have to be addressed during the permitting phase. Possible changes to the topography around the site may be required to bring Floodway WSE back to original conditions.

Black & Veatch modeled the observed flooding condition of EL. 74.5 feet reported by PSE&G during Hurricane Irene. In order to realize an inundation of that depth at the site, a flow of approximately 1,700 cfs would be necessary.

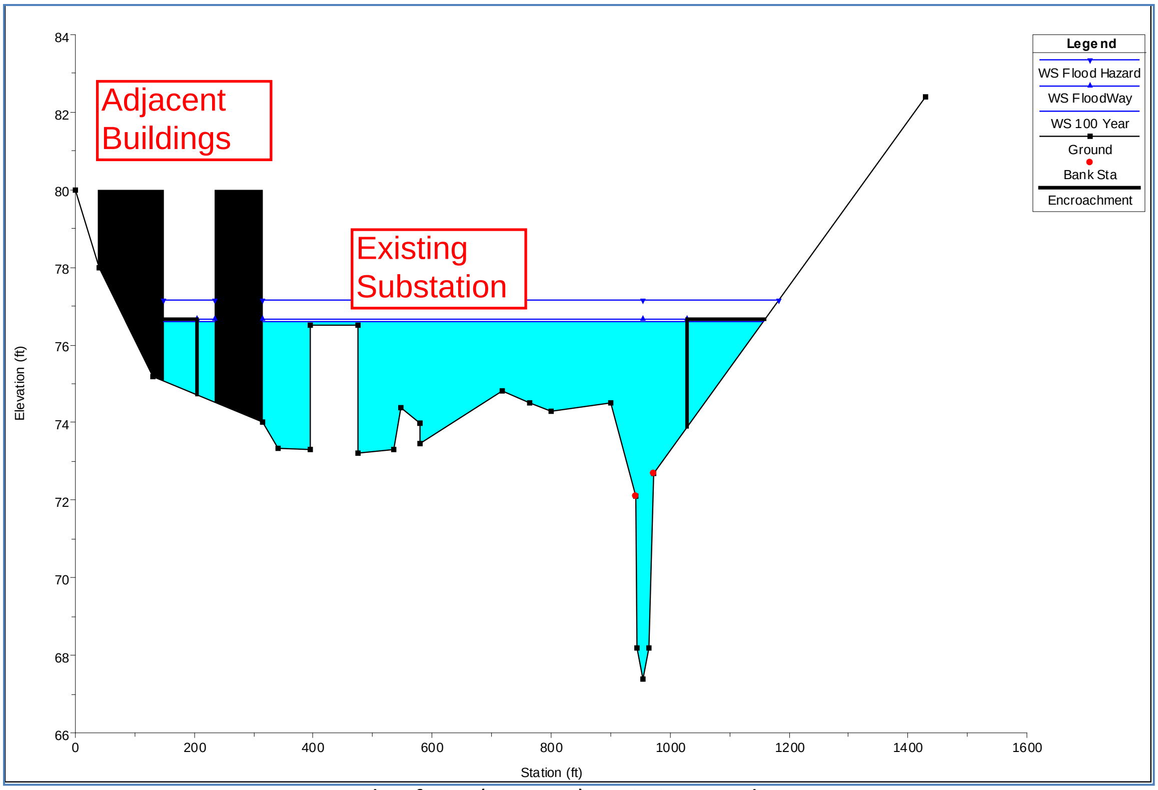
3.0 Conclusions and Recommendation

The proposed flood protection facilities will not significantly impact flooding upstream of the Ewing Substation. If PSE&G proceeds with the design and construction of the proposed flood mitigation measures for the Ewing Substation, there should be little to no impact to upstream existing structures. Hydraulically and based on the model results, there are no impacts to downstream structures.

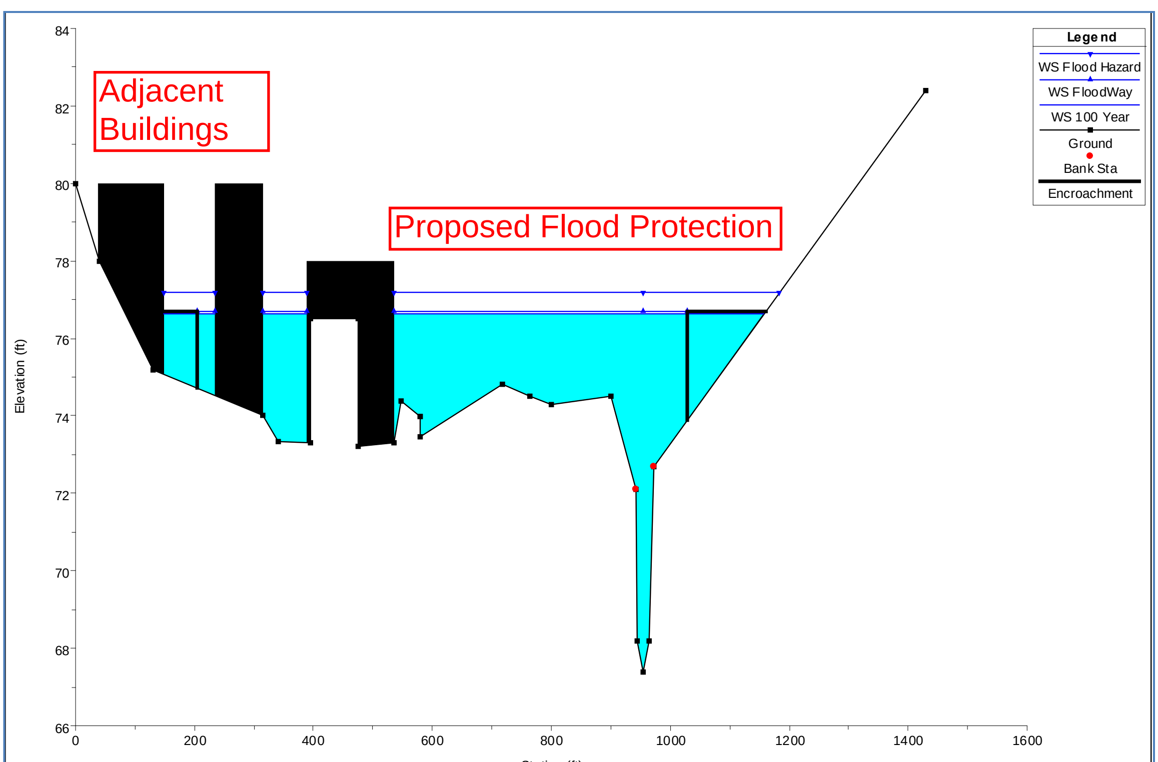
During Hurricane Irene, a maximum flood level of 73.5 feet was observed at the Ewing site. The flow and resulting inundation from Hurricane Irene were less than the 100-year flows in the West Branch Shabakunk Creek. During Hurricane Floyd in 1999, a maximum flood level of 74.5 was observed. The modeled NJDEP Flood Hazard Elevation of 76.2 would theoretically overtop the existing floodwall protection, which has a top elevation of 75.5. An elevation of 77.2 feet, which is 1 foot above the Black & Veatch estimated Flood Hazard Elevation, was selected as the top of wall design level.

ELEVATION SUMMARY (FEET NAVD 88)				
Site	Minimum Site EL.	Maximum Observed Flood EL. (PSE&G)	NJDEP Flood Hazard EL.	Proposed Flood Protection EL.
Ewing	72.5	74.5	76.2	77.2

[redacted]

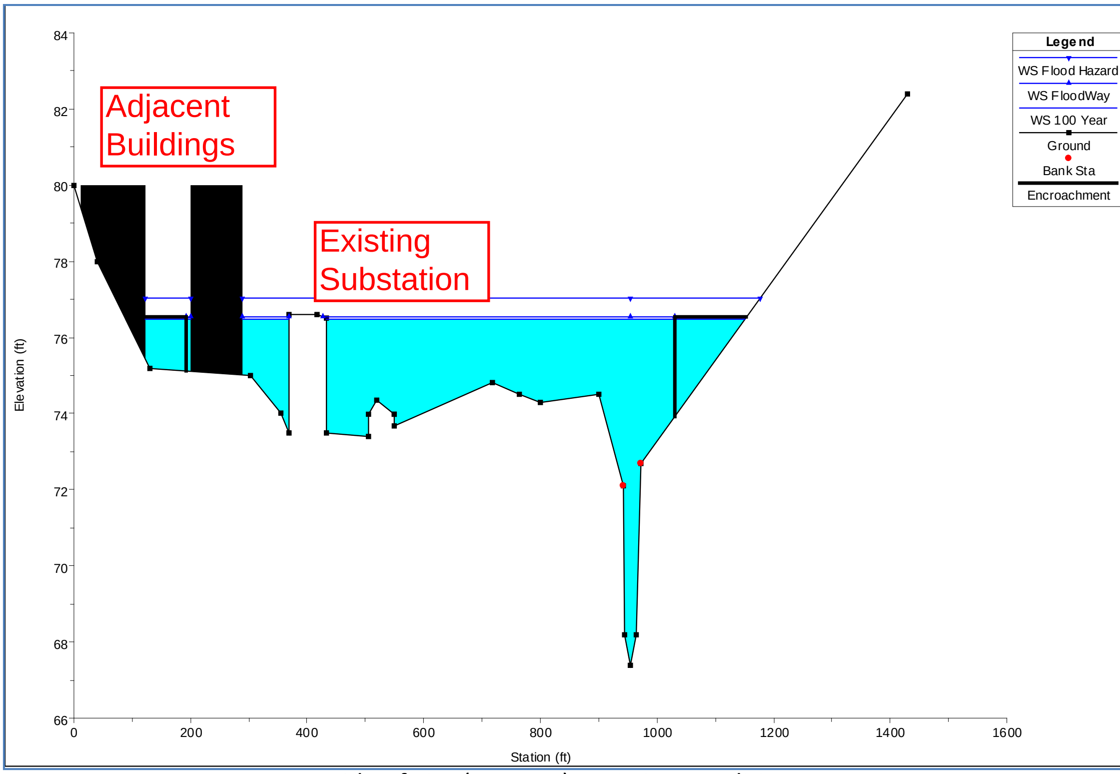


West Side of Site (XS 6500): Existing Conditions.

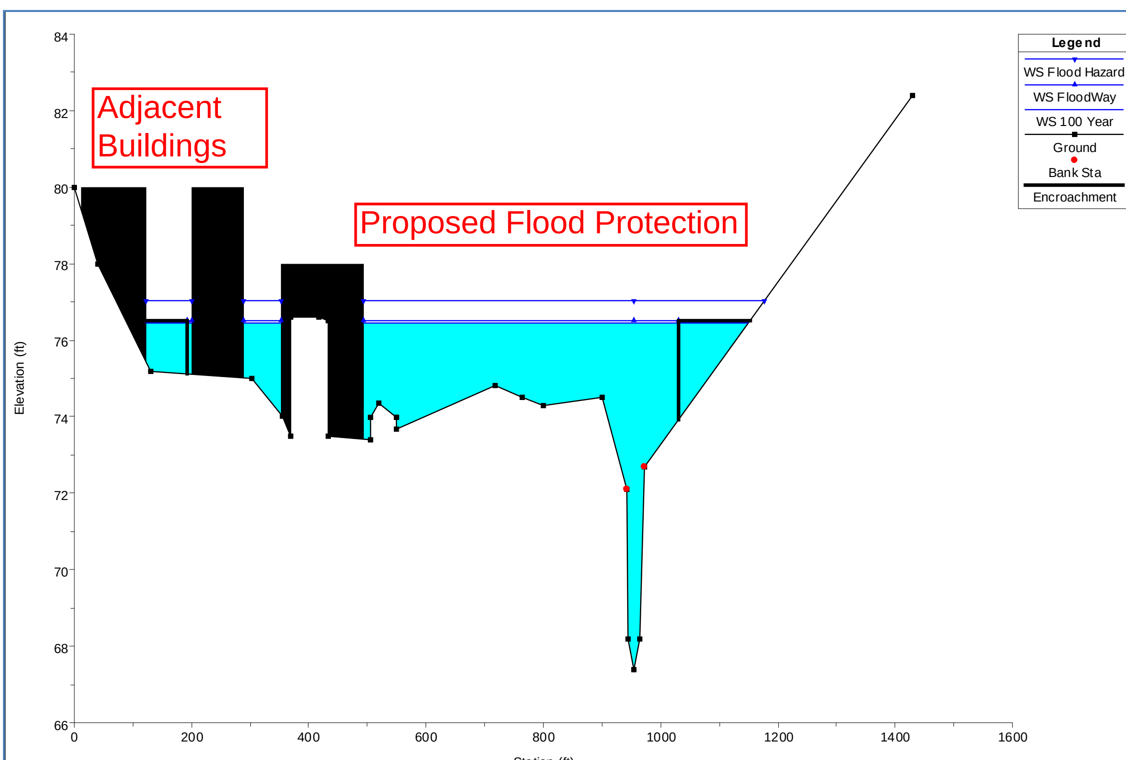


West Side of Site (XS 6500): Proposed Conditions – Sheetpile Flood Protection Installed.

Figure 2: Cross-sectional view from west side of site (XS 6500) looking downstream.
PF1 = FEMA 100-yr flow 2,117 cfs; PF2 = Floodway Run at 2,117 cfs; PF3 = NJDEP Flood Hazard flow 2,646 cfs.



East Side of Site (XS 6330): Existing Conditions.



East Side of Site (XS 6330): Proposed Condition – Sheetpile Flood Protection Installed.

Figure 3: Cross-sectional view from east side of site (XS 6330) looking downstream.
PF1 = FEMA 100-yr flow 2,117 cfs; PF2 = Floodway Run at 2,117 cfs; PF3 = NJDEP Flood Hazard flow 2,646 cfs.

FLOOD IMPACT STUDY FOR BELMONT SUBSTATION

Public Service Electric & Gas

11 OCTOBER 2012

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1.0 Background

On August 28, 2011 Hurricane Irene moved through PSE&G's service territory leaving several thousand customers without power while causing substantial impact to some electric and gas facilities. This event flooded several PSE&G substations in North and Central New Jersey to varying depths. Based on this and prior flooding events a "Flood Protection Report" was completed for twelve of PSE&G's substations (Black & Veatch, Substation Flood Protection – Summary Evaluation Report, 2012). The Report defines the preliminary requirements to provide flood protection at the twelve flood prone substation sites. Since most of the substation sites are located within either the FEMA 100-year floodplain or the defined floodway area, construction of flood protection facilities at these sites could potentially impact upstream flood water elevations.

Flood Impact Studies will be performed for ten of the twelve substation sites, and will be based on the recommendations for flood protection measures included in the Flood Protection Report. Flood impact studies are not required for two of the twelve sites as they are either a) not in the FEMA 100-year floodplain (Bayway) or b) the proposed flood protection facilities will be located behind existing site floodwall protection (Garfield). PSE&G has provided guidance as to the order in which they would like the substations studied. This prioritization is denoted in the list below in parentheses after the substation name. The ten substations to be studied are as follows:

Central Division

1. Cranford Substation (2)
2. Rahway Substation (5)
3. Somerville Substation (6)

Metro Division

4. Belmont Substation (10)
5. Jackson Road Substation (7)

Palisades Division

6. New Milford Switching Station (1)
7. River Edge Substation (4)
8. Hillsdale Substation (3)
9. Marion Switching Station (8)

Southern Division

10. Ewing Substation (9)

This Flood Impact Study addresses the potential for flooding upstream of the Belmont Substation. It describes the upstream flood impacts resulting from construction of the recommended flood protection facilities. It is intended that the results of this study will be used by PSE&G in evaluating the implementation of the flood protection measures at this site. It is recognized that additional flood studies will likely be required to support the permitting process if the recommended mitigation methods are chosen.

The Belmont Substation is located at an approximate address of 605 River Rd, Garfield, NJ, 07026 and is approximately 0.3 acres. The site is bounded by Quality Oil Company to the west; a used car dealership to the east; River Rd to the north; and the Passaic River to the south. Overhead power lines, approximately 25-ft above grade at the lowest point, are located just north of the site and run parallel with River Rd. There is a 2.5-ft tall sandbag barrier wall that currently surrounds the substation. There is gated access to the site on the north side from River Road. The terrain is very steep to the south of the station along the Passaic River bank; otherwise there is no appreciable change in elevation across the site.

2.0 Data Review and Hydraulic Modeling

DATA REVIEW

The following documents were utilized in the development of the hydraulic model for the Belmont Substation.

1) NJDEP. HEC-2 Input and Output Printouts from 24 AUG 1978 (PASSAIC_RIVER_Passaic_Wallington.pdf)
2) NJDEP. Delineation of Floodway and Flood Hazard Area – Flood Profiles Passaic River Sta 410+00 to Sta 920+00. March 1976.
3) FEMA. Federal Insurance Rate Map (FIRM) Bergen County, New Jersey – Maps 34003C0188G and 34003C0251G.
4) Kennon Surveying Services, Inc (KSS). Boundary and Topographic Survey – Belmont Substation (29 May 2012)
5) Black & Veatch. 2012 Substation Flood Protection – Summary Evaluation Report. 2 March 2012.

The NJDEP provided printouts of their HEC-2 Passaic River Model dated from 1978 (document 1). This document was the basis of the model development, and its associated output provided model results for the NJDEP 100-year floodplain and floodway. The Flood Profile (document 2) and FEMA FIRMs (document 3) assisted in locating the cross-sections in the HEC-2 model. The site survey (document 3) was used to determine ground elevations at and around the site. The Substation Flood Protection Report (document 5) provided the estimated height for the flood protection measures. The vertical datum for elevations reported in the NJDEP HEC-2 files (document 1) and the NJDEP Floodway Delineation (document 2) is NGVD 29, while the vertical datum for documents 5 and 6 is NAVD 88. NAVD 88 is one foot below NGVD 29 elevations. All elevations presented in this report are NAVD 88 unless otherwise noted (i.e., Figures 3 through 5, which are based on model data from document 1).

The Substation Flood Protection – Summary Evaluation report (document 5), recommends a top elevation for the flood protection wall at the Belmont Substation 2 feet above the 100-year flood level. Based on reference 1, the 100-year flood level in the vicinity of the site is 20.3 ft (NAVD 88). This recommendation would yield a top of the wall at 22.3 ft (NAVD 88). Final recommendations for the flood protection height are based on the findings of this hydraulic study and are presented in the Conclusions and Recommendations (Section 3.0).

HYDRAULIC MODEL SCENARIOS

Black & Veatch used the HEC-RAS one-dimensional hydraulic computer software program, as developed by the U.S. Army Corps of Engineers Hydraulic Engineering Center, to develop a hydraulic model for the Passaic River in the vicinity of the Belmont Substation. The hydraulic model used for this study was developed from NJDEP's HEC-2 input data.

In order to achieve the goal of this study, four geometry models were considered.

- The first model was the Effective Model. These are the water surface elevations (WSEs) as presented in the results of the HEC-2 printouts. The results of the Effective Model provide the New Jersey Department of Environmental Protection (NJDEP) 100-year flood levels and floodway levels.

The remaining three other models were developed from the Effective model: the Duplicate Effective Model, the Existing Conditions Model, and the Proposed Conditions Model.

- The Duplicate Effective Model is the input data from the HEC-2 files, input into a HEC-RAS model and run to ensure similar results and proper calibration.
- The Existing Conditions Model was based on the Duplicate Effective Model, but includes additional cross-sections in the vicinity of the site and modifications to some cross-sections.
- The Proposed Conditions Model was based on the Existing Conditions Model and includes proposed flood protection.

The flood elevation differences between proposed conditions and existing conditions throughout the modeled length along the river will represent the potential flood impact associated with the proposed improvements.

HYDRAULIC MODEL DEVELOPMENT

Belmont Substation lies along the north eastern bank (left bank) of the Passaic River downstream of Outwater Lane (also known as Ackerman Avenue) and 3,500 feet upstream of the Monroe Street Bridge, along River Road. The FEMA FIRMs provided cross-section locations for most cross-sections in the NJDEP HEC-2 model. Additional cross-sections in the HEC-2 model were located based on distances presented within the HEC-2 printout (Effective Model) and aerial imagery in Google Earth. The HEC-2 model extended up to cross-section 87800. Based on distances presented in the HEC-2 model and estimated distances determined from aerial imagery, this cross-section was determined to be 570 feet downstream of the Belmont Substation site.

In order to model flooding at the Belmont site, it was necessary to add a cross-section to the model upstream of the site. The FEMA FIRM indicates a cross-section located 800 feet upstream of cross-section 87800 which is 170 feet upstream of Belmont Substation. Cross-section 88600 was added to the model by copying cross-section 87800. However, the width of the river was reduced based on aerial imagery. Belmont Substation and the estimated river model layout are shown in Figure 1. Cross-sections taken from the HEC-2 model are shown in white.

The building associated with Quality Oil Company, which lies to the west of Belmont Substation, was included as an obstruction on cross-section 88600 and is presented in Figure 3. The presence of the building will reduce effective flows onto the Belmont site, reducing the impact of the proposed flood protection wall.

Two other cross-sections (88430 and 88370) were added in the vicinity of the Belmont site for the Existing Conditions Model (Belmont Model 3). Cross-section 88430 runs along the western edge/border of the site while cross-section 88370 runs along the eastern border. The hatched area on cross-section 88430 shown in Figure 4 represents the ineffective area experienced at this cross-section caused by the upstream Quality Oil Company building. As the flow conveys downstream to the next cross-section, 88370, the ineffective flow effects of the building are not present, therefore the hatching is eliminated on cross-section 88370 as shown in Figure 5. Added cross-sections were based on the site survey as shown in Figure 2 (KSS, 2012). The added cross-sections are shown in yellow on Figure 1. Figures 4 and 5 present the profiles for cross-sections 88430 and 88370 in the vicinity of the Belmont Substation site.

As shown in Figures 3 through 5, blocked obstructions were placed in the north (left) bank of the cross-sections to represent buildings and homes that would inhibit effective flow in the overbank. This approach to modeling the buildings as blocked obstructions provides more conservative results regarding the flooding implications resulting from the proposed flood protection wall around the Belmont Substation.

In development of the Proposed Conditions Model (Belmont Model 4), the proposed flood protection was inserted on the north eastern bank in each of the two cross-sections that transect the site (88430 and 88370). It is represented as a blocked obstruction in the HEC-RAS models and can be visualized in Figures 4 and 5. It can also be seen that the flood protection lies within the downstream shadow effects of the ineffective flow area on cross-section 88430. This is why only a portion of the hatched ineffective flow area is shown on the proposed condition cross-section 88430 in Figure 4.

The following flows were considered:

- 30,200 cfs – Passaic River FEMA 100-year flood flow in the vicinity of the Belmont Site.
- 37,500 cfs – NJDEP Flood Hazard Limit Criterion = 125% of the Passaic River, 100-year flood flow

During Hurricane Irene, the Belmont Substation experienced 2.5 feet of flooding up to an approximate WSEL of 17 ft. Based on the HEC-RAS model this would correspond to a flow of 23,100 cfs. This flow is 24 percent less than the 100-year flood flow of 30,200 cfs in the vicinity of the substation.

PRELIMINARY FLOOD IMPACTS

The Duplicate Effective Model yields results that are very similar to those of the Effective Model.

The Existing Conditions Model, which includes additional cross-sections, also yielded flood levels that are similar to those in the Effective and Duplicate Effective Models.

Table 1 presents the results from the four models considered under 100-year flow flood conditions. River stations in bold indicate added and modified cross-sections in the model.

Table 1: Hydraulic Model Results – FEMA 100-year Flood Levels (30,200 cfs)

	1	2	3	4	(4-3)
River Station	**Effective Model**	**Duplicate Effective**	**Existing Conditions**	**Proposed Conditions**	**Difference**
	(ft)	(ft)	(ft)	(ft)	(ft)
88600	**n/a**	**n/a**	**20.11**	**20.11**	**0.00**
88430	**n/a**	**n/a**	**20.27**	**20.27**	**0.00**
88370	**n/a**	**n/a**	**20.30**	**20.29**	**-0.01**
87800	20.27	20.29	20.29	20.29	0.00
87000	19.67	19.69	19.69	19.69	0.00
85800	19.65	19.67	19.67	19.67	0.00
84871	19.33	19.34	19.34	19.34	0.00
84821	19.32	19.33	19.33	19.33	0.00
84820	Monroe Street Bridge				
84773	18.83	18.82	18.82	18.82	0.00
84751	18.82	18.82	18.82	18.82	0.00

The Existing Conditions Model yields WSEs that are very similar to the Effective and Duplicate Effective models in the vicinity of Belmont Substation.

The Proposed Conditions Model includes the flood protection on the north bank of the model. A decrease in water surface elevation of 0.01 foot occurs at the downstream end of the site due to the minor constriction of flow from the flood protection. However this constriction was not enough to cause a noticeable rise in WSE upstream. A rise in WSE due to the flood protection installation is not predicted in the vicinity of the site.

Table 2 presents the results for the NJDEP Flood Hazard Criteria with flows at 37,500 cfs. River stations in bold indicate cross-sections added to the model in the vicinity of the site.

