# BENEFICIAL USE OF DREDGED MATERIAL TO RESTORE WETLANDS FOR COASTAL FLOOD MITIGATION BARNEGAT BAY, NEW JERSEY

**Prepared for:**

**The State of New Jersey**
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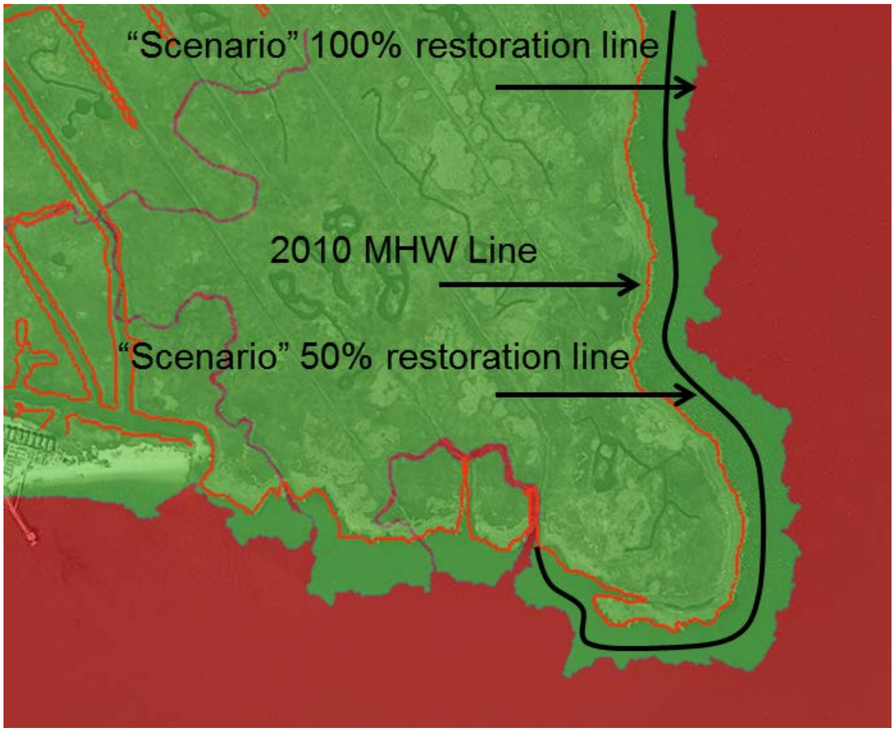
# Summary:

The Richard Stockton College Coastal Research Center (CRC) and the Monmouth University Urban Coast Institute (UCI) have completed a reconnaissance –level project to determine if there is a relationship between selected areas of intertidal wetland (i.e. *Spartina alterniflora* salt marsh) ***edge erosion*** along the mainland shoreline of Barnegat Bay and nearby state channels as well as other waterways in need of dredging which were shoaled as a result of Hurricane Sandy. The goal of the project is to identify eroded edges of intertidal wetlands that can be restored to pre-existing conditions can be defined as using sediment dredged from the shoaled state navigation channels in an effort to reduce future flood risk to adjacent coastal development. Pre-existing conditions refer to the extent of intertidal wetlands (i.e. salt marsh) as of the establishment of the New Jersey tidelands "claim line". The New Jersey Department of Environmental Protection (NJDEP, 2013) states that, "*the Tidelands claims line depicts areas now or formerly flowed at or below mean high tide. Since the mean high water line may change because of rises in sea level, the line does not represent the current mean high water line. Rather it depicts the mean high water line at the time of mapping and the historic mean high water line predating artificial alterations.*" Generally speaking, if the edge of an intertidal marsh has eroded landward of the established tidelands claim line (tidal waters are now present where marsh has eroded), that area of eroded marsh between the established tidelands claim line (pre-existing mean high water line) and the existing mean high water line (MHW) could potentially receive dredged material to restore the intertidal marsh to the tidelands claim line (Figure 1).

**Figure 1. Example of tidelands claimed (red) and unclaimed (green) lands compared to 2010 MHW line (red line). The area between the 2010 MHW line and the tidelands claim line (boundary between red and greed areas) represents the 100% restoration scenario (that area is currently covered by water). The area between the black line and the 2010 MHW line represents the 50% restoration scenario.**



