			Southern Crossing Lines (Overhead)		Red Lion to Artificial Island Lines						
							From Salem			From Hope Creek			
		LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - Overhead	Dominion 1B - 500kV Overhead	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion 1C - Red Lion to Hope Creek (Remove HC-S 2 nd Tie)	PSE&G 7K- Red Lion to Hope Creek (Remove HC-S 2 nd Tie)
Technical Analysis Criteria	Stability	Maximum angle swing range of 80 - 112 degrees, dependent on solution and SVC location			Maximum angle swing range of 80 - 110 degrees, dependent on solution and SVC location		Maximum angle swing range of 77 - 102 degrees, dependent on solution and SVC location						
	Thermal	Preliminary analysis indicates no thermal overloads			Preliminary analysis indicates no thermal overloads		Preliminary analysis indicates no thermal overloads						
	Market Efficiency Results	Approximate \$92 M cost savings over 15 Years			Approximate \$92 M cost savings over 15 Years		Approximate \$57 M cost savings over 15 Years						
	Short Circuit	Three overdutied 230 kV breakers		No overdutied breakers	Three overdutied 230 kV breakers		No overdutied breakers						

- The following slides provide a summary review of PJM's assessment of the modified proposals in terms of technical performance, cost, constructability and other factors, which are covered in greater detail in the preceding slides.
- Legend:

Positive or limited impact	
Some impact	
Negative impact	
Does not apply	



Southern Crossing Lines – Project Complexity

Project Class		Southern Crossing 230kV Lines (Submarine)			Southern Crossing Lines (Overhead)	
Criteria	Proposal	LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - 230kV Overhead	Dominion 1B - 500kV Overhead
	Sub-Criteria					
Project Complexity	Line Crossings	None	None	None	None	Generator lead line
	Outage Requirements	New bay tie-in at Salem	Relocation of 5024 line at Salem	Relocation of 5024 line at Salem; Cedar Creek ring-bus expansion	New bay tie-in at Salem	New tie-in at Salem will necessitate a unit outage; Breaker installation may require multiple Salem outages.
	Modification to other Transmission Facilities	Cutting the two 230kV lines into the new Delaware substation	Cutting the two 230kV lines into the new Delaware substation; installing one new span on the 5024 line.	Expanding the Cedar Creek ring bus by two positions to bring in the new Salem line and the existing Red Lion to Cartanza line; installing one new span on the 5024 line.	Cutting the two 230kV lines into the new Delaware substation	Cutting the two 230kV lines into the new Delaware substation

Southern Crossing Lines – Project Complexity

Project Class		Southern Crossing 230kV Lines (Submarine)			Southern Crossing Lines (Overhead)	
Criteria	Proposal	LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - 230kV Overhead	Dominion 1B - 500kV Overhead
	Sub-Criteria					
Project Complexity	Modification of Artificial Island Substations	New bay and auto-transformer to the south in Salem	New bay for 5024 line to the south in Salem	New bay for 5024 line to the south in Salem	New bay and auto-transformer to the south in Salem	Installing two breakers into the open middle bay in Salem
	Modification of Red Lion Substation	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable

AI to Red Lion Lines – Project Complexity

Project Class		Red Lion to Salem 500kV Lines			Red Lion to Hope Creek 500kV Lines			
Criteria	Proposal	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion Red Lion to Hope Creek w/ 2nd tie removed	PSE&G Red Lion to Hope Creek w/ 2nd tie removed
	Sub-Criteria							
Project Complexity	Line Crossings	5023, 5021, 5024 lines	5015 and 5023 lines	5023 line	5015 line; aerial tie has multiple crossings	5015 line	None	None
	Outage Requirements	5015 line position changing at both ends; Raising the three 500kV lines	Raising 5015 line and moving it to the new position at Red Lion. Relocation of 5037 line at Salem; Raising the 5023 line	Relocating the 5024 and 5021 lines at Salem; New line crosses the 5023 line.	Multiple 500kV outages to convert the Red Lion ring bus to a breaker and a half scheme; New line crosses the 5015 line; Outages to support the new Hope Creek to Salem tie	Multiple 500kV outages to convert the Red Lion ring bus to a breaker and a half scheme; New line crosses the 5015 line; Outages to support the new Hope Creek to Salem tie; 5037 into new position at Hope Creek	5015 line position changing at Red Lion. New bay tie-in at Hope Creek	5015 line position changing at Red Lion. New bay tie-in at Hope Creek
	Modification to other Facilities	Impacts detailed in other sub-criteria	Installing one new span on the 5037 line.	Use of the existing 5021 for a number of spans and build a new portion of 5021 along that length; installing one new span for the 5024 line	Impacts detailed in other sub-criteria	Impacts detailed in other sub-criteria	Impacts detailed in other sub-criteria	Impacts detailed in other sub-criteria

AI to Red Lion Lines – Project Complexity

Project Class		Red Lion to Salem 500kV Lines			Red Lion to Hope Creek 500kV Lines			
Criteria	Proposal	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion Red Lion to Hope Creek w/ 2nd tie removed	PSE&G Red Lion to Hope Creek w/ 2nd tie removed
	Sub-Criteria							
Project Complexity	Modification of Artificial Island Substations	New bay to the south in Salem	New bay for 5037 line to the north in Salem	New bay for 5024 line to the south and relocate 5021 line in Salem	New bay in Hope Creek and a new tie between Hope Creek and Salem	New bay in Hope Creek and a new tie between Hope Creek and Salem; moving the 5037 into the existing open bay at Hope Creek	New bay in Hope Creek	New bay in Hope Creek
	Modification of Red Lion Substation	Moving 5015 line into new ring-bus position	Moving 5015 line into new ring-bus position	New position created for the new line.	Rebuilding the substation as a double bus - double breaker scheme	Rebuilding the substation as a breaker and a half scheme	Moving 5015 line into new ring-bus position	Moving 5015 line into new ring-bus position

Southern Crossing Lines – Cost Factors

Project Class		Southern Crossing 230kV Lines (Submarine)			Southern Crossing Lines (Overhead)	
Criteria	Proposal	LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - 230kV Overhead	Dominion 1B - 500kV Overhead
	Sub-Criteria					
Cost Factors	PJM Estimated Project	\$248-\$302	\$257-\$313	\$366-\$446	\$211-\$257	\$233-\$283
	Proposed Project Costs	\$148	\$165-\$208	\$213-269	\$116	\$133
	Market Efficiency	Approximately \$92 over 15 years			Approximately \$92 over 15 years	
	Outage Cost	230kV outage during substation cut-in	230kV outage during substation cut-in	230kV outage during substation cut-in	230kV outage during substation cut-in	230kV outage during substation cut-in

Note: Costs are for the line project only; SVC costs are not included.

AI to Red Lion Lines – Cost Factors

Project Class		Red Lion to Salem 500kV Lines			Red Lion to Hope Creek 500kV Lines			
Criteria	Proposal	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion Red Lion to Hope Creek w/ 2nd tie removed	PSE&G Red Lion to Hope Creek w/ 2nd tie removed
	Sub-Criteria							
Cost Factors	PJM Estimated Project	\$216-\$263	\$221-\$269	\$232-\$282	\$242-\$294	\$249-\$304	\$211-\$257	\$211-\$257
	Proposed Project Costs	\$181	\$171	\$123-156	\$199	\$297		
	Market Efficiency	Approximately \$57 over 15 years			Approximately \$57 over 15 years			
	Outage Cost	5015 outage estimated at 30 days	5015 outage estimated at 30 days	5015 outage estimated at 14 days	5015 outage estimated at 40 days	5015 outage estimated at 40 days	5015 outage estimated at 14 days	5015 outage estimated at 14 days

Note: Costs are for the line project only; SVC costs are not included.