Table 2: Hydraulic Model Results – NJDEP Flood Hazard Flows (37,500 cfs)

	2	3	4	(4-3)
River Station	**Duplicate Effective**	**Existing Conditions**	**Proposed Conditions**	**Difference**
	(ft)	(ft)	(ft)	(ft)
88600	**n/a**	**22.28**	**22.28**	**0.00**
88430	**n/a**	**22.48**	**22.48**	**0.00**
88370	**n/a**	**22.52**	**22.51**	**-0.01**
87800	22.51	22.51	22.51	0.00
87000	21.81	21.81	21.81	0.00
85800	21.82	21.82	21.82	0.00
84871	21.45	21.45	21.45	0.00
84821	21.44	21.44	21.44	0.00
84820	Monroe Street Bridge			
84773	21.25	21.25	21.25	0.00
84751	21.25	21.25	21.25	0.00

Based on model results, the proposed sheetpile flood wall around the Belmont Substation will not significantly impact water surface elevations in the Passaic River Floodplain under Flood Hazard Flow Conditions. As demonstrated with the 100-year flood flow conditions, there is a decrease in water surface elevation of 0.01 foot that occurs at the downstream end of the site due to the minor constriction of flow from the flood protection. Again, this was not enough of a constriction to cause a noticeable rise in WSE upstream. A rise in WSE due to the flood protection installation is not predicted in the vicinity of the site.

Black & Veatch modeled the observed flooding condition of EL. 17 feet reported by PSE&G during Hurricane Irene. In order to realize an inundation of that depth at the site, a flow of approximately 23,100 cfs would be necessary.

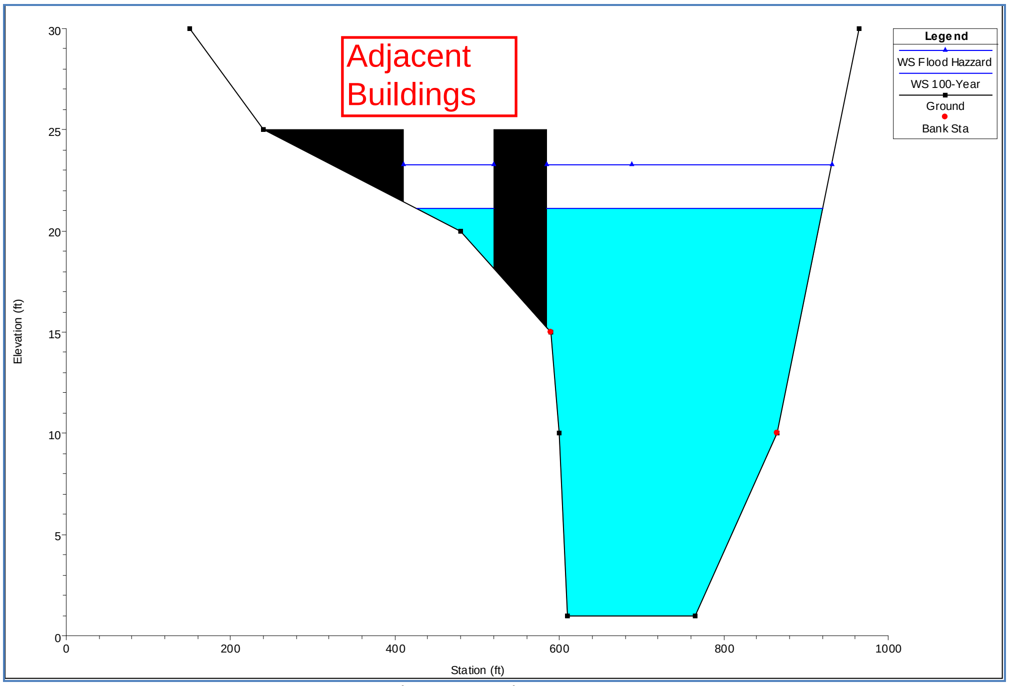
3.0 Conclusions and Recommendation

The proposed flood protection facilities will not significantly impact flooding upstream of the Belmont Substation. If PSE&G proceeds with the design and construction of the proposed flood mitigation measures for the Belmont Substation, there should be little to no impact to upstream existing structures. Hydraulically and based on the model results, there are no impacts to downstream structures.

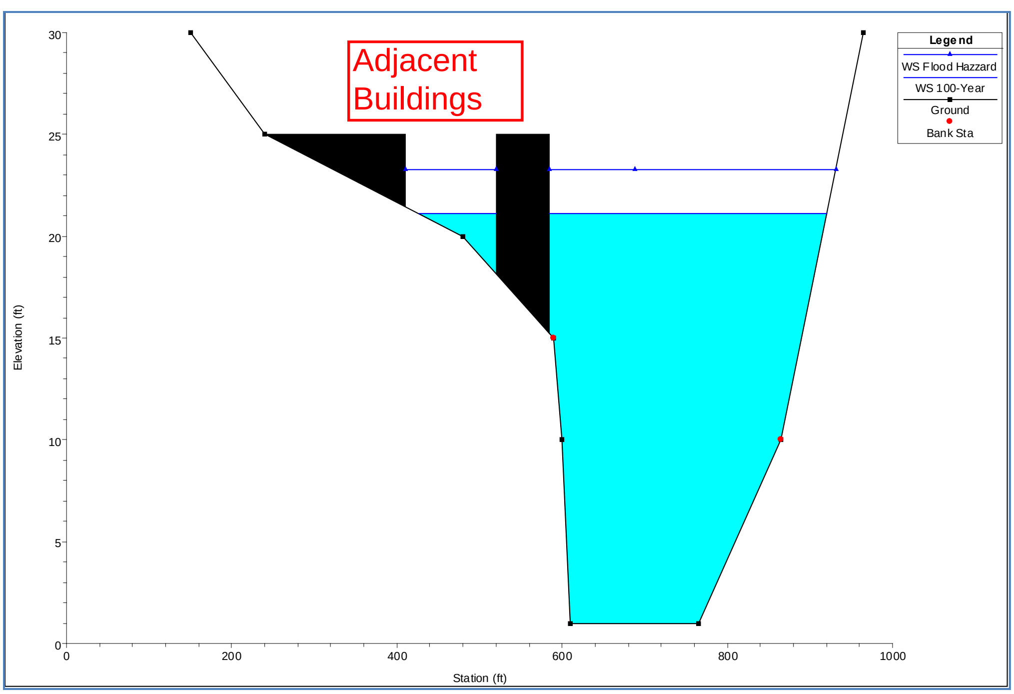
During Hurricane Irene, a maximum flood level of Elevation 17 feet was observed at the Belmont site. The flow and resulting inundation from Hurricane Irene were less than the 100-year flows in the Passaic River. An elevation of 23.5 feet, which is 1 foot above the Black & Veatch estimated Flood Hazard Elevation, was selected as the top of wall design level. This elevation would result in a floodwall of approximately nine feet in height, and should be reviewed during the design phase. The original assumption of a sheetpile wall will not likely be feasible for a wall of that height.

ELEVATION SUMMARY (FEET NAVD 88)				
Site	Average Site EL.	Maximum Observed Flood EL. (PSE&G)	NJDEP Flood Hazard EL.	Proposed Flood Protection EL.
Belmont	14.5	17.0	22.5	23.5

[redacted]

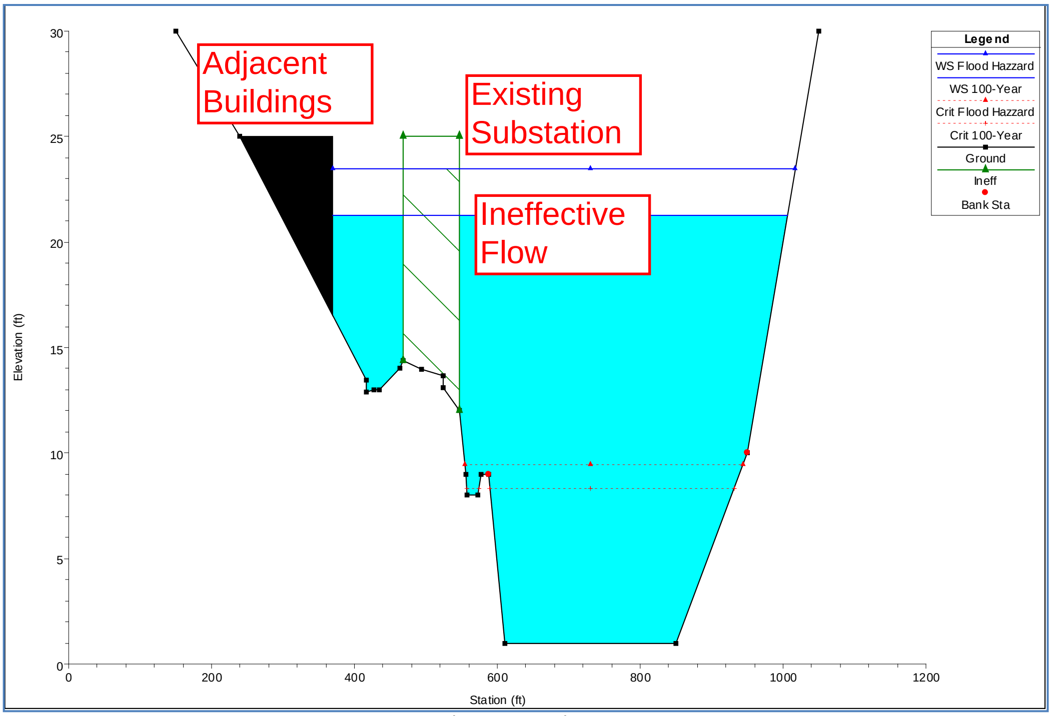


Upstream of Site (XS 88600): Existing conditions.

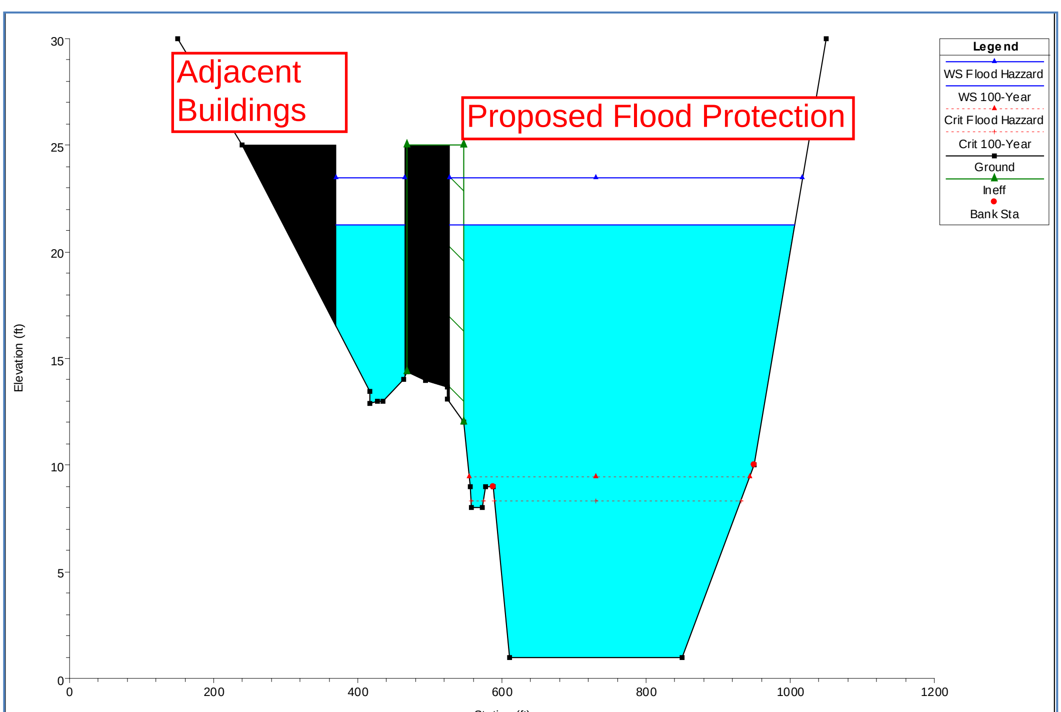


Upstream of Site (XS 88600): Proposed Condition – Sheetpile Flood Protection Installed.

Figure 2 Cross-sectional view from upstream of site (XS 88600) looking downstream.
PF1 = FEMA 100-yr flow 30,200 cfs; PF2 = NJDEP Flood Hazard flow 37,500 cfs.

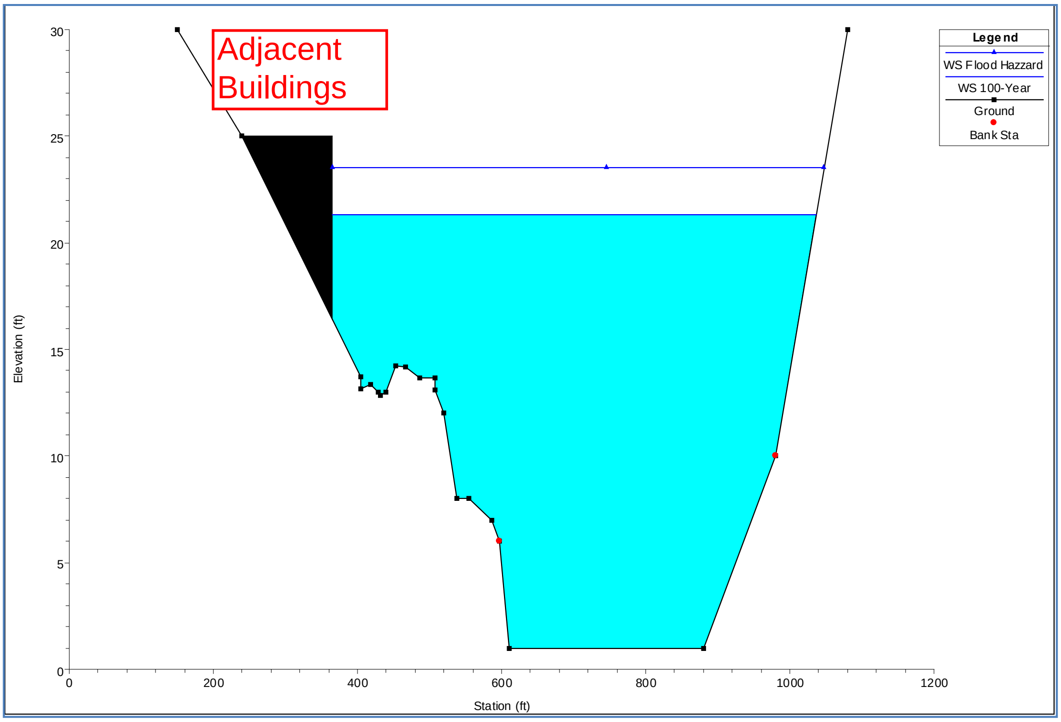


West Side of Site (XS 88430): Existing conditions.

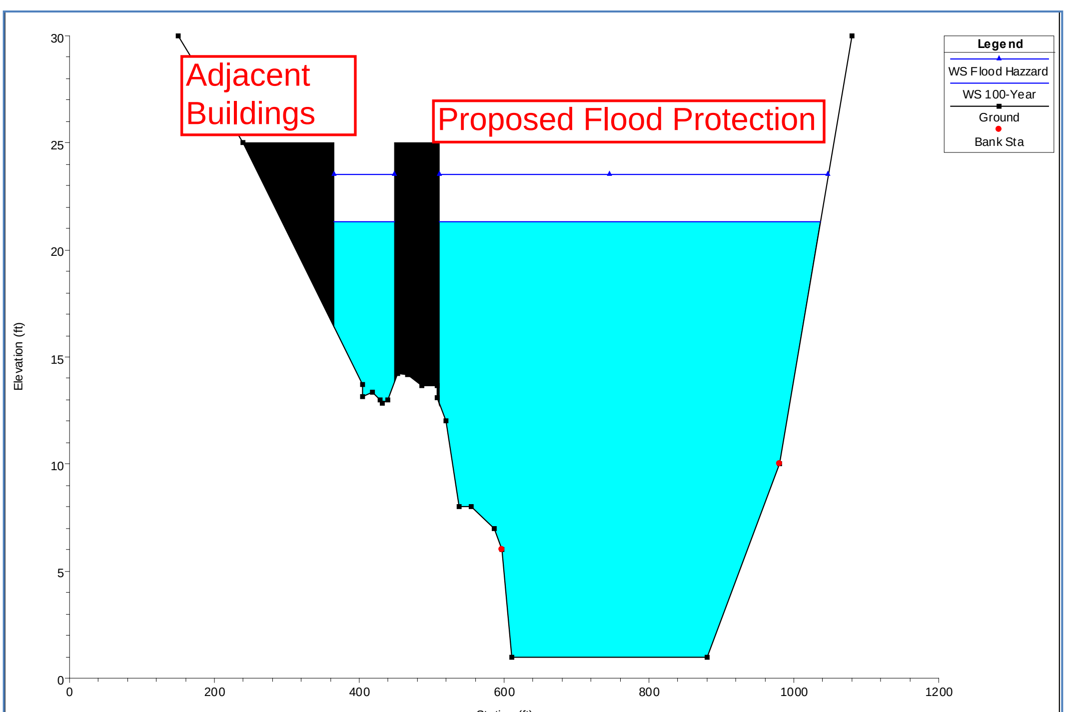


West Side of Site (XS 88430): Proposed Condition – Sheetpile Flood Protection Installed.

Figure 3: Cross-sectional view from west side of site (XS 88430) looking downstream. PF1 = FEMA 100-yr flow 30,200 cfs; PF2 = NJDEP Flood Hazard flow 37,900 cfs.



East Side of Site (XS 88370): Existing conditions.



East Side of Site (XS 88370): Proposed Condition – Sheetpile Flood Protection Installed.

Figure 4: Cross-sectional view from east side of site (XS 88370) looking downstream. PF1 = FEMA 100-yr flow 30,200 cfs; PF2 = NJDEP Flood Hazard flow 37,

SUBSTATION FLOOD PROTECTION

Summary Evaluation Report

B&V PROJECT NO. 175550

PREPARED FOR

Public Service Electric & Gas

2 MARCH 2012

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Executive Summary

During the Hurricane Irene event in August 2011, several PSE&G substations in the North and Central New Jersey service areas were inundated to varying depths. This Substation Flood Protection Evaluation Report presents the results of evaluations performed to determine the preliminary requirements for providing appropriate flood protection at each of the twelve substation sites. This Report describes the results of discussions with PSE&G field personnel and the observations made during site visits to each of the substations. A summary of the flooding problems that have occurred and preliminary recommendations for flood protection provisions at each site are also provided.

The maximum observed flood water level during Hurricane Irene was used as basis for determining the height of the flood protection required. At each site, it was determined the maximum flood elevation resulting from Hurricane Irene was equal to or greater than the 100-year flood elevation as taken from the appropriate Flood Maps as published by the Federal Emergency Management Agency (FEMA). It is noted the substations were constructed during the period 1925-1976, which pre-dates the organization of FEMA and the development of comprehensive flood studies for the substation areas. Additionally, considerable residential, commercial and industrial development has occurred following substation construction within the watersheds above the substations, which has no doubt increased the magnitude of flooding events and the resulting flood elevations.

Flood protection measures that were considered consisted of earthen berms, sheetpile barriers and concrete floodwalls. In general, earthen berms were selected for flood protection when sufficient space existed at the substation site as this is the lowest cost alternative, and sheetpile barriers were selected for use at sites where sufficient space does not exist for use of berms. Due to high cost, concrete floodwalls were not selected for any of the sites. Based on the evaluations performed to date, the total estimated cost for providing the recommended flood protection at all sites is $10,115,000 in 2012 dollars. The estimated cost at each site varies considerably based on the height of flood protection required and the perimeter length of the protected area, as shown in the Summary of Flood Protection Alternatives on page 35.

Subsequent activities associated with implementation of the flood protection measures at one or more sites would include permitting, site subsurface and topographic investigations, engineering design, and construction. These activities could be conducted for all substation sites together, or could be conducted over a period of time to provide for a phased implementation of the flood protection measures at selected sites.

Introduction

The events and subsequent flooding from Hurricane Irene on and around August 28, 2011 inundated several substations located throughout the PSE&G service areas in North and Central New Jersey. PSE&G contracted with Black & Veatch to perform a Flood Protection Evaluation of the twelve substation sites, and provide preliminary guidance on protecting the sites from future flood events. Black & Veatch Engineers accompanied PSE&G representative Larry Johnson during site visits to each substation from December 13th through December 15th, 2011. A site visit technical memorandum was submitted to PSE&G on December 22, 2011. This Summary Evaluation Report presents the observations and findings for each station, as well as flood protection alternatives and order of magnitude cost estimates.

Flooding Considerations

According to the USGS, Hurricane Irene was the first Hurricane to make landfall in New Jersey since 1903, with six to seven inches of rain falling across most of the state. Most river gages recorded their highest or second highest peaks on record. Thirty gages experienced peaks greater than the 100-year recurrence interval and ten of these gages experienced greater than a 500-year event.

Other events of record for the area substations, as noted by the majority of the PSE&G personnel, include Hurricane Floyd (1999), a 2007 storm event, and another storm event in March 2010. B&V has summarized the pertinent flood elevation information available for each site to support development of the top of flood protection elevation. FEMA 100-year flood elevations were taken from the FIRMs; all of the sites are located within the FEMA 500-year flood plain.

RIPARIAN BUFFERS

The New Jersey Department of Environmental Protection (NJDEP) has defined riparian buffer zones that require permitting for work inside 300 feet of Category 1 waters. According to New Jersey Administrative Code 7:9B, Surface Water Quality Standards (last amended April 4, 2011), "Category One Waters" means those waters designated for protection from measurable changes in water quality. All of the rivers or streams in proximity to the stations are classified as Category 1 waters. The sites that lie within the 300 foot buffer zone are indicated in Table 1.

ELEVATION CONSIDERATIONS

Black & Veatch received various historical site drawings from PSE&G for each of the sites. However, only a portion of the drawings were able to provide viable reference to the North American Vertical Datum 1988 (NAVD 88) elevation datum. This datum is the most recent, universally utilized elevation. PSE&G uses an internal survey datum for site layout, which does not have a defined correlation to NAVD 88. We referenced available USGS elevation data to best estimate the current site elevations where specific reference was not made on the drawings. A new site topographic survey will be required for each site in advance of the design stage to verify the elevations. Changes in the site ground surface will affect the final elevation of the flood protection and therefore will affect the heights and costs for flood protection presented in this Report. Note that the FEMA flood map elevations are reported in NGVD 1929, and have been converted to NAVD 1988 for the updated, consistent project datum.

Table 1. Substation Site Characteristics and Flood Elevations

ELEVATION SUMMARY				
Site	Site EL. (NGVD 88)	Maximum Observed Flood EL. (PSE&G)	100-year Flood EL. (NGVD 88)	NJDEP Riparian Buffer Zone
Belmont	19	20.5	20 (floodway)	Yes
Jackson Road	172	173.5	172	Yes
Ewing	74	75	75 (floodway)	No
Somerville	46	49	48	No
Cranford	60	63.5	62 (floodway)	Yes
Rahway	10	13	11	Yes
Bayway	6.5	8.5	7	Yes
Marion	7	8.5	8	No
Garfield	16.5	21.5	18 (floodway)	Yes
River Edge	7	8	8 (floodway)	Yes
New Milford	8	11	9	Yes
Hillsdale	60	63	63 (floodway)	Yes

It is also important to note that FEMA is currently working to update their flood mapping for Bergen, Hudson, and Union Counties. The revised maps, expected in draft form the summer of 2012, will likely affect the reported 100-year flood elevations. Final designs must reference the most recent mapping to ensure proper flood protection.

HISTORICAL INFORMATION

The PSE&G sites were constructed between 1925 and 1976, as summarized in the table below. The FEMA FIRM program was not legislated until 1973, and local participation did not develop in earnest until the late 1970s. Riparian buffer zones as determined by the NJDEP were not enacted as part of the New Jersey Administrative Code until 2004. At the time of construction, the location of the stations in relation to flood plains and their flood impacts were not clearly known.

Table 2. Construction History

SITE	YEAR CONSTRUCTED	SITE	YEAR CONSTRUCTED
Belmont	1951	Bayway	1959
Jackson Road	1972	Marion	1925
Ewing	1953	Garfield	1953
Somerville	1965	River Edge	1976
Cranford	1967	New Milford	1971
Rahway	1928	Hillsdale	1965

Flood Protection Alternatives

Black & Veatch has laid out conceptual site plans on aerial photography to convey the proposed approach to the flood protection. All of the sites are presented in Appendix B. Where possible, we have attempted to utilize existing access roads and gate locations, to minimize overall impacts to the site and the daily operations of PSE&G. Additionally, the flood protection perimeters closely follow the existing perimeter fence lines of the sites to maintain the existing footprint of the substation. The preliminary flood protection perimeter layout on the sites may be realigned and reduced in length in collaboration with PSE&G to reduce the protected area, as many of the sites have available open areas without equipment or structures. This would also result in a commensurate reduction in flood protection costs.

COMPACTED EARTHEN BERM

The compacted earth berm alternative utilizes imported earth fill with an embedded geomembrane cutoff and anchor trench. The existing ground surface is stripped and compacted, and the berm is built in successive layers or “lifts” to reach the final flood protection design height as shown in Appendix A. For comparative purposes the berm height is estimated to be 3 feet above the existing grade. The footprint of the earthen berm alternative is 15 feet wide. The total width required for constructing this alternative is 25 feet, including a 10-foot wide construction zone to one side. Installation of the earthen berm alternative would not affect existing underground utilities. Several of the sites do not have sufficient clearance for this alternative within the site due to proximity of the station equipment. Furthermore, several of the sites do not have sufficient perimeter clearance from adjacent properties and other obstructions. The earthen berm will require maintenance, and is not as robust a protection system as a concrete floodwall or sheetpile barrier.

