

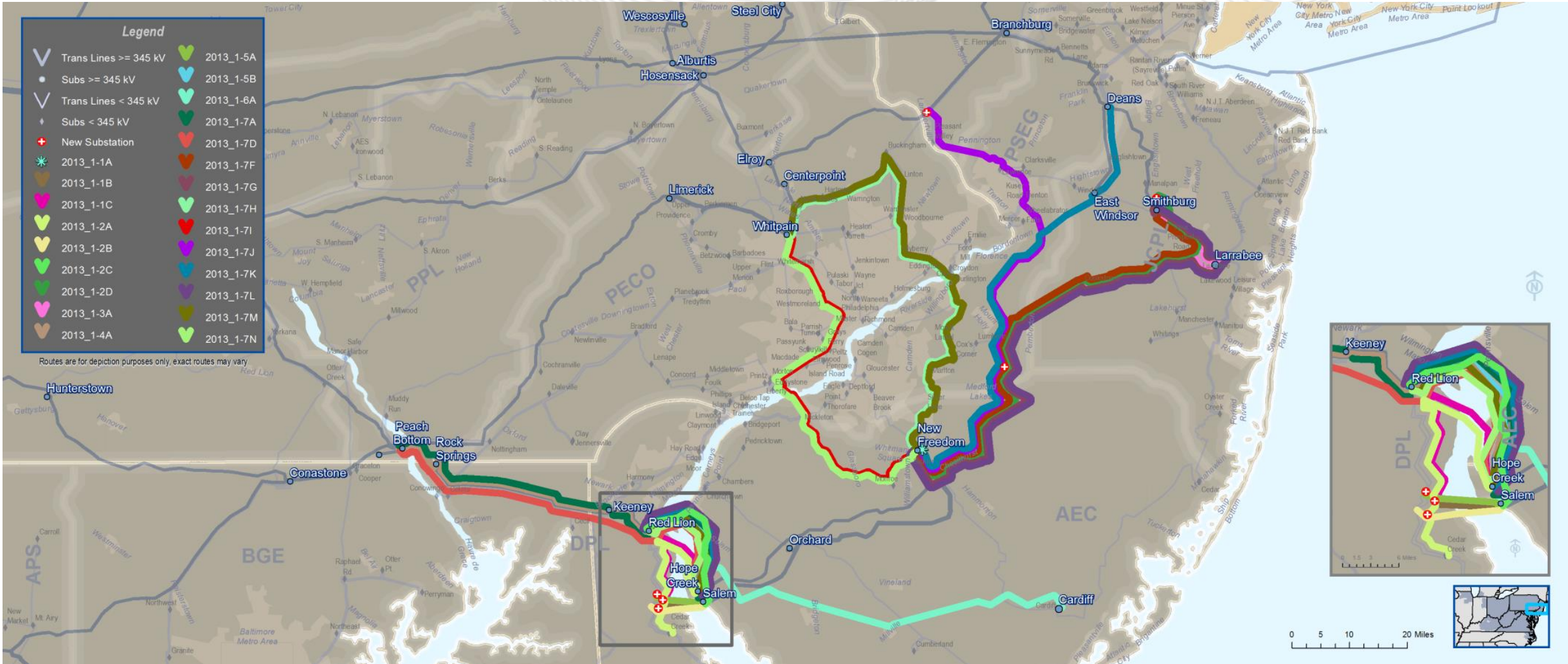
Transmission Expansion Advisory Committee

April 28, 2015

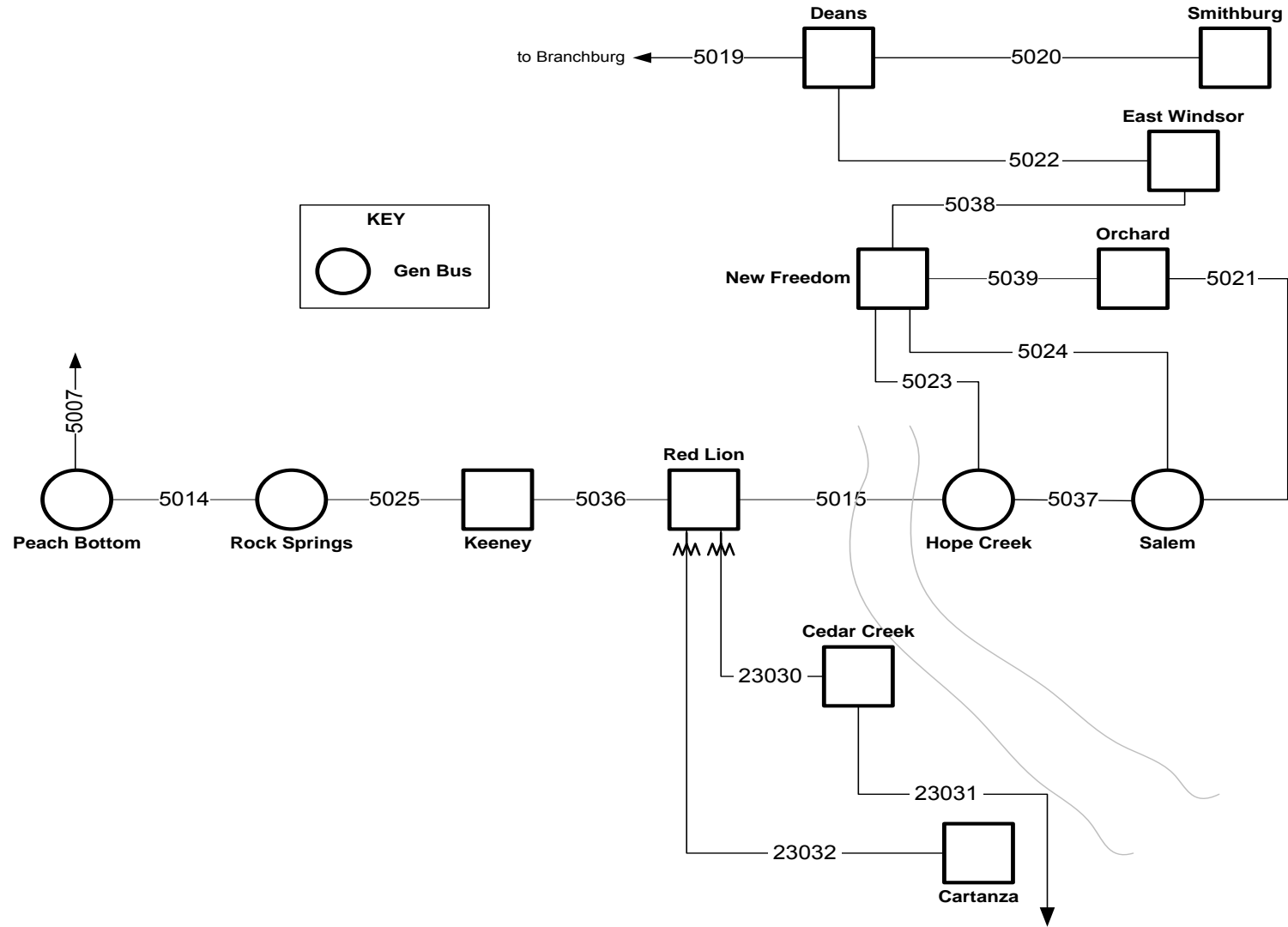
Artificial Island

- Stakeholder Comments
- Project Evaluation
 - Performance
 - Cost
 - Constructability
- Artificial Island Project Recommendations
- Next Steps