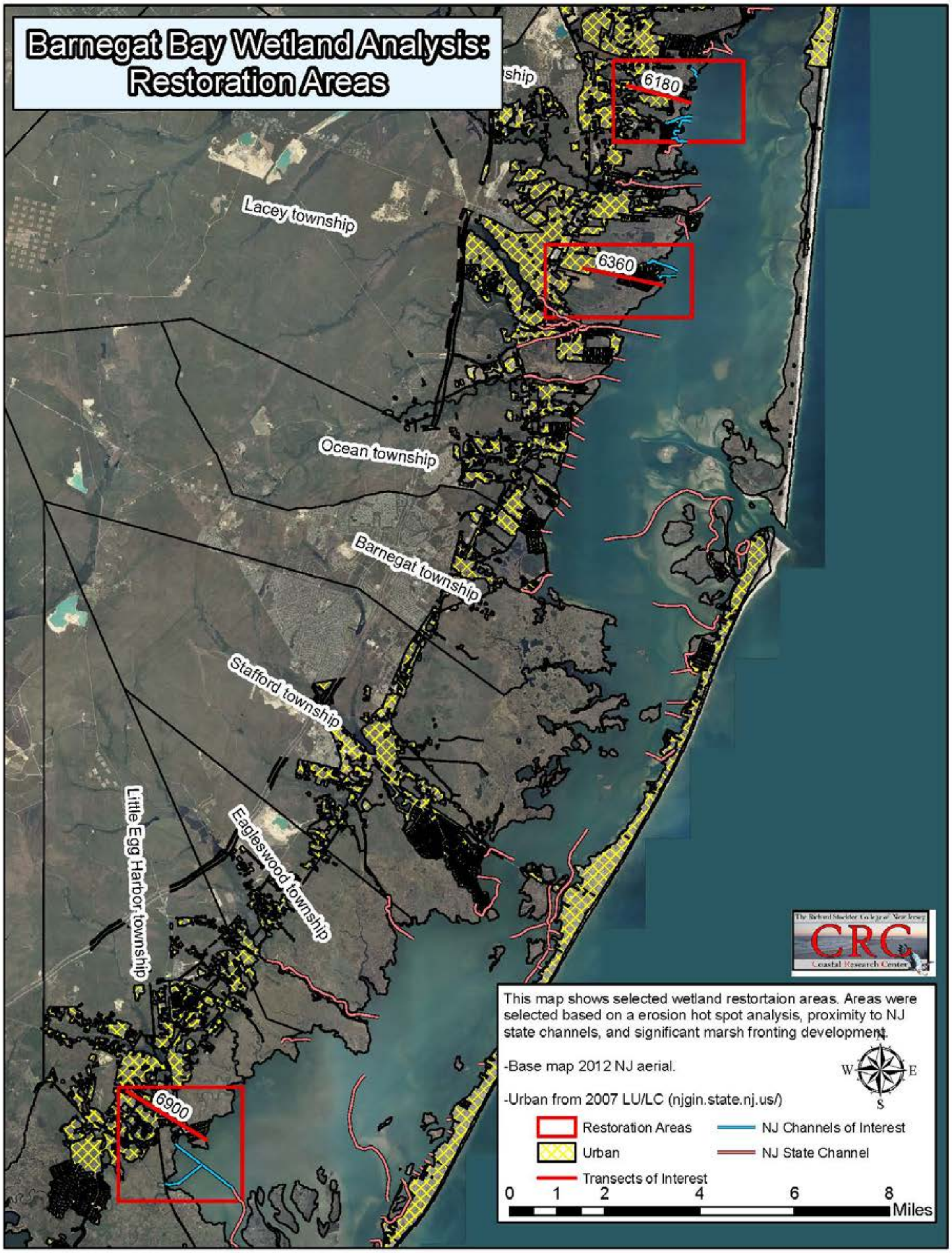
There are two common methods for using dredged sediments for intertidal wetland enhancements: (1) hydraulically spraying a thin layer of fine-grained sediments to raise the elevation of a degraded marsh and (2) creation/restoration of a pre-existing eroded marsh footprint by pumping dredged sediments into a diked area (Broome, 1989; Colenutt, 2001; Ray, 2007). As Ray (2007) suggests, calculating appropriate thickness for thin-layer application requires an understanding of desired/target elevations, but also the type of sediment that will be utilized, the extent of dewatering, and sediment compression. The CRC/UCI study is a basic assessment that focuses on marsh edge restoration. While thin-layer application has been implemented along the Gulf and Atlantic coasts of the United States (Ray, 2007), this study focuses on restoration of marsh edge in intertidal wetland areas proximal to development. The goal here is to reduce future flood damages in coastal communities that are caused by storm surge and wave energy. Restoration of eroded marsh edge will require the installation of in-water containment dikes and backfill confined areas to existing marsh elevations. It is assumed herein that increasing the footprint (expanding the seaward edge of the mainland intertidal marsh) adjacent to development will increase the distance from storm-related surge and wave energy, thus reducing flood damages in a coastal storm event. Since this is a reconnaissance-level investigation, it should be noted that future site-specific studies will be necessary to implement an intertidal marsh restoration project using dredged material and include sediment analysis, containment options, etc. Additionally, the scope and level of this study did not allow the project team to account for the effects of future sea-level rise on intertidal marsh or how repetitive marsh restoration efforts using dredged material can influence future intertidal marsh growth or degradation in the study area (i.e. Barnegat Bay, New Jersey). The project team feels these research questions should be addressed in future assessments. This study is a “snapshot” in time to understand how restoring intertidal marsh in Barnegat Bay to its former extent can reduce flood damages from coastal storm events while beneficially reusing dredged material.

The Barnegat Bay Partnership’s “State of the Bay” report (2011) identified significant areas of intertidal and freshwater wetlands as “degraded” since 1995. Utilizing dredged material to enhance intertidal wetlands within Barnegat Bay is timely due to the ever decreasing capacity of the state’s confined disposal facilities (CDFs) to accommodate increased dredging needs from sedimentation within the state’s channels (Farrell et al., 2009). Additionally, utilizing dredged material for wetland enhancement has been identified as a primary beneficial use for New York-New Jersey Harbor (Yozzo, Wilber & Will 2004). The intertidal wetlands within Barnegat Bay are an important natural resource that provides ecological benefits including habitat and nursery sites for multiple shore birds, juvenile fish and shellfish (Zedler, Kercher 2005). Intertidal wetlands are also important because they can potentially act as buffers from storm surge and storm-generated waves within the Bay that have an impact on adjacent development. This natural buffer can reduce coastal flood risk (King, Lester 1995). Hurricane Sandy demonstrated devastating impacts to New Jersey’s coastal development and infrastructure and exposed the many vulnerabilities our communities face in coastal storm events. It is imperative that new approaches to reduce coastal flood risk be investigated to increase resilience of the New Jersey coast in the future.

Hurricane Sandy produced two distinct types of shoaling in the coastal waterways and lagoons of New Jersey, and primarily in Barnegat Bay. These included: (1) Direct wave overwash of the barrier islands that deposited sand in the Bay adjacent to the islands and (2) tidal surge current velocities and waves generated by the fierce storm winds re-mobilized finer bay floor sediments and moved it to problematic locations.

Following Hurricane Sandy, the New Jersey Department of Transportation-Office of Maritime Resources (NJDOT-OMR) coordinated an effort to collect bathymetric data within all of the State’s 209 navigation channels to determine the extent of shoaling. As a result of this effort, the NJDOT identified the amount of sediment needed to be dredged from each state channel (Parsons Brinckerhoff, 2013). In this study, CRC calculated sediment volumes required for marsh edge restoration within three specific areas along Barnegat Bay’s mainland (western) shoreline where there has been significant intertidal marsh-edge erosion relative to the Tidelands Claim Line and where eroded intertidal marsh fronts development. These areas are found within Berkeley Township, Lacey Township, and Tuckerton, NJ. The CRC also identified proximal state channels to these three areas that can provide sufficient amounts of sediment for marsh edge restoration (Figure 2). Table 2 lists the state channels analyzed within each restoration area.

