ISO New England

Greater Boston Solutions Study; Cost Reviews

Prepared By:

Electrical Consultants, Inc.

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ECI
ELECTRICAL CONSULTANTS, INC.

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ACRONYMS

ACSR	Aluminum conductor, steel-reinforced
AC	Alternating Current
Al	Aluminum
ALPC	Agricultural Lands Preservation Commission
Cu	Copper
DHR	New Hampshire Division of Natural Resources
DOT	Department of Transportation
ECI	Electrical Consultants Incorporated
EPCS	EPC Services – a turnkey Construction company owned by ECI
FAA	Federal Aviation Administration
FTB	Fluidized Thermal Backfill
Ft	Foot
EPA	United Stated Environmental Protection Agency
ESA	Federal Endangered Species Act
HDD	Horizontal Directional Drill
HPFF	High Pressure Fluid Filled Cable
HVDC	High Voltage Direct Current
GIS	Gas Insulated Switch
ISO-NE	ISO New England
kV	Kilovolt
M	Millions of Dollars
MEPA	Massachusetts Environmental Policy Act
MESA	Massachusetts Endangered Species Act
MA	State of Massachusetts
MA DCR	Massachusetts Division of Urban Parks & Recreation
MassDOT	Massachusetts Department of Transportations
MBTA	Massachusetts Bay Transportation Authority
MCM	Million Circular Mils
MHC	Massachusetts Historical Commission
MI	Mass Impregnated
MVAR	Megavolt ampere reactive power
MW	MegaWatt
NEPA	National Environmental Policy Act
NHDES	New Hampshire Department of Environmental Services
NHESP	Natural Heritage and Endangered Species Program
NH	State of New Hampshire
NHT	New Hampshire Transmission
NU	Northeast Utilities
NOAA	National Oceanic and Atmospheric
NOI	Notice of Intent
NSTAR	NSTAR Electric and Gas
OH	Overhead
PM	Project Management
PNF	Project Notification Form

PSNH	Public Service of New Hampshire
PVC	Polyvinylchloride
RR	Railroad
RPR	Request of Project Review Form
ROW	Right of Way
UG	Underground
USDA	United State Department of Agriculture
Sq. Ft	Square Foot
T&E	Threatened and Endangered Species
THPO	Potential Tribal Offices
USACE	United States Army Corps of Engineers
USFWS	United States Fish and Wildlife Service
XLPE	Cross Linked Polyethylene

1.0 OVERVIEW

The purpose of this assignment herein named the "Greater Boston Solutions Study; Cost Reviews" is to perform a "High Level" review of the cost estimates of two alternative projects.

1.1 Plan Overviews

1) AC Solution with the following main components:

   - New Overhead 345 kV transmission line between Scobie Pond Substation and Tewksbury Substation within an existing ROW. This shall also include an upgrade of Y-151 overhead line from Dracut Junction to NU border.
   - New 345 kV AC XLPE Underground Transmission Line between Wakefield Substation and Woburn Substation.
   - New 115 kV AC HPFF Underground Transmission Line between Woburn Substation and Mystic Substation.
   - New Dynamic Reactive Device in Maine (not evaluated here).

2) HVDC solution with the following main components:

   - 200 kV HVDC Land/Submarine Cable System between Seabrook Substation (345 kV) and Mystic Substation (115 kV).
   - Reconductoring 115 kV Y-151 overhead transmission line from Pelham to Dracut Junction.
   - Reconfiguration of the Mystic 115 kV Substation.
   - Reconductoring the existing 345 kV 337 overhead transmission line between Sandy Pond Substation and Tewksbury Substation.
   - Joining the two (2) existing 345 kV circuits between Mystic Substation and North Cambridge Substation to enable them to operate as a single circuit.

ISO New England (ISO-NE) has provided conceptual estimates (-25% to +50%) developed by NU, NGRID and NHT for each of these proposed upgrades as summarized in *Table 1-1, Overview of Cost Estimate Reviews* on the following page. Overview maps of each of the respective AC and DC plans are included at the end of Section 1.

AC Plan				HVDC Plan			
ECI Project #	**Description**	**Length (miles)**	**ISO-NE Cost**	**ECI Project #**	**Description**	**Length (miles)**	**ISO-NE Cost**
A-1	Scobie – Tewksubry 345 kV Line	25	$122.9M	D-1	HVDC submarine cable and two (2) terminals	68	$543.0M
	Reconductor Y-151 kV NU border to Dracut Jct.	9		D-2	Seabrook 345 kV Interconnection for HVDC	NA	$31.7M
A-2	Wakefield – Woburn 345 kV UG cable plus 2 reactors	8	$107.3M	D-3	Mystic 115 kV Interconnection for HVDC	NA	$29.9M
A-3	Bifurcate a new Woburn – Mystic 115 kV cable with the existing cable	8	$75.0M	D-4	Reconductor Y-151 kV NU border to Dracut Jct.	9	$16.6M
				D-5	Reconductor Sandy Pond – Tewksbury 345 kV	16	$46.4M
				D-6	Bifurcate Mystic – North Cambridge 345 kV	NA	$12.5M

Table 1-1
Overview of Cost Estimate Reviews

Electrical Consultants, Inc. (ECI) was tasked to provide cost verifications of major unique components associated with the above described AC Plan and HVDC Plan. ISO-NE's overall intent is to be able to provide a cost comparison between the AC Plan and the HVDC Plan. For each of the plans, the upgrades were categorized into:

- Common Upgrades
- AC Plan Major Unique Components
- DC Plan Major Unique Components
- Similar Components

The completed plans can be viewed on ISO New England website or by the following link:
http://www.iso-ne.com/system-planning/key-study-areas/greater-boston

The common upgrades for the AC Plan and HVDC Plan total $221M; however, review of these costs are not included within this comparative cost review.

1.2 Approach

ECI's approach for completing the cost reviews for each of the respective projects outlined in *Table 1-1* includes the following components:

1) Obtain the proposed project information from the respective Transmission Owners (TO's) to understand the elements of each of the alternatives. This would include, where available, facility drawings, maps, estimate take-off quantities, detailed estimates and scope-of-work.
2) Perform a "high level" cost estimate based on "available" information. Such "high level" estimate would be based on ECI's experience in similar projects, industry data and, where feasible or necessary, obtaining budgetary quotes from vendors and contractors.
3) Comment on other project cost components. These components include right of way, engineering/permitting, risks, etc.

Supporting information pertaining to each of the respective cost estimates is included in the Appendix.

Figure 1

Greater Boston Solutions Study Update
Unique Components and Cost
AC PLAN

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Project A-1
New Scobie Pond to Tewksbury 345 kV Line
Length: ~25 miles

Project A-1
Reconductor Y-151 115 kV
NU Border to Dracut Jct.
Length: ~9 miles

Project A-2
Wakefield to Woburn 345 kV
UG Cable plus 2 reactors
Length: ~8 miles

Project A-3
Bifurcate a new Woburn to Mystic 115 kV
Underground Cable with existing cable
Length: ~8 miles

- Existing Substations
- Project A-1: New Scobie Pond to Tewksbury OH
- Project A-1: Reconductor Y-151
- Project A-2: Wakefield to Woburn UG
- Project A-3: Woburn to Mystic UG
- Existing OH Transmission
- Existing UG Transmission
- Airport
- Interstates
- Railroads
- Rivers/Streams
- Fish & Wildlife Service (FWS)
- Department of Defense (DOD)
- National Park Service (NPS)
- Other Federal Land
- State Park & Recreation
- State Fish & Wildlife
- State Department of Natural Resources
- Other State Land
- Regional Water Districts
- County Land
- City Land
- Audubon Society
- Land Trust
- Town Boundary
- County Boundary
- State Boundary

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0 2 4 8 Miles

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Source: ISO New Englad, NSTAR, MUN, ECI, ESRI

Figure 2

Greater Boston Solutions Study Update
Unique Components and Cost
HVDC PLAN

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Project D-2
Seabrook 345 kV
Interconnection for HVDC

Project D-1
HVDC Submarine Cable
and 2 Terminals
Length: ~68 miles

Project D-4
Reconductor Y-151 115 kV
NU border to Dracut Jct.
Length: ~9 miles

Project D-5
337 Reconductor Sandy Pond
to Tewksbury 345 kV
Length: ~16 miles

Project D-6
North Cambridge to Mystic Substations
Bifurcate Lines 351 and 358

Project D-3
Mystic 115 kV
Interconnection for HVDC

- Existing Substations
- Mystic, Generating Plant
- Seabrook, Generating Plant
- North Cambridge Substation
- Projects D-1, D-2, & D-3
- Project D-2: Reconductor Y-151
- Project D-5: Reconductor Sandy Pond to Tewksbury
- Bifurcate Mystic to North Cambridge 345 kV
- Existing OH Transmission
- Existing UG Transmission
- Airport
- Interstates
- Railroads
- Rivers/Streams
- Fish & Wildlife Service (FWS)
- Department of Defense (DOD)
- National Park Service (NPS)
- Other Federal Land
- State Park & Recreation
- State Fish & Wildlife
- State Department of Natural Resources
- Other State Land
- Regional Water Districts
- County Land
- City Land
- Audubon Society
- Land Trust
- Town Boundary
- County Boundary
- State Boundary

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Source: ISO New Englad, NSTAR, MUN, ECI, ESRI

2.0 EXECUTIVE SUMMARY

Electrical Consultants, Inc. (ECI) was tasked by the ISO New England (ISO-NE) to provide an independent high level estimate (-25% - +50%) of two (2) electrical transmission projects. These projects are being proposed to improve electric grid reliability in the Greater Boston area.

ECI greatly appreciates the cooperation of the ISO-NE and the TO's – National Grid, Northeast Utilities and New Hampshire Transmission. We also appreciate ISO-NE's support of ECI as we work to try to develop an understanding of the project.

The details of the projects were provided by Northeast Utilities/National Grid and New Hampshire Transmission Partners and are explained herein. For purposes of this evaluation, the basic system information was provided by the respective transmission owners. It is understood that these projects are in the conceptual stages and in some cases a limited amount of engineering has been done; however, it is understood that the projects are both constructible. ECI has not performed any detailed engineering on these projects, nor have we produced detailed bills of materials or approached all of the providers of goods and services necessary to construct projects of this nature. Rather, we have relied on comparable information available to ECI from its own experience and that which was obtainable within the industry. To this end, it is possible and expected that there will be some disparities in the estimates and work approaches developed by the parties.

In terms of estimating, we are using 2014 estimates and have not accounted for the time value of money, significant variations in raw materials, nor costs for outside engineering, real estate acquisition/easements, and handling and disposal of contaminated soils. Additionally, we have not added the utility overhead burdens or any contingency that the utility would normally add to project costs.

In the spirit of our comments above and information contained in this report, ECI's "high level cost estimate" based on the available information is contained in *Table 2-1, ECI Cost Estimate Summary* located on the following page.