- Request from Transource and PHI:
 - Has any documentation that materially changes the supplemental information been supplied outside of what is posted on the PJM website?
 - No. Meetings were held with the FERC ALJ to clarify the supplemental information.
 - Requested project scope details for LS Power and PSE&G projects
 - December 9 PJM TEAC, Appendix slides 26 through 35
 - Included in the Appendix of this presentation



Artificial Island Area Network

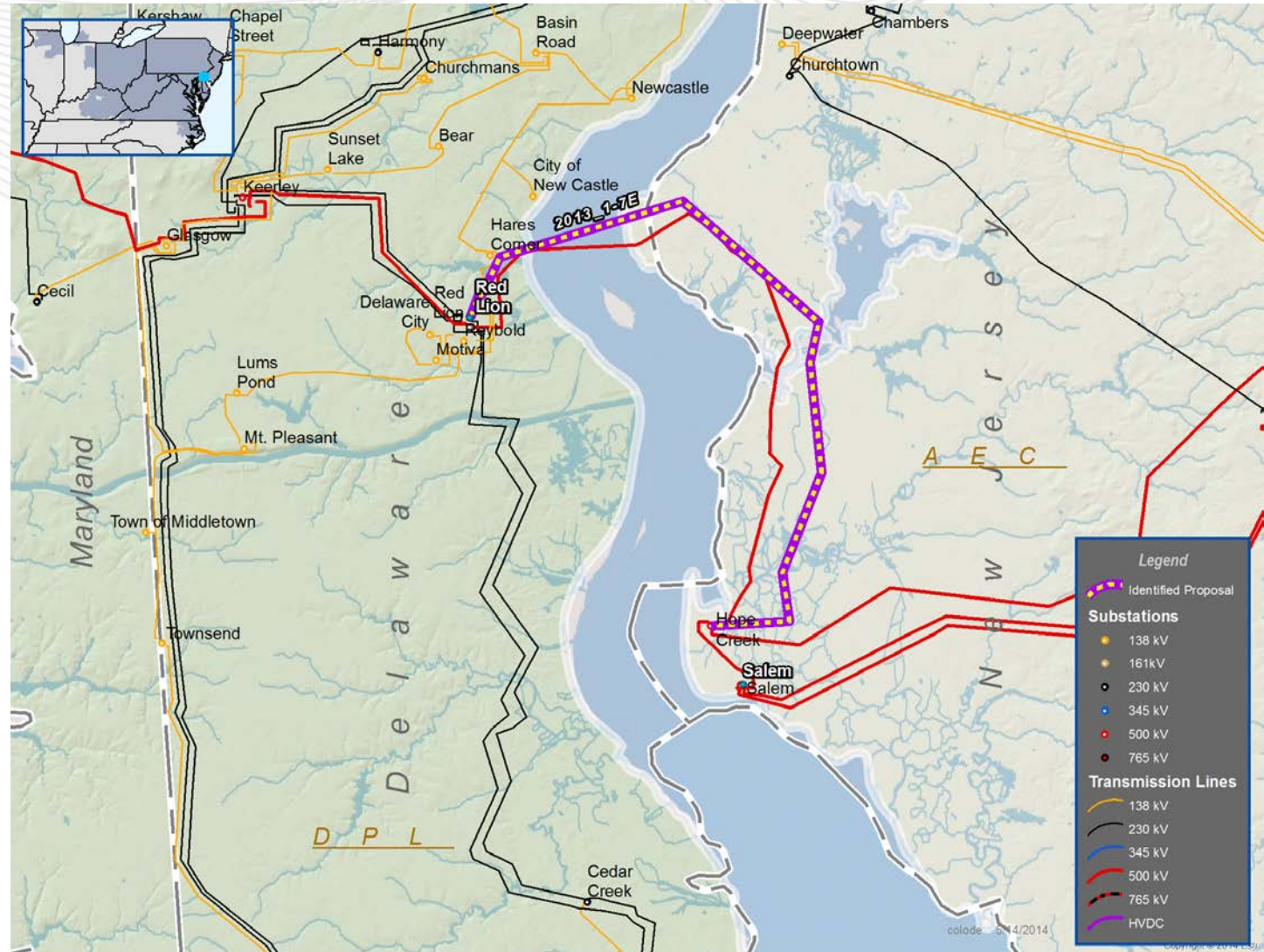


Dominion Virginia Power (DVP) 1A

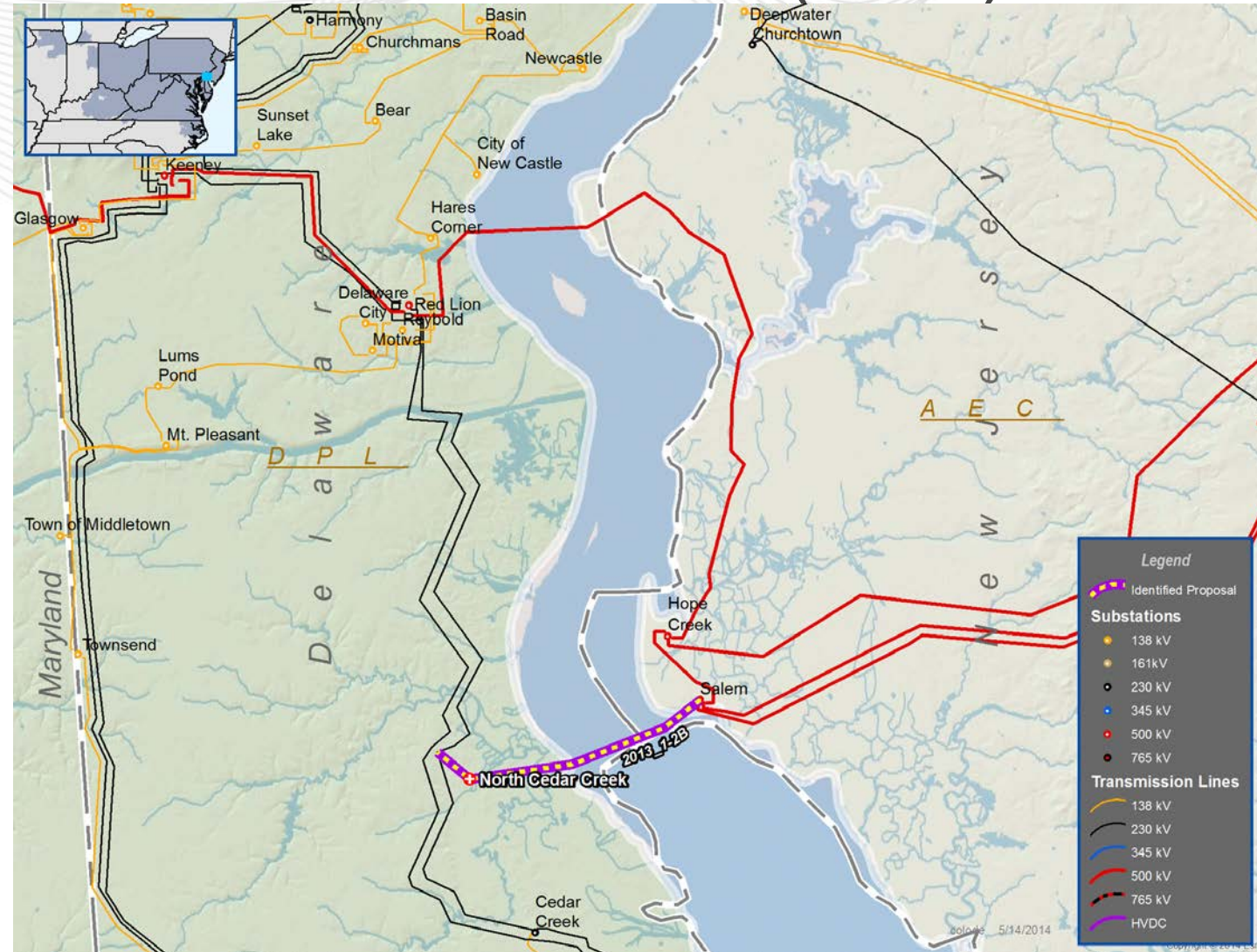
- New switching station cutting the 5023 and 5024 lines near New Freedom substation that includes
 - 500kV SVC (+750 to -375 MVAR)
 - Two Thyristor Controlled Series Compensation (TCSC) devices