**Figure 2. Barnegat Bay, NJ study area. Red boxes highlight three selected areas where there has been marsh-erosion within 1000-feet of development and where a significant amount of marsh is directly seaward of development.**



In order to determine where marsh edge restoration using dredged material would be beneficial along the mainland shoreline of Barnegat Bay for flood risk reduction, two marsh-edge restoration scenario digital elevation models (DEMs) were created based on the FEMA-provided 2010 DEM used for the recent NY/NJ Coastal Flood Study. Scenario DEMs generated by the CRC represent 50% and 100% restoration for the marsh-edge relative to the NJ tidelands claim line. Using these scenario DEMs, the CRC utilized FEMA's CHAMP (Coastal Hazard Analysis Modeling) and HAZUS (Hazards-US) modeling software to determine if there would be any significant reduction in overland wave heights, storm surge, and resulting damages (in dollar amounts) relative to a 1-percent annual chance storm. Utilizing data provided by FEMA Region 2, the CRC identified 6 transects used for overland wave modeling in the Coastal Flood Study along the mainland shoreline of Barnegat Bay where eroded tidal marsh was directly seaward of development (Figure 3). The HAZUS-MH model was applied for one area to see if there were any major differences in flood damages (in dollars) between the original DEM and the 100% restoration scenario.

The costs associated with tidal marsh-edge restoration were difficult to calculate since this type of work has never been completed within the state of New Jersey. Currently, the NJDOT is using a fixed cost per cubic yard of $25 (personal communication) to account for a multitude of placement options including hydraulic placement within Confined Disposal Facilities (CDFs), hydraulic upland placement and trucking to landfills, and wetland enhancement (thin-layer application and marsh-edge restoration). Cost breakdowns are unknown at this point, however it is assumed that costs would be less when reducing distance to placement or "double-handling" sediment (dewatering at a temporary upland location, then trucking to landfill). The cost differences between CDF placement and marsh-edge restoration may be similar since CDF maintenance is often needed to increase berm elevations and improve weir structures. Costs for marsh-edge restoration would include installing in-water containment dikes (hay bales, for example) and Spartina seed (if deemed necessary where low recruitment exists). A more thorough investigation would be needed to determine cost per cubic yard for each method since the current cost of dredging per cubic yard established by the state includes various placement options. The cost will ultimately depend on the location of channel being dredged relative to the dredged materials' final placement location.

## Literature Review:

Dredging waterways can be very costly for governments. The process often requires that dredged material that has been determined to contain toxins in excess of allowable Environmental Protection Agency (EPA) thresholds must be disposed of carefully and in accordance with EPA guidelines. This can mean that municipalities have to dispose of such material offsite and at times at great distance and cost. The legal parameters are complex and geographically-specific. For instance, dumping dredged materials in the ocean is statutorily regulated by the Marine Protection, Research and Sanctuaries Act and EPA regulates the process of ocean dumping though its Ocean Dumping Regulations (US EPA, 2012). Furthermore, the dumping of dredged material in inland waters and the territorial sea (12 nautical miles seaward from baseline) falls under the Clean Water Act statutory regulations. Many states regulate the dumping of dredged material on land through state-run departments of environmental quality/protection. These regulatory landscapes make dredging and the use and disposal of dredged material considerable tasks beyond the physicality of removing material from the seafloor. Dredged material which meets or surpasses EPA standards is useful in restoring coastal features. The use of dredge material to reestablish tidal and salt marshes is a common practice in California, North Carolina, Texas, and elsewhere in the United States (Zedler, 2000).

Use of dredged materials is sanctioned by the US Army Corps of Engineers (USACE) as well as Congress. The Rivers and Harbors Act of 1970 directed the USACE to study the effects of dredging and dredged material on ecosystems and provide recommendations for improving the quality of the environment in the overall public interest (USEPA, 2007). The Rivers and Harbors Act allowed the USACE to establish a program that examined “the effects of dredging and dredged material placement on fish and wildlife habitats and developed recommendations for how those habitats could be enhanced or created with dredged material”(Yozzo, Wilber, & Will, 2004). The USACE currently allows the following uses of dredged material: creation of artificial reefs and shoals; oyster reef restoration; bathymetric recontouring; creation/restoration of intertidal marshes and mudflats; filling dead-end basins and canals; creation of bird/wildlife islands; remediation/creation of upland habitats (landfill/brownfields reclamation) (Yozzo et al., 2004).

There are reasons to carefully consider the use of dredged material to create/restore coastal marshes. Marshes are beneficial in many coastal processes, including but not limited to improvement of water quality, expansion and improvement of viewsheds; increased bird and other shore species habitat, and wave energy reduction in flooding events; however, these functions ought to be considered in tandem with the adverse effects coastal marsh restoration can have on the benthic ecosystems. For instance, subtidal habitats can be important breeding grounds for shellfish, finfishes, and other species (Yozzo et al., 2004). Further consideration should be given to the kind of dredged material used to create coastal marshes.

Soil texture plays an important role in the utility of dredged material for wetland restoration. It is important that the texture be conducive to plant habitat, drainage, stability, and longevity of the restored wetland. An example from San Diego Bay proves that texture and properties of dredged materials play central roles in effective restoration: wetlands restored with a dredged material that is too sandy proved to have ineffective nitrogen retention or production which limited the growth of groundcover species (Zedler & Kercher, 2005). Certain species are especially effective at stabilizing sediment and that is why the USACE has encouraged the use of dredged materials to create *Spartina alterniflora*, a marsh grass, habitat since the late 1960s (Streever, 2000). While such grasses may aide in shoreline stabilization and reduction of erosion, dredged material may be required in order to sustain the health of a restored marsh. Dredged materials can contain elevated levels of toxins that must be contained in temporary or permanent locations such as Confined Disposal Facilities (CDFs).