Southern Crossing Lines – Operational Impact

Project Class		Southern Crossing 230kV Lines (Submarine)			Southern Crossing Lines (Overhead)	
Criteria	Proposal	LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - 230kV Overhead	Dominion 1B - 500kV Overhead
	Sub-Criteria					
Operational Impact	Artificial Island Facility Requirements	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained
	Blackstart	Additional access to blackstart resources	Additional access to blackstart resources	Additional access to blackstart resources	Additional access to blackstart resources	Additional access to blackstart resources
	Route Diversity	New route	New route	New route	New route	New route
	Ongoing Maintenance	Salt spray concern with proximity to Delaware river; auto-transformer maintenance may increase line outage frequency	Salt spray concern with proximity to Delaware river; auto-transformer maintenance may increase line outage frequency	Salt spray concern with proximity to Delaware river; auto-transformer maintenance may increase line outage frequency	Salt spray concern with proximity to Delaware river; auto-transformer maintenance may increase line outage frequency	Auto-transformer maintenance may increase line outage frequency

AI to Red Lion Lines – Operational Impact

Project Class		Red Lion to Salem 500kV Lines			Red Lion to Hope Creek 500kV Lines			
Criteria	Proposal	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K - Red Lion to Hope Creek	Dominion Red Lion to Hope Creek w/ 2nd tie removed	PSE&G Red Lion to Hope Creek w/ 2nd tie removed
	Sub-Criteria							
Operational Impact	Artificial Island Facility Requirements	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Expansion at Salem needs to incorporate maintenance access to substation equipment; Salem is space constrained; Control house access is also constrained	Land available to the north of Hope Creek for expansion and control house has adequate space and access for expansion	Land available to the north of Hope Creek for expansion and control house has adequate space and access for expansion
	Blackstart	No blackstart advantage	No blackstart advantage	No blackstart advantage	No blackstart advantage	No blackstart advantage	No blackstart advantage	No blackstart advantage
	Route Diversity	Parallels existing 5015 line	Parallels existing 5015 line	Parallels existing 5015 line	Parallels existing 5015 line	Parallels existing 5015 line	Parallels existing 5015 line	Parallels existing 5015 line
	Ongoing Maintenance	Salt spray concern with proximity to Delaware river	No impact	Salt spray concern with proximity to Delaware river	The new gas-insulated bus tie line between Salem and Hope Creek may require more frequent maintenance	Limited physical access could lead to maintenance issues on the new tie line between Salem and Hope Creek	No impact	No impact

Southern Crossing Lines Right of Way and Land Acquisition

Project Class		Southern Crossing 230kV Lines (Submarine)			Southern Crossing Lines (Overhead)	
Criteria	Proposal	LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - 230kV Overhead	Dominion 1B - 500kV Overhead
	Sub-Criteria					
Right of Way and Land Acquisition	No Eminent Domain in Delaware	1.5-3 miles of new RoW to acquire in Delaware	1.5-3 miles of new RoW to acquire in Delaware	3 miles of new RoW to acquire in Delaware	1.5-3 miles of new RoW to acquire in Delaware	1.5-3 miles of new RoW to acquire in Delaware
	New Right of Way Required	1.5-3 miles of new RoW to acquire in Delaware	1.5-3 miles of new RoW to acquire in Delaware	3 miles of new RoW to acquire in Delaware	1.5-3 miles of new RoW to acquire in Delaware	1.5-3 miles of new RoW to acquire in Delaware
	Substation Land Required	Acquired an option on a substation location in Delaware	New substation land required in Delaware and New Jersey	New substation land required in Delaware and New Jersey	Acquired an option on a substation location in Delaware	New substation land required in Delaware