CONCRETE FLOODWALL

The concrete floodwall alternative utilizes a cast in place concrete wall founded 3.5 feet below grade. The existing ground surface is stripped and excavated, and the wall is constructed as shown in the alternative section in Appendix A. For comparative purposes the wall height is estimated to be 3 feet above the existing grade. The footprint of the concrete wall alternative is 7.5 feet wide. The total width required for constructing this alternative is 17.5 feet, including a 10-foot wide construction zone to one side. Installation of the wall alternative would likely affect existing underground utilities, and provisions would need to be made in design if this approach is selected. Several of the sites do not have sufficient clearance for this alternative within the site due to proximity of the station equipment. Several of the sites do not have sufficient perimeter clearance from adjacent properties and other obstructions.

SHEETPILE BARRIER

The sheetpile alternative utilizes vinyl sheetpiles installed to an approximate depth of 7 feet below grade. The existing ground surface is stripped and excavated, and the wall is constructed as shown in the alternative section in Appendix A. For comparative purposes an exposed sheetpile height is estimated to be 3 feet above the existing grade. The footprint of the sheetpile alternative is 1 foot wide. The total width required for constructing this alternative is 11 feet, including a 10-foot wide construction zone to one side. Provision can be made in design to install the sheets above and around existing utilities. Clearance inside the site is a minor issue with this alternative. Additionally, this alternative may be implemented without affecting the existing perimeter fencing. The depth of installation reduces the possibility of underseepage, and is appropriate for frequent events without the need for maintenance.

A unit cost comparison per alternative is presented below. These values take into account materials and installation per unit foot of perimeter flood protection. They do not include general construction items, floodgates, dewatering systems, or long term operation and maintenance costs.

Table 3 Unit Cost Summary

ALTERNATIVE	COST PER LINEAR FOOT OF PERIMETER PROTECTION
Earthen Berm	$145
Sheetpile Barrier	$270
Concrete Floodwall	$315

WATERPROOF ACCCESS GATES

Each site will have at least one waterproof access gate in the flood protection perimeter. Some sites have been assigned two to match existing conditions, large site size, or observed access issues. Final layout and number of gates will be coordinated with PSE&G to account for operations and access. The gate(s) would be mounted on a concrete apron and column structure with appropriate transition and seals to the perimeter flood protection.

There are various types of flood protection gates available for use. Black & Veatch has contacted Presray Industries of Wassaic, NY for pricing and design details of flood gates. A Presray gate installation near the PSE&G Somerville site was inspected during the field visits with Larry Johnson and Bill Labos of PSE&G. This gate reportedly held back 6 feet of floodwater without seepage during the Hurricane Irene event. The gate used for costing purposes is the FB 44 model hinged aluminum gate with inflatable seals. We have included product information for FB44 and CG3S model gates in Appendix C.

Detailed Site Summaries

METRO DIVISION

Belmont Substation

The Belmont Substation is located at an approximate address of 605 River Rd, Garfield, NJ, 07026 and is approximately 0.3 acres. The site is bounded by Quality Oil Company to the west; a used car dealership to the east; River Rd to the north; and the Passaic River to the south. Overhead power lines, approximately 25-ft above grade at the lowest point, are located just north of the site and run parallel with River Rd. There is a 2.5-ft tall sandbag barrier wall that currently surrounds the substation. There is gated access to the site on the north side from River Road. The terrain is very steep to the south of the station along the Passaic River bank; otherwise there is no appreciable change in elevation across the site.

A portion of the Belmont site is located within the floodway (see Figure 1), which comprises the river channel and adjacent floodplain that should be kept free of encroachment in accordance with FEMA recommendations. The site is also located within the NJDEP Riparian Buffer Zone.

[redacted]

Figure 1. Belmont FEMA Map Excerpt

As indicated by PSE&G Substation Supervisor, Mike Burns, historical flooding at the site is summarized below.

- **Maximum Flood Depth as Indicated by PSE&G:** 1.5 feet (measured from the ground surface at the breaker). Other significant events can be up to 6 inches deep.
- **Applicable Description of Flood as Indicated by PSE&G:** The site floods frequently from the close proximity to the Passaic River. The Hurricane Irene depth was noted as the deepest flood according to PSE&G.

The selected alternative for the flood protection at Belmont is the sheetpile barrier. Because of the physical site constraints and the regularity of flooding, the sheetpile barrier will provide the most reliable flood protection. The barrier would follow the existing fence perimeter (which is a smaller area than that of the property boundary), and the gate location would be the same, with a protected perimeter length of 230 feet. The site conditions at Belmont would also allow for feasible installation of the concrete wall alternative, however that alternative has a higher cost without any specific flood protection benefit. Costs for the Sheetpile Barrier are shown below in Table 2. Contingent and further design work percentages are approximate. Permitting considerations for Belmont will include the NJDEP, Garfield Township, and Bergen County entities.

BELMONT PRELIMINARY COST ESTIMATE				
Item	Quantity	Unit	Cost	Total
Mobilization	1	ls	$15,000.00	$15,000
Erosion and Sedimentation Controls	1	ls	$2,500.00	$2,500
Vinyl Sheetpile	2150	sf	$6.00	$12,900
Sheetpile Cap	215	lf	$30.00	$6,450
Sheetpile Sealant	1450	lf	$2.00	$2,900
Sheetpile Installation	1	ls	$31,100.00	$31,100
Flood Gate	1	ls	$35,000.00	$35,000
Flood Gate Foundation	10	cy	$700.00	$7,000
Dewatering System	1	ls	$10,000.00	$10,000
Site Restoration	2150	sf	$1.00	$2,150
Construction Subtotal				$125,000
PSE&G Admin.		10%		$13,750
Engineering Design		10%		$13,750
Site Investigations		20%		$25,000
Detailed Flood Study		20%		$25,000
Permitting		10%		$13,750
Construction Phase Services		15%		$18,750
Additional Services Subtotal				$110,000
Subtotal				$235,000
Total Contingency		35%		$85,000
Project Total				$320,000

Jackson Road Substation

The Jackson Substation is located at an approximate address of 11 Jackson Rd, Totowa, NJ, 07512 and is approximately three acres. The site is bounded by a forest/wetland to the west; Jackson Rd to the east; a warehouse to the north; and Madison Road and a Trucking Company's warehouse to the south. Overhead power lines, approximately 30-ft above grade at the lowest point, are all around and inside the site. There is an approximate 2.5-ft tall Jersey barrier wall that encompasses all but the eastern side of the substation. There is gated access to the site from Jackson Road. The site perimeter is located in close proximity to the limit of the 300 foot NJDEP Riparian buffer zone, and should be verified during design. The majority of the site lies within the 500-year flood zone, with small areas at the northwest and southeast corners shown in the 100-year flood zone.

[redacted]

Figure 2. Jackson Road FEMA Map Excerpt

As indicated by PSE&G Division Superintendent, Mike Burns, historical flooding at the site is summarized below.

- **Depth as Indicated by PSE&G:** 14 inches at the breaker (highest recorded – Hurricane Floyd);
- **Applicable Description of Flood as Indicated by PSE&G:** The site has not flooded since Hurricane Floyd.

The site conditions at Jackson Road would allow for feasible installation of any of the 3 reviewed alternatives. The selected alternatives for the flood protection at Jackson Road are the Earthen Berm or Sheetpile Barrier. The protection would follow the existing fence perimeter (which is a smaller area than that of the property boundary), and the gate location would be the same, with a protected perimeter length of 1560 feet. Costs for the Berm and Sheetpile are shown below; contingent and further design work percentages are approximate. Permitting considerations for Jackson Road will include the NJDEP, Borough of Totowa, and Passaic County entities.

JACKSON ROAD PRELIMINARY COST ESTIMATE - BERM				
Item	Quantity	Unit	Cost	Total
Mobilization	1	ls	$15,000.00	$15,000
Erosion and Sedimentation Controls	1	ls	$4,000.00	$4,000
Site Preparation	23200	sf	$1.00	$23,200
Excavation	300	cy	$5.00	$1,500
Berm Construction	1450	cy	$15.00	$21,750
Geomembrane	31000	sf	$3.00	$93,000
Turf Reinforcing Mat and Seeding	31000	sf	$2.00	$62,000
Flood Gate	1	ls	$35,000.00	$35,000
Flood Gate Foundation	10	cy	$700.00	$7,000
Fencing	1550	lf	$3.00	$4,650
Dewatering System	1	ls	$17,400.00	$17,400
Site Restoration	15500	sf	$1.00	$15,500
Construction Subtotal				$300,000
PSE&G Admin.		10%		$30,000
Engineering Design		10%		$30,000
Site Investigations		20%		$60,000
Permitting		10%		$30,000
Construction Phase Services		15%		$45,000
Additional Services Subtotal				$195,000
Subtotal				$495,000
Total Contingency		35%		$175,000
Project Total				$670,000

JACKSON ROAD PRELIMINARY COST ESTIMATE - SHEETPILE				
Item	Quantity	Unit	Cost	Total
Mobilization	1	ls	$15,000.00	$15,000
Erosion and Sedimentation Controls	1	ls	$4,000.00	$4,000
Vinyl Sheetpile	15,450	sf	$6.00	$92,700
Sheetpile Cap	1,545	lf	$30.00	$46,350
Sheetpile Sealant	1,450	lf	$2.00	$2,900
Sheetpile Installation	1	ls	$235,700.00	$235,700
Flood Gate	1	ls	$35,000.00	$35,000
Flood Gate Foundation	10	cy	$700.00	$7,000
Dewatering System	1	ls	$17,400.00	$17,400
Site Restoration	15500	sf	$1.00	$15,500
Construction Subtotal				$470,000
PSE&G Admin.		10%		$47,000
Engineering Design		10%		$47,000
Site Investigations		20%		$94,000
Detailed Flood Study		20%		$94,000
Permitting		10%		$47,000
Construction Phase Services		15%		$71,000
Additional Services Subtotal				$400,000
Subtotal				$870,000
Total Contingency		35%		$300,000
Project Total				$1,170,000

SOUTHERN DIVISION

Ewing Substation

The Ewing Substation is located about 700 ft south of the N. Olden Avenue and Prospect Street intersection, Ewing, NJ, 08638 and is approximately 0.75 acres. The site is bounded by an abandoned house and abandoned driving range to the west; Prospect St to the east; a warehouse to the north; and an abandoned miniature golf course to the south. There are no overhead power lines in the site boundary limits, but there are to the east, running parallel with Prospect St. There is a 2.5-ft tall concrete flood wall that encloses the feeder rows at the substation. There is a gate for access to the feeder rows from Prospect Street. The flood wall has 3 removable panels located along the south side of the wall. The control house and transformer are not protected by the floodwall. There is a 4 x 4 x 3.5 foot deep sump located in the western corner of the site with piping that conveys floodwaters to the eastern side boundary.

A portion of the Ewing site is located within the floodway (see Figure 3), which comprises the river channel and adjacent floodplain that should be kept free of encroachment in accordance with FEMA recommendations.

[redacted]

Figure 3. Ewing FEMA Map Excerpt

As indicated by PSE&G Substation Supervisor, Ed Chase, historical flooding at the site is summarized below.

- **Depth as Indicated by PSE&G:** One foot deep at the site inside the floodwall.
- **Applicable Description of Flood as Indicated by PSE&G:** The floodwaters came from the creek located about 1,500 ft to the northwest of the site. There was a six-inch differential between the depths within the substation and on the exterior of the cutoff wall; 6 inches deep and 12 inches deep, respectively for Hurricane Irene. During Hurricane Floyd, the flooding was 2 feet on the exterior, and 1 foot on the interior.

The selected option for the flood protection at Ewing is the Sheetpile Barrier. The barrier would follow the existing fence perimeter (which is a smaller area than that of the property boundary), and the gate location would be the same, with a total protected perimeter of 615 feet. The site conditions at Ewing would also allow for feasible installation of all three alternatives. The berm cost is lower than the sheetpile, but the location in the floodway and expected frequency of flooding would be better protected by the sheetpile barrier. Costs for the Sheetpile Barrier are shown below; contingent and further design work percentages are approximate. Permitting considerations for Ewing will include the NJDEP, Ewing Township, and Mercer County entities.

This estimate is for new flood perimeter protection of the site. A rehabilitation plan of the existing site and flood protection can also be developed.

EWING PRELIMINARY COST ESTIMATE				
Item	Quantity	Unit	Cost	Total
Mobilization	1	ls	$15,000.00	$15,000
Erosion and Sedimentation Controls	1	ls	$2,500.00	$2,500
Vinyl Sheetpile	6000	sf	$6.00	$36,000
Sheetpile Cap	600	lf	$30.00	$18,000
Sheetpile Sealant	1450	lf	$2.00	$2,900
Sheetpile Installation	1	ls	$92,600.00	$92,600
Flood Gate	1	ls	$35,000.00	$35,000
Flood Gate Foundation	10	cy	$700.00	$7,000
Dewatering System	1	ls	$10,000.00	$10,000
Site Restoration	6000	sf	$1.00	$6,000
Construction Subtotal				$225,000
PSE&G Admin.		10%		$23,000
Engineering Design		10%		$23,000
Site Investigations		20%		$46,000
Detailed Flood Study		20%		$46,000
Permitting		10%		$23,000
Construction Phase Services		15%		$34,000
Additional Services Subtotal				$195,000
Subtotal				$420,000
Total Contingency		35%		$150,000
Project Total				$570,000

CENTRAL DIVISION

Somerville Substation

The Somerville Substation is located about 700 feet north of the Route 206 and S. Bridge Street intersection, Somerville, NJ, 08876 and is approximately 2 acres. The site is bounded by SAS Medical Arts to the southwest; S. Bridge Street to the east; and a cemetery to the north. There are many overhead power lines in and around the site with the lowest point approximately 25-ft above grade. There is gated access to the site from S. Bridge St and is generally open around the property.

[redacted]

Figure 4. Somerville FEMA Map Excerpt

As indicated by PSE&G Substation Supervisor, Steve Daroci, historical flooding at the site is summarized below.

- **Depth as Indicated by PSE&G:** Three feet deep at voltage regulators during Hurricane Floyd and Hurricane Irene.
- **Applicable Description of Flood as Indicated by PSE&G:** The floodwaters came from the creek located about 1,000 ft to the southeast of the site

The site conditions at Somerville are feasible for installation of any of the 3 reviewed alternatives. The selected alternatives for the flood protection at Somerville are the Earthen Berm or Sheetpile Barrier. The protection would follow the existing fence perimeter (which is a smaller area than that of the property boundary), and the gate location would be the same, for a total protected perimeter length of 915 feet. Costs for the Berm and Sheetpile are shown below; contingent and further design work percentages are approximate. Permitting considerations for Somerville will include the NJDEP, Borough of Somerville, and Somerset County entities.

SOMERVILLE PRELIMINARY COST ESTIMATE - BERM				
Item	Quantity	Unit	Cost	Total
Mobilization	1	ls	$15,000.00	$15,000
Erosion and Sedimentation Controls	1	ls	$4,000.00	$4,000
Site Preparation	12800	sf	$1.00	$12,800
Excavation	200	cy	$5.00	$1,000
Berm Construction	900	cy	$15.00	$13,500
Geomembrane	18000	sf	$3.00	$54,000
Turf Reinforcing Mat and Seeding	18000	sf	$2.00	$36,000
Flood Gate	1	ls	$35,000.00	$35,000
Flood Gate Foundation	10	cy	$700.00	$7,000
Fencing	900	lf	$3.00	$2,700
Dewatering System	1	ls	$10,000.00	$10,000
Site Restoration	9000	sf	$1.00	$9,000
Construction Subtotal				$200,000
PSE&G Admin.		10%		$20,000
Engineering Design		10%		$20,000
Site Investigations		20%		$40,000
Permitting		10%		$20,000
Construction Phase Services		15%		$30,000
Additional Services Subtotal				$130,000
Subtotal				$330,000
Total Contingency		35%		$120,000
Project Total				$450,000

SOMERVILLE PRELIMINARY COST ESTIMATE - SHEETPILE				
Item	Quantity	Unit	Cost	Total
Mobilization	1	ls	$15,000.00	$15,000
Erosion and Sedimentation Controls	1	ls	$4,000.00	$4,000
Vinyl Sheetpile	9000	sf	$6.00	$54,000
Sheetpile Cap	900	lf	$30.00	$27,000
Sheetpile Sealant	1450	lf	$2.00	$2,900
Sheetpile Installation	1	ls	$136,100.00	$136,100
Flood Gate	1	ls	$35,000.00	$35,000
Flood Gate Foundation	10	cy	$700.00	$7,000
Dewatering System	1	ls	$10,000.00	$10,000
Site Restoration	9000	sf	$1.00	$9,000
Construction Subtotal				$300,000
PSE&G Admin.		10%		$30,000
Engineering Design		10%		$30,000
Site Investigations		20%		$60,000
Detailed Flood Study		20%		$60,000
Permitting		10%		$30,000
Construction Phase Services		15%		$45,000
Additional Services Subtotal				$255,000
Subtotal				$555,000
Total Contingency		35%		$195,000
Project Total				$750,000

Cranford Substation

The Cranford Substation is located on South Avenue east of High Street, at the Rahway River. The site is bounded to the north by a high NJ Transit retaining wall; the Rahway River to the east; South Avenue to the south; and an adjacent driveway to the east. On the east side of the site there is a 12" thick concrete retaining wall at the crest of the River bank. A four foot fence is mounted on top of the retaining wall. There is a curb inside the station yard for spill prevention. South Avenue is a heavily travelled urban thoroughfare, with street plantings and lights. The front area of the station is a public parking lot utilized by the Town of Cranford. PSE&G equipment is 15 feet from the edge of the river bank, and access to the east side of the site is limited.

A portion of the Cranford site is located within the floodway (see Figure 5), which comprises the river channel and adjacent floodplain that should be kept free of encroachment in accordance with FEMA recommendations. The site is also located within the NJDEP Riparian Buffer Zone.

[redacted]

Figure 5. Cranford FEMA Map Excerpt

As indicated by PSE&G representative Joe Signorello, historical flooding at the site is summarized below.

- **Maximum Flood Depth as Indicated by PSE&G:** 3.5 feet deep from the top of the generator slab in the rear yard. The basement of the substation also flooded to a depth of approximately 6.5 feet.

- **Applicable Description of Flood as Indicated by PSE&G:** The Rahway River crested its banks and rose to maximum flood depth in 90 minutes. The station experienced severe flooding During Hurricane Floyd and also in March 2010. Two basement sump pumps were overwhelmed during the storm. There was also flow from open duct banks in the basement, as well as surface flow through the basement door and ground level vents around the building. The flood stage extended around the entire property, nearly a block in all directions.

The selected option for the flood protection at Cranford is the sheetpile barrier. Due to the site conditions at Cranford, sheetpile is the only feasible option. The steep river bank adjacent to the site to the east and the public frontage of the control house limit the available perimeter area for flood protection. The barrier would follow the existing fence perimeter along the river, and the gate locations would be the same, for a total protected perimeter length of 360 feet. The barrier would terminate at the front southeast corner of the control house. The barrier would also extend from the west side of the control house along the perimeter until it meets the NJ Transit retaining wall. A basement dewatering system and foundation repairs were also considered, along with plugging open duct banks and exterior vents at ground surface. Costs for the sheetpile barrier are shown below; contingent and further design work percentages are approximate. Permitting considerations for Cranford will include the NJDEP, Town of Cranford, and Union County entities.

CRANFORD PRELIMINARY COST ESTIMATE				
Item	Quantity	Unit	Cost	Total
Mobilization	1	ls	$15,000.00	$15,000
Erosion and Sedimentation Controls	1	ls	$2,500.00	$2,500
Vinyl Sheetpile	3600	sf	$6.00	$21,600
Sheetpile Cap	200	lf	$30.00	$6,000
Sheetpile Sealant	1450	lf	$2.00	$2,900
Sheetpile Installation	1	ls	$31,300.00	$34,400
Flood Gate	2	ls	$35,000.00	$70,000
Flood Gate Foundation	20	cy	$700.00	$14,000
Dewatering System and Foundation	1	ls	$30,000.00	$30,000
Additional Flood Control Pumps	1	ls	$10,000.00	$10,000
Site Restoration	3600	sf	$1.00	$3,600
Construction Subtotal				$210,000
PSE&G Admin.		10%		$21,500
Engineering Design		10%		$21,500
Site Investigations		20%		$42,000
Detailed Flood Study		20%		$42,000
Permitting		10%		$21,500
Construction Phase Services		15%		$31,500
Additional Services Subtotal				$180,000
Subtotal				$390,000
Total Contingency		35%		$135,000
Project Total				$525,000

Rahway Substation

The station is located across Clarkson Place from the Rahway River, in an urban residential/industrial area. The river in this area is well below the street elevation and has steep banks. The substation has two gated access points from Monroe Street, and access is generally open along Clarkson Place. The east side of the side is graded higher, at the same elevation as the station building, and the site has a total area of approximately 0.75 acres. The site is located within the NJDEP Riparian Buffer Zone.

[redacted]

Figure 6. Rahway FEMA Map Excerpt

As indicated by PSE&G representative Joe Signorello, historical flooding at the site is summarized below.

- **Maximum Flood Depth as Indicated by PSE&G:** Three feet above ground surface at front of substation.
- **Applicable Description of Flood as Indicated by PSE&G:** The Rahway River crested its bank and inundated the station; over a 12 foot rise in normal water surface elevation in the river channel was observed (and 15 feet overall).

The selected option for the flood protection at Rahway is the sheetpile barrier. The barrier would follow the existing fence perimeter, and the gate locations would be the same, for a total protected perimeter length of 800 feet. The site conditions at Rahway would also allow for the installation of the concrete wall alternative, but at a higher cost with no increase in flood protection. Costs for the Sheetpile barrier are shown below; contingent and further design work percentages are approximate. Permitting considerations for Rahway will include the NJDEP, City of Rahway, and Union County entities.

RAHWAY PRELIMINARY COST ESTIMATE				
Item	Quantity	Unit	Cost	Total
Mobilization	1	ls	$15,000.00	$15,000
Erosion and Sedimentation Controls	1	ls	$2,500.00	$2,500
Vinyl Sheetpile	7850	sf	$6.00	$47,100
Sheetpile Cap	800	lf	$30.00	$24,000
Sheetpile Sealant	1450	lf	$2.00	$2,900
Sheetpile Installation	1	ls	$117,750.00	$117,750
Flood Gate	1	ls	$35,000.00	$35,000
Flood Gate Foundation	10	cy	$700.00	$7,000
Dewatering System	1	ls	$20,900.00	$20,900
Additional Flood Control Pumps	1	ls	$10,000.00	$10,000
Site Restoration	7850	sf	$1.00	$7,850
Construction Subtotal				$290,000
PSE&G Admin.		10%		$30,000
Engineering Design		10%		$30,000
Site Investigations		20%		$58,000
Detailed Flood Study		20%		$58,000
Permitting		10%		$30,000
Construction Phase Services		15%		$44,000
Additional Services Subtotal				$250,000
Subtotal				$540,000
Total Contingency		35%		$190,000
Project Total				$730,000

Bayway Switching Station

The Bayway Substation is located in the much larger PSE&G Switching Station's northeast corner. Gated access is a significant distance from the site, however there is open access onto Trenton Avenue in the area. The general site grades in the direction of the northeast corner; the area for flood protection is approximately 0.1 acres. There are two deep sumps located near the area; the details of which are not yet confirmed. During the site visit, water was observed in the sumps just below the ground surface elevation. The site is located within the NJDEP Riparian Buffer Zone, and the floodplain is controlled by existing levees along the Elizabeth River, including a large flood gate on the adjacent City of Elizabeth property.

[redacted]

Figure 7. Bayway FEMA Map Excerpt

As indicated by PSE&G representative Joe Signorello, historical flooding at the site is summarized below.

- **Maximum Flood Depth as Indicated by PSE&G:** Two feet above the ground surface at the northern end of the site.
- **Applicable Description of Flood as Indicated by PSE&G:** Topography rises to the south, where the majority of the other site equipment is located; flooding extended from the Elizabeth River (tidal) and various low points around the site. Flooding was limited by a sandbag wall and a 5-inch diameter trash pump, which conveyed flow across Trenton Avenue to an adjacent low area. Trenton Avenue was not submerged during the flood.

The selected option for the flood protection at Bayway is the Sheetpile Barrier. The barrier would closely ring the substation area, with an open and accessible gate location, with a total protected perimeter length of 280 feet. The proximity to the Elizabeth River and the overland site drainage on a working site make the rigid and durable sheetpile the best barrier. The site conditions at Bayway would also allow for the installation of all three alternatives. Costs for the Sheetpile Barrier are shown below; contingent and further design work percentages are approximate. Permitting considerations for Bayway will include the City of Elizabeth and Union County entities.