Dredged material can be useful in raising either the total or partial height of restoration sites. For instance, in San Francisco Bay dredged material is used to establish the marsh plain height, as to allow a natural 20 to 30 centimeters of sentiment accumulation, thus achieving a total desired height and the formation of a more natural creek system (Callaway, 2001). Even if low levels of contaminates are present in dredged material, the Handbook for Restoring Tidal Wetlands suggests that such material be used below the plant rooting zone and capped with clean fill (Callaway, 2001). Contaminated sediments can be used but require "capping." Capping is the use of clean material as a binder of sorts; preventing seepage of contaminates into surrounding waters. Other concerns include "potential uptake and sequestration of contaminants by emergent vegetation, infaunal/epifaunal invertebrates, fish, and wading birds" (Yozzo et al., 2004). Determination must be made as to whether or not the contaminated dredged material requires permanent or temporary retention structures in order to maintain the location of contaminates.

Marshes, when affronting seawalls, bulkheads, or other permanent features (retention or otherwise) not only provide habitat, but act as flood and damage mitigators. Marshes elongate the lives of such permanent structures as they reduce wear and maintenance costs for these structures. There is a linear correlation between the width of a marsh and its effectiveness in preventing damage to flood mitigating structures (King & Lester, 1995). This means that the wider the marsh the more effective it is in reducing maintenance costs on seawalls and bulkheads.

# Methods:

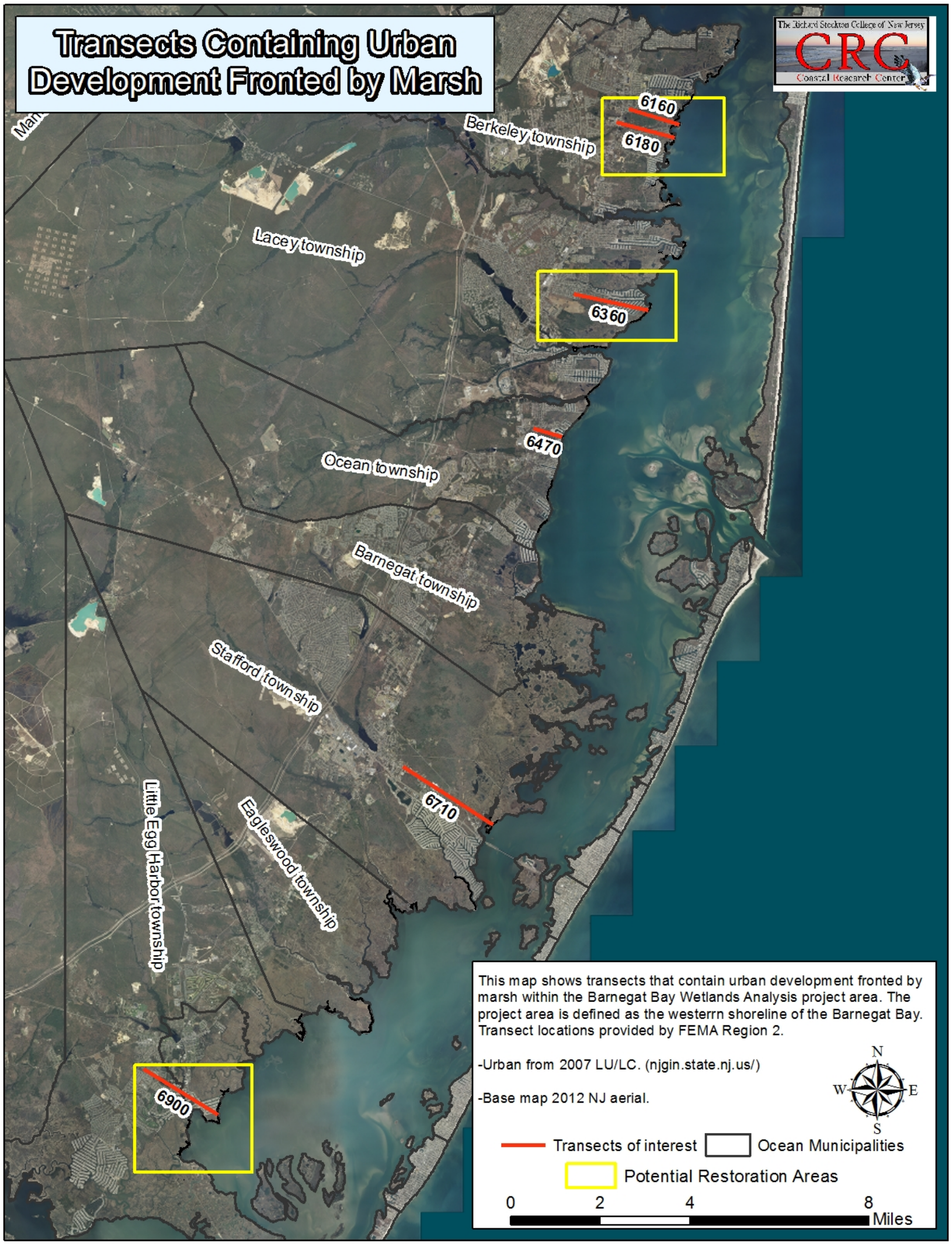
*Wetland Erosion and Analysis Site Selection*

This project utilized Geographic Information Systems (GIS) software (ArcGIS) to analyze wetland area change within Barnegat Bay by quantifying the amount of marsh-edge erosion between the New Jersey "tidelands claim line" and the mean high water line (MHW) that was derived from a 10-foot resolution DEM generated from 2010 LiDAR (Light Detection and Ranging) elevation data (provided by FEMA Region 2). Polygons representing wetland loss between the 2010 MHW line and the existing tidelands claim line were generated. The DEM provided by FEMA Region 2 was the same DEM used in the recent NY/NJ Coastal Flood Study("Coastal Flood Study Overview," 2014). Once the CRC generated wetland loss polygons, the polygons were filtered to only include polygons representing wetland loss within 1,000 feet of development. This reduced processing time and aided in identifying areas where marsh restoration will have a more direct impact on flood risk reduction. Additionally, a wetland loss hotspot analysis was performed in ArcGIS to identify areas of increased wetland loss. The CRC has identified three tidal wetland areas that have experienced significant erosion that "front" development along the Barnegat Bay's mainland shoreline. These areas are located Berkeley Township, Lacey Township, and Tuckerton, NJ (Figure 2).