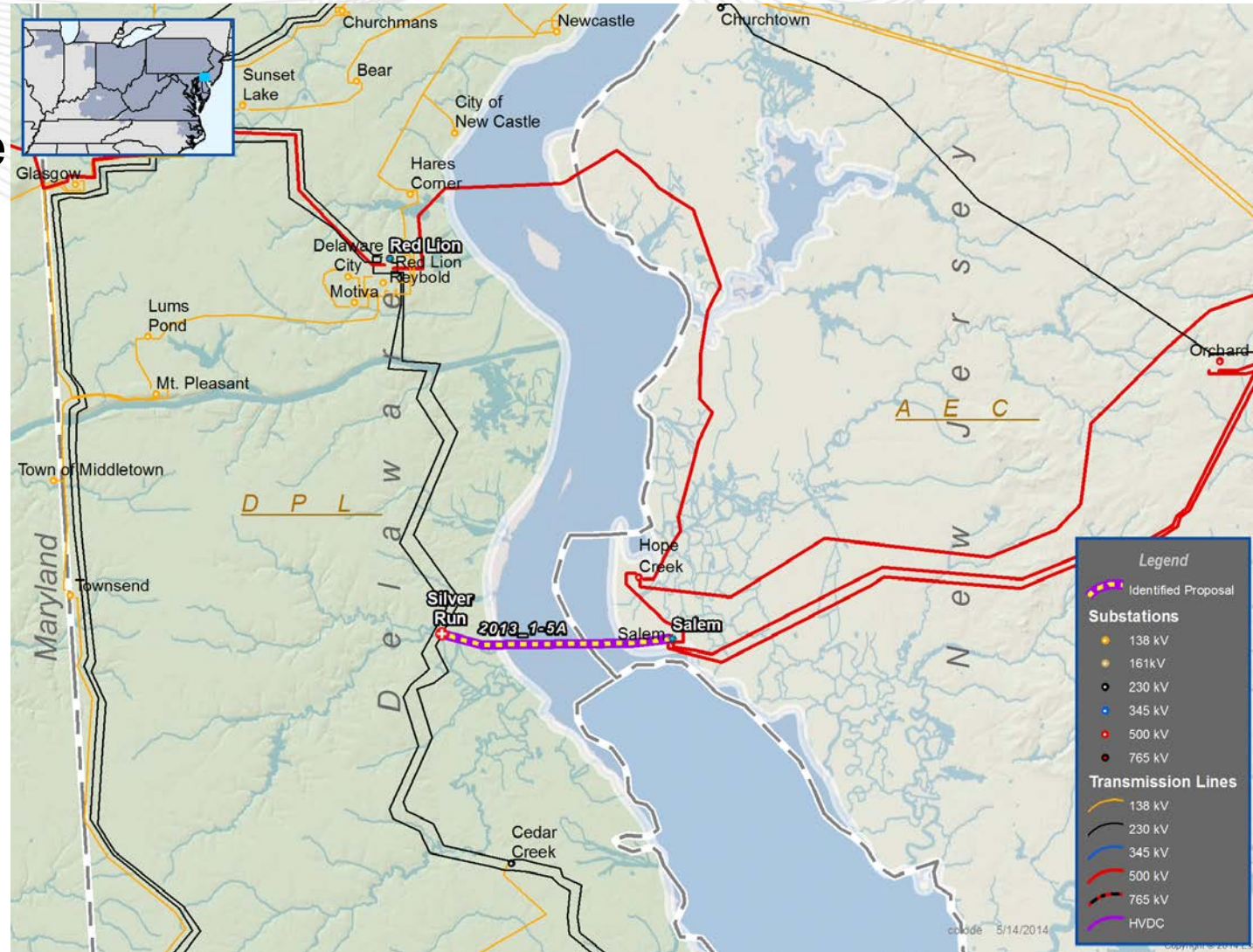
- Expansion of Hope Creek substation
- 500kV line from Hope Creek to Red Lion
 - Parallels existing 5015 Red Lion to Hope Creek 500 kV line
- Reconfigure Red Lion substation to accommodate new line



- 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



- Expansion of the Salem substation to the south to include a new 500/230kV auto-transformer
- Submarine line under 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



Performance

- Siemens Power Technologies International (Siemens PTI) was contracted to perform a Sub Synchronous Resonance screening study of the Dominion 1A proposal
- Siemens SSR Screening Study
 - Available Data
 - Mass moment of inertia and torsional modes
 - Assumptions
 - Approximate two-mass modeling approach
 - Critical conditions (including system configuration and critical faults)
 - Analysis
 - PSCAD simulation and frequency scan
 - Result
 - Negative damping at the Artificial Island for several resonant frequencies

- Exponent's report summary:
 - Determined Siemens SSR study is inconclusive based on the study assumptions
 - The 90% post contingency TCSC compensation level is very high leaving little margin to avoid resonance
 - Identifies that 70-80% compensation is highest in general industry practice
 - To be credible, additional study should consider simulations in a real time digital power system simulation such as RTDS

- Dominion provided a timeline of studies required to design the TCSC controller that estimates 26 weeks for completion
 - Assumptions:
 - All required study data has been acquired
 - This includes the machine data for the nuclear units at Artificial Island
 - Does not include review time between study stages

- Assessment of the impact of reduced fault clearing times and Artificial Island generator step-up transformer tap optimizations on the performance of the proposals:
 - Faster fault clearing times will be realized by installing new line relaying and high speed fiber optic communication channels on several lines
 - PJM analysis quantified the improved stability margins from the relay and GSU tap setting changes

- High speed relaying utilizing OPGW to be implemented on the following existing lines:

5037 Salem – Hope Creek

5015 Hope Creek – Red Lion

5023 Hope Creek – NF

5021 Salem - Orchard

5022 East Windsor - Deans

5038 New Freedom – East Windsor

5024 Salem – New Freedom

5039 New Freedom – Orchard

- Tap setting optimization for the three Artificial Island generator step-up transformers

- Pushed each project to failure
 - Determined the longest duration fault clearing time (cycles) for which a project remained stable
- PJM Manual 14B
 - Add a $\frac{1}{4}$ and $\frac{1}{2}$ cycle of fault clearing time and re-test
 - Margin test accounts for uncertainty in actual clearing times



Margin Testing Results – Cycles to Fail

Project	Project ID	Proposing Entity	OPGW Wire	GSU Tap Optimization	TCSC Compensation (Normal/Transient)	SVC	Outage	Limiting Contingency (redacted)	Maximum Angle Swing	Fault Clearing Time (Tcl) (cycles)	CCT ⁽¹⁾ (cycles)	Margin to CCT (cycles) (CCT – Tcl)
230kV	P2013_1-5A	LS Power		Yes	N/A	No	5015		114	9.06 ⁽⁵⁾	9.31	0.25
				No		300MVAR	5015		91	9.06	10.31	1.25
	P2013_1-2B	Transource		Yes		No	5015		107	9.06	9.56	0.50
				No		300MVAR	5015		88	9.06	10.56	1.50
				Yes		650MVAR	5015		109	10.14	10.64	.5
				No		No	5015		100	9.06	9.81	0.75
500kV	P2013_1-7K	PSE&G		Yes	No	5015		100	9.06	9.81	0.75	
				No	300MVAR	5015		83	9.06	10.81	1.75	
	P2013_1-1C	DVP		Yes	650MVAR	5021		107	4.02	4.27	.25	
				No	No	5015		100	9.06	10.06	0.75	
				Yes	300MVAR	5015		83	9.06	10.81	1.75	
				No	650MVAR	5021		107	4.02	4.27	0.25	
TCSC only	P2013_1-1A	DVP		Yes	40,45/90%	No	5038		Unstable	2.90	< 2.90	-
TCSC+SVC				40,45/90%	500MVAR	5038		93	2.90	3.15	0.25	
				0/50%	750MVAR	5038		99	2.90	2.90	0.00	
				0/70%	750MVAR	5038		81	2.90	3.40	0.50	

(1) CCT: critical clearing time – maximum fault clearing time for which a system remains transiently stable. In this study CCT resolution is ¼ cycle.

(2) (redacted)

(3) (redacted)

(4) (redacted)

(5) For a SLG fault w/ delayed clearing contingency, back-up clearing time is increased in CCT calculation. Primary clearing time is fixed to 2.90 cycle during the CCT calculation.



Margin Testing Results – M14B Margin Test

Project	Project ID	Proposing Entity	FOG Wire	GSU Tap Optimization	TCSC Compensation (Normal/Transient)	SVC	Outage	Limiting Contingency (redacted)	Maximum Angle Swing	Margin to CCT (CCTM) (cycles)	M14B Margin (M14B) (cycles)	Margin Results (CCTM-M14B) (cycles)
230kV	P2013_1-5A	LS Power		Yes	N/A	No	5015		114	0.25	0.5	-0.25
				No		300MVAR	5015		91	1.25	0.5	0.75
	P2013_1-2B	Transource		Yes		No	5015		112	0.25	0.5	-0.25
				No		300MVAR	5015		107	0.50	0.5	0.0
				Yes		650MVAR	5015		109	0.50	0.5	0.0
				No		650MVAR	5015		100	0.75	0.5	0.25
500kV	P2013_1-7K	PSE&G		Yes	No	5015		100	0.75	0.5	0.25	
				No	300MVAR	5015		83	1.75	0.5	1.25	
	P2013_1-1C	DVP		Yes	No	5021		107	0.25	0.25	0.0	
				No	No	5015		100	1.00	0.5	0.25	
				Yes	300MVAR	5015		83	1.75	0.5	1.25	
				No	650MVAR	5021		107	0.25	0.25	0.0	
TCSC only	P2013_1-1A	DVP		Yes	40,45/90%	No	5038		Unstable			
TCSC+SVC				40,45/90%	500MVAR	5038		93	0.25	0.25	0.0	
				0/50%	750MVAR	5038		99	0.00	0.25	-0.25	
				0/70%	750MVAR	5038		81	0.50	0.25	0.25	

(1) CCT: critical clearing time – maximum fault clearing time for which a system remains transiently stable. In this study CCT resolution is ¼ cycle.

(2) (redacted)

(3) (redacted)

(4) (redacted)

(5) For a SLG fault w/ delayed clearing contingency, back-up clearing time is increased in CCT calculation. Primary clearing time is fixed to 2.90 cycle during the CCT calculation.

- SSR and control interaction study duration
 - Six month study duration does not account for data acquisition time
 - If measured data required, acquisition timeframe tied to Artificial Island unit outages
- Compensation
 - Proposed 90% compensation level well above industry norms of 70-80%
- Performance
 - Baseline performance with 90% compensation level and very large SVC is in line with other projects
 - Performance at lower compensation levels not as good as line solutions
 - Performance under margin testing is less robust than line solutions
- Due to the above, the TCSC project is not recommended

Proposed Cost Commitments and Project Cost Estimates



Cost Commitment / Containment Mechanism Summary

Proposing Entity	LS Power	PSE&G	Transource	Dominion
<p>Summary of Terms and Conditions (as specified by the Proposing Entity)</p>	<p>Includes all project costs; exceptions below:</p> <ol style="list-style-type: none"> 1. PJM scope changes 2. Breach/default of DEA/ICA by PJM 3. Breach / Default / interference or failure to cooperate with ICA Terms by TO 4. Costs caused by changes in laws or regulations 	<p>Includes all project costs; exceptions below:</p> <ol style="list-style-type: none"> 1. PJM scope changes 2. Non-construction project cost changes deemed outside of the control of PSE&G 3. Commitment includes all escalation cost 	<p>Includes all project costs; no exceptions</p> <ol style="list-style-type: none"> 1. Up to \$203 million: all ROE / incentives 2. \$243 to \$299.8 million: half ROE / incentives 3. Above \$299.8 million: forego all ROE / incentives 	<p>No cost commitment proposed</p>

- Total cost estimates combine Proposing Entity cost commitment numbers with PJM cost estimates
 - Costs estimates provided by Proposing Entities for project components within their cost commitment
 - PJM cost estimates used for project components outside of proposed cost commitment



Cost Estimates Incorporating Cost Commitments

Line Projects Coupled with SVC and OPGW/GSU TAP Projects

In Current Year Dollars

Dominion 1C	
500kV Line Hope Creek to Red Lion	
Cost Containment	\$0
Project Cost Estimate	\$211 - \$257
OPGW/GSU Taps	\$20 ¹
SVC Cost Estimate	\$31 - \$38
Project Total	\$263 - \$316