AC Plan Estimates					
ECI Proj. #	**Items**	**Description**	**Length (miles)**	**ECI Base Est. ($M)**	**ISO-NE Est. ($M) including contingency, etc.**
A-1	A-1-1-a (3.1.1)	Scobie – Tewksubry 345 kV Line (Tewksbury Sub Upgrade; NG Component)	NA	9.4	
	A-1-1-b (3.1.1)	Scobie – Tewksubry 345 kV Line (Scobie Pond Sub Upgrade; NU Component)	NA	5.5	
	A-1-2-a (3.1.2.)	Scobie – Tewksubry 345 kV Line	25	97.8	
	A-1-2-b (3.1.2.)	Reconductor Y151 NU border to Dracut Jct	9	10.5	
Total A-1				**123.2**	**122.9**
A-2	A-2-1-a (3.2.1)	Wakefield – Woburn 345 kV UG cable plus 2 reactors (Woburn Sub Upgrade; NU Component)	NA	20.6	
	A-2-1-b (3.2.1)	Wakefield – Woburn 345 kV UG cable plus 2 reactors (Wakefield Sub Upgrade; NG Component)	NA	13.8	
	A-2-2 (3.2.2)	Wakefield – Woburn 345 kV UG cable plus 2 reactors (345 kV XLPE UG T-Line)	8	66.5	
Total A-2				**100.9**	**107.3**
A-3	A-3-1-a (3.3.1)	Bifurcate new Woburn – Mystic 115 kV cable with existing cable (Mystic Sub; NU component)	NA	4.5	
	A-3-1-b (3.3.1)	Bifurcate new Woburn – Mystic 115 kV cable with existing cable (Woburn Sub; NU component)	NA	1.6	
	A-3-2 (3.3.2)	Bifurcate new Woburn – Mystic 115 kV cable with existing cable (115 kV HPFF UG T-Line)	8	62.7	
Total A-3				**68.8**	**75**
Total A-1, A-2 & A-3				**292.9**	**305.2**

HVDC Plan Estimates					
ECI Proj. #	**Items**	**Description**	**Length (miles)**	**ECI Base Est. ($M)**	**ISO-NE Est. (M) including contingency, etc.**
D-1	D-1-1-a (4.1.1)	HVDC submarine cable and two (2) terminals (Seabrook-Mystic: Sealink 200 kV DC submarine & land cables)	65.5	181.1	
	D-1-1-b (4.1.1)	HVDC submarine cable and two (2) terminals (Seabrook 345 kV AC XLPE land cable)	0.4	4.8	
	D-1-1-c (4.1.1)	HVDC submarine cable and two (2) terminals (Mystic 115 kV AC XLPE land cable double circuit)	1.3	20.3	
	D-1-2 (4.1.2)	HVDC submarine cable and two (2) terminals (Converter stations at Seabrook and Everett)	NA	291.7	
Total D-1				**497.9**	**543**
D-2	D-2 (4.2)	Seabrook 345 kV Interconnection for HVDC (Sub upgrade)	NA	28.3	31.7
Total D-2				**28.3**	**31.7**
D-3	D-3-1 (4.3.1)	Mystic 115 kV Interconnection for HVDC (Sub upgrade)	NA	20.5	29.9
	D-3-2 (4.3.2)	Mystic interconnection 115 kV HPFF cable & termination relocation	NA	4.6	
Total D-3				**25.1**	**29.9**
D-4	D-4 (4.4)	Reconductor Y-151 kV NU border to Dracut Jct.	9	10.5	16.6
Total D-4				**10.5**	**16.6**
D-5	D-5-1 (4.5.1)	Reconductor Sandy Pond – Tewksbury 345 kV (Substation Upgrade)	NA	2.2	
	D-5-2 (4.5.2)	Reconductor Sandy Pond – Tewksbury 345 kV (337 Line reconductor)	16	32.2	
Total D-5				**34.4**	**46.4**
D-6	D-6-1 (4.6.1)	Bifurcate Mystic – North Cambridge 345 kV (Mystic & North Cambridge Sub bifurcating)		10.6	
	D-6-2 (4.6.2)	Bifurcate Mystic – North Cambridge 345 kV (351 & 358 Lines 345 kV HPFF cable and termination bifurcating)		4.1	
Total D-6				**14.7**	**12.5**
Total D-1, D-2, D-3, D-4, D-5 & D-6				**610.9**	**680.1**

Table 2-1

ECI Cost Estimate Summary

3.0 AC PLAN

This section of the report provides details on the AC portion of the work. Project descriptions, cost estimates and, where necessary, assumptions are noted. The major unique components associated with the AC Plan include the following:

Project A-1; New 345 kV line between Tewksbury and Scobie Pond, station upgrades at each of the terminals and upgrade of Y-151 Dracut Jct. to NU border.

Project A-2; Wakefield to Woburn 345 kV underground cable, substation upgrades at each of the respective terminals and addition of 160 MVAR shunt reactor banks at each of the terminals.

Project A-3; Install new 115 kV underground line from Mystic to Woburn and create a GIS bi-furcated termination with the existing 211-514 Mystic to Woburn line. In addition, add 115 kV series reactor at Woburn Substation.

The substation and transmission line components for each of these respective unique AC Plan upgrades are summarized in the following sections of the narrative. Note that each of these respective projects include components from different entities including Northeast Utilities, NSTAR and National Grid.

3.1 Project A-1; Scobie -Tewksbury 345 kV Line and Reconductor Y-151 kV NU Border to Dracut Jct.

This project includes both National Grid and Northeast Utilities components. Specifically, upgrades associated with the Tewksbury Substation are under the ownership of National Grid and the upgrades on the Scobie Pond Substation end of the terminal are owned by Northeast Utilities. Consequently, the cost components are split up into two (2) separate entities.

3.1.1 Description of Substation Upgrades

Substation upgrades are required at the Tewksbury Substation and the Scobie Pond Substation specific to the accommodation of termination of the 345 kV circuits entering each of these respective facilities.

Tewksbury Substation Upgrades; NG Component

The Tewksbury Substation upgrades include addition of a new 345 kV line position as well as extension of the yard for future expansion. The following specific components are included in ECI's cost estimate:

(2) GIS 345 kV Breakers
(4) 345 kV Disconnect switches (included with GIS breakers)
(1) Deadend structure
(28) 2-Legged bus support structures
(84) 345 kV Bus support insulators
(3,240 ft.) 5" IPS AL Bus
(120,000 sq. ft.) Yard expansion

ECI's total estimated cost associated with the Tewksbury Substation and expansion is $9.4M.

Scobie Pond Substation Upgrades; NU Component

The Scobie Pond Substation upgrades include addition of a new 345 kV line position as well as extension of the yard for future expansion. The following specific components are included in ECI's cost estimate:

(2) 345 kV Breakers
(6) 345 kV Disconnect switches
(1) Deadend structure
(28) 2-Legged bus support structures
(84) 345 kV Bus support insulators
(1,300 ft.) 5" IPS AL Bus
Control building expansion
(3) 345 kV CCVT's

ECI's total estimated cost associated with the Scobie Pond Substation and expansion is $5.5M.

3.1.2 Description of Transmission Upgrades

Scobie to Tewksbury 345 kV Line

For the purpose of our pricing we adhered to the detailed scope description provided by National Grid and the Greater Boston Map & Data Package by New Hampshire Transmission. The Scobie to Tewksbury line is an exceptionally complex reconfiguration of the existing transmission corridor. The preparatory work required to install the new 345 kV line includes several sections of 230 kV line relocation to new structures in a new alignment, one section relocating two (2) 115 kV lines to new structures in new alignments, and minor relocation of some 13.8 kV distribution line. The work also requires highway crossing and water crossings.

ECI's estimate is fundamentally conceptual and is based on review of the project scope, conceptual estimates provided by ISO-NE, as well as past experience from similar work performed by personnel in our subsidiary, EPC Services Company, which specializes in turnkey project execution. No bill of materials was created for hardware, conductor, insulators, poles, concrete, reinforcing casing or other ancillary physical components of the installation.

Due to the re-configuration of the existing corridor and the urban/suburban environment, we anticipated high usage of guard structures throughout the project. We are also anticipating that contractor laydown areas would be approximately 5-7 miles apart dispersed somewhat equally along the route. However, because the work is located in the same corridor, much of the underground work for piers should be able to be done simultaneously for each line as the work progresses. We do not anticipate fencing any of the project with the exception of the laydown areas as needed.

There are also known areas of the route with swamp/surface water conditions. Swamp matting is included in the estimate as were premium costs associated with "wet method" concrete installation. Costs for handling of contaminated water or soils is not included. No geotechnical information was available for our review, subsequently no costs were carried for mitigation of subsurface conditions including rock or fill materials of any kind.

ECI's total cost estimate associated with the Scobie to Tewksbury 345 kV overhead transmission line upgrade is $97.8M.

Pricing Clarifications and Assumptions

1) This estimate is based on the detailed description provided by National Grid for 14.6 miles of construction and extended to the entire 25 mile total length.

2) Costs for swamp matting are included in our estimate.

3) Foundation costs for drilled piers on hard angles and dead end structures are based on the use of removable casing and "wet method" concrete installation.

4) No costs have been included for dewatering piers or surface water.

5) We have included the cost of guard structures for crossing existing lines and roads in our estimate.

6) No costs have been included for drilling or removing subsurface rock.

7) No costs have been included for handling of contaminated soils or liquids.

8) No costs have been included for the acquisition of real property or rights of way.

9) No costs have been included for fencing other than for contractor laydown yards.

10) No costs have been included for control of fugitive dust emissions.

11) No costs have been included for winter conditions. Construction would be expected to take place spring through fall.

12) No costs have been included for material or labor escalation.

13) No contingency dollars have been included in the base estimate.

14) Payment and Performance bond costs have not been included in this estimate.

15) Permitting and legal costs are not included in this estimate.

16) All reconductor work is assumed to be done de-energized.

Reconductor Y-151 NU Border to Dracut Junction

As with the Scobie to Tewksbury line we adhered to the detailed scope description provided by National Grid and the Greater Boston Map & Data Package by New Hampshire Transmission. The reconductor of Y-151 is 9.3 miles long and referring to the scope as a reconductor is somewhat of a misnomer due to the fact that it is essentially rebuilding the line.

For the estimates most, if not all, of the structures are being replaced as well as all insulators, shield wire, hardware and conductor. In addition to the scope of constructing the newly reconfigured line, the estimate includes removal of existing conductor, shield wire, and structures.

Costs are based on installation of sixteen (16) pole-arm suspension structures, seventy-two (72) H-frame suspension structures, six (6) steel H-frame dead-end structures, four (4) three-pole dead-end structures, one (1) transposition structure, and installing 9.3 miles of 1590 kCM ACSS conductor and 7.5 miles of shield wire. Thirty three (33) concrete foundations are also included in the scope.