AI to Red Lion Lines Right of Way and Land Acquisition

Project Class		Red Lion to Salem 500kV Lines			Red Lion to Hope Creek 500kV Lines			
Criteria	Proposal	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion Red Lion to Hope Creek w/ 2nd tie removed	PSE&G Red Lion to Hope Creek w/ 2nd tie removed
	Sub-Criteria							
Right of Way and Land Acquisition	No Eminent Domain in Delaware	0.5 miles of right of way to expand in Delaware; land is coastal and under state jurisdiction	0.5 miles of right of way to expand in Delaware; land is coastal and under state jurisdiction	0.5 miles of right of way to expand in Delaware; land is coastal and under state jurisdiction	0.5 miles of right of way to expand in Delaware; land is coastal and under state jurisdiction	0.5 miles of right of way to expand in Delaware; land is coastal and under state jurisdiction	0.5 miles of right of way to expand in Delaware; land is coastal and under state jurisdiction	0.5 miles of right of way to expand in Delaware; land is coastal and under state jurisdiction
	New Right of Way Required	Participant in the LDV agreement which governs 5015 RoW	Negotiate with LDV parties or individual land owners	Negotiate with LDV parties or individual land owners	Negotiate with LDV parties or individual land owners	Participant in the LDV agreement which governs 5015 RoW	Negotiate with LDV parties or individual land owners	Participant in the LDV agreement which governs 5015 RoW
	Substation Land Required	None	None	None	None	None	None	None



Southern Crossing Lines - Siting and Permitting

Project Class		Southern Crossing 230kV Lines (Submarine)			Southern Crossing Lines (Overhead)	
Criteria	Proposal	LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - 230kV Overhead	Dominion 1B - 500kV Overhead
	Sub-Criteria					
Siting and Permitting	Wetlands Impact	New route will allow flexibility	New route will allow flexibility	Impacts approximately 10 acres of forested wetland	New route will allow flexibility	New route will allow flexibility
	Land Permitting	No major permit identified	No major permit identified	No major permit identified	No major permit identified	No major permit identified
	Public Opposition Risk	No view-shed impact; some opposition to any river crossing is expected	No view-shed impact; some opposition to any river crossing is expected	No view-shed impact; some opposition to any river crossing is expected	Creates a new view-shed impact and would become the southern-most aerial infrastructure on the Delaware River	Creates a new view-shed impact and would become the southern-most aerial infrastructure on the Delaware River
	Historic and Scenic Highway	New line parallels Delaware state route 9	New line crosses Delaware state route 9	Not applicable	New line parallels Delaware state route 9	New line crosses Delaware state route 9
	Delaware River Crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing

AI to Red Lion Lines - Siting and Permitting

Project Class		Red Lion to Salem 500kV Lines			Red Lion to Hope Creek 500kV Lines			
Criteria	Proposal	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion Red Lion to Hope Creek w/ 2nd tie removed	PSE&G Red Lion to Hope Creek w/ 2nd tie removed
	Sub-Criteria							
Siting and Permitting	Wetlands Impact	Impacts approximately 350 acres of forested wetland	Impacts approximately 350 acres of forested wetland	Impacts approximately 350 acres of forested wetland	Impacts approximately 350 acres of forested wetland	Impacts approximately 350 acres of forested wetland	Impacts approximately 350 acres of forested wetland	Impacts approximately 350 acres of forested wetland
	Land Permitting	USFWS RoW permit to cross Supawna National Wildlife Refuge required	USFWS RoW permit to cross Supawna National Wildlife Refuge required	USFWS RoW permit to cross Supawna National Wildlife Refuge required	USFWS RoW permit to cross Supawna National Wildlife Refuge required	USFWS RoW permit to cross Supawna National Wildlife Refuge required	USFWS RoW permit to cross Supawna National Wildlife Refuge required	USFWS RoW permit to cross Supawna National Wildlife Refuge required
	Public Opposition Risk	View-shed impacts minimized by proximity to the existing 5015; some opposition to any river crossing is expected	View-shed impacts minimized by proximity to the existing 5015; some opposition to any river crossing is expected	View-shed impacts minimized by proximity to the existing 5015; some opposition to any river crossing is expected	View-shed impacts minimized by proximity to the existing 5015; some opposition to any river crossing is expected	View-shed impacts minimized by proximity to the existing 5015; some opposition to any river crossing is expected	View-shed impacts minimized by proximity to the existing 5015; some opposition to any river crossing is expected	View-shed impacts minimized by proximity to the existing 5015; some opposition to any river crossing is expected
	Historic and Scenic Highway	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
	Delaware River Crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing	Numerous approvals and permits will be required for any Delaware river crossing