PSE&G 7K	
500kV Line Hope Creek to Red Lion	
Cost Containment	\$221
Red Lion Expansion	\$4 - \$6
OPGW/GSU Taps	\$20 ¹
SVC Cost Estimate	\$31 - \$38
Project Total	\$277 - \$285

Transource 2B	
230kV Submarine	
Cost Containment	\$203 - \$259
New Salem Substation	\$41
Salem Expansion	\$14 - \$17
OPGW/GSU Taps	\$25
SVC Cost Estimate	\$31 - \$38
Project Total	\$313 - \$380

LS Power 5A	
230kV Submarine	
Cost Containment	\$146
Salem Expansion	\$61 - \$74
OPGW/GSU Taps	\$25
SVC Cost Estimate	\$31 - \$38
Project Total	\$263 - \$283

¹ Cost for OPGW upgrade work is reduced for 1C and 7K because new line construction includes OPGW



Cost Estimates Incorporating Cost Commitments

Line Projects Coupled with SVC and OPGW/GSU TAP Projects
In-Service Year Dollar Costs (2.5% per year escalation)

Dominion 1C 500kV Line Hope Creek to Red Lion	
Capital Cost (current year \$)	

Project Total \$263 - \$316

Capital Cost (with escalation)	
--------------------------------	--

Project Total \$284 - \$341

PSE&G 7K 500kV Line Hope Creek to Red Lion	
Capital Cost (current year \$)	

Project Total \$277 - \$285¹

Capital Cost (with escalation)	
--------------------------------	--

Project Total \$281 - \$290¹

Transource 2B 230kV Submarine	
Capital Cost (current year \$)	

Project Total \$313 - \$380

Capital Cost (with escalation)	
--------------------------------	--

Project Total \$346 - \$411

LS Power 5A 230kV Submarine	
Capital Cost (current year \$)	

Project Total \$263 - \$283¹

Capital Cost (with escalation)	
--------------------------------	--

Project Total \$284 - \$306¹

¹ Cost estimates do not capture the risk of cost commitment exclusions discussed on slide 27, 'Cost Containment Comparison'

Transource 2B

- Due to the high estimated cost relative to the other projects under consideration, the Transource 2B project is not recommended at this time

Dominion 1C

- Due to the high estimated cost relative to the other projects under consideration and the lack of a cost commitment the Dominion 1C project is not recommended at this time

Cost Containment Comparison

Proposing Entity	LS Power	PSE&G
Cost Containment Provision		
Escalation	Costs would be escalated against an industry standard index	Commitment includes all escalation cost
Exclusions to the cost commitment	<ul style="list-style-type: none"> • PJM project scope changes • Costs caused by changes in laws or regulations • Cost caused by PJM's breach or default • Cost caused by any Transmission Owner breach, default interference or failure to cooperate 	<ul style="list-style-type: none"> • PJM project scope changes • Costs caused by changes in laws or regulations • Greater than anticipated environmental mitigation costs • Costs caused by route changes driven from permitting or land acquisition • Costs incurred due to delays in permit issuance • Cost incurred due to delays incurred due to a court order or action

- Current Year Dollars
 - LS Power 5A project cost commitment, which is based on current year dollars and tied to an industry escalation index, has lower cost in current year dollars
- In Service Year Dollars
 - PSE&G 7K project cost commitment, which is based on a guaranteed maximum price with escalation included, may have lower cost based on in-service year dollars
- Cost Cap Terms and Conditions
 - Entities will collect revenues based on actual costs
 - LS Power terms and conditions provide fewer exclusions in comparison to the PSE&G terms and conditions
 - Greater potential for increased costs with the PSE&G proposal due to cost containment exceptions

Constructability Analysis

- PJM met with permitting agencies
 - U.S. Army Corps of Engineers (USACE)
 - Delaware Department of Natural Resource and Environmental Control (DNREC)
 - New Jersey DEP
 - U.S. Fish and Wildlife Service (USFWS)
 - National Marine Fisheries
 - National Oceanic and Atmospheric Administration (NOAA)

- Feedback is based on preliminary information
 - Without detailed design and route, agencies will not state likelihood of permitting success of any of the projects
 - Various permitting agencies will be involved in review of the project proposals based on the preliminary project information
- Various entities will coordinate review through the lead agency
 - USACE is likely to be the lead agency

Meetings with Permitting Agencies

- River Crossing will be major challenge for all projects
 - Type of construction will impact permitting
 - Overhead
 - Jet-plow
 - Horizontal directional drilling
 - Issues will include:
 - View shed
 - Navigational impacts
 - Burial depth
 - Use of existing RoW
 - Construction time
- Permitting through the sensitive environmental areas may be difficult
 - Supawna Meadows National Wildlife Refuge
 - Augustine Wildlife Area

- 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 Commitments
- Cost effectiveness
- Market efficiency
- PJM estimated costs

- Right of Way and Land Acquisition

- 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
- Operational Robustness

- **Outage Requirements**

- 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
 - Coordination with planned generation and transmission outages

- A solution that minimizes outage requirements during construction is preferred

- Land Permitting
 - All projects will face challenges
 - Red Lion to Artificial Island
 - State wildlife management areas
 - Supawna Meadows National Wildlife Refuge
 - » Permitting may be made more difficult with the availability of a viable alternative
 - Southern crossing lines
 - Augustine Wildlife Area
 - » Permitting may be made more difficult with the availability of a viable alternative
 - » Potentially mitigated through HDD and route selection
- A solution that can mitigate land permitting is preferred

- Delaware River Crossing

- Type of construction will impact permitting
 - Overhead
 - Jet-plow
 - Horizontal directional drilling (HDD)
- Issues will include:
 - View shed
 - Navigational impacts
 - Burial depth
 - Use of existing RoW
 - Construction time

- Siting and permitting for a new river crossing will be a major component in the project schedule for all projects under consideration, but there appears to be a lower risk for a NEPA EIS being required for a solution utilizing HDD