Two contractor laydown areas were assumed for the estimates.

ECI's total cost estimate associated with the Y-151 overhead transmission line reconductoring/rebuild is $10.5M.

Pricing Clarifications and Assumptions

1) Costs for swamp matting are included in our estimate.

2) Foundation costs for drilled piers on hard angles and dead end structures are based on the use of removable casing and "wet method" concrete installation.

3) No costs have been included for dewatering piers or surface water.

4) We have included the cost of guard structures for crossing existing lines and roads in our estimate.

5) No costs have been included for drilling or removing subsurface rock.

6) No costs have been included for handling of contaminated soils or liquids.

7) No costs have been included for the acquisition of real property or rights of way.

8) No costs have been included for fencing other than for contractor laydown yards.

9) No costs have been included for control of fugitive dust emissions.

10) No costs have been included for winter conditions. Construction would be expected to take place spring through fall.

11) No costs have been included for material or labor escalation.

12) No contingency dollars have been included in the base estimate.

13) Payment and Performance bond costs have not been included in this estimate.

14) Permitting and legal costs are not included in this estimate.

15) All reconductor work is assumed to be done de-energized.

3.2 Project A-2; Wakefield – Woburn 345 kV UG Cable Plus Two Reactors

This project consists of new underground 345 kV cable between the Wakefield and Woburn Substations as well as addition of shunt reactors at each of the respective terminal locations. Entities associated with these upgrades include NU at Woburn Substation and National Grid at Wakefield Jct. Substation.

3.2.1 Description of Substation Upgrades

Cost estimates associated with the Woburn Substation and Wakefield Jct. Substation upgrades are summarized in the following line items.

Woburn Substation; NU Component

The Woburn Substation upgrades include addition of a new 345 kV line position which includes the following specific components:

(3) GIS 345 kV Breakers
(1) 3-Phase 345 kV shunt reactors; 160 MVAR
(2) Deadend structures
(6) 2-Legged bus support structures
(18) 345 kV Bus support insulators
(1,500 ft.) 4" IPS AL Bus
(64,800 sq. ft.) Yard expansion

ECI's total estimated cost associated with the Woburn Substation expansion is $20.6M.

Wakefield Substation; NG Component

The Wakefield Substation upgrades include addition of a new 345 kV line position which includes the following specific components:

(2) 345 kV Breakers
(4) 345 kV Gang-operated disconnect switches
(1) 3-Phase 345 kV shunt reactors; 160 MVAR
(2) Deadend structures
(6) 2-Legged bus support structures
(18) 345 kV Bus support insulators
(1,500 ft.) 4" IPS AL Bus
(64,800 sq. ft.) Yard expansion

ECI's total estimated cost associated with the Wakefield Substation expansion is $13.8M.

3.2.2 Description of Transmission Upgrades

Transmission upgrades include installation of a new 345 kV XLPE 3000 MCM copper cable totaling 42,243 circuit feet between Woburn and NG's Wakefield Substations. Cable will be installed in a Fluidized Thermal Backfill (FTB) encased duct bank consisting of three (3) 8" PVC and four (4) 2" PVC to be used for ground and communication cables.

The following specific components are included in ECI's estimate based on information supplied by NU:

- 42,008 linear Fluidized encased duct bank in city streets constructed with three (3) 8" PVC and four (4) 2" PVC
- (21) Splice vaults in city streets placed every 2,000 feet (approx.)
- 129,727 Conductor feet of 345 kV XLPE 3000 MCM copper cable
- (63) Single phase (213-phase) 345 kV cable splices installed in vaults
- (12) 345 kV terminations; six (6) units at Wakefield and six (6) units at Woburn Substation
- Curb to curb restoration paving.

ECI's total estimated cost associated with the installation of the 345 kV XLPE Woburn to Wakefield cable is $66.5M.

Current Identified Risks

- Subsurface conditions
- Permits
- Contaminated Soil
- Work hour & traffic restrictions
- Material Lead time
- Metals and materials escalation

3.3 Project A-3; Bi-Furcate a New Woburn – Mystic 115 kV Cable with Existing Cable

This project consists of the installation of new 115 kV underground circuit between Mystic Substation and Woburn Substation, approximately eight (8) circuit miles in length. This project also includes relocation of the GIS termination location at Mystic Substation with the existing 488-518 line and create a GIS bi-furcated termination with the existing 211-514 Mystic to Woburn line. The last component includes addition of 115 kV series reactors at the Woburn Substation. The entity associated with these upgrades is NU at both Mystic and Woburn terminals.

3.3.1 Description of Substation Upgrades

Cost estimates associated with the Mystic Substation and Woburn Substation are summarized in the following line items.

Mystic Substation; NU Component

The Mystic Substation upgrades include a terminal swap for the 211-514 line and a GIS bi-furcated termination. The following specific components are included in the Mystic Substation cost estimates:

(1) 115 kV GIS Breaker/#25
Connect new Mystic – Chelsea Line to GIS between breakers 24 and 25
Move Mystic – Woburn 211-514 line between breakers 24 and 25
Move Mystic – Chelsie 488-518 line between breakers 23 and 24

Woburn Substation; NU Component

Upgrades required at Woburn Substation for this project include installation of a new 115 kV series reactor and bi-furcate the new line termination with the existing 211-514 line which includes the following specific components:

(1) 115 kV Series reactor
(1) Termination of new Mystic to Woburn 211-514 line

ECI's total estimated cost associated with the Mystic Substation upgrades is $4.5M and with the Woburn series reactor addition is $1.6M.

3.3.2 Description of Transmission Upgrades

Transmission upgrades consist of installing a new 115 kV 2500 MCM CU HPFF circuit from Woburn Substation to Mystic Substation, both owned by NU. The installed circuit length is estimated to be 7.72 miles (40,762 circuit feet). This circuit will be installed in 8" coated steel pipe encased in FTB and cathodically protected in city streets parallel to the existing 211-514 line which is 115 kV HPFF 1250 MCM CU. This new line is to be bifurcated with line 211-514 at the terminations at both Woburn and Mystic Substations. The estimated cost of this project is $62.7M.

Assumptions

- Existing spare cable pipe under the Mystic River is suitable for use.

- The thirteen (13) existing manholes for the existing 211-54 line can be utilized to accommodate the new circuit. As a precaution, ECI has included the costs of seven (7) new manholes as did the TO. There will be four (4) stop joints and nine (9) straight joints installed on the system.
- The existing pumping plant is large enough and can be modified to accommodate the new circuit. A total of fifteen (15) new terminations will be installed, three (3) at Woburn Substation and three (3) at Mystic Substation as part of the new circuit, and to accommodate the swapping of positions 3 each for lines 211-54, 488-518X and 488-518 W.

The following specific components are included in the transmission upgrades cost estimates:

New Circuit
40,763 circuit feet of 8" coated steel pipe in city streets (not adjusted for existing pipe under the Mystic River)
128,400 ft. (40,763 circuit feet plus 5% for change in elevation and terminations) 115 kV 2250 CU HPFF cable
Seven (7) new manholes and the reconstruction of six (6)
(4) 3-Phase stop joints
(9) 3-Phase straight joints
(3) Open air terminations in Woburn Substation
(3) GIS Terminations in Mystic Substation
Fluid to fill the line
Cathodic Protection System

Mystic Substation - Line 21-514
Freeze pipe
Remove existing cable
Install short length of new riser pipes
New termination structure
Short length new cable
(1) Direct buried trifurcating splice
(3) New GIS terminations

Mystic Substation - Line 488-518X
Freeze pipe
Remove existing cable
Install short length of new riser pipes
New termination structure
Install short length new cable
(1) Direct buried trifurcating splice
(3) New GIS terminations

Mystic Substation - Line 488-518Y
Freeze pipe

Remove existing cable
Install short length of new riser pipes
New termination structure
Install short length new cable
(1) Direct buried trifurcating splice
(3) New GIS terminations

Current Identified Risks

- Lack of detailed design
- Subsurface conditions
- Contaminated soil
- Permitting
- Reworking of manhole
- Work space within the existing manholes (i.e.: is there enough room to safely install and physically work on another circuit?)
- Can line 211-514 be de energized if necessary to install the new circuit?
- Suitability for use of existing pipe under the Mystic River
- Is the current pumping plant large enough to operate the new circuit?
- High pressure fluid filled cable is currently available from a single source which could impact schedule and obtaining additional cable if required.
- Potential of extended outages given the intricate station work
- Metals and materials escalation

3.4 Environmental Discussion Relative to AC Plan

The proposed transmission projects included in this discussion is "AC Plan" alternative. These projects are designed to address the reliability needs of the Greater Boston Study Area, including 16 towns as shown in *Table 3.4-1, Towns Potentially Affected by AC Plan*.

Project(s)	State	Towns	Project(s)	State	Towns
A-1	MA	Andover	A-1	MA	Tewksbury
A-3	MA	Arlington	A-2	MA	Wakefield
A-3	MA	Cambridge	A-2, A-3	MA	Winchester
A-1	MA	Dracut	A-2	MA	Woburn
A-3	MA	Everett	A-1	NH	Hudson
A-3	MA	Medford	A-1	NH	Londonderry
A-3	MA	Somerville	A-1	NH	Pelham
A-2	MA	Stoneham	A-1	NH	Windham

Table 3.4-1
Towns Potentially Affected by AC Plan

The AC Plan consists of the following projects:

- Project A-1 consists of twenty-five (25) miles of new 345 kV line from Scobie Pond to Tewksbury and nine (9) miles of reconductoring for line Y-151 115 kV NU Border to Dracut Jct. (RSP# 1220 & 1213).

- Project A-2 consists of eight (8) miles of new 345 kV XLPE underground (RSP #1552) line from Wakefield to Woburn.

- Project A-3 consists of eight (8) miles of a new bi-furcated 115 kV underground line (RSP# 1356) from Woburn Substation to Mystic Substation.

3.4.1 Environmental Overview

The purpose of this section is to provide an outline of the AC Plan Unique Components environmental factors, thus helping identify any potential major risks and variations in the cost estimates. ECI's Environmental Services Group performed a cursory evaluation of the environmental review, permits and applications for the project. The cost for environmental services for the proposed project includes the following:

- Review of critical issues
- Army Corps of Engineers Permit and 404 Certification
- Road, railroad, utility and pipeline crossings and approaches
- Local permits within counties, townships and municipalities
- Coastal management zones, tidal waters and floodplains
- Endangered species and cultural resources

- FAA permits
- State land crossings
- Public utility commission processes

It is assumed that resource surveys will be completed for the majority of the project due to a certificate being required from both the State of Massachusetts and the State of New Hampshire (NH Code Title 12, Chapter 162-H:2(VII)(e) and Chapter 162-H:5(I)).