BAYWAY PRELIMINARY COST ESTIMATE				
Item	Quantity	Unit	Cost	Total
Mobilization	1	ls	$15,000.00	$15,000
Erosion and Sedimentation Controls	1	ls	$2,500.00	$2,500
Vinyl Sheetpile	2650	sf	$6.00	$15,900
Sheetpile Cap	270	lf	$30.00	$8,100
Sheetpile Sealant	1450	lf	$2.00	$2,900
Sheetpile Installation	1	ls	$40,950.00	$40,950
Flood Gate	1	ls	$35,000.00	$35,000
Flood Gate Foundation	10	cy	$700.00	$7,000
Dewatering System	1	ls	$10,000.00	$10,000
Site Restoration	2650	sf	$1.00	$2,650
Construction Subtotal				$140,000
PSE&G Admin.		10%		$14,000
Engineering Design		10%		$14,000
Site Investigations		20%		$28,000
Permitting		10%		$14,000
Construction Phase Services		15%		$20,000
Additional Services Subtotal				$90,000
Subtotal				$230,000
Total Contingency		35%		$80,000
Project Total				$310,000

PALISADES DIVISION

Marion Substation

The Marion Substation is located on West Side Avenue adjacent to the Hudson Generating Station. The substation is located on the larger station property, and occupies approximately 5 acres. There is gated access at the north end of the site. This is a large industrial site, with open access to the north and east along West Side Avenue. The west and south sides are adjacent to existing equipment with limited access. The basement of the substation was flooded, but was not inspected due to North American Electrical Reliability Corporation (NERC) security requirements. The basement has four sumps, each with 3-inch discharge lines. Further underdrain details were not available. There are several ducts running into the basement, which are sealed. There are two exterior duct vaults adjacent to the station building, with a sump in each. The applicable FEMA FIRM map was not included because it does not provide mapping data for the Marion site, which is under the jurisdiction of the Hackensack Meadowlands Commission.

As indicated by PSE&G representative Maurice Andreula, historical flooding at the site is below.

- **Maximum Flood Depth as Indicated by PSE&G:** 1.5 feet from ground surface.
- **Applicable Description of Flood as Indicated by PSE&G:** The site is on the backside of the Hudson Generating Station, which is adjacent to the Hackensack River (tidal). The topography of the area is a "bathtub", as flows proceeded overland, and did not recede for a week. A newer transformer unit in the southeast corner was above the flood impacts, on a berm with a concrete curb.

Because of the space restrictions with existing equipment, and adjacent PSE&G operations, the selected option for the flood protection at Marion is the sheetpile barrier. The barrier would follow the existing site fence perimeter, and would have 2 gate locations at current points of access, with a total protected perimeter of 2155 feet. The proximity to the Hackensack River and the overland site drainage on a working site make the rigid and durable sheetpile the best barrier. Additional points of access should also be considered, along with sump rehabilitation in the control building and adjacent vaults. Duct bank penetrations reportedly contributed to vault and basement flooding, and will also be addressed. The site conditions at Marion could allow for the installation of the concrete wall alternative (at a higher cost). A berm could be considered, but alignment would need to be studied and refined further. Better documentation of the building must be secured through NERC clearance to enable the basement and vault rehabilitation design. Costs for the sheetpile barrier are shown below; contingent and further design work percentages are approximate. Permitting considerations for Marion would include the NJDEP, Hackensack Meadowlands Commission, Jersey City, and Hudson County entities.

MARION PRELIMINARY COST ESTIMATE				
Item	Quantity	Unit	Cost	Total
Mobilization	1	ls	$15,000.00	$15,000
Erosion and Sedimentation Controls	1	ls	$10,000.00	$10,000
Vinyl Sheetpile	21250	sf	$6.00	$127,500
Sheetpile Cap	2125	lf	$30.00	$63,750
Sheetpile Sealant	1450	lf	$2.00	$2,900
Sheetpile Installation	1	ls	$320,600.00	$320,600
Flood Gate	2	ls	$35,000.00	$70,000
Flood Gate Foundation	20	cy	$700.00	$14,000
Dewatering System	1	ls	$30,000.00	$30,000
Additional Flood Control Pumps	1	ls	$10,000.00	$10,000
Site Restoration	21250	sf	$1.00	$21,250
Construction Subtotal				$685,000
PSE&G Admin.		10%		$68,500
Engineering Design		10%		$68,500
Site Investigations		20%		$137,000
Detailed Flood Study		20%		$137,000
Permitting		10%		$68,500
Construction Phase Services		15%		$105,500
Additional Services Subtotal				$585,000
Subtotal				$1,270,000
Total Contingency		35%		$445,000
Project Total				$1,715,000

Garfield Substation

The Garfield Substation is located at the end of Garfield Place at the Saddle River near Lodi, NJ with an approximate area of 0.4 acres. There is a 6-foot high concrete flood wall surrounding the substation, which is adjacent to the Saddle River. The main entrance is the single point of access, and has a 6-foot high flood gate. There is a sump pit with a 3-inch discharge in the northwest corner of the site out to the Saddle River (over the wall). The power source for the sump pump is the station power supply, which can be compromised during flood events. There is a flood berm on the adjacent property between the station and the river, owned by others.

A portion of the Garfield site is located within the floodway (see Figure 8), which comprises the river channel and adjacent floodplain that should be kept free of encroachment in accordance with current FEMA recommendations. The site is also located within the NJDEP Riparian Buffer Zone.

[redacted]

Figure 8. Garfield FEMA Map Excerpt

As indicated by the PSE&G representative, historical flooding at the site is summarized below.

- **Maximum Flood Depth as Indicated by PSE&G:** 4.75 feet from the ground surface.
- **Applicable Description of Flood as Indicated by PSE&G:** The existing floodwall and sump were not sufficient to dewater the station during Hurricane Irene or other previous storm events. During Hurricane Floyd, the water came over the floodwall, though it is not clear exactly how flood waters entered during Irene; there are open conduits from the exterior that may have contributed, and the sump was overwhelmed. The area around the substation was flooded for several blocks.

The existing flood wall is in good structural condition, and does not need to be replaced. Further, the property size and adjacent properties would not provide sufficient area for flood protection except the sheetpile barrier (assuming demolition of the existing wall). The sump pump and existing subgrade drainage system should be replaced, along with the existing access gate. Further, duct banks leading into the station should be sealed to prevent inflow during flood events. The proposed work would likely not require permits, however could be subject to the jurisdiction of NJDEP, Township of South Hackensack, or Bergen County.

GARFIELD PRELIMINARY COST ESTIMATE				
Item	Quantity	Unit	Cost	Total
Mobilization	1	ls	$10,000.00	$10,000
Flood Gate	1	ls	$35,000.00	$35,000
Dewatering System	1	ls	$20,000.00	$20,000
Additional Flood Control Pumps	1	ls	$10,000.00	$10,000
Construction Subtotal				$75,000
PSE&G Admin.		10%		$7,500
Engineering Design		10%		$7,500
Site Investigations		10%		$7,500
Permitting		7%		$5,000
Construction Phase Services		10%		$7,500
Additional Services Subtotal				$35,000
Subtotal				$110,000
Total Contingency		35%		$40,000
Project Total				$150,000

River Edge Substation

The River Edge Substation is located at the end of Main Street East of Hackensack Avenue. There is gated access to the site from Main Street, the only accessible side of the site. The site covers approximately 0.5 acres, and has no existing flood protection. The site is located at the confluence of the Hackensack River and the small tributary of Coles Brook.

A portion of the River Edge site is located within the floodway (see Figure 9), which comprises the river channel and adjacent floodplain that should be kept free of encroachment in accordance with FEMA recommendations. The site is also located within the NJDEP Riparian Buffer Zone.

[redacted]

Figure 9. River Edge FEMA Map Excerpt

As indicated by the PSE&G representative, historical flooding at the site is summarized below.

- **Maximum Flood Depth as Indicated by PSE&G:** One foot inside the control house.
- **Applicable Description of Flood as Indicated by PSE&G:** The substation is located on the bank of the Hackensack River, less than 3 feet (vertical) from the typical river water elevation. The entire station perimeter and surrounding block was inundated by Hurricane Irene, though the historical high water was recorded for Hurricane Floyd.

The selected option for the flood protection at River Edge is the sheetpile barrier. The barrier would follow the existing perimeter fence line, and utilize the same access gate location that exists now, with a total protected perimeter length of 435 feet. The proximity to the Hackensack River and the Coles Brook require a narrow profile structure. The site conditions at River Edge are not conducive to the installation of the other alternatives. Costs for the sheetpile barrier are shown below; contingent and further design work percentages are approximate. Permitting considerations for River Edge will include the NJDEP, Borough of River Edge, and Bergen County entities.

RIVER EDGE PRELIMINARY COST ESTIMATE				
Item	Quantity	Unit	Cost	Total
Mobilization	1	ls	$15,000.00	$15,000
Erosion and Sedimentation Controls	1	ls	$2,500.00	$2,500
Vinyl Sheetpile	4200	sf	$6.00	$25,200
Sheetpile Cap	420	lf	$30.00	$12,600
Sheetpile Sealant	1450	lf	$2.00	$2,900
Sheetpile Installation	1	ls	$65,600.00	$65,600
Flood Gate	1	ls	$35,000.00	$35,000
Flood Gate Foundation	10	cy	$700.00	$7,000
Dewatering System	1	ls	$10,000.00	$10,000
Site Restoration	4200	sf	$1.00	$4,200
Construction Subtotal				$180,000
PSE&G Admin.		10%		$18,000
Engineering Design		10%		$18,000
Site Investigations		20%		$37,000
Detailed Flood Study		20%		$37,000
Permitting		10%		$18,000
Construction Phase Services		15%		$27,000
Additional Services Subtotal				$155,000
Subtotal				$335,000
Total Contingency		35%		$115,000
Project Total				$450,000

New Milford Switching Station

The New Milford Switching Station is located on Henley Avenue, west of River Road. Primary gated access is from Henley Avenue. The north side is open for access, however all other sides of the site are not easily accessible. The entire site is approximately 8 acres. Elevations along the Hackensack River during Hurricane Irene were reportedly higher, possibly due to flood gate releases from the Oradell Dam, upstream of the site. The site is located within the NJDEP Riparian Buffer Zone.

[redacted]

Figure 10. New Milford FEMA Map Excerpt

As indicated by the PSE&G representative, historical flooding at the site is summarized below.

- **Maximum Flood Depth as Indicated by PSE&G:** Three feet above the ground surface at the main gate.

- **Applicable Description of Flood as Indicated by PSE&G:** The site was relatively dry, until approximately 45 minutes after the opening of the flood gates at the Oradell Dam, located about 1.5 miles upstream on the Hackensack River. The River is 200 feet from the northeast corner of the site.

The site conditions at New Milford would allow for installation of any of the 3 reviewed alternatives. The selected alternative for the flood protection at New Milford is the earthen berm or sheetpile barrier. The flood protection would follow the existing fence, and the gate locations would be the same, with a total protected perimeter of 2480 feet. Costs for the berm and sheetpile are shown below; contingent and further design work percentages are approximate. Permitting considerations for New Milford will include the NJDEP, New Milford Borough, and Bergen County entities.

Oradell Dam is located upstream of the New Milford site. The spillway at the dam has gates that are operated by the owner during extreme storm events to regulate reservoir levels. The releases from this dam can affect the downstream flood levels, and should be taken into account during future hydraulic studies to verify the anticipated flood levels.

NEW MILFORD PRELIMINARY COST ESTIMATE - BERM				
Item	Quantity	Unit	Cost	Total
Mobilization	1	ls	$15,000.00	$15,000
Erosion and Sedimentation Controls	1	ls	$10,000.00	$10,000
Site Preparation	37000	sf	$1.00	$37,000
Excavation	500	cy	$5.00	$2,500
Berm Construction	2500	cy	$15.00	$37,500
Geomembrane	49300	sf	$3.00	$147,900
Turf Reinforcing Mat and Seeding	49300	sf	$2.00	$98,600
Flood Gate	2	ls	$35,000.00	$70,000
Flood Gate Foundation	20	cy	$700.00	$14,000
Fencing	2500	lf	$3.00	$7,500
Dewatering System	1	ls	$20,000.00	$20,000
Additional Flood Control Pumps	1	ls	$10,000.00	$10,000
Site Restoration	25000	sf	$1.00	$25,000
Construction Subtotal				$495,000
PSE&G Admin.		10%		$50,000
Engineering Design		10%		$50,000
Site Investigations		20%		$100,000
Detailed Flood Study		20%		$100,000
Permitting		10%		$50,000
Construction Phase Services		15%		$70,000
Additional Services Subtotal				$420,000
Subtotal				$915,000
Total Contingency		35%		$320,000
Project Total				$1,235,000

NEW MILFORD PRELIMINARY COST ESTIMATE - SHEETPILE				
Item	Quantity	Unit	Cost	Total
Mobilization	1	ls	$15,000.00	$15,000
Erosion and Sedimentation Controls	1	ls	$10,000.00	$10,000
Vinyl Sheetpile	24650	sf	$6.00	$147,900
Sheetpile Cap	2465	lf	$30.00	$73,950
Sheetpile Sealant	1450	lf	$2.00	$2,900
Sheetpile Installation	1	ls	$371,250.00	$371,250
Flood Gate	2	ls	$35,000.00	$70,000
Flood Gate Foundation	20	cy	$700.00	$14,000
Dewatering System and Foundation	1	ls	$20,000.00	$20,000
Additional Flood Control Pumps	1	ls	$10,000.00	$10,000
Site Restoration	25,000	sf	$1.00	$25,000
Construction Subtotal				$760,000
PSE&G Admin.		10%		$76,000
Engineering Design		10%		$76,000
Site Investigations		20%		$150,000
Detailed Flood Study		20%		$150,000
Permitting		10%		$76,000
Construction Phase Services		15%		$112,000
Additional Services Subtotal				$640,000
Subtotal				$1,400,000
Total Contingency		35%		$500,000
Project Total				$1,900,000

Hillsdale Substation

The Hillsdale Substation is located at Knickerbocker Avenue, west of Paterson Street, and encompasses approximately 2.5 acres. Primary gated access is off of Knickerbocker Avenue, and secondary gated access is off of Paterson Street. The north and east sides are heavily wooded, and businesses are located on the other sides of the site. The substation is located less than 200 feet from the Pascack Brook.

A portion of the River Edge site is located within the floodway (see Figure 11), which comprises the river channel and adjacent floodplain that should be kept free of encroachment in accordance with FEMA recommendations. The site is also located within the NJDEP Riparian Buffer Zone.

[redacted]

Figure 11. Hillsdale FEMA Map Excerpt

As indicated by the PSE&G representative, historical flooding at the site is summarized below.

- **Maximum Flood Depth as Indicated by PSE&G:** Three feet above the ground surface at the Transformer No. 2 breaker box.

- **Applicable Description of Flood as Indicated by PSE&G:** Maximum depths were noted as up to 5 feet at the west end of the site.

The selected option for the flood protection at Hillsdale is the sheetpile barrier. The barrier would follow the existing perimeter fence line, and utilize the same access gate locations that exist now, for a total protected perimeter of 1,965 feet. The site conditions at Hillsdale are not conducive to the installation of the earthen berm alternative. The concrete wall alternative is feasible, but has a higher cost and does not provide any superior flood protection to that of the sheetpile barrier wall. Costs for the sheetpile barrier are shown below; contingent and further design work percentages are approximate. Permitting considerations for Hillsdale will include the NJDEP, Borough of Hillsdale, and Bergen County entities.

Woodcliff Lake Dam is located upstream of the Hillsdale site. The spillway at the dam is an uncontrolled flow structure, which is slated for rehabilitation work according to public sources. The proposed increased spillway capacity should be taken into account during future hydraulic studies to verify the anticipated flood levels.

HILLSDALE PRELIMINARY COST ESTIMATE				
Item	Quantity	Unit	Cost	Total
Mobilization	1	ls	$15,000.00	$15,000
Erosion and Sedimentation Controls	1	ls	$5,000.00	$5,000
Vinyl Sheetpile	19350	sf	$6.00	$116,100
Sheetpile Cap	1935	lf	$30.00	$58,050
Sheetpile Sealant	1450	lf	$2.00	$2,900
Sheetpile Installation	1	ls	$289,600.00	$289,600
Flood Gate	2	ls	$35,000.00	$70,000
Flood Gate Foundation	20	cy	$700.00	$14,000
Dewatering System	1	ls	$10,000.00	$10,000
Additional Flood Control Pumps	1	ls	$10,000.00	$10,000
Site Restoration	19350	sf	$1.00	$19,350
Construction Subtotal				$610,000
PSE&G Admin.		10%		$61,500
Engineering Design		10%		$61,500
Site Investigations		20%		$122,000
Detailed Flood Study		20%		$122,000
Permitting		10%		$61,500
Construction Phase Services		15%		$91,500
Additional Services Subtotal				$520,000
Subtotal				$1,130,000
Total Contingency		35%		$395,000
Project Total				$1,525,000

Summary of Flood Protection Alternatives

Table 2 below summarizes the preliminary, order of magnitude costs estimated for each site. The actual costs will vary as the designs are developed. Black & Veatch has included the appropriate level of conservatism at this stage of the program, and costs can be refined moving forward. The Sheetpile Barrier cost is shown for sites with more than one viable alternative.

Table 4. Flood Protection Alternatives

SITE	PERIMETER (FT)	FLOOD PROTECTION	ESTIMATED TOTAL COST
Belmont	230	Sheetpile Barrier	$320,000
Jackson Road	1560	Sheetpile (or Earthen Berm)	$1,170,000
Ewing	615	Sheetpile Barrier	$570,000
Somerville	915	Sheetpile (or Earthen Berm)	$750,000
Cranford	220	Sheetpile Barrier	$525,000
Rahway	800	Sheetpile Barrier	$730,000
Bayway	280	Sheetpile Barrier	$310,000
Marion	2155	Sheetpile Barrier	$1,715,000
Garfield	n/a	Rehabilitation	$150,000
River Edge	435	Sheetpile Barrier	$450,000
New Milford	2480	Sheetpile (or Earthen Berm)	$1,900,000
Hillsdale	1965	Sheetpile Barrier	$1,525,000
		Program Total	$10,115,000

Black & Veatch recommends the top elevation of the flood protection to equal the 100-year flood elevation plus two feet of freeboard to account for the variability of extreme storm events. Our experience in energy infrastructure has shown this to be effective in protecting sites and maintaining service. This elevation is equal to or higher than all observed maximum flood elevations. The design height may be adjusted slightly to account for updated data from field surveying of the sites.

Each site should be surveyed to verify the existing ground surface elevation and design top of flood protection elevation. Geotechnical investigations should be performed to support the flood protection design, as well as to provide data for interior site dewatering systems.

Detailed reports on the flood studies performed for the basis for each map are available from FEMA and should be referenced during the design phase. Detailed flood studies for sites inside the floodway may be required by the NJDEP to quantify flow affects in the upstream and downstream channel from the proposed flood protection.

Specific site logistics such as fence relocation, replacement, and temporary security fencing during construction will need to be considered during design and construction. Construction staging areas for the smaller sites may require additional consideration. Work planning in accordance with PSE&G safety and operations criteria will also need to be considered moving forward.

A preliminary schedule for execution of a single substation is presented below. The schedule would also be extended for projects executed concurrently.

Item	**Months After Notice to Proceed**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
Task 1: INVESTIGATION										
Task 2: DESIGN										
Task 3: PERMITTING										
Task 4: BID AND AWARD PHASE										
Task 5: CONSTRUCTION										

Appendix A

Alternative Sections and Typical Plan Views

FEMA FIRM Legend

Appendix B

Site plans

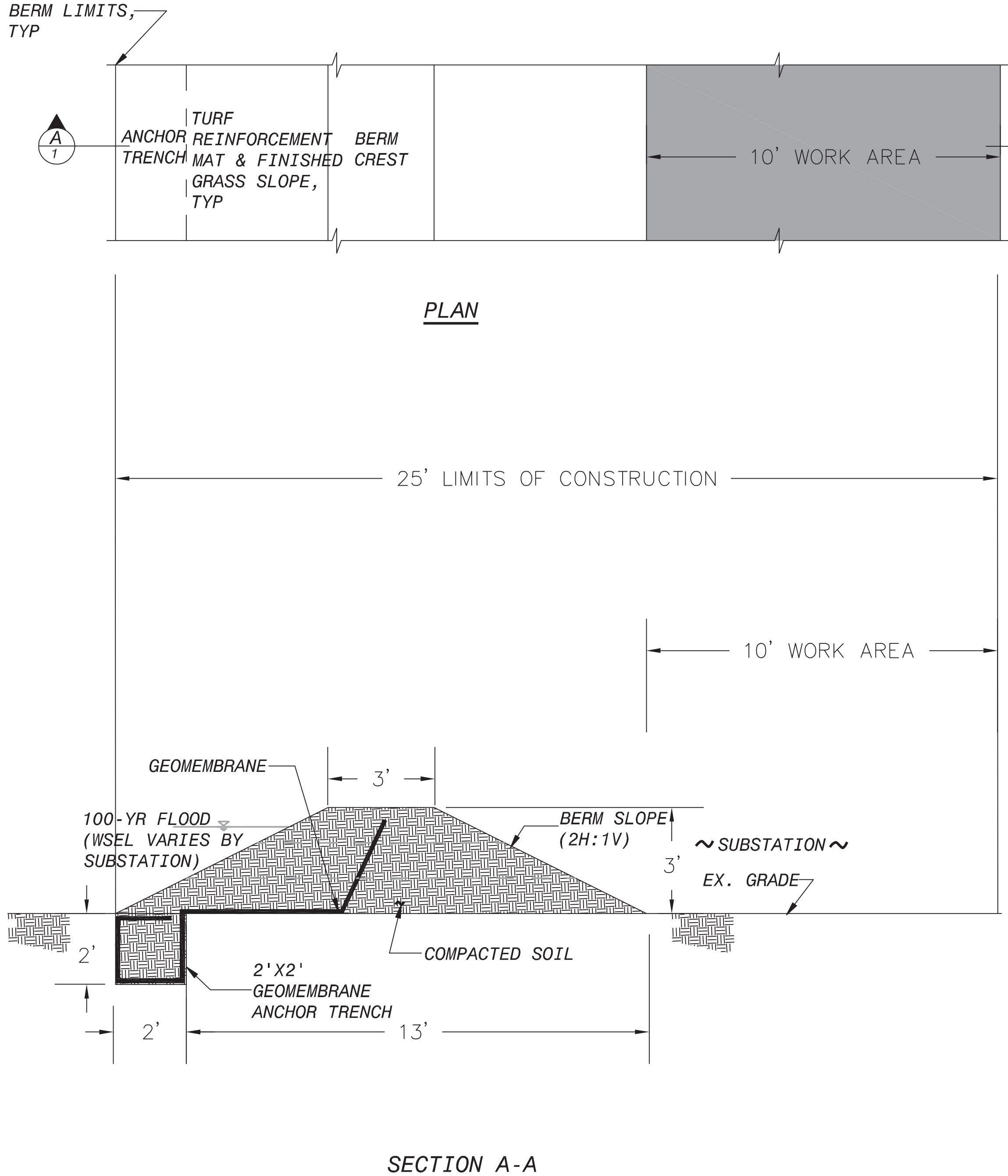
Appendix C

Flood Gate Information

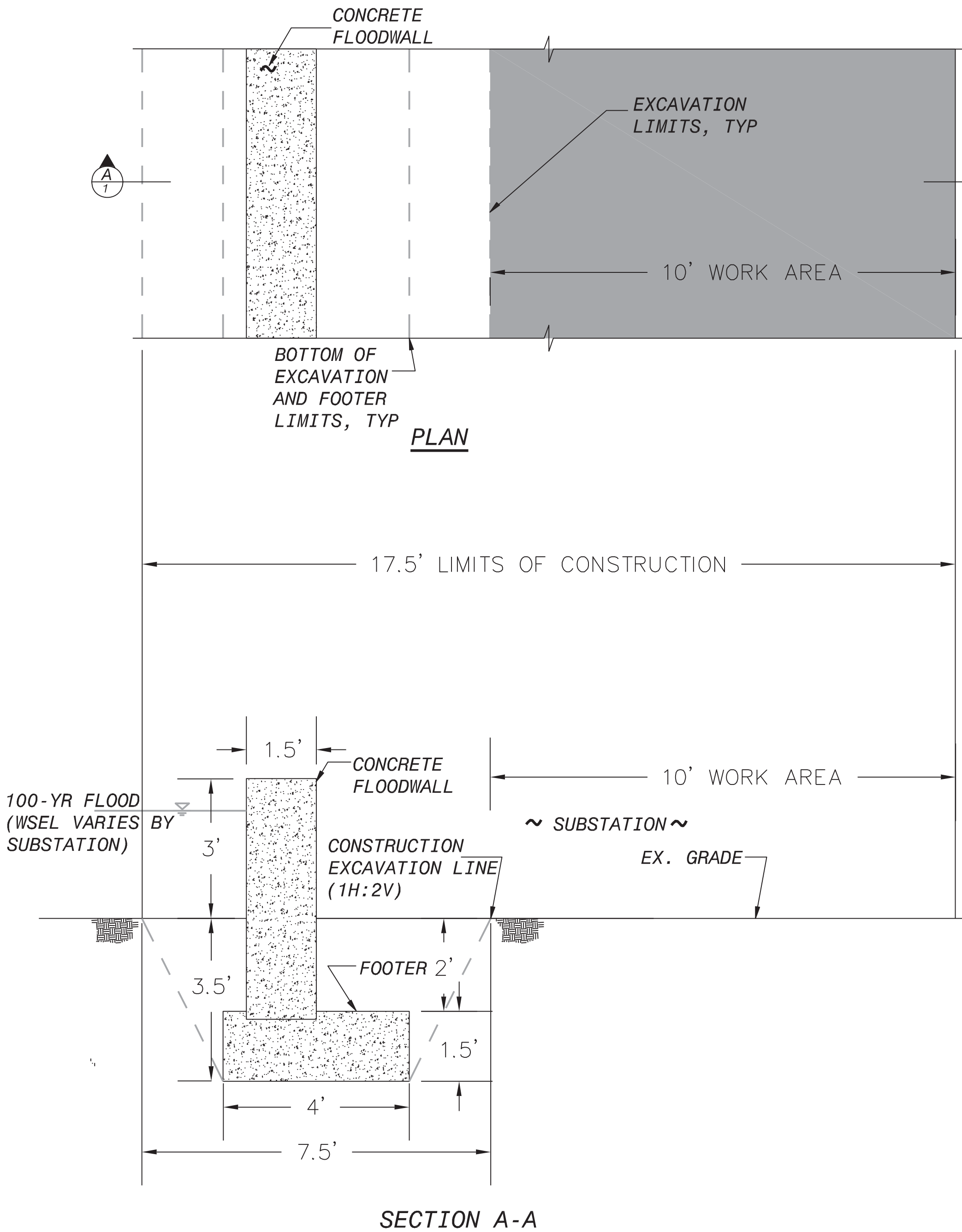
Appendix A

Alternative Sections and Typical Plan Views

FEMA FIRM Legend



BLACK & VEATCH Building a world of difference.	PUBLIC SERVICE ELECTRIC & GAS	01/23/2012
PROJECT 175550	BERM PLAN & CROSS SECTION	FIGURE 1