Southern Crossing Lines – Project Schedule

Project Class		Southern Crossing 230kV Lines (Submarine)			Southern Crossing Lines (Overhead)	
Criteria	Proposal	LS Power 5A - Submarine Option	Transource 2B - North Cedar Creek	Transource 2A - Cedar Creek Expansion	LS Power 5A - 230kV Overhead	Dominion 1B - 500kV Overhead
	Sub-Criteria					
Project Schedule	Permitting	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits
	Construction	Submarine cable installation requires specialized equipment; Spawning/nesting seasons of endangered species may impact construction timeframes	Submarine cable installation requires specialized equipment; Spawning/nesting seasons of endangered species may impact construction timeframes	Submarine cable installation requires specialized equipment; Spawning/nesting seasons of endangered species may impact construction timeframes	Spawning/nesting seasons of endangered species may impact construction timeframes	Spawning/nesting seasons of endangered species may impact construction timeframes
	Long Lead Time Materials	Submarine cable and auto-transformers	Submarine cable and auto-transformers	Submarine cable and auto-transformers	Auto-transformers	Auto-transformers

AI to Red Lion Lines – Project Schedule

Project Class		Red Lion to Salem 500kV Lines			Red Lion to Hope Creek 500kV Lines			
Criteria	Proposal	PHI/Exelon 4A - Red Lion to Salem	LS Power 5B - Red Lion to Salem	Transource 2C - Red Lion to Salem	Dominion 1C - Red Lion to Hope Creek	PSE&G 7K- Red Lion to Hope Creek	Dominion Red Lion to Hope Creek w/ 2nd tie removed	PSE&G Red Lion to Hope Creek w/ 2nd tie removed
	Sub-Criteria							
Project Schedule	Permitting	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits	Multiple permits required including CPCNs from two states and Army Corp of Engineers permits
	Construction	Spawning/nesting seasons of endangered species may impact construction timeframes	Spawning/nesting seasons of endangered species may impact construction timeframes	Spawning/nesting seasons of endangered species may impact construction timeframes	Spawning/nesting seasons of endangered species may impact construction timeframes	Spawning/nesting seasons of endangered species may impact construction timeframes	Spawning/nesting seasons of endangered species may impact construction timeframes	Spawning/nesting seasons of endangered species may impact construction timeframes
	Long Lead Time Materials	None	None	None	None	None	None	None

[illegible]

- **Today - Monday, May 19th Special TEAC**
 - 3 hour stakeholder technical meeting
 - In-person at PJM CTC
- Monday, June 2nd – Due date for stakeholder comment/feedback (14 day comment period)
- June 5th TEAC
- **Monday, June 16th – PJM review of stakeholder comment/feedback and final decision meeting**
 - **Special TEAC Webex / Teleconference**
- Comment Period to the PJM Board (36 days for comment period)
- July 10th TEAC
- **Tuesday, July 22nd – PJM Board meeting**
 - **Artificial Island solution recommendation to the PJM Board**

Appendix

Technical Overview

Minimum AI voltage for 230kV proposals

Comparison Method:

Assume 1.065 p.u. at the AI (unstable below 1.065), solve the power flow for the corresponding Salem and Hope Creek MVAR output. Simulate the combination of the most critical fault and outage. Do not assume the addition of an SVC.