3.4.2 Environmental Cost Estimate

ECI's internal assessment for the Environmental portion of the AC Plan is approximately $800,000 (this figure is NOT included in the totals shown in the Executive Summary), excluding any remediation cost. This estimate includes approximately 6,000 labor hours and additional resource survey hours based on 2014 labor estimates. The following assumptions are included in ECI's environmental cost estimate:

Endangered Species Survey	$50,000
Cultural Resources Survey	$75,000
Wetland Delineation Survey	$50,000

These costs are for labor and do not include individual permitting fees.

Note that the estimates for environmental contracts that include resources surveys are highly variable and could fluctuate based on the preferred vendor for environmental services. Subcontractors were not solicited to estimate actual costs.

3.4.3 Federal, State or Local Permit/Action

ECI assumes that the siting board(s) has approved the locations of the above mentioned projects based on energy needs and transmission stability. Possible federal, state, or local permits and/or actions that may be required for the projects are outlined as follows:

1) National Environmental Policy Act (NEPA) and Massachusetts Environmental Policy Act (MEPA) and New Hampshire Department of Environmental Services (NHDES) review will be required for all projects

2) Cultural & Historical Laws and Preservation
   All projects will require adherence the following federal and state statutes and regulations:

   A) Federal

      i. Section 106 of the National Historic Preservation Act (36 CFR § 800)
      National Register of Historic Places – If a National Register eligible or listed site, building, or structure is identified within the impact area of the project, the state or the federal agency will apply the criteria of effect to determine whether the effect will be adverse. Not all projects have adverse effects on historic properties.

B) State

i. Massachusetts General Laws Chapter 9, section 26-27C
Massachusetts Historical Commission (MHC) – If the proposed project will involve state or federal funding, licenses or permits, the project proponent must submit a Project Notification Form (PNF). Review can take 30 days. The MHC will determine if an archaeological survey is required.

ii. New Hampshire Statutes (XIX Chapter 227-C)
New Hampshire Division of Historic Resources (DHR) – The project proponents MUST complete and submit a Request of Project Review (RPR) Form. The DHR will determine if an archaeological survey is required.

C) Potential Tribal Offices (THPO) that may need consultation due to proximity:

i. Nipmuc Nation - South Grafton, MA
Hassanamesit Reservation is located beyond all Project Areas

ii. Wampanoag Tribe of Gay Head – Aquinnah, MA
The island is located beyond all Project Areas
THPO Officer – Bettina Washington

iii. Mashpee Wampanoag Tribe – South Mashpee, MA
Mashpee is located beyond all Project Areas
THPO Officer – Ramona Peters

3) Natural Laws and Preservation

A) Wetland impacts

i. Massachusetts Wetlands Protection Act (9 reasons of protection)
1. Public water supplies
2. Private water supplies
3. Groundwater supplies
4. Flood control
5. Storm damage prevention
6. Prevention of pollution
7. Protection of land containing marine shellfish
8. Protection of wildlife habitat
9. Protection of fisheries

ii. New Hampshire Wetland Program Plan
iii. New Hampshire Shoreland Water Quality Protection Act (1991)
iv. The local Conservation Commissions

B) Threatened and Endangered (T&E) Species

i. US Fish & Wildlife Service (USFWS) Section 7/10 of the Federal Endangered Species Act (ESA)
ii. Massachusetts Endangered Species Act (MESA), highly recommended that project proponents request this information prior to development, especially if the project falls within Priority Habitat for rare species.
iii. Department of Massachusetts Conservation Commission
iv. Proponents with projects and activities proposed within Priority Habitat of Rare Species and Estimated Habitat of Rare Wetland Species must file with NHESP for review and approval.
v. Under MESA, certain projects or activities within Priority Habitat may qualify for a MESA filing exemption. Other projects may have met specific permitting milestones before being mapped in Priority Habitat, and are therefore "grandfathered."
vi. Under WPA, if a Notice of Intent (NOI) is required for a project or activity in Estimated Habitat, a copy of that NOI must be sent to the NHESP.

Hillsborough County, New Hampshire		
Flowering Plant	Small Whorled Pogonia	Threatened
Rockingham County, New Hampshire		
Birds	Piping Plover	Threatened
	Roseate Tern	Endangered
Flowering Plant	Small Whorled Pogonia	Threatened
Reptiles	Hawksbill Sea Turtle	Endangered
	Leatherback Sea Turtle	Endangered
	Green Sea Turtle	Threatened
Middlesex County, Massachusetts		
Flowering Plants	Small Whorled Pogonia	Threatened
	Sand Plain Gerardia	Endangered
Essex County, Massachusetts		
Birds	Piping Plover	Threatened
	Roseate Tern	Endangered
Flowering Plant	Small Whorled Pogonia	Threatened
Reptiles	Hawksbill Sea Turtle	Endangered
	Leatherback Sea Turtle	Endangered
	Green Sea Turtle	Threatened
Suffolk County, Massachusetts		
Birds	Piping Plover	Threatened
Reptiles	Hawksbill Sea Turtle	Endangered
	Leatherback Sea Turtle	Endangered
	Green Sea Turtle	Threatened

Table 3.4-2
T&E Species by County

C) Waterways
See crossings.

D) Floodplains
Could require special design considerations for engineering.

E) Stormwater Permits (NH and Mass)
Projects that disturb more than one (1) acre must submit NOI, prepare a SWPPP and submit an NOT at project re-stabilization.

F) Vegetation Management

i. Invasive Plant Management (limit disturbance)
ii. (Massachusetts) 220 CMR 22.00 – Notification of Vegetation Maintenance Activities for Transmission Rights-of-Way

4) Crossings

A) Highways

i. MassDOT prefers underground, as opposed to aerial crossings, of all utilities; further prefers use of directional boring methods.
ii. Consult – "Utility Accommodation Policy on State Highway Right of Way"; there are different policies for UG vs OH.

B) County & Town Roads
Most, if not all, roads crossed by the project will require a road crossing permit and/or road approach permit, depending on the specific regulations of the individual counties or towns.

C) Railroads
i. Many projects cross the MBTA commuter rail, which is active. Must consult the MBTA "Railroad Operations Directorate". May require a License for Entry, License Agreement, Easement, or Letter of Authorization.
ii. Entry for the purpose of conducting surveys, etc… will be permitted only with a proper entry permit prepared by the MBTA Real Estate Dept.

D) Jurisdictional Waters
Army Corps of Engineers (USACE) General Permit for Massachusetts and New Hampshire will be required (likely for all projects).

E) Navigable Waters

i. All Tidal Waters under Section 10 of the River and Harbors Act and their tributaries to the head of tide – affects all projects near Mystic
ii. Connecticut River – no projects
iii. Merrimack River affects Project A-1

F) Coastal Management Zones
Will impact all projects that tie near the Mystic Substation.

5) Agency Scoping is a critical issues identifier used by project proponents to identify permits and approvals needed for a proposed project. At a minimum, the following agencies will need to be contacted and regulations reviewed:

A) Federal

i. US Fish and Wildlife Service (FWS)
ii. Department of Game, Fish & Parks (Federal & State levels)
iii. US Army Corps of Engineers (USACE) – New England District
iv. USDA/Natural Resource Conservation Service (NRCS)
v. FAA
vi. Railroads
vii. DOT – interstates

B) State

i. SHPO/THPO (Section 106)
ii. DOT – state highways
iii. DEQ
iv. Mass. Wetlands Protection Act
v. Mass. Department of Agricultural Resources (330 CMR 18.00)
vi. Massachusetts Office of Coastal Zone Management

C) Counties & Towns Agencies that would be required for consultation

i. Local Conservation Commissions (based on towns)
ii. Agricultural Lands Preservation Committee (ALPC)
iii. Local Agricultural Commissions

6) Public Scoping identifies critical non-agency issues for project by contacting stakeholders like landowners and holding public meetings.

3.4.4 Specific Project Impacts & Crossings

1) Project A-1: Scobie to Tewksbury 345 kV Line & Reconductor Y-151 kV NU Border to Dracut Jct.

- Jurisdiction Crossed by Project:

States	Counties	Towns
New Hampshire	Rockingham	Derry
		Londonderry
		Windham
	Hillsborough	Hudson
		Pelham
Massachusetts	Middlesex	Dracut
		Tewksbury
	Essex	Andover

- Other Easements (within 100 ft of centerline):
  - NH Dept. of Resources & Economic Development - Musquash Swamp
  - Town of Derry - Derry Railbed
  - Town of Hudson - Bockes Memorial Forest, David Drive Lot
  - Town of Londonderry - Lordes Parcel, Sunnycrest Orchards, Town of Londonderry Land, Ingersoll Addition
  - Town of Pelham - Town of Pelham Land, Peabody Town Forest
  - Town of Windham - Beaver Brook Parcel
  - MA Department of Agricultural Resources - Dumaresq Farm
  - Town of Andover - Pheasant Ridge Green Area
  - Dracut Land Trust
- Interstates Crossed by Project: I-93, I-495
- State Highways Crossed by Project: New Hampshire State Routes 28, 38, 102, 111, and 128; Massachusetts State Routes 110, 113, and 133
- Additional Roads Crossed by Project: approximately 52 (will require road crossing permits and approach permits)
- RR Crossed by Project: Boston and Maine RR (near Scobie Sub)
- Water Crossed by Project: Beaver Brook, Nesenkeag Brook, Chase Brook, Golden Brook, Tonys Brook, Merrimack River, Meadow Brook
  - Note: All of these are listed as Impaired Waterways by the EPA (may add to SWPPP requirements)
  - Note: Merrimack River is considered Navigable by the USACE (will require Nationwide 12 Permit with notification)
- Closest Airport: Manchester (~4-5 miles northwest of proposed project)

2) *Project A-2: Wakefield to Woburn new Underground 345 kV cable*

- Jurisdiction Crossed by Project:

States	Counties	Towns
Massachusetts	Middlesex	Wakefield
		Stoneham
		Woburn
		Winchester

- Other Easements (within 100 ft of centerline):
  - City of Woburn: Horn Pond Mt. Area
  - Town of Wakefield: Nasella Playground, Moulton Playground
- Interstates Crossed by Project: I-93
- State Highways Crossed by Project: Massachusetts State Routes 28, 38, and 129
- Additional Roads Crossed by Project: approximately 86 (will require road crossing permits and approach permits)
- RR Crossed by Project: MBTA Commuter Rail
- Water Crossed by Project: Malden River and 2 unnamed streams
  - Note: Malden River is listed as an Impaired Waterway by the EPA
- Closest Airport: Hanscom Air Force Base (~ 7 miles west of proposed project)

3) *Project A-3: Bifurcate New Woburn to Mystic Underground 115 kV cable*

- Jurisdiction Crossed by Project:

States	Counties	Towns
Massachusetts	Middlesex	Woburn
		Winchester
		Arlington
		Cambridge
		Somerville
		Everett
	Suffolk	Boston

- Other Easements (within 100 ft of centerline):
  - MA DCR – Div. of Urban Parks & Rec: Foss Park, Middlesex Fells Reservation, Mystic Lakes, Mystic River Reservation, Mystic Valley Parkway, Veterans Memorial Park
  - City of Boston: Ryan Playground
  - City of Medford: Victory Park
  - City of Woburn: Horn Pond Mt. Area
  - Town of Winchester: Ginn Field, Winter Pond
- Interstates Crossed by Project: I-93
- State Highways Crossed by Project: Massachusetts State Routes 16, 28, 38, 60, 99
- Additional Roads Crossed by Project: approximately 81 (will require road crossing permits and approach permits)

- RR Crossed by Project: MBTA Commuter Rail, MBTA Orange Line
- Water Crossed by Project: Malden River, Mystic River
  - Note: All of these are listed as Impaired Waterways by the EPA
  - Note: Crossing at Mystic River may be located within the Coastal Management Zone
- Closest Airport: General Edward Lawrence Logan International (~4 miles southeast of the proposed project)

4.0 HVDC PLAN

4.1 Project D-1; HVDC Submarine Cable and Two Terminals

Project D-1 includes sea cable, land cable and converter stations required for reliable transmission of 520 MW High Voltage Direct Current (HVDC) between Seabrook, NH and Everett, MA. The following sections outline the estimates associated with each of the respective components.