*Flood Modeling at Selected Sites*

To determine the relative impact a marsh-edge restoration project will have in the selected areas, two marsh-edge restoration scenario digital elevation models (DEMs) were created in ArcGIS based on the 2010 FEMA-provided DEM used for the recent NY/NJ Coastal Flood Study. Using the wetland loss polygons created for the erosion analysis, the scenario DEMs were generated by the CRC to represent 50% and 100% restoration of the marsh-edge relative to the NJ tidelands claim line. Then, using the original wetland loss polygons and the 2010 DEM, the mean adjacent marsh elevations were applied to the wetland loss polygons. These polygons were then converted to raster format and merged with the original 2010 DEM to represent the 100% restoration of marsh edge scenario. To create the 50% restoration scenario, centerlines were generated within the wetland loss polygons and used to split them. The landward sides (adjacent to existing marsh) of the split polygons were retained and then converted raster using adjacent marsh elevations. The raster representing the split polygons was merged with the 2010 DEM to represent the 50% restoration scenario. Using these scenario DEMs, the CRC utilized FEMA's WHAFIS (Wave Height Analysis for Flood Insurance Studies) and HAZUS-MH (Hazards US, Multi-Hazard) modeling software to determine if there would be any significant reduction in overland wave heights, storm surge, and resulting damages (in dollar amounts) relative to a 1-percent annual chance storm. WHAFIS is a DOS-based modeling application that uses a transect-based approach for computing wave crest elevations across a study area and accounts for the effects of topographic, vegetative, and cultural features on wave heights ("WHAFIS," 2014). HAZUS-MH is a GIS-based modeling application using a standardized methodology for estimating potential losses from earthquakes, floods and hurricanes ("Hazus," 2014). Utilizing data provided by FEMA Region 2, the CRC identified 6 transects used for overland wave modeling in the Coastal Flood Study along the mainland shoreline of Barnegat Bay where eroded tidal marsh was directly seaward of development. The HAZUS model was applied to the 3 identified potential restoration areas to see if there were any major differences in flood damages (in dollars) between the original DEM and only the 100% restoration scenario (to determine if there would be any impact to damage at the maximum restoration level). Since no significant reductions in damages between the original DEM and the 100% restoration scenario were observed for the 1-percent chance storm, an analysis comparing damages between the original DEM and the 50% restoration scenario was not performed (Figure 3).

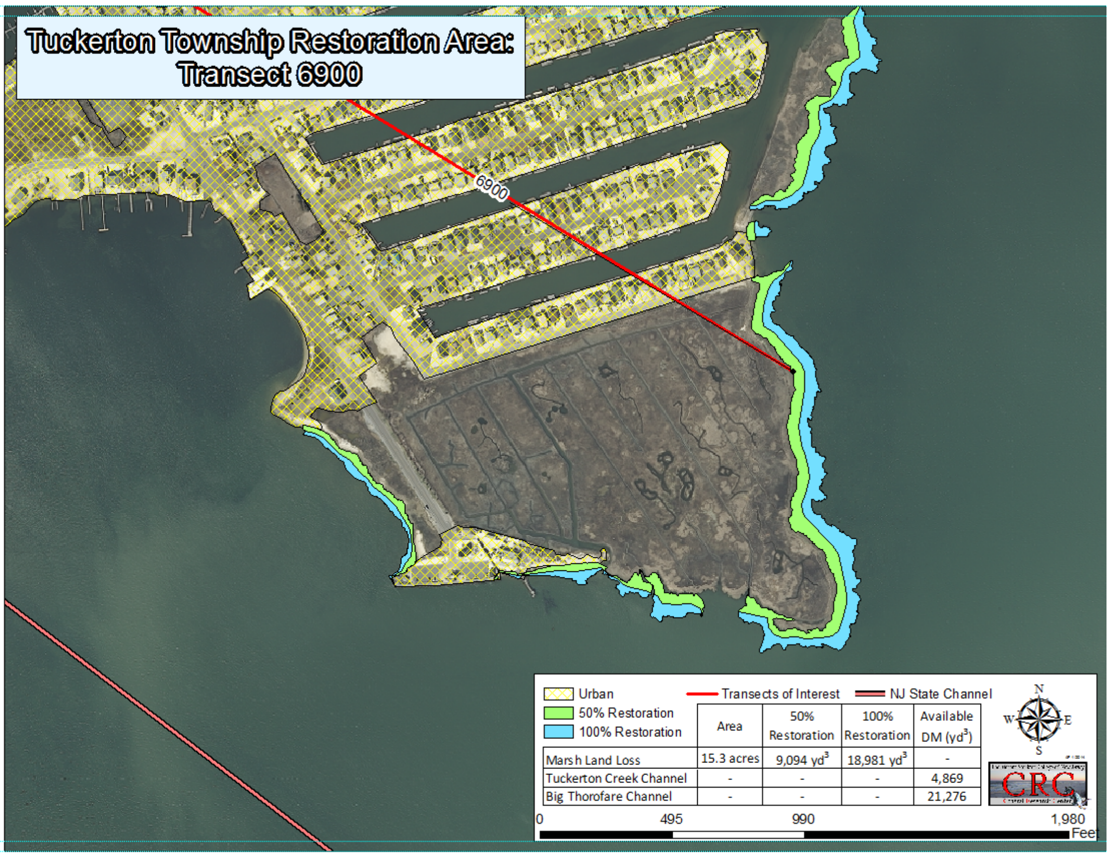
**Figure 3. Study area displaying 6 transects (red lines) used in study containing urban development fronted by eroded marshlands and 3 potential restoration areas (yellow boxes).**



*Determining Necessary Dredged Material Volume for Marsh-Edge Restoration*

Using the original 2010 DEM and the two scenario DEMs, sediment volumes for marsh-edge restoration were determined in ArcGIS by using the raster calculator in the spatial analyst extension. Using the raster calculator, each scenario DEM was subtracted from the original 2010 DEM. This method produced two rasters representing elevation change. Using the polygons representing 50% and 100% restoration, the zonal statistics tool within ArcGIS Spatial Analyst software was used to calculate the sum of elevation change within each wetland loss polygon (Figure 4). For this analysis, the wetland loss polygons also represent the 50% and 100% restoration scenarios. To derive volumes from the elevation change sums based on the zonal analysis, the values were multiplied by the cell size of the raster (10-foot x 10-foot), thus performing a basic volume calculation (length x width x height). Volumes were then converted the standard cubic yard units from cubic feet.