Result:

Measure the maximum machine angle swing.

All 230 kV proposals pass the stability criteria.

Group	Project ID	230 kV Transmission Solution	AI 500kV bus voltage	AI MVAR output	Critical Outage	Critical Contingency	Maximum Angle Swing (deg.)
1.1	P2013_1-5A	LS Power	1.065 pu	1044	5015*	14b**	102
1.1	P2013_1-2B	Transource (AEP)	1.065 pu	965	5015	14b	105
1.1	P2013_1-2A	Transource (AEP)	1.065 pu	940	5015	14b	110
1.2	P2013_1-1B	DVP	1.065 pu	926	5015	14b	115

5015*: Hope Creek – Red Lion 500kV line

14b**: single-line-to-ground fault on the new line from Salem w/ delayed clearing due to stuck breaker

230kV proposal comparison - 5015 outage

Comparison Method:

For each proposal, assume a fixed MVar output at the Artificial Island, solve the power flow for the corresponding Artificial Island bus voltages. Simulate the combination of the most critical fault and outage. Do not assume the addition of an SVC.

Result:

Measure the maximum machine angle swing.

All 230 kV proposal pass the stability criteria.

Group	Project ID	230 kV Transmission Solution	AI 500kV bus voltage	AI MVar output	Critical Outage	Critical Contingency	Maximum Angle Swing (deg)
1.1	P2013_1-5A	LS Power	1.065	1044	5015	14b	102
1.1	P2013_1-2B	Transource (AEP)	1.071	1044	5015	14b	95
1.1	P2013_1-2A	Transource (AEP)	1.074	1044	5015	14b	95
1.2	P2013_1-1B	DVP	1.074	1044	5015	14b	97

5015*: Hope Creek – Red Lion 500kV line

14b**: single-line-to-ground fault on the new line from Salem w/ delayed clearing due to stuck breaker

230kV proposal comparison – 5038 outage

Comparison Method:

For each proposal, assume a fixed MVar output at the Artificial Island, solve the power flow for the corresponding Artificial Island bus voltages. Simulate the combination of the most critical fault and outage. Do not assume the addition of an SVC.

Result:

Measure the maximum machine angle swing.

All 230 kV proposal pass the stability criteria.

Group	Project ID	230 kV Transmission Solution	AI 500kV bus voltage	AI MVar output	Critical Outage	Critical Contingency	Maximum Angle Swing (deg)
1.1	P2013_1-5A	LS Power	1.044	832	5038*	2b**	121
1.1	P2013_1-2B	Transource (AEP)	1.052	832	5038	2b	89
1.1	P2013_1-2A	Transource (AEP)	1.053	832	5038	2b	93
1.2	P2013_1-1B	DVP	1.049	832	5038	2b	87

5038*: New Freedom – East Windsor 500kV line

2b**: single-line-to-ground fault on Hope Creek-Red Lion 500kV line w/ delayed clearing due to stuck breaker

230kV+ SVC proposal comparison

Comparison Method:

For each proposal, assume the addition of an SVC at each of three locations. Simulate the combination of the most critical fault and outage.

Result:

Measure the maximum machine angle swing.

All 230 kV proposals with SVC additions pass the stability criteria with greater margin than without SVCs.

Project ID	230 kV Transmission Solution	SVC option	AI 500kV Bus Voltage	AI MVar Output	Critical Outage	Critical Contingency	Maximum Angle Swing
P2013_1-5A-SVC	LS Power	Artificial Island	1.042	728	5015	14b	80
		Orchard	1.041	724	5015	14b	108
		New Freedom	1.041	721	5015	14b	112
P2013_1-2B-SVC	Transource (AEP)	Artificial Island	1.042	664	5015	14b	81
		Orchard	1.042	662	5015	14b	105
		New Freedom	1.042	662	5015	14b	109
P2013_1-2A-SVC	Transource (AEP)	Artificial Island	1.043	655	5015	14b	82
		Orchard	1.042	658	5015	14b	107
		New Freedom	1.042	658	5015	14b	112
P2013_1-1B-SVC	DVP	Artificial Island	1.042	672	5015	14b	85
		Orchard	1.041	670	5015	14b	106
		New Freedom	1.041	674	5015	14b	110

Note: The study results are obtained under the assumption of unity power factor at the high side of GSU.