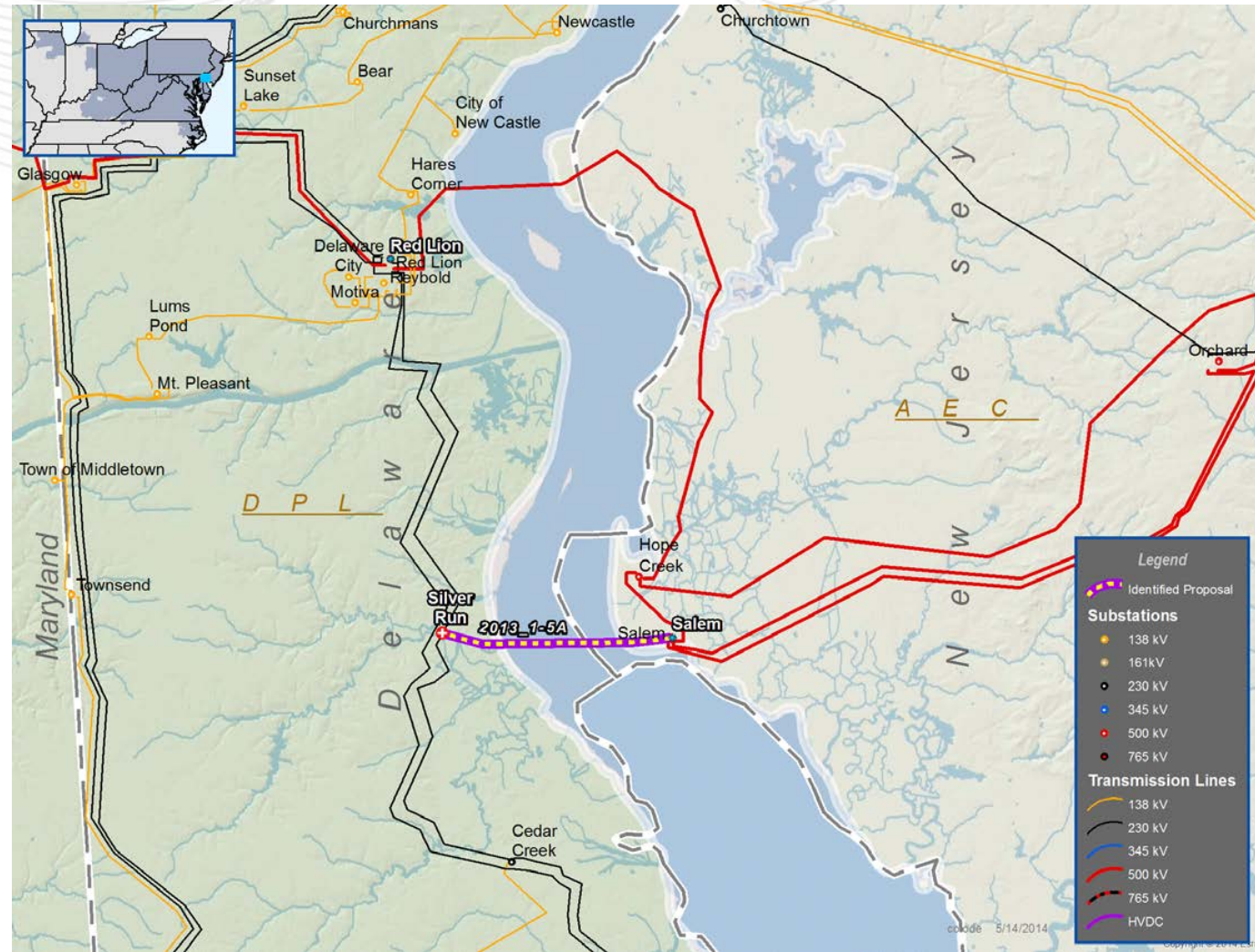
Additional Evaluation Considerations

- Blackstart
 - LS Power 5A provides access to additional blackstart resources
- Historic and scenic highway
 - LS Power 5A line parallels Delaware state route 9
- Market efficiency
 - LS Power 5A: \$92M over 15 years
 - PSE&G 7K: \$57M over 15 years
- Route diversity
 - LS Power 5A project is a new, diverse route
- Salem expansion
 - Constrained with limited space
- Operational robustness
 - PSE&G 7K project improves voltage drop for loss of 500kV facilities
- Wetlands impact
 - PSE&G 7K project potentially impacts approximately 16 acres of forested wetlands
 - LS Power 5A project potentially impacts approximately 8 to 11 acres of forested wetlands
- Construction and long lead time equipment
 - LS Power 5A project construction involves specialized equipment and transmission cable and auto-transformers are long lead time equipment

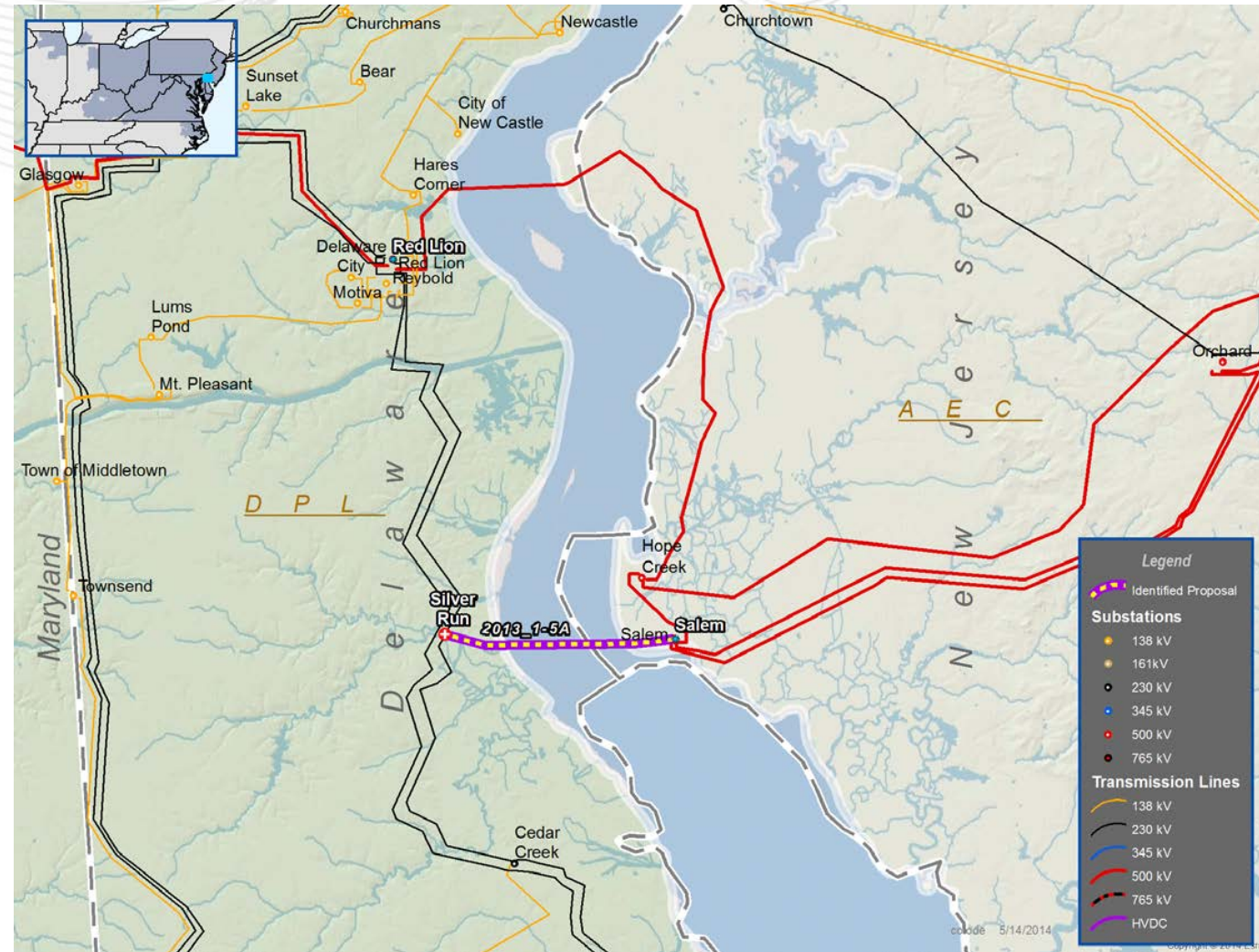
- Performance
 - The line proposals along with a 300MVAR SVC at New Freedom and the protective relay improvements satisfy all requirements of the request for proposal
- Cost
 - The LS Power proposal and the PSE&G proposal are the lowest cost alternatives
 - PJM's evaluation of the cost commitments finds that the LS Power proposal provides greater cost certainty with fewer exclusions to the cost commitment
- Constructability
 - Siting will be challenging for both line proposals however the LS Power proposal through the use of horizontal directional drilling technology provides greater flexibility to mitigate permitting risk