**Figure 4. Map displaying the 50% and 100% restoration scenarios (wetland loss polygons) in the Tuckerton restoration area. Transect 6900 (red line) was used for WHAFIS analysis in this area.**




| | Area | 50% Restoration | 100% Restoration | Available DM ($yd^3$) |
|---|---|---|---|---|
| Marsh Land Loss | 15.3 acres | 9,094 $yd^3$ | 18,981 $yd^3$ | - |
| Tuckerton Creek Channel | - | - | - | 4,869 |
| Big Thorofare Channel | - | - | - | 21,276 |

*State Channels Proximal to Potential Restoration Areas*

State channels proximal to areas of marsh restoration were selected by determining if they fell within each potential restoration area. Restoration areas were visually drawn in ArcGIS to capture contiguous wetland loss polygons within 1000-feet of development that had a significant portion of wetland loss directly seaward of development. Additionally, an erosion hotspot raster was created (based on wetland loss area density) using an Inverse Distance Weighting (IDW) function in ArcGIS to visually validate the selection of potential restoration areas. For calculating state channel proximity to wetland loss areas within a given restoration area, state channel centerlines (provided by NJDOT) were used to generate channel centroid points. Using these centroid points, the calculate distance tool was used in ArcGIS to determine the distance from the channel centroids to each wetland loss polygon. These distances were averaged within each restoration area to provide an average distance of wetland loss polygons to state channels with restoration area polygons.

## Results:

*Sediment Volume Analysis for Wetland Restoration*

Based on the wetland loss polygons for the mainland shoreline Barnegat Bay, there has been approximately 117 acres of marsh-edge lost to erosion relative to the tidelands claim line. If all wetlands loss areas identified in this study were restored to 50% and 100% (not just in the selected restoration areas) relative to the tidelands claim line, approximately 97,030 cubic yards and 189,424 cubic yards of sediment would be needed, respectively. Out of 111 state channels within Barnegat Bay, 64 are found to extend to the mainland shoreline. The total Hurricane Sandy deposited sediment volume within state channels in Barnegat Bay is 524,364 cubic yards and 395,592 cubic yards of the total volume represents Hurricane Sandy deposited sediments within the 64 state channels extending to the mainland (table 1).

**Table 1. Total Sediment Volumes for Needed Wetland Restoration and Available Dredged Material within State Channels.**

| Scenario | Area (Acres) | Sediment Volume | Available DM ($yd^3$) from Channels Extending to Mainland | Available DM ($yd^3$) from All State Channels within Barnegat Bay | Available Over Dredge Material (ODM, yd3) from Channels Extending to Mainland | Available Over Dredge Material (ODM, yd3) from All State Channels within Barnegat Bay |
|---|---|---|---|---|---|---|
| 50% Restoration | 58.22 | 97,030.71 | 395,592.00 | 524,364.00 | 840,011.00 | 1,132,817.00 |
| 100% Restoration | 117.49 | 189,424.55 | | | | |

**Figure 5. Maps displaying the three selected wetland restoration areas. Each map includes polygons representing 50% and 100% marsh edge restoration, state channels proximal to each site, and the FEMA Coastal Flood Study transect used in the flood analysis.**


Within the three identified restoration areas (Figure 5), total sediment volumes needed for 50% and 100% marsh edge restoration are 13,551 cubic yards and 28,595 cubic yards respectively (table 2). Tuckerton will require by far the largest volume of dredged material with 18,981 cubic yards needed for the 100% restoration scenario. Berkeley Township and Lacey Township will require considerably less material, but for all restoration sites, the proximal state channels can supply the needed dredged material. A more in-depth study will be required to determine if the sediments within the identified state channels are suitable to marsh edge restoration.

**Tuckerton Township**

| | Area | 50% Restoration | 100% Restoration | Available DM ($yd^3$) | ODM ($yd^3$) | Proximity to Channel* |
|---|---|---|---|---|---|---|
| Marsh Land Loss | 15.3 acres | 9,094 $yd^3$ | 18,981 $yd^3$ | - | - | - |
| Tuckerton Creek Channel | - | - | - | 4,869 | 21,560 | 3,601 ft |
| Big Thorofare Channel | - | - | - | 21,276 | 38,242 | 3,880 ft |

*Proximity is based on the average distance from the centroid of channel of interest to the centroid of all areas of loss in the selected area.

**Berekeley Township**

| | Area | 50% Restoration | 100% Restoration | Available DM ($yd^3$) | ODM ($yd^3$) | Proximity to Channel* |
|---|---|---|---|---|---|---|
| Marsh Land Loss | 5.3 acres | 3,354 $yd^3$ | 7,126 $yd^3$ | - | - | - |
| Sloop Creek | - | - | - | 1,393 | 3,095 | 2,746 ft |
| Clamming Creek North | - | - | - | 5,301 | 10,266 | 3,012 ft |
| Clamming Creek South | - | - | - | 2,991 | 9,436 | 3,071 ft |
| Whites Channel | - | - | - | 2,194 | 5,181 | 4,530 ft |
| Butler Blvd Access Chan. | - | - | - | 251 | 1,519 | 5,350 ft |

*Proximity is based on the average distance from the centroid of channel of interest to the centroid of all areas of loss in the selected area.