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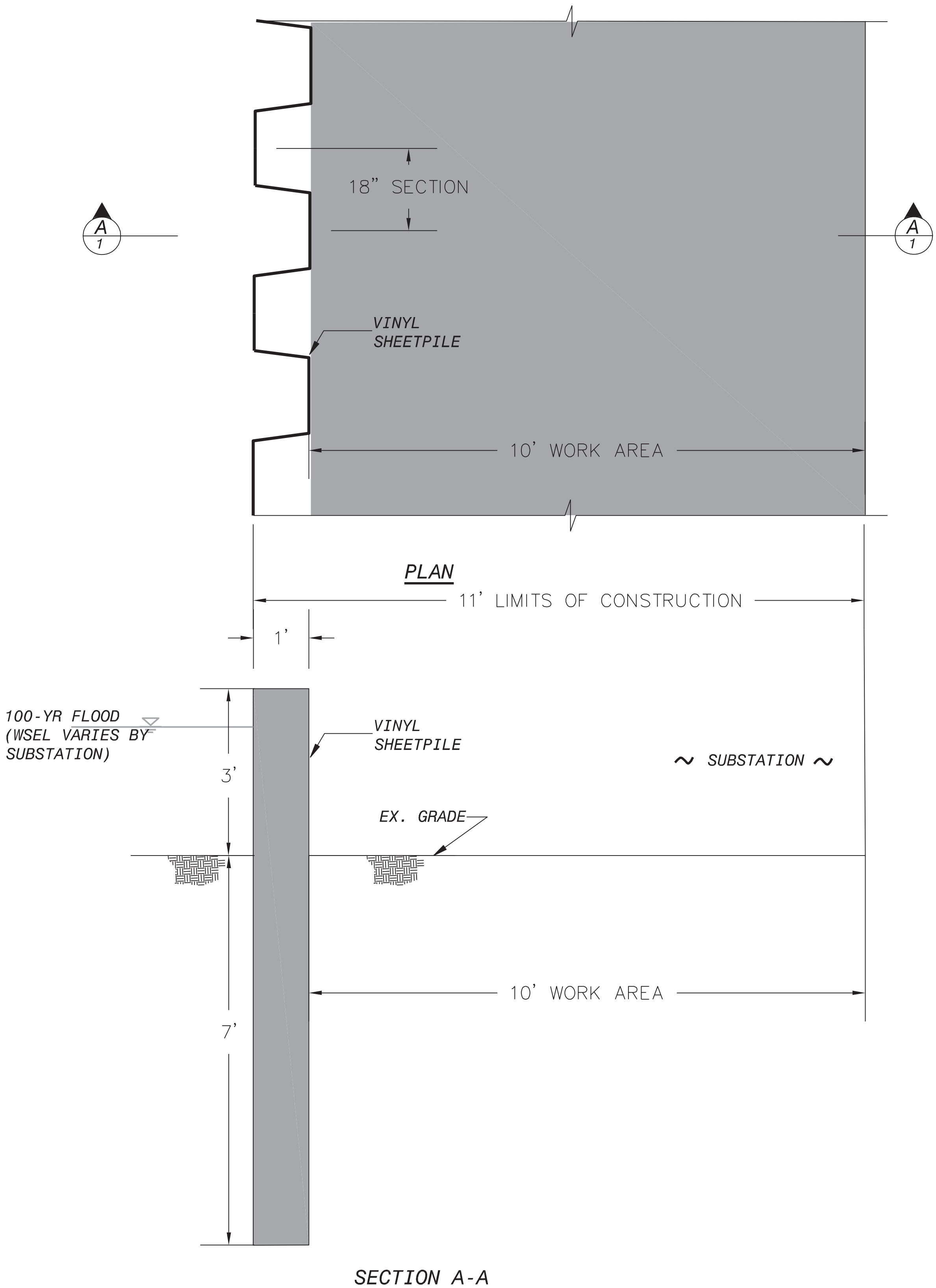
PROJECT 175550	PUBLIC SERVICE ELECTRIC & GAS	01/23/2012
	CONCRETE FLOODWALL PLAN & CROSS SECTION	FIGURE 2



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PROJECT
175550

PUBLIC SERVICE ELECTRIC & GAS

01/23/2012

SHEETPILE PLAN & CROSS SECTION

FIGURE 3

LEGEND

SPECIAL FLOOD HAZARD AREAS (SFHAs) SUBJECT TO INUNDATION BY THE 1 % ANNUAL CHANCE FLOOD

The 1% annual chance flood (100–year flood), also known as the base flood, is the flood that has a 1% chance of being equaled or exceeded in any given year. The Special Flood Hazard Area is the area subject to flooding by the 1% annual chance flood. Areas of Special Flood Hazard include Zones A, AE, AH, AO, AR, A99, V, and VE. The Base Flood Elevation is the water–surface elevation of the 1% annual chance flood.

ZONE A No Base Flood Elevations determined.

ZONE AE Base Flood Elevations determined.

ZONE AH Flood depths of 1 to 3 feet (usually areas of ponding); Base Flood Elevations determined.

ZONE AO Flood depths of 1 to 3 feet (usually sheet flow on sloping terrain); average depths determined. For areas of alluvial fan flooding, velocities also determined.

ZONE AR Special Flood Hazard Area formerly protected from the 1% annual chance flood by a flood control system that was subsequently decertified. Zone AR indicates that the former flood control system is being restored to provide protection from the 1% annual chance or greater flood.

ZONE A99 Area to be protected from 1% annual chance flood by a Federal flood protection system under construction; no Base Flood Elevations determined.

ZONE V Coastal flood zone with velocity hazard (wave action); no Base Flood Elevations determined.

ZONE VE Coastal flood zone with velocity hazard (wave action); Base Flood Elevations determined.

FLOODWAY AREAS IN ZONE AE

The floodway is the channel of a stream plus any adjacent floodplain areas that must be kept free of encroachment so that the 1% annual chance flood can be carried without substantial increases in flood heights.

OTHER FLOOD AREAS

ZONE X Areas of 0.2% annual chance flood; areas of 1% annual chance flood with average depths of less than 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood.

Appendix B

Site plans

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Appendix C

Flood Gate Information

PRESRAY
Critical Containment Solutions
www.Presray.com

FB44

Side Hinged Aluminum Panel With Inflatable Seals

DESIGNED FOR

- Keeping flood water out of building openings or perimeter flood walls. Ideal for quick deployment requirements where a flush bottom sill is required.

PROTECTION TO

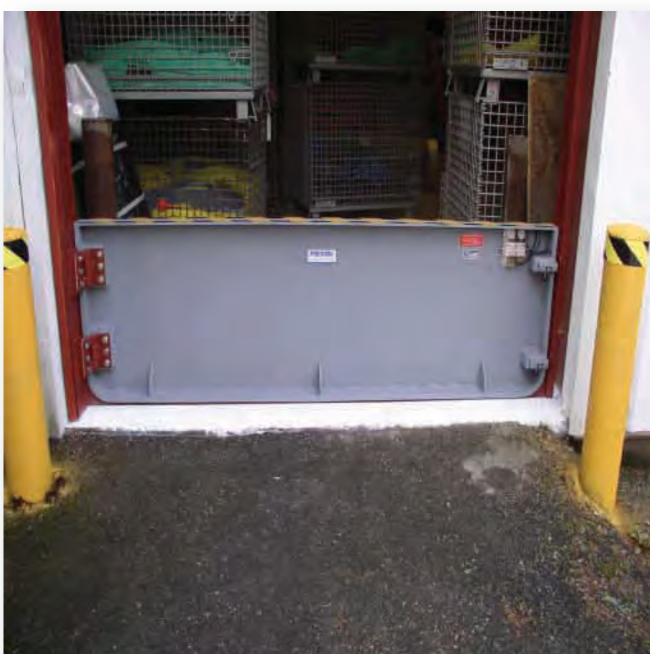
- Custom designed to match any size needs.

SEAL TYPE

- Dual inflatable for redundant protection

SEAL AREA

- 3 Sides, sill & both sides



UNIQUE FEATURES

- 3/8"thick sill can be recessed to prevent tripping hazzard
- Hinged panel glides effortlessly into place
- Dual seals provide redundant protection
- Seals can be inflated by a hand pump, compressed air tank, or air compressor
- Slide latches secure panel when in place

INSTALLATION

- Available for new or existing construction
- For existing openings, frame is mounted to the opening using expansion anchors or epoxy type anchors
- For new construction the frame can be poured in place or anchors can be used similar to existing

PRESRAY
P.O. BOX 200, 32 NELSON HILL ROAD, WASSAIC, NY 12592
P: 845.373.9300 • F: 845.855.8034 • E:CONTACT@PRESRAY.COM

PRESRAY
Critical Containment Solutions
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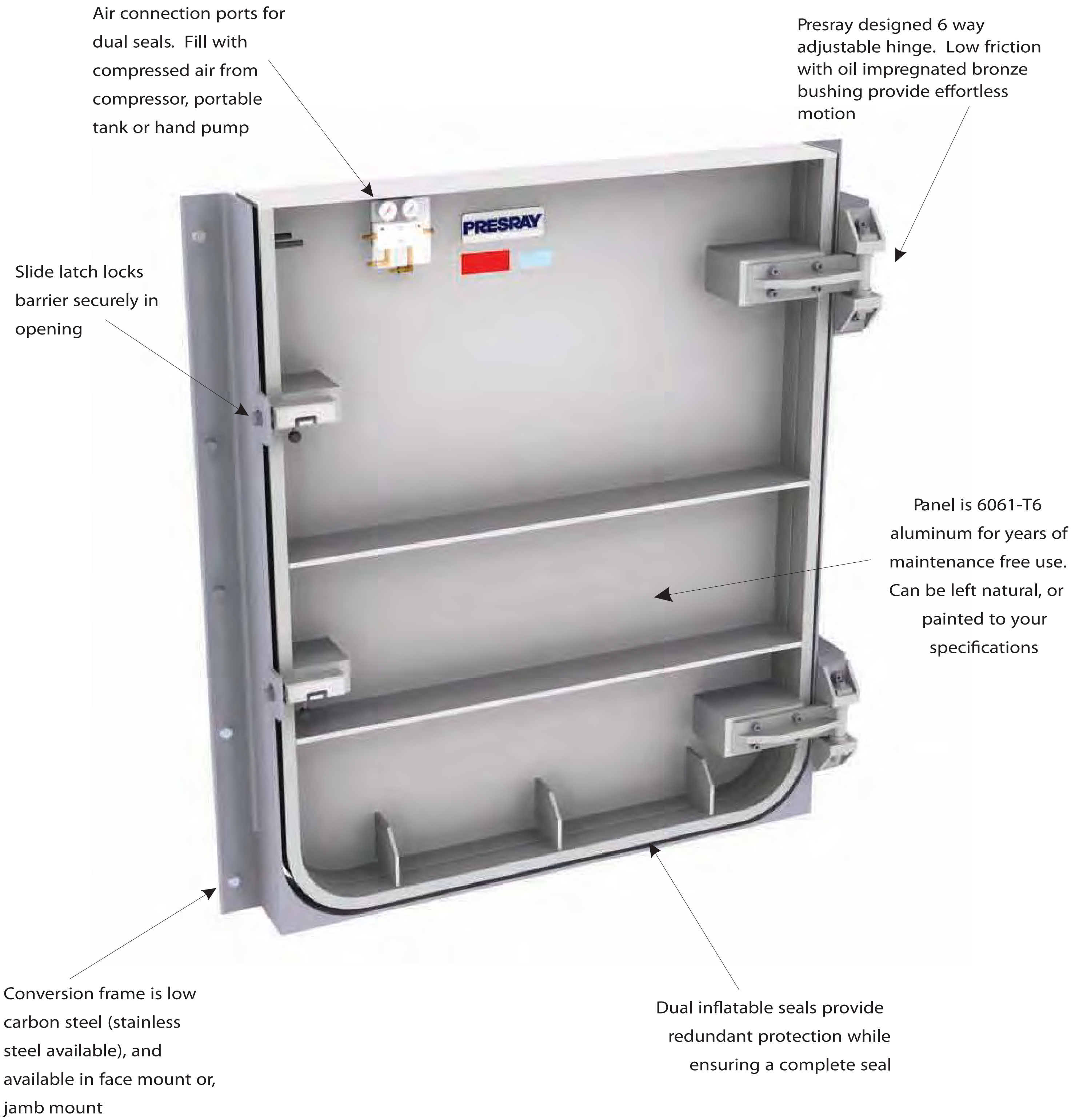
FB44 Design



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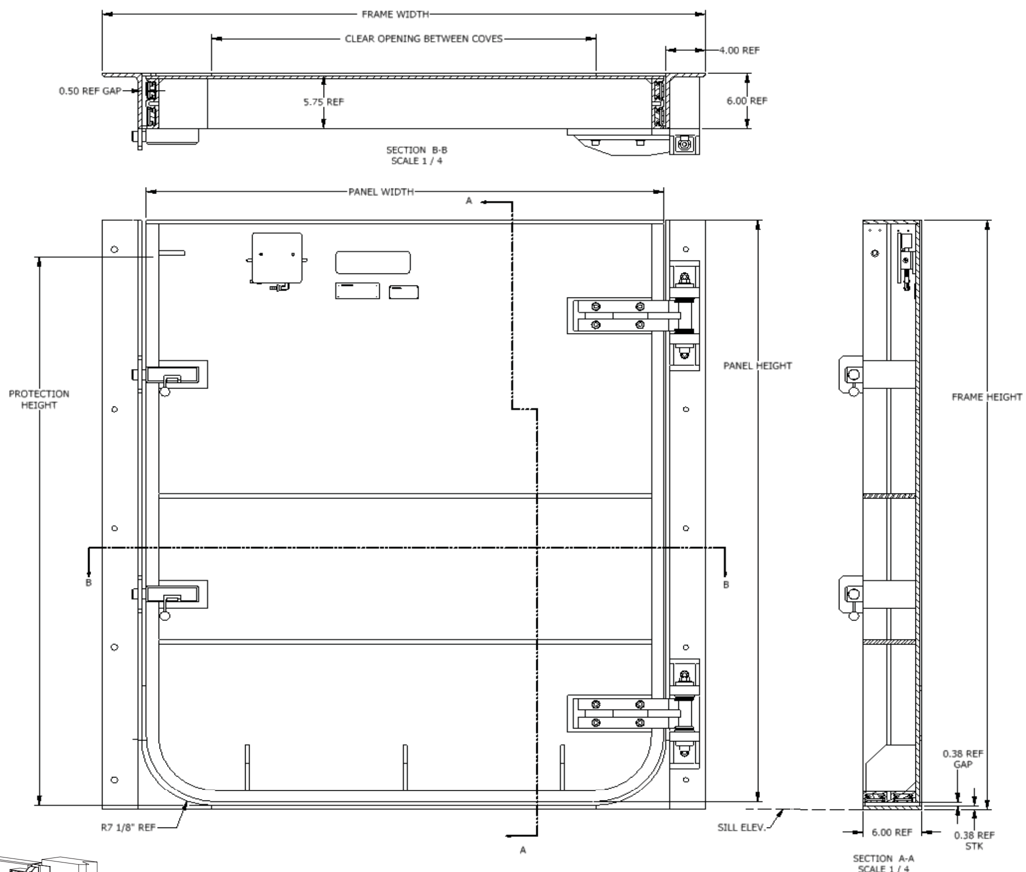
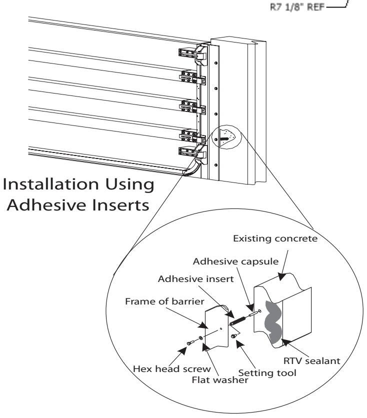
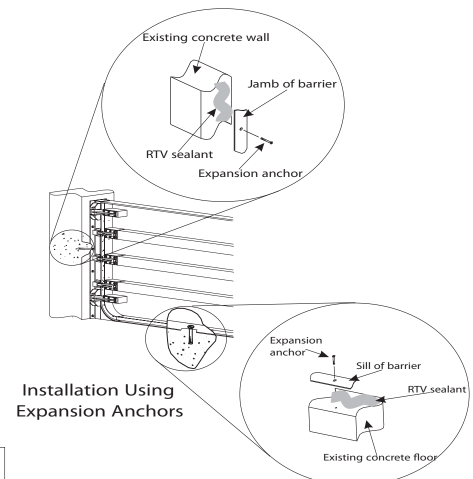
FB44
Installation Detail

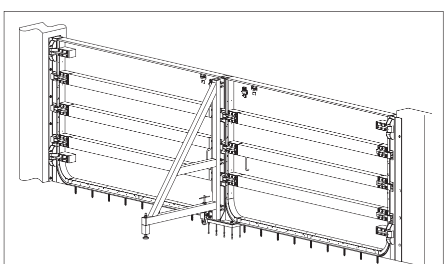




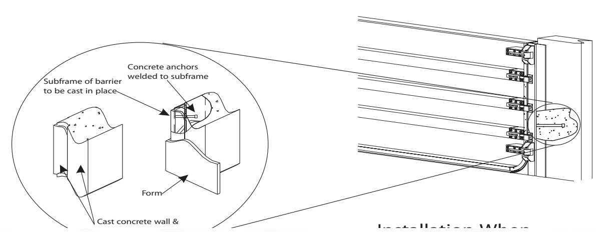


The FB44 Hinged Flood Barrier provides maximum protection by simply closing a gate! The barrier is always in place, always ready to go! In the event of a flood condition, simply close the gate, lock the latch and inflate the seals. The dual redundant seals provide excellent protection.

For large width openings, dual FB44's with attached center mullion provide fast protection. Simply close the first gate (with center mullion attached) and seal and secure the mullion to the ground. After the center mullion is secured the second gate is closed and latched. Then inflate the seals. That's it



FB 44 Double Gate With Attached Center Mullion



Installation When

PRESRAY
Critical Containment Solutions
www.Presray.com

CG3S

Sliding Flood Panel With Compression Gasket

DESIGNED FOR
- Keeping flood water out of building openings or perimeter flood walls. Ideal for quick deployment requirements where a flush bottom sill is required.

PROTECTION TO
- Custom designed to match any size needs.

SEAL TYPE
- Compression, fully molded with molded corners
- Neoprene standard, viton available

SEAL AREA
- 3 Sides-Floor & Both Sides

UNIQUE FEATURES
- Compression gasket provides maximum protection with minimum maintenance
- No compressed air required
- Panel slides effortlessly into place when needed, stays hidden behind wall when not in use
- Sill trench covered by plate, no tripping hazard
- Frame is concealed by hinged cover plate

INSTALLATION
- Available for new or existing construction
- For existing openings, the frame is mounted to the face of the building using expansion anchors. A trench is cut into the existing concrete floor and the sill is cast in place. Once the frame and sill are secured, the storage side of the frame can be covered over using standard construction material.

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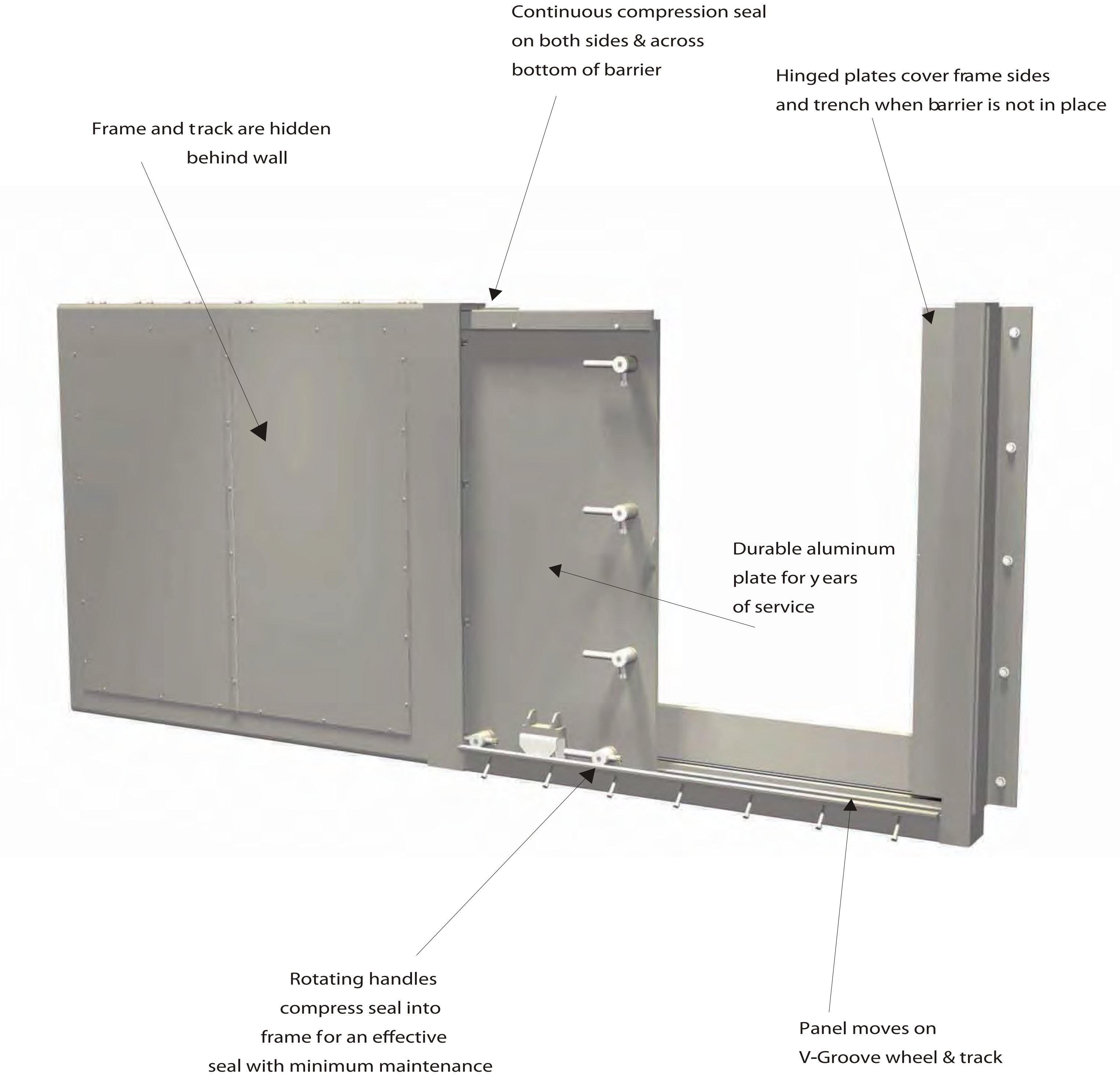
CG3S
Design



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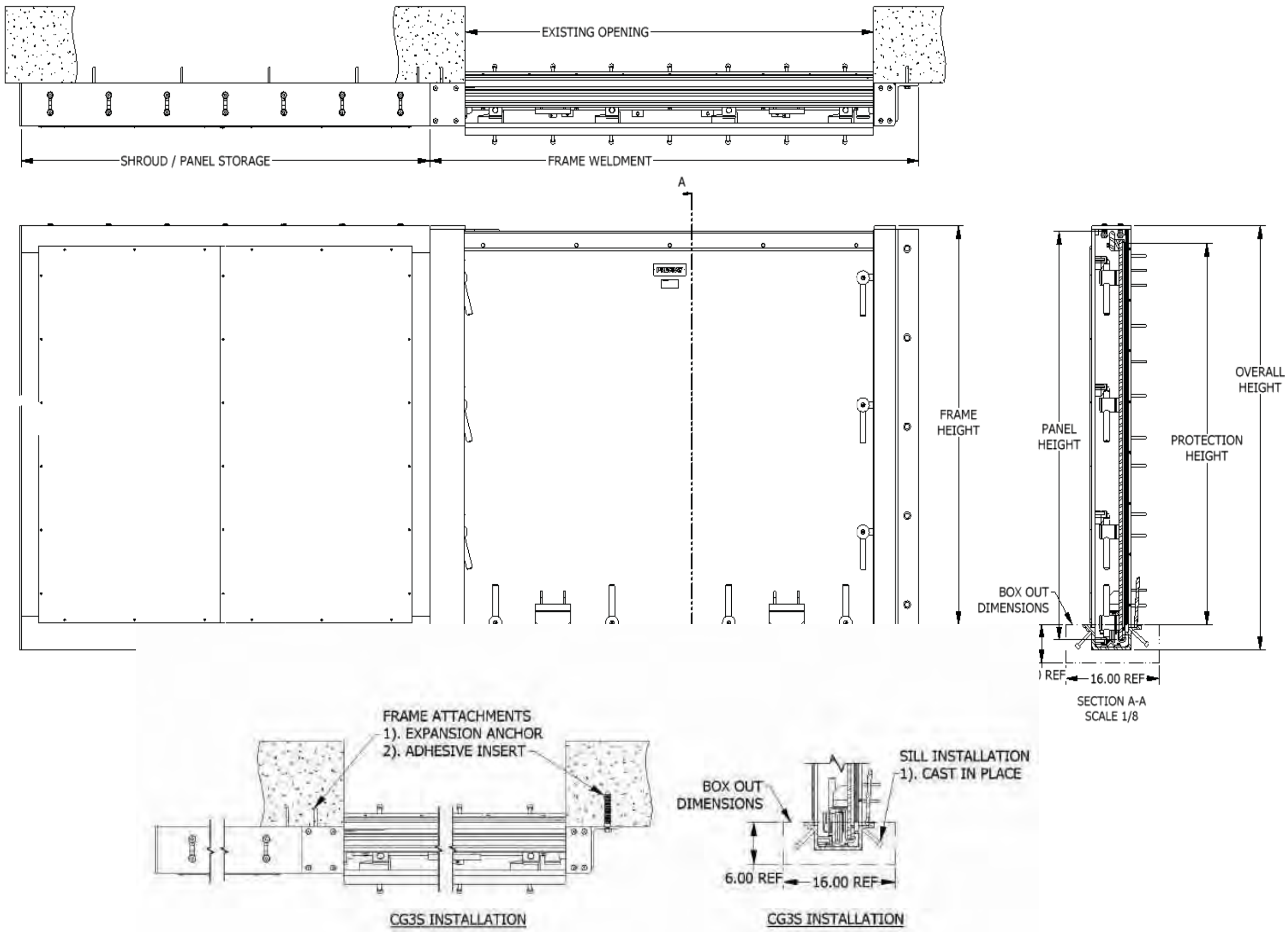
CG3S
Installation Detail



The unique design of the CG3S allows the barrier to stay at the opening, yet out of sight! When not in use the barrier panel sits behind the wall, with the jamb sides & sill hidden by a cover plate. When needed, the hinged sill & jamb cover plates are opened revealing the track, jamb & barrier panel. The panel is then rolled into position and secured using the quarter turn handles. Your opening is secured in under 1 minute with nothing to lift, no screws to remove, no compr essed air needed!
Models are available in all sizes for new or existing construction. For new construction, the sill is poured in place and the frame is bolted onto the wall using expansion anchors. For existing openings, a trench is cut into the floor to receive the sill. Once the sill is in place, concrete is poured to secure it. After the sill is completed the frame is installed using expansion anchors.