- At the July 27 PJM Board meeting, PJM staff will recommend for inclusion in the RTEP:
 - 230kV transmission line under the Delaware river from Salem to a new substation near the 230kV transmission RoW in Delaware utilizing HDD under the river designated to LS Power
 - Associated substation work at Salem designated to PSE&G
 - Associated work on the 230kV RoW designated to PHI
 - SVC at New Freedom designated to PSE&G
 - OPGW upgrades designated to PSE&G and PHI
 - Artificial Island GSU tap settings upgrade designated to PSEG Power

- In consideration of all factors, PJM staff will recommend for inclusion in the RTEP:
 - A new 230kV circuit from Salem to a new substation near the 230kV corridor in Delaware tapping the existing Red Lion to Cartanza and Red Lion to Cedar Creek 230 kV lines, utilizing HDD under the river (b2633.1)
 - Designate transmission line to LS Power



- Required connection facilities to accommodate the new transmission facilities:
 - Expansion of the Salem substation (b2633.2)
 - Designate to PSE&G
 - Interconnecting to the existing Red Lion to Cartanza and Red Lion to Cedar Creek 230 kV lines into the new substation (b2633.3)
 - Designate to PHI



SVC Upgrade Project Recommendation

- Construct an SVC at New Freedom 500 kV substation
 - Facilities design will determine the final technical parameters (b2633.4)
- Project cost estimate:
 - \$31M to \$38M
- Designate SVC upgrade at New Freedom to PSE&G

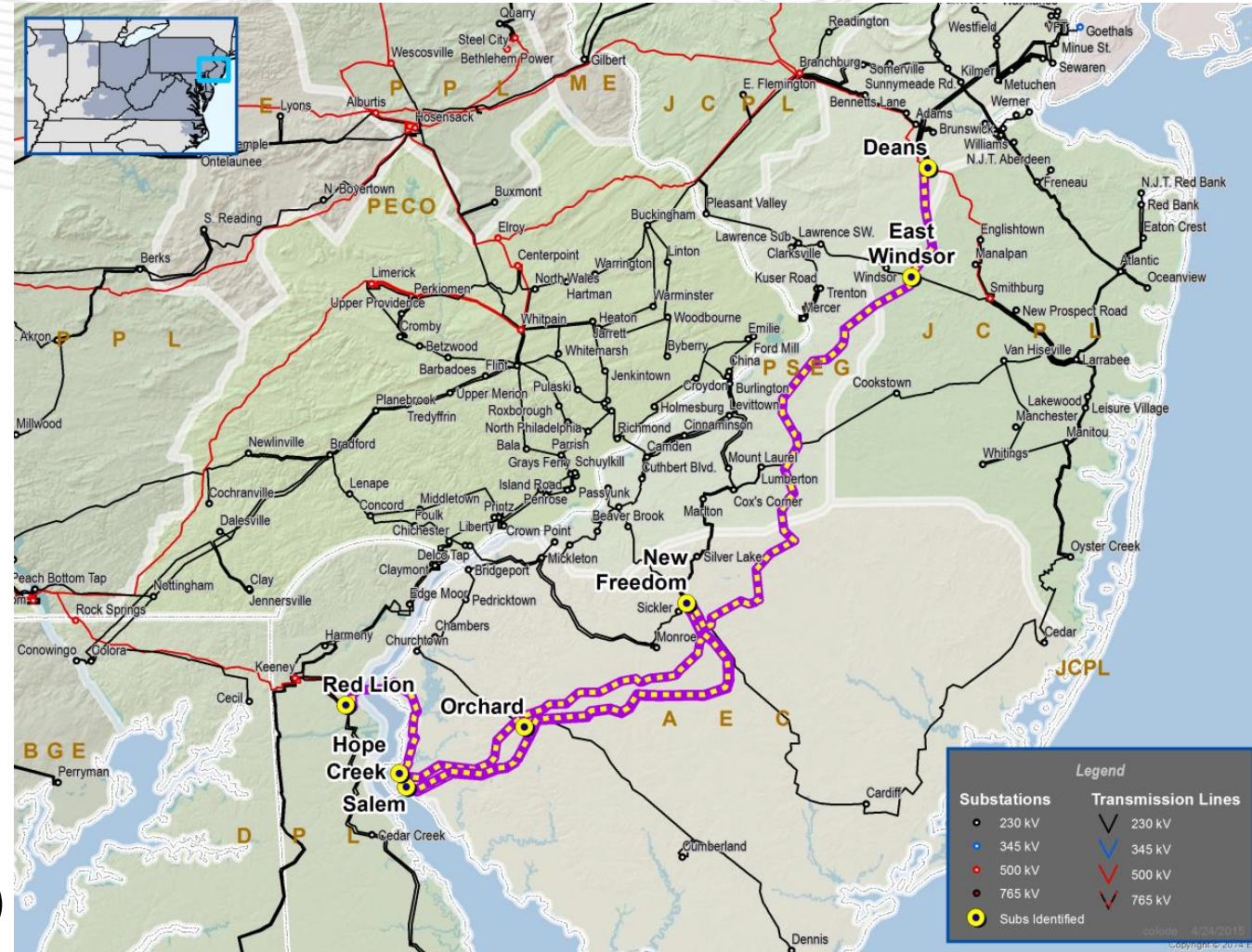


OPGW Upgrade Project Recommendation

- Implement high speed relaying utilizing OPGW on the following existing lines (b2633.5 and b2633.6):