4.1.1 Part A - HVDC & AC Cable Installed Cost Estimates

The HVDC project would provide the facilities to deliver approximately 520 MW from Seabrook, NH to Everett, MA. The required transmission capacity of the DC cables should be around 550 MW. It includes the four segments shown below.

1) 50.2 miles (80.77 km) of 200 kV XLPE DC submarine cables (including two 1600' HDDs and gas pipe protection)

2) 15.3 miles (24.62 km) of 200 kV XLPE DC land cables to be installed in duct and manhole system

3) 0.4 miles (0.64 km) of 345 kV XLPE AC land cables for Seabrook Interconnect (to be installed in ducts)

4) 1.3 miles (2.1 km) of 115 kV XLPE AC land cables for Everett/Mystic Interconnect (two cables per phase; to be installed in duct and manhole system)

The following paragraphs provide a detailed estimate of the individual segments.

SeaLink 200 kV DC Submarine Cables

The most recent submarine cable rated 500 MW at 200 kV HVDC was awarded by EMERA's subsidiary Nova Scotia Power in Canada to Nexans in early 2014. It includes approximately 106 miles (170 km) of submarine crossing, or a total approximately 212 miles of cables. However, they are of the MI type (Mass Impregnated) cables. This would not have much influence on the project pricing as compared to XLPE (Cross Linked Polyethylene insulated) Cables that would usually require many factory flexible joints. The cost of transportation and laying of the two long DC power cables and the fiber optic would be similar in both cases.

Both projects are similar as they include fiber optic elements of multi-pair optic cable; four (4) transition joints from submarine cables to land cables and embedment under the sea bottom.

This contract to supply and install 106 miles (170 km) of submarine and land cables is estimated at $175 Million Euros ($227.5 Million US Dollars). This translates into ($2.153 Million US $/circuit mile on average).

Based on these prices, the cost of the total 67.2 circuit miles required for the SeaLink would be $144.7 Million US Dollars.

However, considering the following differences between the two projects:

- The higher required transmission capacity for SeaLink is 550 MW (520 MW plus the losses in the DC cables). This would necessarily require a larger conductor cable.
- The long land portion (17.0 miles/27 km) requiring extensive civil work as well as cable pulling and splicing (estimated number of joints is 54; based on one (1) jointing location every 3000').
- The two long HDD's (one on each side of the installation).
- The need to protect an existing pipe line under water using concrete mattresses.

Thus, the following additional cost should be considered:

1) For the submarine cables, a 20 % adder on the cost of the cables $2.153/mi x 50.2 mi x 0.7 x .20 = $15.1 Million US Dollars. This 20% adder is applicable to cable cost only, not the installation cost. It can generally be assumed that cable cost is 70% of the total submarine installed cost.
2) For the two HDD's = approximately $3 Million US Dollars
3) For the land cables, a 50% adder should be added to the cost of the installation component only; for the duct and MH system as well as the cable pulling and jointing, the cost would be $2.153/mi x 17 mi x 0.5 = $18.4 Million US Dollars.

The above additions would bring the estimated cost of submarine and land DC cables to a total of $181.1 Million US Dollars.

345 kV AC Seabrook Interconnect Land Cables

The 345 kV transporting 520 MW would have to carry 870 Amps per phase. This would be possible with XLPE insulated cables having 5000 KCM (2500 mm^2) segmental copper conductors.

The cost of installing the 345 kV XLPE cables is estimated at $8 Million dollars per mile based on industry experiences in the Northeast. However, considering the short length of the required cable circuit, this figure should be increased by 50% to take into consideration the cost of short length cable production and the mobilization and demobilization by the civil contractor for such short installation. This segment of the project is estimated at $8M/mi x 1.5 x 0.4 mi = $4.8 Million US Dollars.

520 MW 115 kV AC Everett/Mystic Interconnect Land Cables

Considering the required transmission capacity of 520 MW (2610 Amps per phase), two (2) XLPE insulated 115 kV cables with large segmental conductors (5000 kCM; 2500 mm^2) will be required per phase.

The estimated cost of a 260 MW/115 kV XLPE insulated cable circuit in an urban setting is $7.8 Million US Dollars per mile based on industry experiences in the Northeast. The cost of two (2) 1.3 miles of double circuit would be 2 x 1.3 mi x $7.8M/mi = $20.3 Million US Dollars.

The total cost of the cable portion of the project would be $206.2 Million US Dollars.

Notes:

1) The engineering activities of HV cable projects are usually carried out by the manufacturer. However, in-house engineers or a consulting firm should validate and approve (accept) the proposed design.
2) The completed marine survey would enhance the clarity of the tender for the submarine cables.
3) The target "in service" date of April 2018 is realistic. However, the tendering process should be undertaken in 2014.
4) The supply and delivery of land cables is very short as compared to that of submarine cables that would take three to four years to complete the manufacturing and installation depending on the availability of transportation and installation vessels.
5) Some coordinating activities are essential between the supplier of the converter stations and that of the cables to ensure compatibility, in the case of awarding two separate contracts to different suppliers.

A summary of the cost estimates is shown in the *Table 4-1* below.

Item	L (Miles)	Unit Cost	Cost
DC submarine Cables	50.2	$2.153M	$108.1M
DC land Cables	17.0	$2.153M	$36.6M
			$144.7M
Incremental Increase			
DC land Cables	17.0	$1.08M	$18.4M
DC submarine Cables	50.2	$0.3M	$15.1M
HDD's			$3.0M
Total cost DC Cables			**$181.1M**
345 kV AC Cables	0.4		$4.8M
115 kV AC Cables	1.7		$20.28M
Grand Total	**136.5**		**$206.2M**

Table 4-1
Cost Estimate Summary

4.1.2 Converter Station Cost Estimates

HVDC Power Transmission Feasibility

The basic circuit concept for an HVDC transmission system consists of two (2) converter station terminals, one sending and one receiving, interconnected by a transmission line. The transmission line provides a current flow path between sending to receiving converter stations. The resulting system configuration provides a complete electrical circuit between sending and receiving stations. For these estimates a symmetrical monopole system is assumed.

Converter Station Feasibility

HVDC transmission lines have power conversion stations at each end. The conversion stations are equipped with solid state devices that convert alternating current to direct current and vice versa. When a line is in operation, alternating current power flows into a converter station, at the sending end, where it is converted (rectified) into direct current. At the receiving end of the line the converter station (inverts) the direct current back into alternating current.

The HVDC alternative includes use of Voltage Source Converter (VSC) technology at the converter stations. ABB, Siemens and Alstom Grid are the three primary suppliers of this equipment and all have deployed VSC stations in a class commensurate with the HVDC Plan. The VSC technology can be considered "proven". However, due to the highly technical nature of the converter stations it would be wise to stay with one single supplier from the three named manufacturers at both converter stations.

At the planning stage, estimates from manufacturers normally include network studies, system design, engineering, equipment procurement, delivery, civil works, installation and commissioning activities. Numerous VSC station configurations are possible but the basic components are rather similar. An example layout is shown in *Figure 4-1*.

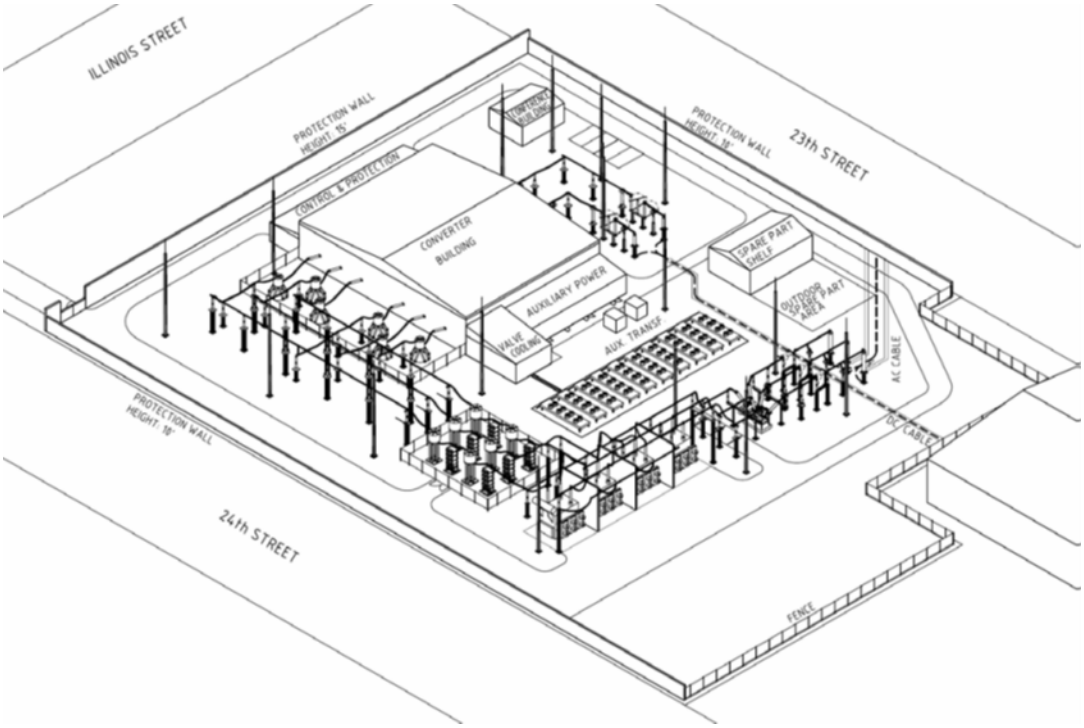

Figure 4-1
Isometric View of an HVDC Terminal Station

Approach to Converter Station Cost Estimates

The following estimates include the total cost to deliver the converter stations. The work includes network studies, system design, engineering, equipment procurement, delivery, civil works, installation and commissioning activities.