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
MICROPROCESSOR RELAYS WILL REDUCE SERVICE TIME

QUESTION:
Paragraph 63 states that "[t]he use of microprocessor relays will reduce service time." Please provide detailed technical and diagnostic analysis to justify this position, including, but not limited to, examples of microprocessor relays used during previous Major Storm Events, and a cost/benefit review thereof.

ANSWER:
The Energy Strong filing is based on extreme weather conditions as experienced over the past three years. It is the Company's current practice to replace defective protective relaying with microprocessor devices (Smart Relays) as failures occur. The Energy Strong Program will create a pro-active replacement program for protective relaying with Smart Relays. These Smart Relays provide more information in a digital format, which can easily be shared with other smart devices to provide various types of automation. This allows integration with Supervisory Control and Data Acquisition (SCADA) systems, which enables the Company to centrally collect data, remotely visualize stations and control equipment. The data can then be used to provide important information, such as customer outage information, and will be available at one central control point for decision making. In the context of paragraph 63, smart devices would be placed on all feeders. This means PSE&G can collect circuit conditions (open/closed), fault locations, voltage levels, and current flow, which provides valuable information during the storm restoration process. This information will allow dispatchers to more accurately and rapidly assess outages during large storms.

The current storm restoration process requires PSE&G personnel to visit affected substations to determine the station and circuit status. The challenge occurs during a major storm where resources are stretched and qualified personnel may not be allocated to the high impact stations due to lack of damage information or due to the inability to access the stations. By equipping stations with Smart Devices, SCADA and Fiber communication feed to our Distribution Management System (DMS), appropriate resources can be more efficiently deployed to restore customers based on the data provided by the Smart Devices.

Microprocessor relays are currently installed in several stations across the state with the majority of them being deployed on the transmission system, sub-transmission system, and all new distribution installations. These installations have proven to be beneficial on numerous occasions and have assisted in restoration in several instances. Based on the cost, success and availability of microprocessor relays on the transmission and sub-transmission systems, PSE&G has begun to deploy these same relays on all new distribution circuits. The value gained by these installations are mainly achieved when they are coupled with a Remote Terminal Unit (RTU), high speed communications and a SCADA system, but are still valuable on a stand-alone basis. Microprocessor relays will provide information such as: high speed fault clearing, distance to fault, loading information, circuit breaker position and more. Communications put the data in the hands of the dispatcher who can take the appropriate actions based on real-time conditions.

The best example to demonstrate the benefits of microprocessor relays during a Major Storm Event was on the transmission system to restore the City of Newark and Newark Airport and can be applied to additional benefits on the Distribution system when microprocessor relays are installed. Superstorm Sandy caused an interruption to about one-third of the transmission and sub-transmission lines across the state. The following lines supply the City of Newark and Newark Airport. The G-2207 line between Deans Switching station and Linden Switching station, the H-2234 line between Linden Switching station and Bayway Switching station and the K-1311 line between Bayway Switching station and Federal Square substation all having microprocessor relays were out. To rapidly and effectively restore these lines, relay technicians were dispatched to each station to manually retrieve fault information from the microprocessor relays. The information from these devices was utilized to determine the cause of the outage and restore the impacted lines. By reviewing the sequence of events logs stored in the microprocessor relays, it was determined that the cause of the outage was transient in nature with no evidence of a permanent fault, thus making the line available for re-energization without patrol. This rapid evaluation and restoration enabled by fault data stored in the microprocessor relays allowed the three transmission lines previously mentioned to be re-energized whereby creating or re-establishing the transmission backbone in that part on the system that was out of service. Without these microprocessor relays the restoration effort would be much more complicated and time consuming. The restoration process that would be followed if microprocessor relays did not exist would require several associates patrolling the line, along long right of ways, sometimes on foot, to determine the health on the line. Additionally, if the line was "bumped" or re-energized without knowing its true condition, additional damage could be incurred if a permanent fault existed, thus prolonging the outage. This long inspection process would delay the eventual restoration of this segment of the transmission backbone and adversely affect the restoration efforts in the connected distribution stations. Energy Strong proposes to capitalize on the capabilities available in microprocessor relays on all distribution circuits and improve the performance by adding high-speed fiber optic communications and SCADA to allow for remote assessment and even faster outage response.

In summary, PSE&G's installation of smart devices, SCADA systems, and reliable communication paths will increase its accuracy in evaluating resource requirements on the day of the storm. Customers will also see a decrease in restoration time due to in the increase in coordination of staff. In addition, the SCADA system will provide remote control of feeders rather than requiring physical presence at the station, which will enable a safe work environment remotely and faster turnaround in customer restoration.

See Table 1 for the cost-benefit results, which show the Advanced Technologies Segment as significantly cost-beneficial for a single Major Storm Event. The cost-benefit methodology is the same as described in the response to S-PSEG-ES-2. For the assumptions on the outage durations for a storm event used in the cost-benefit analysis, see Table 2.

Table 1

Program	Actions	Total Estimated Costs ($ Million)	Number of Customers	Avoided Outages (Hrs)	Outage Duration Decrease (Hrs)	Total Customer Outage Reduction (Hrs)	Value (to customers) of Lost Load ($ Million)	Cost/Benefit Ratio
Advanced Technologies	**System Visibility** **1a.** Expand implementation of 26kV, 13kV, and 4kV Microprocessor Relays and SCADA field equipment (RTUs) to enable remote operation and position indication of each feeder circuit breaker, provide remote monitoring capabilities including circuit and transformer loading, circuit breaker position, load imbalance, will assist in fault location and more.	$ 250	1,134,374	0	4,537,496	4,537,496	$ 1,722	0.09
	1c. System to visualize, control, collect and analyze all monitored points from each Distribution station. This includes SCADA monitors and servers, dispatch consoles, communications switches and servers, historical serves with appropriate back-up and redundancy. (DMS)	$ 50	Combined with 1A	Combined with 1A	Combined with 1A	Combined with 1A	$ -	
	Communication Network **2a**. High Speed Fiber Optic Network (Backbone)- Transmission - Complete build out equating to approximately 30% of the total system (in-progress). Distribution - Build fiber optic network from (91) of the (125) Distribution substations (Class A, B, C, CN, CS, etc) to facilitate the information transfer from the station to the new DMS system.	$ 73	Combined with 1A	Combined with 1A	Combined with 1A	Combined with 1A	$ -	
	2b. Pilot Satellite Communication Program	$ 3	2,250,511	0	1,350,307	0	$ -	
	Storm Damage Assessment (need all items in System Visibility) **3a**. Advanced Distribution Management System (ADMS) functionality to improve visibility of circuit operations in storm conditions and support restoration of customers. Integration of SCADA, DMS, OMS and GIS.	$ 15	Combined with 1A	Combined with 1A	Combined with 1A	Combined with 1A	$ -	
	3b. Enhance Storm Management Systems to improve plant damage assessment process, optimize restoration work plans, integrate mutual aid crews, and develop capability to provide predictive ETRs under complex storm conditions.	$ 50	2,250,511	0	9,002,044	9,002,044	$ 3,417	
	3c. Expand communication channels to improve ability to communicate storm-related information to customers. (Outage Map, Mobile App, Preference Management, SMS, Mobile Web)	$ 10	2,250,511	0	0	0	$ -	

Table 2

Program	Description	Actions	Potential Customer Benefits	Avoided Outage Assumptions	Outage Duration Decrease Assumptions
Advanced Technologies	1. This program will utilize new and significantly enhanced technologies, including GIS, OMS, Mobile Solutions, Predictive Analytics, and Advanced Customer Communications solutions to improve storm and emergency response and enhance communications to customers.	**System Visibility** **1a.** Expand implementation of 26kV, 13kV, and 4kV Microprocessor Relays and SCADA field equipment (RTUs) to enable remote operation and position indication of each feeder circuit breaker, provide remote monitoring capabilities including circuit and transformer loading, circuit breaker position, load imbalance, will assist in fault location and more.	# Customers in Stations	No Benefit	Assumed 4 hour improvement in overall restoration time due to indication of circuit outages, immediate load data for decision making and the ability to remotely set-up circuits for work.
		1c. System to visualize, control, collect and analyze all monitored points from each Distribution station. This includes SCADA monitors and servers, dispatch consoles, communications switches and servers, historical serves with appropriate back-up and redundancy. (DMS)	Benefits Aligned with 1A	Combined with 1A	Combined with 1A
		Communication Network **2a**. High Speed Fiber Optic Network (Backbone)- Transmission - Complete build out equating to approximately 30% of the total system (in-progress). Distribution - Build fiber optic network from (91) of the (125) Distribution substations (Class A, B, C, CN, CS, etc) to facilitate the information transfer from the station to the new DMS system.	Benefits Aligned with 1A	Combined with 1A	Combined with 1A
		2b. Pilot Satellite Communication Program	Total number of Customers?	No Benefit	Very low probability event. Assume 5% probability in a major event with Average 12 hour increase in overall restoration.
		Storm Damage Assessment (need all items in System Visibility) **3a**. Advanced Distribution Management System (ADMS) functionality to improve visibility of circuit operations in storm conditions and support restoration of customers. Integration of SCADA, DMS, OMS and GIS.	Benefits Aligned with 1A	Combined with 1A	Combined with 1A
		3b. Enhance Storm Management Systems to improve plant damage assessment process, optimize restoration work plans, integrate mutual aid crews, and develop capability to provide predictive ETRs under complex storm conditions.	Total number of Customers	No Benefit	Through confirmed damage location visibility, improved look-up process and elimination of duplicate records restoration process will be improved. Assume 4 hour improvement in average restoration in overall storm work.
		3c. Expand communication channels to improve ability to communicate storm-related information to customers. (Outage Map, Mobile App, Preference Management, SMS, Mobile Web)	Total number of Customers	No Benefit	No Benefit

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

RANKING OF STATIONS IMPACTED

QUESTION:
Referencing Paragraph 6 regarding brackish water intrusions, as to substation flooding protection, do these mitigative steps assume that all of the substations flooded by Hurricane Irene and/or Superstorm Sandy have been fully repaired (i.e., water intrusion into systems has been repaired and no future problems are anticipated based on those events)?

a. Provide a ranking of the substations impacted by flooding and repaired in order of criticality to PSE&G systems. Explain how the substation priority was based; i.e. total capacity, number of customer, operational concerns, or other.

ANSWER:
All the stations flooded by Hurricane Irene and Superstorm Sandy are in working condition and are supplying customers. The long-term effects of exposure to brackish water such as corrosion will be monitored on an ongoing basis as part of PSE&G's inspection and maintenance program. The Energy Strong proposal for these stations is to mitigate the impacts of future storm events and does not including funding for the repair of previously damaged equipment.

a. The list below is a prioritized list of stations based on customers impacted in the event of a major flood or storm surge event. The only exception to this priority is the Newark Breaker Station, which has the lowest overall customer count but is the supply to Newark Airport.

Station	Priority
Sewaren Switching Station 230/138/26kV	1
Linden Switching Station 230/138/26kV	2
Bayonne Switching Station 138/26/13	3
Marion Switching Station 138/26kV	4
New Milford	5
Hudson Switching Station 230kV	6
Essex Switching Station 230/138/26kV	7
Newark Airport Bkr Station	8
Hoboken Substation	9
Hillsdale	10
Somerville Substation	11
Jackson Road	12
Marshall St Substation	13
Rahway Substation	14
Cranford	15
River Rd Substation	16
Bayway Substation	17
Hackensack Substation	18
Madison Substation	19
South Waterfront Substation	20
Ewing	21
Belmont	22
Jersey City 13kV Substation	23
St. Paul's Substation	24
Garfield Place	25
Little Ferry Substation	26
River Edge	27
Howell Substation	28
Cliff Rd Substation	29
Third St Substation	30
Port St Substation	31

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

QUICK CONNECT DEVICES

QUESTION:
Please explain in detail how PSE&G intends to apportion quick connect devices among its customers.

ANSWER:
PSE&G anticipates working with regulators, municipal agencies, police, fire and the Offices of Emergency Management's (OEM) to identify the target customers designated to provide the devices to during a Sandy-like event and anticipates that the target customers may be residential customers with special medical needs.

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

QUICK CONNECT DEVICES WITH GENERATORS

QUESTION:
In his Testimony, page 34, Mr. Cardenas states that the quick connect devices are currently limited to 9.6 kW or less, smaller than any of the units PSE&G plans to stockpile. Given this limitation, what purpose does PSE&G foresee for the quick connect devices?

ANSWER:
Under the Energy Strong Program, a non-PSE&G-owned generator would need to be used with the PSE&G supplied quick connect. PSE&G anticipates working with regulators, municipal agencies, police, fire and OEM's to identify the target customers to provide the quick connect devices to and anticipates that the target customers may, in significant part, involve residential customers with special medical needs.

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

RANKING PROPOSED ENERGY STRONG INVESTMENTS

QUESTION:
Rank the proposed Energy Strong investments from most important to least important. Provide a list of proposed Energy Strong investments to be undertaken assuming the Board allowed a $1 billion, $2 billion, $3 billion, or $3.94 billion program. The question requests specifics not general indications.

ANSWER:
The attached chart shows the project listed in the groupings requested.

Program Grouping	Program	Description	Actions	Program RANK	$1 Billion Program	$2 Billion Program	$3 Billion Program	$3.94 Billion Program
Electricity delivery Infrastructure Resilience Investments	Advanced Technologies	1. This program will utilize new and significantly enhanced technologies, including GIS, OMS, Mobile Solutions, Predictive Analytics, and Advanced Customer Communications solutions to improve storm and emergency response and enhance communications to customers.	**System Visibility** **1a.** Expand implementation of 26kV, 13kV, and 4kV Microprocessor Relays and SCADA field equipment (RTUs) to enable remote operation and position indication of each feeder circuit breaker, provide remote monitoring capabilities including circuit and transformer loading, circuit breaker position, load imbalance, will assist in fault location and more.	1	$ 120	$ 250	$ 250	$ 250
Electricity delivery Infrastructure Resilience Investments	Advanced Technologies	1. This program will utilize new and significantly enhanced technologies, including GIS, OMS, Mobile Solutions, Predictive Analytics, and Advanced Customer Communications solutions to improve storm and emergency response and enhance communications to customers.	**1c**. System to visualize, control, collect and analyze all monitored points from each Distribution station. This includes SCADA monitors and servers, dispatch consoles, communications switches and servers, historical serves with appropriate back-up and redundancy. (DMS)		$ 24	$ 50	$ 50	$ 50
Electricity delivery Infrastructure Resilience Investments	Advanced Technologies	1. This program will utilize new and significantly enhanced technologies, including GIS, OMS, Mobile Solutions, Predictive Analytics, and Advanced Customer Communications solutions to improve storm and emergency response and enhance communications to customers.	**Communication Network** **2a**. High Speed Fiber Optic Network (Backbone)- Transmission - Complete build out equating to approximately 30% of the total system (in-progress). Distribution - Build fiber optic network from (91) of the (125) Distribution substations (Class A, B, C, CN, CS, etc) to facilitate the information transfer from the station to the new DMS system.		$ 35	$ 73	$ 73	$ 73
Electricity delivery Infrastructure Resilience Investments	Advanced Technologies	1. This program will utilize new and significantly enhanced technologies, including GIS, OMS, Mobile Solutions, Predictive Analytics, and Advanced Customer Communications solutions to improve storm and emergency response and enhance communications to customers.	**2b.** Pilot Satellite Communication Program			$ 3	$ 3	$ 3
Electricity delivery Infrastructure Resilience Investments	Advanced Technologies	1. This program will utilize new and significantly enhanced technologies, including GIS, OMS, Mobile Solutions, Predictive Analytics, and Advanced Customer Communications solutions to improve storm and emergency response and enhance communications to customers.	**Storm Damage Assessment (need all items in System Visibility)** **3a**. Advanced Distribution Management System (ADMS) functionality to improve visibility of circuit operations in storm conditions and support restoration of customers. Integration of SCADA, DMS, OMS and GIS.		$ 9	$ 15	$ 15	$ 15
Electricity delivery Infrastructure Resilience Investments	Advanced Technologies	1. This program will utilize new and significantly enhanced technologies, including GIS, OMS, Mobile Solutions, Predictive Analytics, and Advanced Customer Communications solutions to improve storm and emergency response and enhance communications to customers.	**3b.** Enhance Storm Management Systems to improve plant damage assessment process, optimize restoration work plans, integrate mutual aid crews, and develop capability to provide predictive ETRs under complex storm conditions.		$ 50	$ 50	$ 50	$ 50
Electricity delivery Infrastructure Resilience Investments	Advanced Technologies	1. This program will utilize new and significantly enhanced technologies, including GIS, OMS, Mobile Solutions, Predictive Analytics, and Advanced Customer Communications solutions to improve storm and emergency response and enhance communications to customers.	**3c**. Expand communication channels to improve ability to communicate storm-related information to customers. (Outage Map, Mobile App, Preference Management, SMS, Mobile Web)		$ 10	$ 10	$ 10	$ 10
Electricity delivery Infrastructure Hardening Investments	1. Station Flood Mitigation	This program will target appropriate stations for raising infrastructure, building flood walls and revising standards based on new FEMA flood guidelines	Review and identify stations in newly defined FEMA/NJ DEP flood elevations and develop mitigation plans where appropriate. This will include raising/rebuilding infrastructure and installing flood walls.	2	$ 407	$ 819	$ 1,046	$ 1,678
Electricity delivery Infrastructure Resilience Investments	Contingency Reconfiguration Strategies	This program refers to the ability of utilities to recover quickly from damage to any of its components	Establish contingency reconfiguration strategies by creating multiple sections, utilizing smart switches, smart fuses, and adding redundancy within our loop scheme	3	$ 45	$ 111	$ 200	$ 200
Gas Hardening	Metering & Regulating Station Flood Mitigation	This program will target appropriate stations for raising infrastructure, building flood walls and revising standards based on new FEMA flood guidelines	Review and identify stations in newly defined FEMA/NJ DEP flood elevations and develop mitigation plans where appropriate. This will include raising/rebuilding infrastructure and installing flood walls.	4	$ 53	$ 76	$ 140	$ 140
Gas Hardening	Utilization Pressure Cast Iron (UPCI)	This program will consider accelerated UPCI main and associated services and district regulator replacements located within or in proximity of a flood hazard zone.	Replace existing UPCI main and associated district regulators with plastic or coated cathodically protected welded steel. Replace with high pressure and abandon regulators where feasible - 750 miles	5	$ 247	$ 543	$ 806	$ 1,040
Electricity delivery Infrastructure Hardening Investments	2. Outside Plant Higher Design and Construction Standards	This program will involve improvements to design standards to strengthen construction	Change existing 26kV to 69kV standards while still operating at 26kV (this represents 5% of the 26kV infrastructure)	6		$ -	$ 60	$ 60
Electricity delivery Infrastructure Hardening Investments	5. Undergrounding	This program will consider the conversion of OH to UG in selected areas and the replacement of PM equipment with a submersible equivalent in targeted areas	B. Replace PM xfmrs with submersible xfmrs in target areas	7		$ -	$ 8	$ 8
Electricity delivery Infrastructure Hardening Investments	5. Undergrounding	This program will consider the conversion of OH to UG in selected areas and the replacement of PM equipment with a submersible equivalent in targeted areas	C. Replace ATS switches/transformers with submersible switches	8		$ -	$ 8	$ 8
Electricity delivery Infrastructure Hardening Investments	5. Undergrounding	This program will consider the conversion of OH to UG in selected areas and the replacement of PM equipment with a submersible equivalent in targeted areas	A. Convert certain OH areas to UG	9		$ -	$ 60	$ 60
Electricity delivery Infrastructure Hardening Investments	2. Outside Plant Higher Design and Construction Standards	This program will involve improvements to design standards to strengthen construction	Change existing 4kV OP distribution to 13kV standards (this represents 5% of the 4kV infrastructure)	10		$ -	$ 65	$ 65
Electricity delivery Infrastructure Hardening Investments	2. Outside Plant Higher Design and Construction Standards	This program will involve improvements to design standards to strengthen construction	Add spacer cable to eliminate open wire to targeted areas	11		$ -	$ 10	$ 10
Electricity delivery Infrastructure Hardening Investments	6. Relocate ESOC/GSOC/DERC/SR	This program will relocate our critical Electrical & Gas dispatch operating centers to a higher level within the existing building, making it less susceptible flooding, etc.	Relocate critical operating centers	12		$ -	$ 15	$ 15
Electricity delivery Infrastructure Hardening Investments	3. Strengthening Pole Infrastructure	This program will involve accelerated pole replacements, additional construction hardening, including reduced pole span lengths, and increased pole diameters	Accelerate pole replacements including increased pole diameters and reduced span lengths where appropriate. Enhanced storm guying standards	13		$ -	$ 102	$ 102
Electricity delivery Infrastructure Hardening Investments	3. Strengthening Pole Infrastructure	This program will evaluate the use of new non-wood material to replace wood poles in the future.	Non-wood poles	14		$ -	$ 3	$ 3
Electricity delivery Infrastructure Hardening Investments	4. Rebuild/Relocate Backyard poles	This program will consider the relocation and rebuilding of backyard pole lines to front lot and/or UG configuration	Rebuild backyard poles (including tree trimming)	15		$ -	$ 26	$ 100
Supplemental Investment	Emergency Backup Generator and Quick Connect Stockpile Program	PSE&G to purchase and stockpile emergency backup generators to utilize during storm restoration. Technologies exist whereby a connection can be made to a residential customer electric meter which allows the quick connection of a portable generator.	PSE&G to deploy emergency generators to customers based on priorities driven by local municipal officials. In addition, PSE&G will maintain the supply of quick connects to be deployed as directed.	16		$ -	$ -	$ 2
Supplemental Investment	Municipal Pilot Program	To improve resiliency of the electric system, particularly by engaging valuable municipal resources in the event of prolonged outages	Develop a municipal storm plan which addresses vegetation maintenance, mobile field applications and a combined heat and power (CHP) pilot for targeted critical municipal facilities meeting the high efficiency specifications for application of this technology.	17		$ -	$ -	$ -
					$ 1,000	$ 2,000	$ 3,000	$ 3,942

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

TREE RELATED OUTAGES

QUESTION:
On page 1 of 2, in its answer to question S-PSEG-ES-3, midway through the last paragraph, PSE&G states: "Over 2,500 poles were damaged beyond repair and had to be replaced, while over 48,000 locations required trees to be removed or trimmed." Explain why in its Energy Strong Plan, PSE&G proposes solutions to address pole damages but does not propose any solution/actions to address the massive tree related incidences resulting in large amount of customer-hours of outages during the major storms like Hurricane Sandy[1].