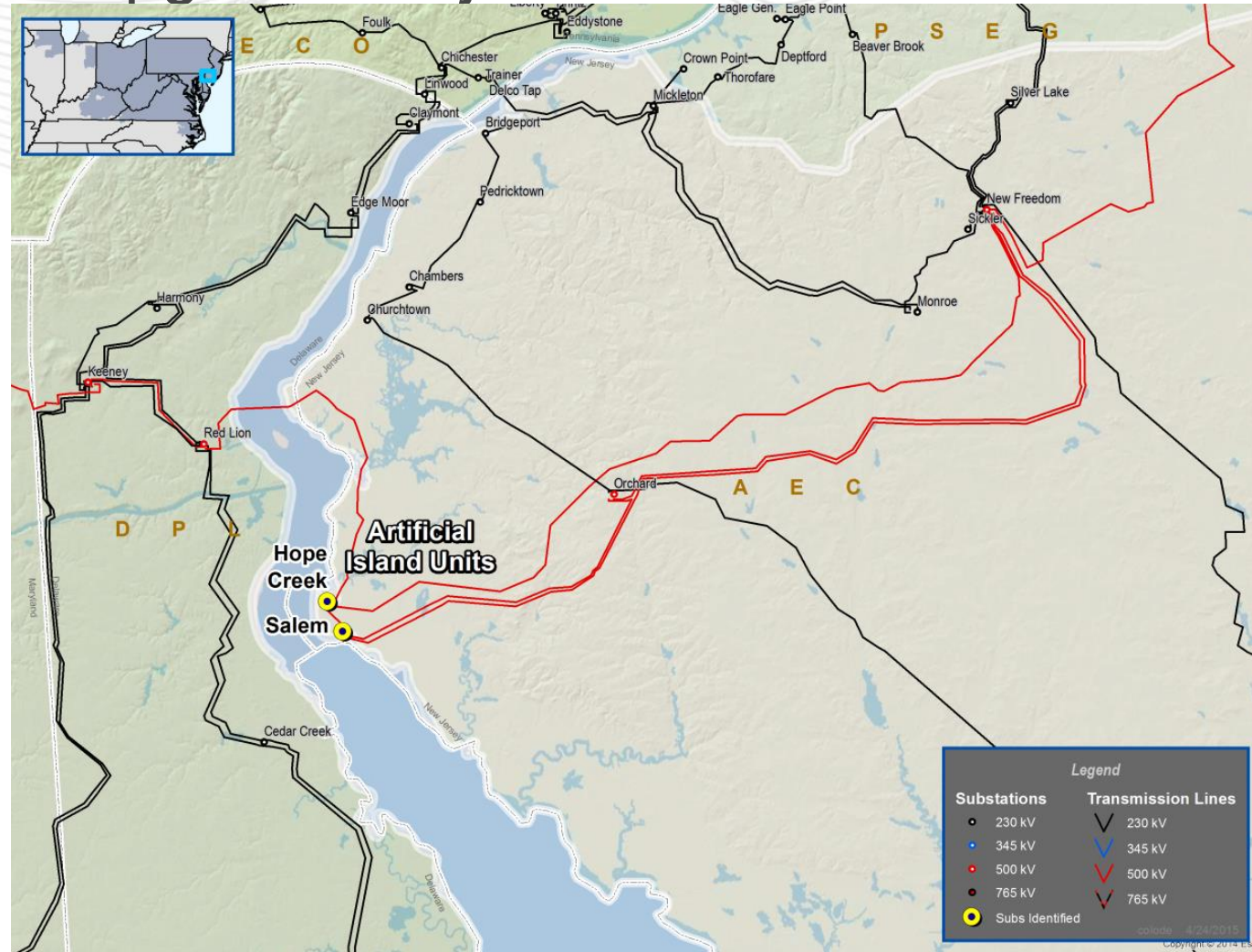
5037	5022
5015	5038
5023	5024
5021	5039

- Project cost estimate:
 - \$25M
- Designate OPGW upgrades to PSE&G and PHI (5015 remote end)



Artificial Island Unit GSU Tap Settings Upgrade Project Recommendation

- Implement changes to the tap settings for the three Artificial Island unit's step-up transformers(b2633.7)
- Designate GSU tap settings change upgrade to PSEG Power



- All stakeholder comments for the PJM Board must be sent no later than close of business on May 29
- If the PJM Board approves these recommendations, PJM staff will proceed to draft the Designated Entity Agreement
 - Recommendation is based upon PJM's understanding of the cost commitment terms and conditions, which will be finalized and incorporated into the Designated Entity Agreement
 - The first required milestone will be related to engineering feasibility of the river crossing utilizing horizontal directional drilling installation

Appendix

Supplemental Information Summary

- 08/12 – Letter sent to Proposing Entity ‘finalists’ to provide opportunity to supplement their proposals
- 09/12 – Supplemental information submitted to PJM by all ‘finalists’
- 09/18 – Redacted versions of the supplemental information is posted to PJM.com
- Oct 22 through Nov 3 – Meetings with FERC Administrative Law Judge and finalists to review and confirm information

- \$146 Million
- Physical scope of work included under proposed mechanism
 - Aerial or submarine line
 - New substation located near the existing 230kV right-of-way in Delaware
- Physical scope of work not included under proposed mechanism
 - Salem substation modifications
 - New bay position
 - New 500/230kV transformer
 - 230kV turning poles cutting the two Delaware transmission lines

- Costs included under the containment mechanism
 - Permits and government approvals
 - Land acquisition
 - Environmental assessment and mitigation
 - Engineering
 - Equipment, supplies and other material procurement
 - All development and construction activities

- Costs not included under the containment mechanism
 - Financing costs
 - AFUDC
 - Additions and modifications to the project scope due to
 - “any material change in the enforcement, interpretation of application of any statute, rule, regulation, order or other applicable law existing..”
 - “any Breach or Default by PJM of its obligations under the DEA or any request by PJM to delay or suspend any activities associated with the Project”.
 - “any breach, default, interference or failure to cooperate by any Transmission Owner in connection with the Interconnection Coordination Agreement or interconnection agreement”

- Proposed tiered cost containment mechanism
 - Up to \$203 Million: entitled to recover all FERC approved ROE plus incentives
 - Portion from \$243 to \$299.8 million: forego 50% of any FERC approved ROE incentives
 - Above \$299.8 million: forego 100% of any FERC approved ROE incentives
- Physical scope of work included under proposed mechanism
 - 230kV submarine cable from Salem substation to new substation in Delaware
 - New substation located near the existing 230kV right-of-way in Delaware
 - New 500/230kV substation adjacent to Salem substation
- Physical scope of work not included under proposed mechanism
 - Modifications in and near Salem substation
 - New bay position at Salem
 - 230kV turning poles cutting the two Delaware transmission lines

- Transource provided a contingency amount of \$52.3 million which is included in the second tier of their cost containment mechanism
 - Some specific contingency items identified (redacted)
 - General 10% project contingency

- \$221 Million
- Physical scope of work included under proposed mechanism
 - Aerial 500kV line from Hope Creek to Red Lion substations
 - Upgrade work at Hope Creek to create the new line bay
- Physical scope of work not included under proposed mechanism
 - Upgrade work at Red Lion to create the new line bay

- Costs included under the containment mechanism
 - All project costs with exceptions as noted below

- Costs not included under the containment mechanism
 - Costs associated with PJM modifications or additions to the scope of work
 - Costs incurred from the following events deemed outside of the control of PSE&G:
 - Changes in applicable laws and regulations
 - Obtaining governmental approvals and permits
 - Obtaining necessary property rights to construct the Project
 - Environmental permitting, remediation and mitigation
 - Orders of courts or action or inaction by governmental agencies

- Dominion did not provide a cost containment mechanism, but rather provided reasons for confidence in their ability to meet cost estimates and elaborated on project management approach and past experience with transmission projects
 - Red Lion to Hope Creek: agreed with PJM's cost estimate of \$242 to \$292 million
 - FACTS based solution: provided a revised cost estimate of \$174.1 million
 - \$86.4 million based upon vendor not-to-exceed budget prices

- V1 4/28/2015 – Original Presentation Posted
- V2 4/28/2015 – Slide 45 updated to reflect May 29th comment date
- V3 05/06/2015 – Slide 39 updated to reflect the July 27 PJM Board meeting