Converter Station cost estimates were developed in the following manner:

1) ECI contacted major suppliers of converter station equipment and obtained pricing for comparative converter stations.
2) ECI used publically available cost information for the TransBay cable project then scaled the costs to reflect differences in the SeaLink project cost.

The HVDC Plan requires a 520 MW through flow. The converter stations must be sized to accommodate losses in the cables and equipment. Cable and equipment characteristics will influence losses. Therefore, for purposes of the estimating, ECI assumed the converter stations would be rated 550 MW.

The converter station estimates include the equipment to connect both the AC and DC cables.

Schedule Feasibility

A typical delivery time from notice-to-proceed to hand-over is in the order of 24-30 months. An overall project schedule of 30 months from start of engineering studies to commercial operation is probably realistic.

Vendor Pricing Information

ECI contacted ABB, Alstom Grid and Siemens to obtain budgetary quotes for two turn-key converter stations. ECI told the suppliers that we were not asking for prices that may have been provided for any specific project but rather for a range of dollars that might be considered typical estimates for a turn-key project with a certain MW and Voltage ratings.

Manufacturers have asked ECI to keep pricing information confidential; therefore, we will only provide limited information and we will not identify pricing as coming from a specific vendor.

- Vendor #1 price estimate for two converter stations was $260M with an estimated ± 15% tolerance.
- Vendor #2 price estimate for two converter stations was $255M with an estimated ± 20% tolerance.
- Vendor #3 price estimate for two converter stations was $320M to $400M total.

The vendor pricing suggests that the converter prices could range from $204M to $400M. The average cost of the three vendor quotes is $291.7M. Factors that influence the pricing are discussed in the Converter Station Cost Risks section below.

Past Project Cost Comparison

The Transbay project went in-service in 2010. The converter stations were built by Siemens and were rated 400 MW compared to 550 MW converter stations that will be needed for the HVDC alternative. The AC & DC delivery voltages on Transbay were approximately the same as those that were expected on the HVDC project. ECI discussed the concept of using the Transbay cost information with engineers working for one of the converter manufacturers. ECI proposed, and manufacturer thought it would be a reasonable first pass estimate, to scale TransBay costs based on MW ratings then include the time value of money.

The original cost data for TransBay was a submittal that was made by TransBay to the City and County of San Francisco Public Utilities Commission. In this 2010 document, the cost of the TransBay converter stations was reported as $73M each for a total cost of $146M. ECI is uncertain if the TransBay converter station numbers included large amounts of loading dollars for legal fees, public outreach, general overhead costs or site remediation. The converter stations for both ends of the Transbay cable were on Brownfield sites that may have required some remediation.

ECI adjusted the TransBay costs as follows:

- To account for the difference in MW ratings, the costs were scaled by a factor of (550/400) or 137.5%
- Since SeaLink has a 2018 in-service date the TransBay costs were inflated over eight (8) years at an assumed annual inflation rate of 3%*.

**It is recognized that the applicable 8 year inflation rate would be a mix of US and European/British rates. A cursory internet search suggested that a 3% rate may be reasonable for this estimate.*

Using this approach the estimated cost of the HVDC converter stations is approximately $256M.

Converter Station Costs Risks

All of the converter suppliers placed large disclaimers on their price estimates. The following cost risks were identified by the converter suppliers:

1) Major modifications to cost of labor and materials (metals, concrete, etc.).
2) The major components are constructed overseas and are therefore subject to changes in foreign currency indices.
3) Unforeseen major environmental activities such as soil replacement and/or remediation of any contaminated material.
4) Unanticipated demolition of existing buildings and/or structures (The proposed sites appear to be vacant so this is only a risk if the sites move).
5) Special audible noise prevention measures.
6) Extraordinary environmental protection activities.
7) The features selected for the converters (black start, etc) may influence the costs but the total impact to converter cost is in the +5 to 7% range.

ECI Opinion of Probable Cost of Converter Stations

The cost data gathered by ECI is summarized as follows:

- The vendor's average estimated cost was $291.7M.
- Based on vendor estimates to ECI the total converter station costs could range from $204M to $400M.
- The TransBay cost approach yielded a cost of $256M.

ECI's opinion of probable cost for the converter stations is the average of the estimates or approximately $291.7M. ECI believes the accuracy of our estimate is within the ISO-NE Class A estimate requirements which are -25% to +50%.

4.2 Project D-2; Seabrook 345 kV Interconnection for HVDC

This project includes New Hampshire Transmission components associated with the connection in the Seabrook GIS switchyard.

4.2.1 Description of Substation Upgrades

Seabrook is an existing 345 kV substation that serves the Seabrook Nuclear Plant and connects three (3) 345 kV lines. The 520 MW DC project will interconnect at the Seabrook Substation. This will require a new 345 kV cable that will tie the Seabrook Substation to the nearby converter station located onsite at Seabrook. The Seabrook Substation will require the following changes:

1) Conversion of Breaker 22 into Gas Zone 22 to create room for cabling and relaying. The gas zone entails moving the protection and locking the breaker closed, essentially allowing the breaker to become part of the bus.
2) Removal of Gas Zone 11 (old Breaker 11).
3) New breaker (711) in the Gas Zone 11 position.
4) New breaker (763 A) replacing Breaker 163.
5) New breaker (763 B) between Breaker 163 position and the Gas Zone 11 position.
6) GIS bus between Breaker 711 and Breaker 763 B to outside protected area.
7) GIS bus will connect to AC cable to feed the HVDC converter station.

ECI's total estimated cost associated with the Seabrook Substation AC upgrades is $28.3M.

4.3 Project D-3; Mystic 115 kV Interconnection for HVDC

This project includes interconnection of a 115 kV line from the DC terminal at Mystic Substation and related station reconfiguration work at Mystic.

4.3.1 Description of Substation Upgrades

The Mystic station upgrades include undergrounding terminals of 423-515 115 kV line; relocation of Transformer 110A and addition of a new 115 kV breaker; relocate Transformer 110E to new termination location; relocate existing 211-514 underground 115 kV line to new termination location; relocate existing 31 & 32 GCB, install new bus connections from east and west busses to 115 kV GUS bus and terminate 115 kV line from DC terminal. A further breakdown of Mystic station upgrades are summarized in the line items below:

1) Convert 423-515 air terminals to underground (to create room to extend west bus for new 115 kV breaker to feed relocated Transformer 110A).
2) Extend west bus and install new 115 kV breaker. Install new foundation for Transformer 110A and relocate Transformer 110A and terminate off new breaker.
3) Temporarily remove Breaker 30 and bus between Breakers 7 and 32 (for rigging access) and move 110E to former 110D transformer location (Transformer 110D will be consolidated with 110C as part of another project). Reinstall bus work and Breaker 30.
4) Relocate line 211-514 (underground 115 kV HPFF line) termination to new termination location (between Breakers 8 and 9) and install new conductor from nearest manhole to new termination location.
5) Move Breaker 31 to new position (on bus between Breakers 17 and 13).
6) Install new 3000A gas insulated bus from west bus (between Breakers 17 and 21) to terminate at GIS switchgear between Breakers 23 and 26.
7) Move Breaker 32 to new position (on bus between Breakers 14 and 11).
8) Install new 3000A gas insulated bus from east bus (between Breakers 18 and 14) to terminate at GIS switchgear between Breakers 24 and 25. Note that new Breaker 25 will be installed as part of another project previous to this project.
9) Remove Breaker 7 connection to GIS switchgear.
10) Terminate new HVDC connection at Breaker 7.

ECI's total estimated cost associated with the Mystic station upgrades is $20.5M.

4.3.2 Description of Transmission Work at Mystic Substation

The interconnection of the 115 kV line from DC terminal at Mystic Substation will consist of underground transmission work within the substation to relocate Line 211-514 terminations to new location, and work related to convert 423-515 Line air terminals to underground. The work scope lacked detailed description and substation layout information; thus a conceptual estimate is done based on the following general work scope:

1) Freeze of 115 kV Line 211-514 at nearest manhole to allow for cutting of the pipe and existing cables.

2) Install the short length of pipe to extend to the new terminal location.
3) Install new terminal structure at new location.
4) Pull in new 3-phase 115 kV short length cable from nearest manhole to new terminal location.
5) Splice cables at the manhole.
6) Terminate cables at new terminal location.
7) Refill pipe with fluid.

Similar work will be required for the 423-515 Line.

The total cost of the underground HPFF cable and termination work for this project is estimated to be $4.6M.

4.4 Project D-4; Reconductor Y-151 115 kV NU Border to Dracut Jct.

The reconductor of Y-151 is 9.3 miles long and referring to the scope as a reconductor is somewhat of a misnomer due to the fact that it is essentially rebuilding the line. Most, if not all, of the structures are being replaced as well as all insulators, shield wire, hardware and conductor. In addition to the scope of constructing the newly reconfigured line, this project includes removal of existing conductor, shield wire, and structures.

The Y-151 reconductor/rebuild project includes installation of sixteen (16) pole-arm suspension structures, seventy-two (72) H-frame suspension structures, six (6) steel H-frame dead-end structures, four (4) three-pole dead-end structures, one (1) transposition structure, and installing 9.3 miles of 1590 kCM ACSS conductor and 7.5 miles of shield wire. Thirty three (33) concrete foundations are also included in the scope.

ECI's total estimated cost associated with the Y-151 reconductor/rebuild is $10.5M.

4.5 Project D-5; Reconductor Sandy Pond – Tewksbury 345 kV (337 Line)

This project consists of reconductoring the 345 kV 337 line between Sandy Pond and Tewksbury. There is both overhead line work and substation work associated with this National Grid improvement. The line work includes replacement of fifty-six (56) H-frame structures, twelve (12) 3-pole structures, eighteen (18) double circuit structures and the reinforcement of fifty-seven (57) existing H-frame structures. The existing conductor is to be replaced with twin bundled 1590 kCM ACSR "Falcon" conductor over the 15.7 mile length of line. The substation estimate portion includes considerations for temporary works required for completion of the project.

4.5.1 Description of Substation Upgrades

The substation upgrades pertain to temporary work required for completion of the project. There are limited details associated with the specific temporary substation work required to complete this project. National Grid's estimated cost for substation work is $2,173,426. Since ECI has no basis to compare this estimate and since the substation cost is such a small portion of the overall improvement cost, ECI has no comments on the substation portion of the estimate of $2.2M.

4.5.2 Description of Transmission Upgrades

Reconductor 345 kV 337 Line with Bundled 1590 ACSR

For estimating the 337 line rebuild, ECI adhered to the detailed scope description provided by National Grid and the Greater Boston Map & Data Package by New Hampshire Transmission. The reconductor of the 337 line is 15.7 miles long and is similar to the Y-151 reconductor in that it is essentially a complete rebuild of the line.