Compare TCSC + SVC (assumes +750 MVAR) alternative to 230 kV + SVC alternatives

Project	Project ID	TO	SVC location	AI 500kV bus voltage	AI MVAR output	Outage	Contingency	Maximum Angle Swing
230kV+SVC	P2013_1-5A-SVC	LS Power	New Freedom	1.032	645	5038	2a	54
	P2013_1-2B-SVC	Transource	New Freedom	1.040	645	5038	2a	47
	P2013_1-2A-SVC	Transource	New Freedom	1.042	645	5038	2a	48
	P2013_1-1B-SVC	DVP	New Freedom	1.037	645	5038	2a	46
TCSC+SVC	P2013_1-1A	DVP	New Freedom	1.029	645	5038	2a	88

- Load Flow Analysis
 - 230 kV Transmission Solutions
 - No thermal or voltage violations identified for summer peak case
 - New 500 kV transmission from the Artificial Island to Red Lion 500 kV
 - No thermal or voltage violations identified for summer peak case

- Short Circuit Analysis
 - 230 kV Transmission Solutions
 - Several 50 kA circuit breakers overdutied at Red Lion 230 kV
 - New 500 kV transmission from the Artificial Island to Red Lion 500 kV
 - No new overdutied breakers identified

Cost Factors



Constructability Review – PJM Cost Estimates

- PJM performed a per-unit cost estimate analysis
- Major components account for 70% - 90% of estimated material and construction costs
 - Submarine cable at \$5.3 million per mile
 - 500kV aerial at \$3.6 million per mile
 - Aerial Delaware river crossing at \$100 million
 - 500/230kV auto transformer at \$7.8 to \$10.5 million per phase

- Costs independently estimated in collaboration with PJM outside consultants
 - Engineering at 2.5%
 - Project management at 5%
 - Contingency range from 15% to 40%
- Estimate Sources
 - RTEP project cost estimates and actuals
 - Inputs from multiple outside consultants
 - Industry sources

Class	Proposals	PJM Estimate	
Southern Crossing Lines (Submarine)	LS Power 5A - Submarine Option	\$ 248	\$ 302
	Transource 2B - North Cedar Creek	\$ 257	\$ 313
	Transource 2A - Cedar Creek Expansion	\$ 366	\$ 446
Southern Crossing Lines (Overhead)	LS Power 5A - Overhead	\$ 211	\$ 257
	Dominion 1B - 500kV Overhead	\$ 233	\$ 283
Red Lion to Salem Lines	PHI/Exelon 4A - Red Lion to Salem	\$ 216	\$ 263
	LS Power 5B - Red Lion to Salem	\$ 221	\$ 269
	Transource 2C - Red Lion to Salem	\$ 232	\$ 282
Red Lion to Hope Creek Lines	Dominion 1C - Red Lion to Hope Creek	\$ 242	\$ 294
	PSE&G 7K- Red Lion to Hope Creek	\$ 249	\$ 304
	Dominion – Red Lion to Hope Creek (No New Bus Tie)	\$ 211	\$ 257
	PSE&G – Red Lion to Hope Creek (No New Bus Tie)	\$ 211	\$ 257

Revision History

- Original Version Distributed to PJM TEAC
 - V1 – 6/16/2014 – Original Version presented to the PJM TEAC
 - V2 – 6/16/2014 – Modified slide 31 – “Project Designation Differentiating Factor” to include FirstEnergy