**Lacey Township**

| | Area | 50% Restoration | 100% Restoration | Available DM ($yd^3$) | ODM ($yd^3$) | Proximity to Channel* |
|---|---|---|---|---|---|---|
| Marsh Land Loss | 3.8 acres | 1,103 $yd^3$ | 2,488 $yd^3$ | - | - | - |
| Stouts Creek | - | - | - | 3,496 | 8,936 | 1,780 ft |
| Sunrise Beach Channel | - | - | - | 0 | 742 | 570 ft |
| Sunrise Beach Chan. Spur | - | - | - | 63 | 982 | 561 ft |

*Proximity is based on the average distance from the centroid of channel of interest to the centroid of all areas of loss in the selected area.

**Table 2. Total sediment volumes needed for wetland restoration and available dredged material within state channels for each potential restoration site.**

### *Flood Analysis for Wetland Restoration Scenarios*

For the WHAFIS analysis, 5 FEMA transects were used in this study (Figure 2) to determine if restoring a marsh edge to 50% and 100% of the tidelands claim line would show any reduction in storm surge elevations, flood zone extents and overland wave heights. For the HAZUS analysis, only the 100% restoration scenario was analyzed to compare the maximum reduction in flood damages. It is assumed that the 50% restoration scenario would not have as large an impact to reduce flood damages in relation to a 1% percent chance storm (one in 100 chance of occurring in any given year). The results of the WHAFIS and HAZUS modeling for the 1-percent annual chance coastal storm show that for both restoration scenarios (50% and 100%) when compared to existing conditions there is no reduction in base flood elevations or flood zone extents.

However, the WHAFIS model output shows a reduction in controlling wave heights and wave crest elevations proximal to the shoreline, suggesting that an expanded marsh footprint will attenuate waves, thus reducing wave energy across. These results coincide with HAZUS-MH output.

While flood zone extents and base flood elevations did not change between restoration scenarios, when comparing the HAZUS-MH total economic losses for the three potential restoration sites, both the Lacey Township and Berkeley Township showed minor reductions in damages of 0.02% ($40,000) and 0.01% ($20,000), respectively (Table 3). The HAZUS-MH model output for the Tuckerton restoration area showed no reduction in flood damages when comparing total economic losses between the 0% and 100% restoration scenario. This suggests marsh restoration efforts Berkeley and Lacey Townships would have more of an impact on wave attenuation (and reduction in flood damages). The full model output files can found in Appendix A.

**Table 3. Comparing the differences in total economic losses between 0% and 100% restoration scenarios for the 1-percent annual chance storm between the three restoration areas.**

| Tuckerton Township | | | | |
|---|---|---|---|---|
| | 1-Percent Chance Storm | | | |
| | 0% Restoration Scenario | 100% Restoration Scenario | Flood Damage Reduction (Millions of Dollars) | Flood Damage Reduction (Percent) |
| Total Economic Loss Estimate (Millions of Dollars) | $124.47 | $124.47 | $0.00 | 0.00 |

| Berkeley Township | | | | |
|---|---|---|---|---|
| | 1-Percent Chance Storm | | | |
| | 0% Restoration Scenario | 100% Restoration Scenario | Flood Damage Reduction (Millions of Dollars) | Flood Damage Reduction (Percent) |
| Total Economic Loss Estimate (Millions of Dollars) | $151.04 | $151.02 | $0.02 | 0.01 |

| Lacey Township | | | | |
|---|---|---|---|---|
| | 1-Percent Chance Storm | | | |
| | 0% Restoration Scenario | 100% Restoration Scenario | Flood Damage Reduction (Millions of Dollars) | Flood Damage Reduction (Percent) |
| Total Economic Loss Estimate (Millions of Dollars) | $260.31 | $260.27 | $0.04 | 0.02 |

The results of the WHAFIS analysis (table 4) show the most significant reduction occurred at transect 6470 (Ocean Township) with a wave height and wave crest elevation reduction of -1.33 feet and -0.94 feet respectively. Transect 6900 (Tuckerton) showed a reduction in wave height and wave crest elevation for the 50% restoration scenario of -0.93 feet and -0.65 feet, respectively. The reduction in wave height and wave crest elevation for the 100% restoration scenario at transect 6900 was -0.96 feet and -0.67 feet respectively. Transect 6360 (Lacey Township) showed no reduction in wave heights or wave elevations between 0%, 50% and 100% restoration scenarios.

Both transects found within the Berkeley Township restoration area (6160 and 6180) showed differing results from the WHAFIS analysis. Transect 6160 showed an *increase* in wave heights and wave crest elevations of 0.03 feet and 0.03 feet, respectively, at the shoreline between 0%

restoration scenario and the 50% and 100% restoration scenarios. Transect 6180 showed a decreases in wave heights and wave crest elevations for the 50% and 100% restoration scenarios of -.30 feet and -0.21 feet, respectively.

The summarized WHAFIS results (table 5) showed that marsh edge restoration to 50% of the tidelands claim line had an average reduction in wave height of -0.548 feet and an average reduction in wave crest elevation of -0.384 feet. The average effect of restoring the marsh edge from 50% to 100% of the tidelands claim line (table 5) showed a negligible addition in reduction of -.006 feet in wave height and -0.004 feet in wave crest elevation.