The costs are based on the reinforcing of fifty-seven (57) H-frame structures with X-braces, the installation of forty-seven (47) steel H-frame suspension structures, nine (9) steel H-frame dead-end structures, twelve (12) three-pole dead-end structures, fifteen (15) 115 kV/345 kV double circuit steel suspension structures, three (3) 115 kV/345 kV double circuit steel dead-end structures, and installing 15.7 circuit miles of bundled 1590 kCM ACSS conductor with two (2) 3/8" shield wires. Seventy-two (72) concrete foundations are also included in the estimate.

We are anticipating that there will be three contractor laydown areas. ECI's total estimated cost associated with the 337 line reconductoring is $32.2M.

Pricing Clarifications and Assumptions

1) No costs for public outreach were included in our estimate.

2) Costs for swamp matting are included in our estimate.

3) Foundation costs for drilled piers on hard angles and dead end structures are based on the use of removable casing and "wet method" concrete installation.

4) No costs have been included for dewatering piers or surface water.

5) We have included the cost of guard structures for crossing existing lines and roads in our estimate.

6) No costs have been included for drilling or removing subsurface rock.

7) No costs have been included for handling of contaminated soils or liquids.

8) No costs have been included for the acquisition of real property or rights of way.

9) No costs have been included for fencing other than for contractor laydown yards.

10) No costs have been included for control of fugitive dust emissions.

11) No costs have been included for winter conditions. Construction would be expected to take place spring through fall.

12) No costs have been included for material or labor escalation.

13) No contingency dollars have been included in the base estimate.

14) Payment and Performance bond costs have not been included in this estimate.

15) Permitting and legal costs are not included in this estimate.

16) All reconductor work is assumed to be done de-energized.

4.6 Project D-6; Bifurcate Mystic – North Cambridge 345 kV

This project consists of bifurcating the two existing 345 kV underground HPFF lines 351 & 358 at the termination ends located at NU's Mystic Substation and North Cambridge Substation. Work consists of two parts; 1) substation upgrade work which includes the necessary work to install a hybrid AIS to GIS switchgear arrangement that would allow for the termination of the two (2) HPFF cables into one (1) 345 kV AIS switching position and 2) actual termination of the two (2) 345 kV HPFF cables into one (1) switching position.

4.6.1 Description of Substation Upgrades

Substation upgrades are required both at the North Cambridge and Mystic stations. Specifically, this includes installation of a hybrid AIS/GIS module to transition from air insulated 345 kV bus to gas insulated 345 kV bus to allow for the termination of two (2) HPFF cables into one (1) 345 kV AIS switching position. The 351 line termination will be moved to the 358 termination position at both Mystic and North Cambridge. Specific upgrades at each of the respective facilities are summarized in the following line items:

North Cambridge Station 509

1) Remove the air insulated exit bus for Line 351 HPFF air terminals and Line 358 HPFF terminals.
2) At the location of the Line 351 switching position, install air gas exit bus consisting generally of the necessary disconnect switches, VTs and HPFF gas terminations.
3) Reroute Line 358 to its new terminal position and install new HPFF gas terminal.
4) Reset line relays.

Mystic Station 250

1) Remove the air insulated exit bus for Line 358 HPFF air terminals and Line 351 HPFF terminals.
2) At the location of the Line 358 switching position, install air gas exit bus consisting generally of the necessary disconnect switches, VTs and HPFF gas terminations.
3) Reroute Line 351 to its new terminal position and install new HPFF gas terminal.
4) Reset line relays.

ECI's total estimated cost associated with the North Cambridge and Mystic station upgrades is $10.6M.

4.6.2 Description of Transmission Upgrades

The transmission upgrades involve moving the existing 351 line terminations to the 358 line termination positions at both Mystic and North Cambridge Substations. The following specific components are included in the transmission upgrades cost estimates:

1) Freezing of two (2) HPFF pipes (one at each substation) to allow for cutting of the existing 351 line pipe and 3-phase cables at some feasible point near the base of existing terminations.
2) (6) Short lengths of 345 kV HPFF cables to allow for extending line 351 from the existing termination location to the line 358 termination location at both Mystic and North Cambridge Substations.
3) (2) Short lengths of pipes for extending the 3-phase cables at both substations
4) (2) 3-phase 345 kV pipe-type cable trifurcating joints (one at each substation) to join the existing 351 line cables to the short length cable extending to the location of the 358 line
5) (6) Disassembling of the existing 351 line terminations
6) (6) Terminations to reconstitute the existing 351 line terminations at 358 line termination position at both substations
7) (2) Termination structures for mounting the newly positioned 351 line terminations at both substations
8) Pipe filling fluid, etc. (to complete the moving of the 351 line cable to the new termination positions)

The assembled estimated material costs (using industry typical estimating cost for construction) associated with the relocation of the 351 line terminations at Mystic Substation and North Cambridge Substation is estimate at $4.1M.

Below are the risks associated with ECI's transmission upgrades estimate:

- Since the work associated with this item is located within the existing substations, there is little to no permitting, environmental, traffic and other external driven risks.
- The estimate is on a general conceptual basis.
- The estimate is done with minimal information regarding the physical condition of the substations vis a vis the feasibility of burying an additional short length of HPFF cable and put in a 3-phase pipe type cable splice within the substation, locating an additional three (3) terminations and its support structure near the 358 line termination locations, and other possible physical constraints within the confined substation space.

If in lieu of trifurcation joints at each of the substations as conceptually envisioned by ECI, the work is to be done via cutting existing cable at the nearest manhole and pull in new short length of cables to facilitate the moving of terminations for 351 Line. The difference in costs of the two different methods are considered minor relative to the overall cost.

4.7 Environmental Discussion Relative to DC Plan

The proposed transmission project included in this discussion is the "HVDC Plan" alternative. These projects are designed to address the reliability needs of Greater Boston Study Area, including 18 towns as shown in *Table 4.7-1, Towns Potentially Affected by HVDC Plan*.

Project(s)	State	Towns	Project(s)	State	Towns
D-4	MA	Andover	D-1	MA	Malden
D-5	MA	Ayer	D-1	MA	Revere
D-5	MA	Billerica	D-1	MA	Salisbury
D-6	MA	Cambridge	D-1	MA	Saugus
D-5	MA	Chelmsford	D-6	MA	Somerville
D-4	MA	Dracut	D-4, D-5	MA	Tewksbury
D-1, D-3, D-6	MA	Everett	D-5	MA	Westford
D-5	MA	Littleton	D-4	NH	Pelham
D1	MA	Lynn	D-1, D-2	NH	Seabrook

Table 4.7-1
Towns Potentially Affected by HVDC Plan

The HVDC Plan consists of the following projects:

- Project D-1: HVDC Submarine Cable and Two Terminals
- Project D-2: Seabrook 345 kV Interconnection for HVDC
- Project D-3: Mystic 115 kV Interconnection for HVDC
  New on land in New Hampshire, approximately 5.4 miles; new in Atlantic Ocean, approximately 50.2 miles; new on land in Massachusetts, approximately 11.6 miles
- Project D-4: Reconductor Y-151 kV NU Border to Dracut Jct
  Reconductor approximately nine (9) miles
- Project D-5: 337 Reconductoring from Sandy Pond – Tewksbury (RSP 1362)
  Reconductor approximately 16 miles
- Project D-6: North Cambridge and Mystic Substations – Bifurcate Lines 351 & 358
  Bifurcate

4.7.1 Environmental Overview

The purpose of this section is to provide an outline of the HVDC Plan's Unique Components environmental factors. The ECI Environmental Services Group performed a cursory evaluation of the environmental review, permits and applications for the project. The cost for environmental services for the proposed project includes the following:

- Review of critical issues

- Army Corps of Engineers Permit and 404 Certification
- Road, railroad, utility and pipeline crossings and approaches
- Local permits within counties, towns and municipalities
- Coastal management zones, tidal waters and floodplains
- Endangered species and cultural resources
- FAA permits
- State land crossings
- Public utility commission processes

It is assumed that resource surveys will be completed for the majority of the project due to a certificate being required from both the State of Massachusetts and the State of New Hampshire (NH Code Title 12, Chapter 162-H:2(VII)(e) and Chapter 162-H:5(I)).

4.7.2 Environmental Cost Estimate

ECI's internal assessment for the environmental portion of the HVDC Plan is approximately $1.4 million (this figure is NOT included in the totals shown in the Executive Summary), excluding any remediation cost. This is estimate includes approximately 8,000 labor hours and additional resource survey hours based on 2014 labor estimates. The following assumptions are included in ECI's environmental cost estimate:

Endangered Species Survey	$250,000
Cultural Resources Survey (including submerged resources)	$225,000
Wetland Delineation Survey	$50,000

These costs are for labor and do not include individual permitting fees.

Note that the estimates for environmental contracts that include resources surveys are highly variable and could fluctuate based on the preferred vendor for environmental services. Subcontractors were not solicited to estimate actual costs.

4.7.3 Federal, State or Local Permit/Action

ECI assumes that the siting board(s) has approved the locations of the above mentioned projects based on energy needs and transmission stability. Possible federal, state, or local permits and/or actions that may be required for the projects are outlined as follows.

1) An Environmental Impact Statement (EIS) may need to be conducted on the HVDC underwater cable project (D-1). This cost can range from $250,000 to $2M+, depending on the schedule, public involvement and critical issues. The cost of a full EIS is not included in the initial project scope.

2) National Environmental Policy Act (NEPA), Massachusetts Environmental Policy Act (MEPA) and New Hampshire Department of Environmental Services (NHDES) review will be required for all projects.

3) Cultural & Historical Laws and Preservation:

All projects will require adherence to the following federal and state statutes and regulations:

A) Federal

i. Section 106 of the National Historic Preservation Act (36 CFR § 800)
National Register of Historic Places – If a National Register eligible or listed site, building, or structure is identified within the impact area of the project, the state or the federal agency will apply the criteria of effect to determine whether the effect will be adverse. Not all projects have adverse effects on historic properties.

B) State

i. Massachusetts General Laws Chapter 9, section 26-27C
Massachusetts Historical Commission (MHC) – If the proposed project will involve state or federal funding, licenses or permits, the project proponent must submit a Project Notification Form (PNF). Review can take 30 days. The MHC will determine if an archaeological survey is required.

ii. New Hampshire Statutes (XIX Chapter 227-C)
New Hampshire Division of Historic Resources (DHR) – The project proponents MUST complete and submit a Request of Project Review (RPR) Form. The DHR will determine if an archaeological survey is required.