[1] Pursuant to the Board's Order, *In the Matter of the Board's Establishment of a Generic Proceeding to Review Costs, Benefits and Reliability Impacts of Major Storm Events; In the Matter of the Board's Review of the Petition of Public Service Electric and Gas Company for Approval of the Energy Strong Program*, Docket Nos. AX 13030197; EO13020155, GO13020156, issued March 20, 2013, pp. 1-2 "Major Storm Event means sustained impact on or interruption of utility service:

1. resulting from conditions beyond the control of the utility, which may include, but are not limited to, thunderstorms, tornadoes, hurricanes, heat waves, snow, and ice storms;
2. which affects at least 10 percent of the customers in an operating area; and
3. due to a utility's documentable need to allocate field resources to restore service to affected areas when one operating area experiences a Major Storm Event, the Major Storm Event shall be deemed to extend to those other operating areas of that utility which are providing assistance to the affected areas."

ANSWER:
PSE&G will meet any tree trimming obligations outside of Energy Strong. Further, the Company has proposed a pilot program in Energy Strong to begin the process to address this issue. Please see the Company's response to RCR-E-82 for details on PSE&G's proposed supplemental vegetation management program.

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

EVALUATION OF SUBSTATION MITIGATION MEASURES

QUESTION:
Regarding the proposed Substation Flood and Storm Surge Mitigation plan stated in the petition (starting at paragraph 15), describe the detailed steps necessary to complete the evaluation of mitigation measures and the project steps/phases; i.e. conceptual design, site investigations, full design, permitting, local municipal steps, through to construction and commissioning. Also, indicate if these mitigation efforts are for flood events only or if they are proposed upgrades/modifications to the substations.

ANSWER:
In accordance with Public Service Electric and Gas Company (PSE&G) Delivery Projects and Construction (DP&C) Processes and Procedures, PSE&G's DP&C organization follows a standardized method of identifying, planning, scheduling, executing and closing out all projects within its project portfolio utilizing established process steps. This ensures comprehensive identification of activities and tasks required, as well as appropriate approvals, detailed planning, and integrated execution of the work to successfully complete all projects.

There are five (5) Phases in the Electric Project Delivery Process. They are:

- Project Initiation
- Preliminary Engineering / Design
- Detail Engineering / Design
- Construction
- Completion

Project Initiation	Preliminary Engineering/Design	Detail Engineering/Design	Construction	Completion
Develop project scope and objectives	Prepare conceptual (70%) estimate	Prepare definitive (90%) estimate	Develop contractual vendor arrangements	Prepare in-service reports
Prepare study level (50%) estimate	Identify/procure long lead time material	Procure all remaining material	Provide site management & project reporting	Assess overall project execution against plan
Develop alternatives & cost estimates to support the business case	Initiate construction as appropriate to meet in-service date	Continue construction as appropriate to meet in-service date	Complete construction to meet in-service date	Conduct final site inspection
Identify & secure resources	Prepare preliminary plans & technical specifications	Prepare detail plans & technical specifications	Complete start-up & commissioning of new facilities	Ensure permit compliance and close-out
Develop budget & preliminary cash flow	Prepare project execution plan	Monitor & manage project execution against schedule and budget	Monitor & manage project execution against schedule and budget	Conduct project review and capture lessons learned
Develop schedules, including key	Monitor & manage project execution against schedule and budget			Complete project close-out

milestones				
Initiate project execution monitoring process				Monitor & manage final project execution against schedule and budget

The DP&C Policies and Procedures prescribe different levels of detail for the activities to be performed in the above table based upon the complexity and magnitude of the project to ensure successful completion of the project and to adhere to any and all regulatory and compliance issues.

The proposed mitigation efforts are for flood events only.

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
FULLY SUBMERSIBLE PADMOUNT TRANSFORMERS

QUESTION:
Regarding the PSE&G response to S-PSEG-ES-23, does the technology currently exist for "fully submersible" padmount transformers? If not, then how does PSE&G plan to proceed with this recommendation?

ANSWER:
The technology is currently being evaluated and tested for deployment in the types of applications proposed by PSE&G. Parts of the padmount transformer currently can be fully submersible. The parts include the transformer tank and the connections on the source side of the transformer. The Company is pursuing several transformer component manufacturers for a reliable and viable option.

In the unlikely event that this technology does not pass expectations, an alternative is that on a cost-effective basis PSE&G would install subway-type transformers. These subway-type transformers are fully submersible and the technology exists. The subway-type proposal would include a raised cost per installation. Subway-type transformers cost more than padmount transformers and are larger. The size of the transformer requires the installation to be in a vault or manhole with a conduit system connection for the source and loads. The installation cost would also be elevated for the added civil engineering and excavation required for the construction of the foundation, vault, manhole, and conduit system.

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
RECOMMENDED FLOOD PROTECTION MEASURE

QUESTION:

SEE QUESTION BELOW MARKED IN BOLD.

ANSWER:
Referring to the executive summary of the Substation Flood Impact Report by Black & Veatch submitted by PSEG in its response to S-PSEG-ES-14, the report reads: "Flood protection measures that were considered consisted of earthen berms, sheetpile barriers and concrete floodwalls. In general, earthen berms were selected for flood protection when sufficient space existed at the substation site as this is the lowest cost alternative, and sheetpile barriers were selected for use at sites where sufficient space does not exist for use of berms. Due to high cost, concrete floodwalls were not selected for any of the sites. Based on the preliminary evaluations, the total estimated cost for providing the recommended flood protection at all sites is $10,115,000 in 2012 dollars."

For each of the 10 substations impacted by Irene that are the subject of the Black and Veatch report, provide the following information in table form as follows:

The tabular information requested is provided below. Also, please see below for a station-by-station breakdown on how each station has been proposed to be mitigated.

Substation	Recommend flood protection measure per Black & Veatch	Estimated Cost per Black and Veatch Report ($M)	Recommended Flood Protection measure per Energy Strong	Estimated Cost per Energy Strong ($M)
New Milford	Sheetpile (or Earthen Berm)**	Earthen Berm - $1.235 Sheetpile - $1.9	Rebuild and Raise	$34
Hillsdale	Sheetpile barrier*	$1.525	Rebuild and Raise	$17
Somerville Sub	Sheetpile (or Earthen Berm)**	$0.450 (or $0.75)	Rebuild and Raise	$17
Jackson Road	Sheetpile (or Earthen Berm)*	$0.67 (or $1.17)	Rebuild and Raise	$30
Rahway Sub	Sheetpile Barrier*	$0.73	Rebuild and Raise	$13
Cranford	Sheetpile Barrier*	$0.525	Eliminate	$67
Ewing	Sheetpile Barrier*	$0.57	Rebuild and Raise	$17
Belmont	Sheetpile Barrier	$0.32	Flood Wall	$3
River Edge	Sheetpile Barrier**	$0.45	Eliminate	$31
Garfield Place	Rehabilitation**	$0.15	Eliminate	$20

NOTE: Garfield Place has been added to this table to reflect the stations in the initial Black & Veatch "Substation Flood Protection" study.

* Subsequent analysis shows that upstream impacts would result from the use of floodwalls at these locations; therefore, floodwalls are not a viable option for these locations.

** PSE&G's view is that a flood wall would not be the most suitable mitigation method for these stations based on PSE&G's experience with flood walls, the cumulative impact of the use of floodwalls on PSE&G's distribution system, and the potential for water intrusion through underground conduits at these locations.

For each substation for which recommended flood protection measures or the cost has changed from the Black & Veatch report to Energy Strong, explain in detail the reason for such changes.

The definition of success of the electric station flood mitigation program is for no customers to lose power due to station flooding. The Black & Veatch study was a targeted study that was focused on the use of flood walls as a mitigation strategy on twelve (12) stations and was commissioned prior to the events of Superstorm Sandy and the subsequent change in FEMA flood map levels. These two factors significantly increased the number of PSE&G customers and the number of stations at risk. During Superstorm Sandy twenty-one (21) stations were impacted and based on the current FEMA flood maps, approximately another sixty-one (61) stations may be at risk.

The events of Superstorm Sandy highlighted the catastrophic impact to PSE&G facilities in the event of a major storm or hurricane. As also discussed in response to subpart a. below, flood walls can be an appropriate measure for some stations but, as PSE&G has learned from actual experience, may not be an appropriate measure for particular sites. In addition, overall impacts on the system, particularly during a storm event, need to be considered in making choices among mitigation methods.

Items to consider in choosing mitigation methods include the fact that flood walls require ongoing maintenance (including maintenance of inflatable ballasts at all egress points), active monitoring during a flood event, and ancillary equipment for the life of the station, which in most cases will be several decades. In addition, for stations that are supplied from underground electric facilities versus overhead, flood walls require technology for duct sealing, dewatering systems (monitoring of pumps and fuel for the pumps), and other sealing methods if the flood wall solution is selected. The ongoing maintenance and the need for manual intervention at a large number of stations in the event of another storm introduces significant overall impact considerations.

PSE&G conducted additional internal engineering review of each option, considering the ability to obtain permits, constructability, the operational and maintenance impacts noted above, restoration impact, and other factors. Recognizing and evaluating these potential factors, PSE&G has reconsidered the recommendations Black & Veatch suggested in their pre-Sandy assessment.

a. For each of the 21 substations identified in Energy Strong as impacted, provide the following information in the table form as follows:

Substation	Recommended Flood Protection Measure per Energy Strong	Estimated Cost of protection measure per Energy Strong ($M)
Sewaren	Rebuild and Raise	$41
Essex	Rebuild and Raise	$41
Hudson*		
Linden	Rebuild and Raise	$19
Bayonne	Rebuild and Raise	$51
Marion	Rebuild and Raise	$25
Newark Airport	Flood Wall	$6
Hoboken	Rebuild and Raise	$35
Marshall Street	Eliminate	$26
River Road**		
South Waterfront	Rebuild and Raise	$25
Bayway	Eliminate	$52
Madison	Rebuild and Raise	$91
Hackensack	Rebuild and Raise	$39
Jersey City 13kV	Rebuild and Raise	$17
St Pauls	Flood Wall	$6
Little Ferry	Flood Wall	$6
Howell	Rebuild and Raise	$17
Cliff Road	Flood Wall	$6
Third Street	Rebuild and Raise	$20
Port Street	Rebuild and Raise	$13

* Hudson does not have any distribution assets and therefore was removed from the list.

** PSE&G has determined that it is appropriate to proceed with mitigation at this station outside of the Energy Strong Program.

For each of the substations above, explain why each lower cost flood protection measure (e.g., Berms and/or sheetpile barriers) was not selected.

As described above, PSE&G believes that for the number of stations, the rebuild and raise, or elimination strategies are the appropriate approaches to prudently and effectively mitigate against future water intrusion events. Additional pre-construction work, such as detailed engineering studies and site evaluations, will confirm or refine these conclusions.

Flood walls can be a good tool in some situations, but factors such as the size of the property involved; the underground facilities that must be moved, circumvented or modified; egress/ingress concerns; previous experience obtaining variances and permits; effectiveness; recurring maintenance; potential infiltration through ducts and conduits; impact of waves requiring very robust designs; and the cumulative system impact of multiple floodwalls needing attention during a storm event, need to be considered.

Below provides additional details as to how PSE&G is proposing to protect each identified station.

New Milford Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $34M

New Milford is located on a large tract of land in New Milford Borough, Bergen County located within the NJDEP Riparian Buffer Zone, and has elevations along the Hackensack River and below the Oradell Dam. The site supplies 230kV to other Transmission stations and supplies 26kV and 13kV to several smaller Distribution stations and customers. This location experienced damage during Hurricane Irene and other water intrusion events. To avoid damaging effects of future storms, three mitigation strategies were considered, and PSE&G believes that the Rebuild and Raise approach is the most effective solution to satisfy the large and diverse nature of this location.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 13kV switchgear consisting of several breakers, disconnect switches, protective relays for the feeders and transformers, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.
- Modifications of existing duct bank systems.
- Installing new13 kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Decommissioning and removal of a 26kV switch rack.
- Removal of existing relay control house including station battery, 13kV switchgear and control cables.
- Removal of foundations for station equipment removed above.

Hillsdale Substation
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $17M

Hillsdale Substation is located on a large tract of land in the Borough of Hillsdale in Bergen County. The Substation is located less than 200 feet from the Pascack Brook with a portion of the site located within the floodway, which comprises the river channel and adjacent floodplain that should be kept free of encroachment in accordance with FEMA recommendations. The site is also located within the NJDEP Riparian Buffer Zone. The site supplies 230kV to other Transmission stations and supplies 26kV to several smaller Distribution stations and 13kV to Distribution customers. T his location experienced damage during Hurricane Irene and other water intrusion events. To avoid damaging effects of future storms, three mitigation strategies were considered, and PSE&G believes that the Rebuild and Raise approach is the most effective solution to satisfy the large and diverse nature of this location.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 13kV switchgear consisting of several breakers, disconnect switches, protective relays for the feeders and transformers, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.
- Modifications of existing duct bank systems.
- Installing new13kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Removal of existing relay control house including station battery, 13kV switchgear and control cables.
- Removal of foundations for station equipment removed above.

Somerville Substation
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $17M

Somerville Substation is located on a large tract of land in Somerville, Somerset County. Somerville Substation supplies 230kV to other Transmission stations and is the power source to transformers that provide 13kV to Distribution customers. T his location experienced water intrusion during Hurricane Irene and other water intrusion events. To avoid damaging effects of future storms, three mitigation strategies were considered, and PSE&G believes that the Rebuild and Raise approach is the most effective solution to satisfy the large and diverse nature of this location.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 13kV switchgear consisting of several breakers, disconnect switches, protective relays for the feeders and transformers, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.
- Modifications of existing duct bank systems.
- Installing new13kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Removal of existing relay control house including station battery, 13kV switchgear and control cables.
- Removal of foundations for station equipment removed above.

<u>Jackson Road Substation</u>
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $30M

Jackson Road Substation is located on a large tract of land in the town of Totowa, Passaic County. The site perimeter is located in close proximity to the limit of the 300 foot NJDEP Riparian Buffer Zone, and should be verified during design. The majority of the site lies within the 500-year flood zone, with small areas at the northwest and southeast corners shown in the 100-year flood zone. Jackson Road Substation supplies 230kV to other Transmission stations and is the power source to transformers that provide 13kV to Distribution customers. This location experienced damage during Hurricane Irene and other water intrusion events. To avoid damaging effects of future storms, three mitigation strategies were considered, and PSE&G believes that the Rebuild and Raise approach is the most effective solution to satisfy the large and diverse nature of this location.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 13kV switchgear consisting of several breakers, disconnect switches, protective relays for the feeders and transformers, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.
- Modifications of existing duct bank systems.

- Installing new13kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Removal of existing relay control house including station battery, 13kV switchgear and control cables.
- Removal of foundations for station equipment removed above.

Rahway Substation
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $13M

Rahway Substation is located in the city of Rahway, Union County adjacent to the Rahway River, located within the NJDEP Riparian Buffer Zone. This station experienced damage during Hurricane Irene and other water intrusion events and was impacted during Superstorm Sandy due to loss of its source. To avoid damaging effects of future storms, three mitigation strategies were considered, and PSE&G believes that the Rebuild and Raise approach is the most effective solution.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- A portion of load is supplied from outdoor switchgear and can be transferred to adjacent stations. This involves pole and wire work outside the station converting approximately 5 miles of existing 4kV circuits to 13kV. The remaining 4kV network feeders will be relocated to an adjacent station.
- Reconfigure the transformer connections to 4kV bus from outside to a different point inside the station. This will require installing new underground cables to get the transformer's secondary into the building.
- Move auxiliary equipment from the basement to higher ground. This will require relocation of 125V DC battery from basement to second floor along with associated station light and power feeds that provide 120/208V power to the building.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Removal of existing outdoor 4kV switchgear, which will include two 4kV capacitors in the rear of the yard, and one 4kV feeder position, and one 4kV transformer position along with associated controls and circuit breakers.
- The existing capacitor bank 4kV feeder breaker position will be utilized and upgraded for the transformer secondary connection.
- Removal of foundations for station equipment removed above.

Cranford Substation
Recommended Mitigation Method: Eliminate
Estimated Cost: $67M

Cranford Substation is located in the town of Cranford, Union County adjacent to the Rahway River. A portion of the Cranford site is located within the floodway, which comprises the river channel and adjacent floodplain that should be kept free of encroachment in accordance with FEMA recommendations. The site is also located within the NJDEP Riparian Buffer Zone. This station experienced damage during Hurricane Irene and other water intrusion events. To avoid damaging effects of future storms, three mitigation strategies were considered, and PSE&G believes that Elimination is the most effective solution.

The flood wall option will create an increase in upstream water surface elevation. By removing, converting and spreading the load amongst many existing stations, the customers once supplied from Cranford will be connected to more resilient supplies and assets will be permanently removed from the floodway and NJDEP Riparian Buffer Zone.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to eliminate the station:

- A portion of load is supplied radially from Cranford Substation and can be transferred to adjacent stations. This involves pole and wire work outside the station converting approximately 55 miles of existing 4kV circuits to 13kV. The remaining 4kV network feeders will be relocated to an adjacent station.
- The installation of new 4kV switchgear consisting of several breakers, disconnect switches, protective relays, DC/AC auxiliary system and large numbers of control cables.
- Installing new 4kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Decommissioning and removal of the Cranford Substation.

Ewing Substation
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $17M

Ewing Substation is constructed in Ewing Township in Mercer County. A portion of the Ewing site is located within the floodway, which comprises the river channel and adjacent floodplain that should be kept free of encroachment in accordance with FEMA recommendations. This location experienced damage during Hurricane Irene and other water intrusion events. To avoid damaging effects of future storms, three mitigation strategies were considered, and PSE&G believes that the Rebuild and Raise approach is the most effective solution.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 4kV switchgear consisting of several breakers, disconnect switches, protective relays for the feeders and transformers, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.
- Modifications of existing duct bank systems.
- Installing new 4kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Removal of existing relay control house including station battery, 4kV switchgear and control cables.
- Removal of foundations for station equipment removed above.

Belmont Unit Substations
Recommended Mitigation Method: Flood Wall
Estimated Cost: $3M

Belmont Substation is constructed in the town of Garfield, Bergen County along the Passaic River. A portion of the Belmont site is located within the floodway, which comprises the river channel and adjacent floodplain that should be kept free of encroachment in accordance with FEMA recommendations. The site is also located within the NJDEP Riparian Buffer Zone. This location experienced damage during Hurricane Irene and other water intrusion events. The Belmont Substation utilizes a unit substation design that provides power to a small geographic area. To avoid damaging effects of future storms, three mitigation strategies were considered, and PSE&G believes that a Flood Wall approach is the most effective solution.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to install a flood wall that meets FEMA flood elevations:

- Flood Impact Study
- Installation of footings and foundations along with pilings if required
- Installation of flood gates
- Dewatering pumping facility with backup power
- Installation of concrete flood wall

River Edge Substation
Recommended Mitigation Method: Eliminate
Estimated Cost: $31M

River Edge Substation is located in River Edge, Bergen County and is located at the confluence of the Hackensack River and the small tributary of Coles Brook. This location experienced damage during Hurricane Irene and other water intrusion events. To avoid damaging effects of future storms, three mitigation strategies were considered, and PSE&G believes that Elimination is the most effective solution. Eliminating this station will remove assets out of floodway, which comprises the river channel and adjacent floodplain that should be kept free of encroachment in accordance with FEMA recommendations. The site is also located within the NJDEP Riparian Buffer Zone.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to eliminate the station:

- The entire station load can be transferred to adjacent stations. This involves pole and wire work outside the station converting approximately 23 miles of existing 4kV circuits to 13kV.
- An adjacent station may have to be expanded.
- Decommission and removal of River Edge Substation

Garfield Place Substation
Recommended Mitigation Method: Eliminate
Estimated Cost: $20M

Garfield Place Substation is located in the town of Wallington, Bergen County. A portion of the Garfield site is located within the floodway, which comprises the river channel and adjacent floodplain that should be kept free of encroachment in accordance with current FEMA recommendations. The site is also located within the NJDEP Riparian Buffer Zone. This station was outfitted several years ago with a flood wall and sump pump to mitigate water intrusion events, which has proven to be ineffective. By eliminating and converting the circuits at this station, the customers once supplied from this station will be fed from a new station that has all the benefits and redundancy offered by a typical 13kV supply.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to eliminate the station:

- The entire station load can be transferred to adjacent stations. This involves pole and wire work outside the station converting approximately 15 miles of existing 4kV circuits to 13kV.
- Adjacent station may have to be expanded.

- Decommissioning and removal of the Garfield Place Substation

Sewaren Switching Station
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $41M

Sewaren Switching Station is located on a large tract of land in Woodbridge Township, Middlesex County situated along the Arthur Kill. The site supplies 230kV and 138kV to other Transmission stations and supplies 26kV to several smaller Distribution stations. Sewaren experienced damage during Superstorm Sandy and the new Advisory Base Flood Elevation (ABFE) reveals high potential flood elevations. To avoid damaging effects of future storms, PSE&G considered three mitigation strategies, and believes that the Rebuild and Raise approach is the most effective solution to satisfy the large and diverse nature of this location.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 26kV switchgear consisting of several breakers, disconnect switches, protective relays for the feeders, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.
- Modification of the existing duct bank system.
- Installing new 26kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Removal of existing relay control house including station battery, 26kV switchgear and control cables.
- Removal of foundations for station equipment removed above.

Essex Switching Station
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $41M

Essex Switching Station is located on a large tract of land in Newark situated along the Passaic River and entrance to Newark Bay. The site supplies 230kV and 138kV to other Transmission stations and supplies 26kV to several smaller Distribution stations. Essex Switching Station experienced damage during Superstorm Sandy and the new Advisory Base Flood Elevation (ABFE) reveals high flood elevations. To avoid damaging effects of future storms, PSE&G considered three mitigation strategies, and believes that the Rebuild and Raise approach is the most effective solutions to satisfy the large and diverse nature of this location.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 26kV switchgear consisting of several breakers, disconnect switches, protective relays for the feeders, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.
- Modification of the existing duct bank system.
- Installing new 26kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Removal of existing relay control house including station battery, 26kV switchgear and control cables.
- Removal of foundations for station equipment removed above.

Hudson Switching Station
Recommended Mitigation Method: Removed from the Energy Strong Program

The Hudson Switching Station, while listed in the original petition, has been removed from the Energy Strong Program.

Linden Switching Station
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $19M

Linden Switching Station is located on a large tract of land in Union County situated along the Arthur Kill. The site contains three stations that currently supply 230kV and 138kV to other Transmission stations and supplies 26kV to several smaller Distribution stations. This location experienced damage during Superstorm Sandy and the new base flood elevation reveals high flood elevations. To avoid damaging effects of future storms, three mitigation strategies were considered, and PSE&G believes that the Rebuild and Raise approach is the most effective solution to satisfy the large and diverse nature of this location.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 26kV switchgear consisting of several breakers, disconnect switches, protective relays for the feeders, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.

- Modification of the existing duct bank system.
- Installing new 26kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Removal of existing relay control house including station battery, 26kV switchgear and control cables.
- Removal of foundations for station equipment removed above.

Bayonne Switching Station
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $51M

Bayonne Switching Station is located on a large tract of land in Hudson County in close proximity to Newark Bay. The site supplies 230kV and 138kV to other Transmission stations and supplies 26kV to several smaller Distribution stations. This location experienced damage during Superstorm Sandy and the new base flood elevation reveals high flood elevations. To avoid damaging effects of future storms, three mitigation strategies were considered, and PSE&G believes that the Rebuild and Raise approach is the most effective solution to satisfy the large and diverse nature of this location.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 13kV switchgear consisting of several breakers, disconnect switches, protective relays for the feeders and transformers, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.
- Modifications of existing duct bank systems.
- Installing new13kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Removal of existing relay control house including station battery, 13kV switchgear and control cables.
- Removal of foundations for station equipment removed above.
- In 26 kV relay house replace all protective relays are raise them above the anticipated high water levels mentioned above.

Marion Switching Station
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $25M

Marion Switching Station is located in Jersey City along the Hackensack River immediately adjacent to Hudson Switching station mentioned above. This location experienced damage during Superstorm Sandy. To avoid damaging effects of future storms, three mitigation strategies were considered, and PSE&G believes that the Rebuild and Raise approach is the most effective solution to satisfy the large and diverse nature of this location.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 26kV switchgear consisting of several breakers, disconnect switches, protective relays for the feeders, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.
- Modification of the existing duct bank system.
- Installing new 26kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Removal of existing relay control house including station battery, 26kV switchgear and control cables.
- Removal of foundations for station equipment removed above.