C) Potential Tribal Offices (THPO) that may need consultation due to proximity:

i. Nipmuc Nation - South Grafton, MA
Hassanamesit Reservation is located beyond all Project Areas

ii. Wampanoag Tribe of Gay Head – Aquinnah, MA
The island is located beyond all Project Areas
THPO Officer – Bettina Washington

iii. Mashpee Wampanoag Tribe – South Mashpee, MA
Mashpee is located beyond all Project Areas
THPO Officer – Ramona Peters

4) Cultural Laws and Preservation

A) Wetland impacts

i. Massachusetts Wetlands Protection Act (9 reasons of protection)
1. Public water supplies

2. Private water supplies
3. Groundwater supplies
4. Flood control
5. Storm damage prevention
6. Prevention of pollution
7. Protection of land containing marine shellfish
8. Protection of wildlife habitat
9. Protection of fisheries

ii. New Hampshire Wetland Program Plan
iii. New Hampshire Shoreland Water Quality Protection Act (1991)
iv. The local Conservation Commissions

B) Threatened and Endangered (T&E) Species

i. US Fish & Wildlife Service (USFWS) Section 7/10 of the Federal Endangered Species Act (ESA)
ii. Massachusetts Endangered Species Act (MESA), highly recommended that project proponents request this information prior to development, especially if the project falls within Priority Habitat for rare species.
iii. Department of Massachusetts Conservation Commission
iv. Proponents with projects and activities proposed within Priority Habitat of Rare Species and Estimated Habitat of Rare Wetland Species must file with NHESP for review and approval.
v. Under MESA, certain projects or activities within Priority Habitat may qualify for a MESA filing exemption. Other projects may have met specific permitting milestones before being mapped in Priority Habitat, and are therefore "grandfathered."
vi. Under WPA, if a Notice of Intent (NOI) is required for a project or activity in Estimated Habitat, a copy of that NOI must be sent to the NHESP.

Hillsborough County, New Hampshire		
Flowering Plant	Small Whorled Pogonia	Threatened
Rockingham County, New Hampshire		
Birds	Piping Plover	Threatened
	Roseate Tern	Endangered
Flowering Plant	Small Whorled Pogonia	Threatened
Reptiles	Hawksbill Sea Turtle	Endangered
	Leatherback Sea Turtle	Endangered
	Green Sea Turtle	Threatened
Middlesex County, Massachusetts		
Flowering Plants	Small Whorled Pogonia	Threatened
	Sand Plain Gerardia	Endangered
Essex County, Massachusetts		
Birds	Piping Plover	Threatened
	Roseate Tern	Endangered
Flowering Plant	Small Whorled Pogonia	Threatened

Reptiles	Hawksbill Sea Turtle	Endangered
	Leatherback Sea Turtle	Endangered
	Green Sea Turtle	Threatened
Suffolk County, Massachusetts		
Birds	Piping Plover	Threatened
Reptiles	Hawksbill Sea Turtle	Endangered
	Leatherback Sea Turtle	Endangered
	Green Sea Turtle	Threatened

Table 4.7-2
T&E Species by County

C) Waterways
See crossings.

D) Floodplains
Could require special design considerations for engineering.

E) Stormwater Permits (NH and Mass)
Projects that disturb more than one (1) acre must submit NOI, prepare a SWPPP and submit an NOT at project re-stabilization.

F) Vegetation Management

i. Submerged aquatic vegetation (SAV) survey will be required for the HVDC Plan.
ii. Invasive Plant Management (limit disturbance).
iii. (Massachusetts) 220 CMR 22.00 – Notification of Vegetation Maintenance Activities for Transmission Rights-of-Way.

5) Crossings

A) Highways

i. MassDOT prefers underground, as opposed to aerial crossings, of all utilities; further prefers use of directional boring methods.
ii. Consult – "Utility Accommodation Policy on State Highway Right of Way"; there are different policies for UG vs OH.

B) County & Town Roads

i. Most, if not all, roads crossed by the project will require a road crossing permit and/or road approach permit, depending on the specific regulations of the individual counties or towns.

C) Railroads

i. Many projects cross the MBTA commuter rail, which is active. Must consult the MBTA "Railroad Operations Directorate". May require a License for Entry, License Agreement, Easement, or Letter of Authorization.
ii. Entry for the purpose of conducting surveys, etc… will be permitted only with a proper entry permit prepared by the MBTA Real Estate Dept.

D) Jurisdictional Waters

i. Army Corps of Engineers (USACE) General Permit for Massachusetts and New Hampshire will be required (likely for all projects).

E) Navigable Waters

i. All Tidal Waters under Section 10 of the River and Harbors Act and their tributaries to the head of tide – affects all projects near Mystic Substation.
ii. Connecticut River – no projects

F) Coastal Management Zones

i. Will impact all projects that tie near the Mystic Substation.

6) Agency Scoping is a critical issues identifier used by project proponents to identify permits and approvals needed for a proposed project. At a minimum, the following agencies will need to be contacted and regulations reviewed:

A) Federal

- US Fish and Wildlife Service (FWS)
- Department of Game, Fish & Parks (Federal & State levels)
- US Army Corps of Engineers (USACE) – New England District
- USDA/Natural Resource Conservation Service (NRCS)
- FAA
- Railroads
- DOT – interstates
- National Oceanic and Atmospheric Administration (NOAA)

B) State

- SHPO/THPO (Section 106)
- Board of Underwater Archaeological Resources (BUAR)
- DOT – state highways
- DEQ
- Mass. Wetlands Protection Act
- Mass. Department of Agricultural Resources (330 CMR 18.00)

- Massachusetts Office of Coastal Zone Management

C) Counties & Towns Agencies that would be required for consultation

- Local Conservation Commissions (based on towns)
- Agricultural Lands Preservation Committee (ALPC)
- Local Agricultural Commissions

7) Public Scoping identifies critical non-agency issues for project by contacting stakeholders like landowners and holding public meetings.

4.7.4 Specific Project Impacts & Crossings

1) Projects D-1, D-2, D-3 "HVDC Plan"

- Jurisdiction Crossed by Project:

States	Counties	Towns
New Hampshire	Rockingham	Seabrook
ATLANTIC OCEAN		
Massachusetts	Essex	Salisbury
		Lynn
		Saugus
	Suffolk	Revere
	Middlesex	Malden

- Other Easements (within 100 ft of centerline):
  - MA Dept. of Conservation and Recreation, Division of Urban Parks and Recreation: Carroll Parkway, Linden and Town Line Brook, Lynn Heritage State Park, Lynn Shore Reservation, Revere Beach Parkway, Rumney Marsh Reservation, Salisbury Beach State Reservation, Saugus River Reservation
  - City of Everett: Wasgatt Playground
  - City of Lynn: Neptune Boulevard Playground, Old Burial Ground, General Electric Athletic Association field
  - City of Revere: Sea Plan Basin
  - Seabrook: Cain's Mill Pond Park
  - Town of Saugus: Off Ella St
- Ocean Crossed by Project: Atlantic
- Highway Crossed by Project: US Hwy 1
- State Highways Crossed by Project: New Hampshire State Route 286; Massachusetts State Routes 1, 1A, 16, 60, 99 and 107
- Additional Roads Crossed by Project: approximately 147 (will require road crossing permits and approach permits)
- RR Crossed by Project: Boston and Maine RR, MBTA Commuter Rail

- Water Crossed by Project: Blackwater River, Saugus River, and 2 unnamed streams
  - Note: Both Rivers are listed as Impaired Waterways by the EPA
- Ferry Route Crossed by Project: Boston-Salem, Water Transportation Alternatives (summer service)
- Existing UW Pipelines Crossed by Project: Algonquin Hubline natural gas pipeline, Massachusetts Bay, Massachusetts
- Most of the project is located in the Atlantic Ocean, Coastal Management Zones: North Shore and South Essex
- Note: The HVDC Plan's underground cable will likely require an assessment of submerged aquatic vegetation (SAV), likely a Tier-2 Survey
- Closest Airport: General Edward Lawrence Logan International (~4 miles southeast of proposed project)

2) *Project D-4: Reconductor Y151 from Pelham to Dracut Junction*

- Jurisdiction Crossed by Project:

States	**Counties**	**Towns**
New Hampshire	Hillsborough	Pelham
Massachusetts	Middlesex	Dracut

- Other Easements (within 100 ft of centerline):
  - MA Department of Agricultural Resources – Dumaresq Farm
  - Dracut Land Trust
  - Pelham – Town of Pelham Land and Peabody Town Forest
- Interstates Crossed by Project: n/a
- State Highways Crossed by Project: Massachusetts State Route 113
- Additional Roads Crossed by Project: approximately 6 (will require road crossing permits and approach permits)
- RR Crossed by Project: n/a
- Water Crossed by Project: 2 unnamed streams
- Closest Airport: General Edward Lawrence Logan International (~4 miles southeast of proposed project)

3) *Project D-5: 337 Reconductor Sandy Pond – Tewksbury (RSP 1362)*

- Jurisdiction Crossed by Project:

States	Counties	Towns
Massachusetts	Middlesex	Tewksbury
		Billerica
		Chelmsford
		Westford
		Littleton
		Ayer

- Other Land Ownership Crossed by Project (within 100 ft of centerline):
  - Town of Ayer – Nemco Way Land
  - Town of Chelmsford – Water Protection Land
  - Town of Tewksbury – Farwood Forest and Rogers Park
  - Town of Westford – Nashoba Farms and Hitchin Post Viii
- Interstates Crossed by Project: I-495
- Highways Crossed by Project: US-3
- State Highways Crossed by Project: Massachusetts State Routes 3A, 4, 27, 38, 110, 119, 129 and 225
- Additional Roads Crossed by Project: approximately 46 (will require road crossing permits and approach permits)
- RR Crossed by Project: Boston and Maine RR, Penn Central RR, MBTA RR
- Water Crossed by Project: Beaver Brook, Concord River, Farley Brook, Gilson Brook, and 3 unnamed streams
  - Note: Beaver Brook, Farley Brook and Concord River are listed as Impaired Waterways by the EPA
- Closest Airport: Hanscom Air Force Base is 8-9 miles south of the proposed project

4) Project D-6: N. Cambridge and Mystic Substations – Bifurcate Lines 351 & 358

- Jurisdiction Crossed by Project:

States	Counties	Towns
Massachusetts	Middlesex	Everett
		Somerville
		Cambridge
	Suffolk	Boston

- Other Land Ownership Crossed by Project (within 100 ft of centerline):
  - MA Division of Urban Parks and Recreations – Mccrehan Pool and Veterans Memorial Rink
  - City of Boston – Ryan Playground
  - City of Cambridge – Comeau Field
  - City of Somerville – Conway Playground

- Interstates Crossed by Project: I-93
- State Highways Crossed by Project: Massachusetts State Routes 2, 2A, 3, 3A, 16, 28, and 99
- Additional Roads Crossed by Project: approximately 91 (will require road crossing permits and approach permits)
- RR Crossed by Project: MBTA Commuter Rail, MBTA Orange Line
- Water Crossed by Project: Mystic River
    - Note: Mystic River listed as impaired by EPA
    - Note: Crossing at Mystic River is located within the Coastal Management Zone
- Closest Airport: General Edward Lawrence Logan International (~4 miles southeast of the proposed project)

APPENDIX