Newark Airport Breaker Station
Recommended Mitigation Method: Flood Wall
Estimated Cost: $6M

Newark Airport Breaker Station will utilize a flood wall to protect its equipment and customers. The flood wall option satisfies immediate concerns and the flood wall should provide an effective solution until the airport expansion project is completed over the next few years. The current station will serve as a backup to the airport once the expansion project is completed.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to install a flood wall that meets FEMA flood elevations:

- Flood Impact Study
- Installation of footings and foundations along with pilings if required

- Installation of flood gates
- Dewatering pumping facility with backup power
- Installation of concrete flood wall

<u>Hoboken Substation</u>
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $35M

Hoboken Substation is located on a tract of land in Hudson County that is in close proximity to the Hudson River. T his location experienced damage during Superstorm Sandy. To avoid damaging effects of future storms, three mitigation strategies were considered, and PSE&G believes that the Rebuild and Raise approach is the most effective solutions to satisfy the large and diverse nature of this location.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 13kV switchgear consisting of several breakers, disconnect switches, protective relays for the feeders and transformers, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.
- Modification of existing duct bank system.
- Installing new13kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Removal of existing relay control house including station battery, 13kV switchgear and control cables.
- Removal of foundations for station equipment removed above.

<u>Marshall Street Substation</u>
Recommended Mitigation Method: Eliminate
Estimated Cost: $26M

Marshall Street Substation is a substation located in Hoboken, Hudson County that has experienced several water intrusion events over the years. Three flood mitigation methods were considered and PSE&G subsequently determined that eliminating this station and combining the load from this station with the load at a newly raised and rebuilt Madison Street Substation is a long term, sustainable solution.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to eliminate the station:

- The entire station load can be transferred to the adjacent Madison Street station. This involves pole and wire work outside the station converting approximately 19 miles of existing 4kV circuits to 13kV.
- Adjacent station may have to be expanded.
- Decommission and removal of Marshall Street Substation

River Road Substation
Recommended Mitigation Method: Removed from Energy Strong Program
Estimated Cost: $0M

The River Road Substation, while listed in the original petition, has been removed from the Energy Strong Program.

South Waterfront Substation
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $25M

South Waterfront Substation is located in Jersey City, Hudson County situated in close proximity to the Hudson River. The station is supplied by 230kV (currently being expanded) and supplies 13kV to several Distribution circuits. This location experienced water intrusion and damage during Superstorm Sandy. To avoid damaging effects of future storms, three mitigation strategies were considered, and PSE&G believes that the Rebuild and Raise approach is the most effective and technically feasible solution to satisfy the requirements of this location.

Rebuild and raise will be utilized on equipment in the yard and in general will be utilized to protect the 26kV switchgear, control house and utilized in future expansion and upgrade projects.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 26kV switchgear consisting of several breakers, disconnect switches, protective relays for the feeders, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.
- Modification of the existing duct bank system.
- Installing new 26kV cables through new duct to manhole for connection to the grid.

- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Removal of existing relay control house including station battery, 26kV switchgear and control cables.
- Removal of foundations for station equipment removed above.

Bayway Substation
Recommended Mitigation Method: Eliminate
Estimated Cost: $52M

Bayway Substation is located in Elizabeth, Union County in the city controlled floodway. The site is located within the NJDEP Riparian Buffer Zone, and the floodplain is controlled by existing levees along the Elizabeth River, including a large flood gate on the adjacent City of Elizabeth property. This location was affected by Superstorm Sandy, Hurricane Irene and other intrusion events. This station has six 4kV circuits that supply customers in the area. Three flood mitigation options were considered, and PSE&G believes that the elimination of this station is the most prudent, permanent and effective solution.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to eliminate the station:

- The entire station load can be transferred to adjacent stations. This involves pole and wire work outside the station converting approximately 44 miles of existing 4kV circuits to 13kV.
- Adjacent station may have to be expanded.
- Decommission and removal of Bayway Substation.

Madison Street Substation
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $91M

Madison Street Substation is located in a highly populated area of Hoboken in Hudson County. Three flood mitigation options were considered, and PSE&G believes that the Rebuild and Raise approach is the most effective and technically feasible solution to satisfy the requirements of this location. The plan for this station requires extensive planning, coordination and build out, but offers long term, reliable hardening benefits for the whole area. Under the Rebuild and Raise approach at the Madison Street Substation, PSE&G will convert 4kV customers to 13kV and incorporate or transfer customers from the elimination of Marshall Street Substation. This extensive rework and transfer of this area will strengthen and harden and provide long term benefits greater than those that might be gained if walls, rebuild and raise or other flood mitigation methods were used individually at both locations. This location experienced water intrusion and damage during Superstorm Sandy.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 4kV and 13kV switchgear consisting of several breakers, disconnect switches, protective relays for the feeders, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.
- A portion of load is supplied radially from Madison Street Substation and can be transferred to 13kV. This station will be replaced by a new 4kV and 13kV station. This will involve pole and wire work outside the station, 4kV built to 13kV and operated at 13kV.
- Modifications of existing duct bank systems.
- Installing new 4kV and13 kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Removal of foundations for station equipment removed above.

Hackensack Substation
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $39M

Hackensack Substation is located in Bergen County near the Hackensack River. This Substation supports many 4kV circuits and is the main source of power to the surrounding community. To avoid damaging effects of future storms, three mitigation strategies were considered, and PSE&G believes that the Rebuild and Raise approach is the most effective solution to satisfy the large and diverse nature of this location. This station experienced water intrusion and damage during Superstorm Sandy.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 4kV switchgear consisting of several breakers, disconnect switches, protective relays for the feeders and transformers, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.

- Modification of existing duct banks.
- Installing new 4kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Removal of existing relay control house including station battery, 4kV switchgear and control cables.
- Removal of foundations for station equipment removed above.

Jersey City Substation
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $17M

Jersey City Substation is located in Jersey City, Hudson County in close proximity of the Hackensack River. All three flood mitigation options were considered. The relocate and eliminate options were found to be impractical due to limited access to suitable land and limited load carrying capabilities of nearby stations to pick up load if elimination was necessary. This station experienced water intrusion and damage during Superstorm Sandy.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 13kV switchgear consisting of several breakers, disconnect switches, protective relays for the feeders and transformers, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.
- Modifications of existing duct bank system.
- Installing new13kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Removal of 13kV switchgear and control cables.
- Removal of foundations for station equipment removed above.

Saint Paul's Unit Substation
Recommended Mitigation Method: Flood Wall
Estimated Cost: $6M

Saint Paul's Unit Substation is located in Jersey City along the Hackensack River. The Substation will utilize a flood wall system. The Substation utilizes a unit substation design that provides power to a small geographic area. This station experienced water intrusion and damage during Superstorm Sandy.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to install a flood wall that meets FEMA flood elevations:

- Flood Impact Study
- Installation of footings and foundations along with pilings, if required
- Installation of flood gates
- Dewatering pumping facility with backup power
- Installation of concrete flood wall

Little Ferry Unit Substation
Recommended Mitigation Method: Flood Wall
Estimated Cost: $6M

Little Ferry Substation is located in the town of Little Ferry in Bergen County. The Little Ferry Substation utilizes a two unit substation design that provides power to a small geographic area. This location was affected by Superstorm Sandy. The solution for this small station will be to install a flood wall system at the station.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to install a flood wall that meets FEMA flood elevations:

- Flood Impact Study
- Installation of footings and foundations along with pilings, if required
- Installation of flood gates
- Dewatering pumping facility with backup power
- Installation of concrete flood wall

Howell
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $17M

Howell is located in Jersey City, Hudson County in close proximity of the Hackensack River. This location was affected by Superstorm Sandy. A ll three flood mitigation options were considered. The eliminate options were found to be impractical due to limited access to suitable land and limited load carrying capabilities of nearby stations to pick up load if elimination was necessary.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 4kV switchgear consisting of several breakers, disconnect switches, reactors, protective relays for the feeders and transformers, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.
- Modifications of existing duct bank system.
- Installing new 4kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Removal of 4kV switchgear and control cables.
- Removal of foundations for station equipment removed above.

Cliff Road Unit Substation
Recommended Mitigation Method: Flood Wall
Estimated Cost: $6M

The Cliff Road Unit Substation is located in Sewaren, Middlesex County. The Substation will utilize a flood wall system. The Substation utilizes a unit substation design that provides power to a small geographic area. This location was affected by Superstorm Sandy.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to install a flood wall that meets FEMA flood elevations:

- Flood Impact Study
- Installation of footings and foundations along with pilings, if required
- Installation of flood gates
- Dewatering pumping facility with backup power
- Installation of concrete flood wall

Third Street Substation
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $20 M

Third Street Substation is a Distribution substation located in South Kearny, Hudson County far from the Passaic River. This Substation supports many 4kV circuits and is the main source of power to the surrounding community. To avoid damaging effects of future storms, three mitigation strategies were considered, PSE&G believes that the Rebuild and Raise approach is the most effective solution to satisfy the large and diverse nature of this location. This location was affected by Superstorm Sandy.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 4kV switchgear consisting of several breakers, disconnect switches, reactors, protective relays for the feeders and transformers, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.
- Modification of existing duct banks within the station property.
- Installing new 4kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.
- Removal of existing relay control house including station battery, 4kV switchgear and control cables.
- Removal of foundations for station equipment removed above.

Port Street Substation
Recommended Mitigation Method: Rebuild and Raise
Estimated Cost: $13M

Port Street Substation is located in the city of Newark, Essex County in close proximity to Newark Bay. This station experienced damage during Superstorm Sandy. To avoid damaging effects of future storms, three mitigation strategies were considered, and PSE&G believes that the Rebuild and Raise approach is the most effective solution.

The project scope at this station includes the detailed engineering, design, procurement, permitting, and construction of the following major equipment and activities required to rebuild and raise equipment above FEMA flood levels:

- The installation of a new pre-fabricated control house on an elevated foundation, which includes 4kV switchgear consisting of several breakers, disconnect switches, reactors, protective relays for the feeders and transformers, DC/AC auxiliary system and large numbers of control cables. Each of these wires must be carefully terminated to ensure proper relay protection and control of equipment.
- Modification of existing duct banks within the station property.
- Installing new 4kV cables through new duct to manhole for connection to the grid.
- Upon completion of installation, a thorough testing and check out of new control systems is required, followed by a phased transfer of facilities to ensure continuity of service to customers.

- Removal of existing relay control house including station battery, 4kV switchgear and control cables.
- Removal of foundations for station equipment removed above.

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

FLOOD PLAN PRIORITIZATION

QUESTION:
Page 56 of the January 23 Order states that, within 120 days of the Order, the "EDCs shall prepare a report, to be submitted to the Board that prioritizes the EDCs' proposed responses to various levels of potential flooding at each substation and switching station at risk of flooding." Additionally, "alternative response levels to various levels of encroachment" must be provided, including "the use of variations of so-called smart grid technologies that would provide greater flexibility to react to various flooding emergencies on the system."

A. What smart grid technologies has PSE&G deployed or does it plan to deploy in respect to this Order? Please provide information about proposed plans and any and all associated documents, including but not limited to the type, timeframe, rationale, cost, and contemplated deployment area of each smart grid technology.

B. Does PSE&G plan to deploy pilot projects in respect to the use of "smart grid technologies" to provide "greater flexibility to react to various flooding emergencies?" If so, please discuss all such plans and provide any and all relevant documents relating to these plans.

C. Please supply a copy of the plan requested at page 56 of the January 23 Order and any and all relevant documents concerning the above.

ANSWER:
Attached is PSE&G's response to this element of the BPU's Order of January 23, 2013 in the Hurricane Irene Investigation. See also the response to S-PSEG-ES-79.

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

FLOOD PLAN PRIORITIZATION

QUESTION:
The EDCs shall prepare a report, to be submitted to the Board that prioritizes the EDCs' proposed responses to various levels of potential flooding at each substation and switching station at risk of flooding (up to and including the levels of water encroachment that occurred in both Hurricane Irene and Superstorm Sandy).

Alternative response levels to various levels of encroachment shall include, but not be limited to hardening measures including (1) sandbagging (2) raising certain facilities in the substation or switching station to higher levels, (3) constructing flood walls around the stations, (4) raising the level of the station and (5) moving the station to higher ground. Other response measures to be considered shall include: (1) the feasibility of adding redundancy to portions of the system; and (2) the use of variations of so-called smart grid technologies that would provide greater flexibility to react to various flooding emergencies on the system. The Report shall include cost benefit analyses for each alternative considered taking into account the likelihood of each considered event, the effectiveness of each alternative considered and the cost of each measure.

ANSWER:
PSE&G has filed a detailed Program in the Energy Strong filing that sets forth PSE&G's proposals related to this question. The "Station Flood and Storm Surge Mitigation" section in the filing has identified stations which could benefit from flood and/or storm surge mitigation, including those which are located within the newly defined Federal Emergency Management Agency (FEMA) Advisory Based Flood Elevations (updated January 2013) and the existing fluvial (river) FEMA 100-year flood plain Base Flood Elevation (BFE) established in the early 1970s. The Company has identified twenty one (21) stations impacted by Superstorm Sandy, and thirteen (13) stations impacted by Hurricane Irene and prior water intrusion events. PSE&G also has identified sixty one (61) additional stations (most of which were in service prior to the 1970s) falling within the FEMA Based Flood Elevations some of which may require flood and/or storm surge mitigation. Many of these stations are located along the Delaware River as far south as Camden and Gloucester counties.

The Energy Strong filing proposes hardening and resiliency initiatives that will strengthen the delivery system. Resiliency refers to the ability of PSE&G to recover quickly from damage to any of its components. In the filing, two sub-programs, Advanced Technologies and Contingency Reconfiguration Strategies, are designed to increase the resiliency of the electric delivery infrastructure and require an investment of $651 million over ten years. The Advanced Technologies' sub-program includes programs that will provide "System Visibility", "Improvements to Communication Network to Better Address Storm Impacts" and "Storm Damage Assessment" utilizing new and significantly enhanced technologies, including the Geographic Information System (GIS), the Outage Management System (OMS), Supervisory

Control and Data Acquisition (SCADA) and Predictive Analytics. These sub-programs will improve storm and emergency response and enhance customer restoration.

Station Flood and Storm Surge Mitigation
The Energy Strong filing has identified three effective mitigation options to be employed to mitigate the damaging effects of future flooding events. The options include the installation of Flood Walls such as sheetpile barriers or earthen berms, Raise and Replace, or Relocate/Eliminate those impacted stations. Each option defines an approach that will help to mitigate the impact of future storms.

Flood Walls
Overall, the installation of flood walls is likely to be the least costly mitigation option. PSE&G estimates that the total time from project initiation to completion of flood wall construction is approximately 12 to 18 months for a typical station, that time frame being driven primarily by local and state permitting requirements. Where flood walls cannot be installed due to constructability issues or technical reasons the Raise and Replace option would be utilized.

Raise and Replace
Where Flood Walls are not an appropriate mitigation method, Raise and Replace would be the next choice. The Raise and Replace option considers local conditions at existing stations to determine whether infrastructure, including control houses, transformers, breakers, and feeder rows can be raised above potential flood levels. PSE&G estimates that the entire project span from project initiation to completion for a single raise and replace infrastructure project is approximately 24 months. In some instances the Raise and Replace option may not be the optimal solution due to cost and electric system configuration considerations. In those situations, Relocation/Elimination would be considered.

Relocation/Elimination
Where Flood Walls and Raise and Replace methods are determined to be an inappropriate mitigation measure for a station, Relocation or Elimination is the next choice. Relocation of existing stations requires adequate parcels of buildable land that are capable of housing a complete substation. Although relocation is possible and in some cases the best option it is usually the most costly and difficult to implement. PSE&G estimates that the entire project span from project initiation to completion for a typical relocation project would take approximately 30-36 months. Elimination of a station is also an appropriate option in some instances but it requires adequate electric capacity at another station so that customers could be transferred to the new station.

Prioritization of Stations
The Energy Strong filing proposes that mitigation work first begin at stations impacted by Superstorm Sandy, Hurricane Irene and previous water intrusion events. Impacted stations were prioritized into three categories (high, medium and low) based on the magnitude of previous flooding or tidal surge events at that station, and the number of customers likely to be affected by a future event. In addition, the Company has identified sixty one (61) other stations that need to be further assessed for potential flood mitigation solutions. Many of these stations are located

along the Delaware River as far south as Camden and Gloucester counties. The benefit associated with the eleven (11) high priority stations listed below, will provide flood mitigation to approximately 130,000 customers. Implementing the Energy Strong Program in its entirety throughout PSE&G's service territory will provide system wide benefits to all 2.2 million PSE&G electric customers.

Stations Impacted by Sandy

Priority	Station
High	Sewaren 230/138/26kV
High	Essex 230/138/26kV
High	Hudson 230kV
High	Linden 230/138/26kV
High	Bayonne 138/26/13
High	Marion 138/26kV
High	Newark Airport Bkr Station**
Medium	Hoboken
Medium	Marshall St
Medium	River Rd
Medium	South Waterfront
Medium	Bayway
Medium	Madison
Medium	Hackensack
Low	Jersey City 13kV
Low	St Paul's
Low	Little Ferry
Low	Howell
Low	Cliff Rd
Low	Third St
Low	Port St

Stations Impacted by Irene and Other Water Intrusion Events

Priority	Station
High	Marion 138/26kV
High	New Milford
High	Hillsdale
High	Somerville Substation
High	Jackson Road
Medium	Rahway Substation
Medium	Cranford
Medium	Bayway Sw./Sub.
Medium	Marshall St
Low	Ewing
Low	Belmont
Low	Garfield Place
Low	River Edge

** As a result of temporary measures taken prior to Superstorm Sandy, this breaker station was not impacted by storm surge, and is therefore not included in the total number of station outages resulting from the storm.

Contingency Reconfiguration Strategies

In a typical 13-kV loop scheme, loss of any section of the loop results in a loss of only a portion of the total customers fed from that circuit. As an example, assume there are 1,000 customers in each section of the loop for a total of 4,000 customers. In the traditional loop design, a failure in one section will result in the loss of 1,000 customers. Utilizing the reconfiguration strategy and by deploying additional feeder reclosers to traditional 13-kV loops will reduce customer outages in proportion to the number of reclosers installed. Using the above example, if two additional reclosers are installed in an existing loop the resulting outages will be reduced from 1,000 customers to 670 customers (a 33% improvement). PSE&G estimates this program will take five years for full implementation with an investment of $200 million. However, there are incremental benefits as phases of the program are executed.

Advanced Technologies

System Visibility

Microprocessor Relays and SCADA Field Equipment:
PSE&G proposed in Energy Strong to expand the implementation of 26-kV, 13-kV, and 4-kV microprocessor relays/smart devices and SCADA field equipment /RTUs. This proposed ten year program, which can be accelerated, will replace a significant number of relays and will include the installation of RTUs in every station at a cost of approximately $250 million. However, there are incremental benefits as phases of the proposed program are executed.

Distribution Management System (DMS):
In the Energy Strong filing, the Company proposed a DMS, which will visualize, control, collect and analyze all monitored points from each distribution station through the development and implementation of circuit and station automation. Microprocessor relays/smart devices, RTUs, automatic circuit reclosers (ACR), automation sectionalizing and restoration (ASR), advanced Voltage/VAR control, network protection/monitoring/control, remote fault detection, equipment health sensors and outage detection devices are proposed to be utilized. Together with the Communication Network described below, the proposed DMS would permit rapid diagnosis of circuit conditions during severe weather events from remote locations. PSE&G has over 200 substations in operation, all of which have some level of SCADA. Approximately 100 of these stations have full capability SCADA while the remaining stations have lesser capabilities. This proposed project will involve the enhancement of those stations with lesser capabilities. The first phase of this proposed project will be the enhancement of 100 stations without full SCADA capability. The proposed upgrades will involve a detailed site specific design, material procurement, major modifications to relay and control systems, coordination of circuit outages and system testing to implement the required modifications. In addition to the proposed modifications at the station, full SCADA capability, as proposed, will require an enhanced communication system utilizing either a PSE&G installed fiber network or a virtual private network provided by a telecommunication provider. Due to the complexity of these installations, PSE&G estimates that approximately 10 substations can be upgraded in a calendar year. PSE&G estimates that each station will require approximately 6 to 9 months to complete. For full implementation the proposed program will be coordinated with the installation of microprocessor relays/smart devices and SCADA field equipment/RTUs over ten years, which can be accelerated, and at an investment of $50 million. However, there are incremental benefits as phases of the proposed program are executed.

Improvements to Communication Network to Better Address Storm Impacts

High Speed Fiber Optic Network:
As part of its Energy Strong filing, the Company proposed to install communications infrastructure to support the System Visibility efforts described above. The information collected

from distribution feeders and circuits needs to be routed to the DMS system. The most cost effective approach is to eliminate reliance on outside communication providers and install fiber optic cables between the existing distribution infrastructure and the nearest transmission substation, which is generally less than eight miles. If difficulties are encountered with dedicated fiber optic cables, communications using bulk communications providers can still be used. The system is proposed to be built in coordination with installation of microprocessor relays/smart devices and SCADA field equipment and the upgrading of stations. The program, as proposed, will take ten years, which can be accelerated, for full implementation with an investment of $73 million. However, there are incremental benefits as phases of the proposed program are executed and recognized as each circuit is completed.

Satellite Communications:
In its Energy Strong filing, the Company proposed to implement a pilot satellite communications system to serve as a back-up communications system to the dedicated fiber optic infrastructure or to the bulk communications providers. The Company estimates this proposed program will take approximately five years for implementation with an investment of $3 million.

Storm Damage Assessment

Advanced Distribution Management System:
In its Energy Strong filing, the Company proposed to develop an Advanced DMS (ADMS), an enhancement of the DMS described above, to incorporate additional data sources such as outage information, intelligent fault indicators, and add-on analysis applications such as load flows and state estimations for data accuracy. ADMS provides tools for dynamic visualization, monitoring and control of the electricity distribution network, together with a wide set of power applications for operations analysis, planning and optimization. The system assimilates data from Geographic Information System and SCADA systems. ADMS will provide efficient management of faults and voltage improvements; real-time network monitoring and control; incident management to assist in damage location identification; mathematical network modeling and power applications; network analysis; reduction of system losses through Volt/Var controls; and improvement of power quality and customer services. The program is expected to coincide with System Visibility efforts, and PSE&G has proposed a ten year plan, which can be accelerated, with investment of $15 million for implementation.

Enhanced Storm Management Systems:
In its Energy Strong filing, the Company proposed to enhance its storm management system by developing an integrated mobile plant damage field application to capture plant damage information, such as location, asset information and pictures, and electronically transfer that information back to the OMS system. PSE&G is interested in exploring how best to work with municipalities in its service territories to optimize the use of these mobile field applications by training Department of Public Works, Police, and Fire Department employees to use the applications during extraordinary events. Municipal workers can potentially support PSE&G's efforts to gather information on outages, clear roads and restore service more quickly. By enhancing and improving these storm management systems, PSE&G would be able to reduce risk, improve customer communications and satisfaction, and shorten customer outage durations.

PSE&G has proposed a four year plan to implement this program with an investment of $50 million. However, there are incremental benefits as phases of the program are executed.

Expand Communication Channels:
In its Energy Strong filing, the Company proposed to expand and enhance its ability to communicate storm-related information to customers. The investment includes enhancement of existing web functionality to improve viewing on mobile devices, expansion of communication in the form of a new Mobile Application, adding two-way SMS (texting) capabilities, and permitting customers to choose the notifications they wish to receive and how they want to receive them. Also included in this plan are major enhancements to customer outage maps. These channels would provide improved mechanisms to communicate storm-related information to customers when they need it most. PSE&G has proposed a three year program for full implementation with an investment of $10 million. However, there are incremental benefits as phases of the program are executed.

In PSE&G's response to S-PSEG-ES-2in the Energy Strong Docket, the cost benefits for each sub-program of Energy Strong are calculated. A copy of this response is attached.

PUBLIC SERVICE ELECTRIC AND GAS COMPANY

COST-BENEFIT ANALYSES

QUESTION:
Cost-Benefit

a. Would the Company be willing to commit to preparing cost benefit analyses and studies associated with each Energy Strong projects before they are approved by the Board or construction is begun by the Company?
b. If the response to (a) is affirmative, please provide a detailed description of the cost/benefit studies that would be performed, the factors that would be examined, and how they would be presented to the Board and other stakeholders.
c. If the response to (b) is not affirmative, please explain in detail why the Company would be unwilling prepare and present to the Board and other stakeholders cost/benefits studies associated with its proposed Energy Strong projects.
d. If the Company has conducted any studies comparable to those described in (a), in connection with any of the Energy Strong programs, please provide these documents and please provide any and all workpapers in electronic spreadsheet form, with all links and formulas intact, source data used, and explain all assumptions and calculations used. To the extent the data requested is not available in the form requested, please provide the information in the form that most closely matches what has been requested.

ANSWER:
a. The Company is having work of this nature undertaken by the Brattle Group of Cambridge Massachusetts and will provide a copy of that study upon its completion.
b. The study, when finalized and provided, will detail its methodologies.
c. N/A
d. All such material has been provided in previous responses. See PSE&G responses to S-PSEG-ES-2 and S-PSEG-ES-52.

RESPONSE TO STAFF
REQUEST: S-INF-3
WITNESS(S): CARDENAS

ENERGY STRONG PROGRAM

PUBLIC SERVICE ELECTRIC AND GAS COMPANY
SUBSTATION PLANS

QUESTION:
How many substations does PSE&G anticipate addressing in the next 5 years without Energy Strong?

ANSWER:
No specific number of stations are planned or anticipated without Energy Strong. Without Energy Strong, PSE&G plans to provide incremental improvements in stations over time based upon equipment failures or assessments or as needed to coordinate with other projects. As noted in S-PSEG-ES-79, PSE&G has determined that it is appropriate to proceed with the mitigation at the River Road Substation outside of the Energy Strong Program. See also response to RCR-E-13.