**Table 4. WHAFIS model results showing effects on wave height and wave elevation for 0%, 50% and 100% marsh edge restoration for all 6 transects. The final line shows the average effects across all transects.**

| Transect ID | 0% Restoration | | 50% Restoration | | 100% Restoration | |
|---|---|---|---|---|---|---|
| | Wave Height(ft) | Elevation | Wave Height(ft) | Elevation | Wave Height(ft) | Elevation |
| 6160 | 4.51 | 9.86 | 4.54 | 9.89 | 4.54 | 9.89 |
| 6180 | 4.48 | 9.80 | 4.18 | 9.59 | 4.18 | 9.59 |
| 6360 | 3.50 | 8.83 | 3.50 | 8.83 | 3.50 | 8.83 |
| 6470 | 4.47 | 9.84 | 3.14 | 8.90 | 3.14 | 8.90 |
| 6710 | 3.84 | 9.65 | 3.63 | 9.50 | 3.63 | 9.50 |
| 6900 | 4.79 | 11.24 | 3.86 | 10.59 | 3.83 | 10.57 |
| Average | 4.27 | 9.87 | 3.81 | 9.55 | 3.80 | 9.55 |

**Table 5. Summarized WHAFIS results showing reduction effects on wave height and wave elevation between restoration amounts. The final line shows the average effects across all transects.**

| Transect ID | 0% - 50% Restoration | | 0% - 100% Restoration | | 50% - 100% Restoration | |
|---|---|---|---|---|---|---|
| | Wave Height(ft) | Elevation | Wave Height(ft) | Elevation | Wave Height(ft) | Elevation |
| 6160 | 0.03 | 0.03 | 0.03 | 0.03 | 0.00 | 0.00 |
| 6180 | -0.30 | -0.21 | -0.30 | -0.21 | 0.00 | 0.00 |
| 6360 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6470 | -1.33 | -0.94 | -1.33 | -0.94 | 0.00 | 0.00 |
| 6710 | -0.21 | -0.15 | -0.21 | -0.15 | 0.00 | 0.00 |
| 6900 | -0.93 | -0.65 | -0.96 | -0.67 | -0.03 | -0.02 |
| Average | -0.46 | -0.32 | -0.46 | -0.32 | 0.00 | 0.00 |

# Discussions & Conclusions

Based on the sediment volume analysis, there is a sufficient amount of dredged material within state channels for marsh edge restoration projects within Barnegat Bay. More in-depth analyses are required to determine if sediments within state channels can be used for wetland restoration. In general, sediment grain sizes within Barnegat Bay transition from predominantly sandy sediments to predominantly fine-grained silts as you move away from tidal inlets/barrier islands to the western side of the bay. This is primarily a function of tidal currents decreasing away from inlets combined with freshwater input from the mainland, causing suspended fine-grained sediments to settle out to the bottom of the bay (Farrell et al., 2009). There is also a need for a cost analysis to compare traditional dredge material placement (i.e. within CDFs) with marsh edge restoration.

While the results of the flood analysis do not show any reduction in surge elevations along any transects, the modest reduction in wave heights and wave crest elevations (from averaged WHAFIS model output) and the minor flood damage reductions to adjacent development in Lacey and Berkeley Townships (from HAZUS-MH output), suggests that there may be some benefit for marsh edge restoration, even if the benefits are minimal during the 1-percent annual change storm. For less intense storms (i.e. 2% annual chance), restoring marsh edge may provide a larger reduction in wave heights as well as storm surge since surge elevations would be lower when compared to the 1% annual chance storm.

In some cases the WHAFIS model results are unexpected. The HAZUS-MH model output shows no reduction in total economic loss between restoration scenarios in Tuckerton, but transect 6900 within the Tuckerton restoration site had the second largest reduction in wave height and crest elevations when comparing restoration scenarios to the 1-percent annual chance storm event. Likewise, transect 6360 in Lacey Township showed no change in wave heights or wave crest elevations between the restoration scenarios but HAZUS-MH model output shows a minor reduction in total economic loss of 0.02%. The differing results for both transects found within the Berkeley Township restoration area (6160 and 6180) are also unexpected. These unexpected results may be caused by several factors. For example, in the WHAFIS analysis, increased water depths at the toe of restored marsh may create conditions for larger waves to break on the marsh edge if the nearshore bathymetry is not a gently sloping profile as compared to other transects analyzed in this study (this is the situation at transect 6160 which exhibits a steeper sloped profile than transect 6180). Another factor that may contribute to unexpected results when comparing HAZUS-MH and WHAFIS output may be the proximity of development to the restored marsh. The majority of development in Berkeley and Lacey Townships is located directly adjacent the marsh restoration and closer to direct wave attack as opposed to Tuckerton which has a smaller portion of development open directly to wave attack in the northeastern side of the restoration area. The remainder of the Tuckerton restoration area has a much larger marsh complex fronting development along its southern shoreline. In this case, since base flood elevations and footprints did not change in the HAZUS-MH model, the majority of damages in the Tuckerton restoration area come from storm surge flooding and not from the combination of storm surge flooding *and* wave damage. Marsh restoration in Lacey and Berkeley Townships appears to have an impact (however minor) on reducing wave energy, thus reducing the total economic losses in this area by a relatively small amount.

Even though some results from the WHAFIS and HAZUS-MH models are unexpected, it is best to analyze all results together due to the relatively small sample size of 6 transects and only one to two transects found within each of the three potential restoration sites analyzed in the HAZUS-MH model. While the scope of this project did not allow for WHAFIS analyses of all transects used in the recent FEMA Region II coastal flood study or applying the HAZUS-MH model to the entire Barnegat Bay (only the three potential restoration sites), the summarized results from this study provide insight into the benefits that marsh-edge restoration provides with regards to flood hazard mitigation and the use of dredged material.

There is a need within the state of New Jersey to beneficially use dredged material since existing capacity at placement sites is decreasing or non-existent and many state channels are shoaled as a result of Hurricane Sandy. Projects restoring wetlands within Barnegat Bay will provide an excellent opportunity for use of available dredged material within state navigation channels, improve degraded intertidal marsh habitat, and potentially reduce coastal storm surge and wave damage to communities along the mainland shoreline of Barnegat Bay.

The scope and level of this study did not allow the project team to account for the effects of future sea-level rise on intertidal marsh or how repetitive marsh restoration efforts using dredged material can influence future intertidal marsh growth or degradation in the study area (i.e. Barnegat Bay, New Jersey). These research questions should be addressed in future assessments especially since dredging is a continuing and episodic process that will require new and innovative placement methods/beneficial uses as traditional placement methods (i.e. placement within CDFs) become more difficult to execute due to decreasing capacity for new sediment within existing CDFs. This study is a “snapshot” in time to understand how restoring intertidal marsh in Barnegat Bay to its former extent can reduce flood damages from coastal storm events while beneficially reusing dredged material.

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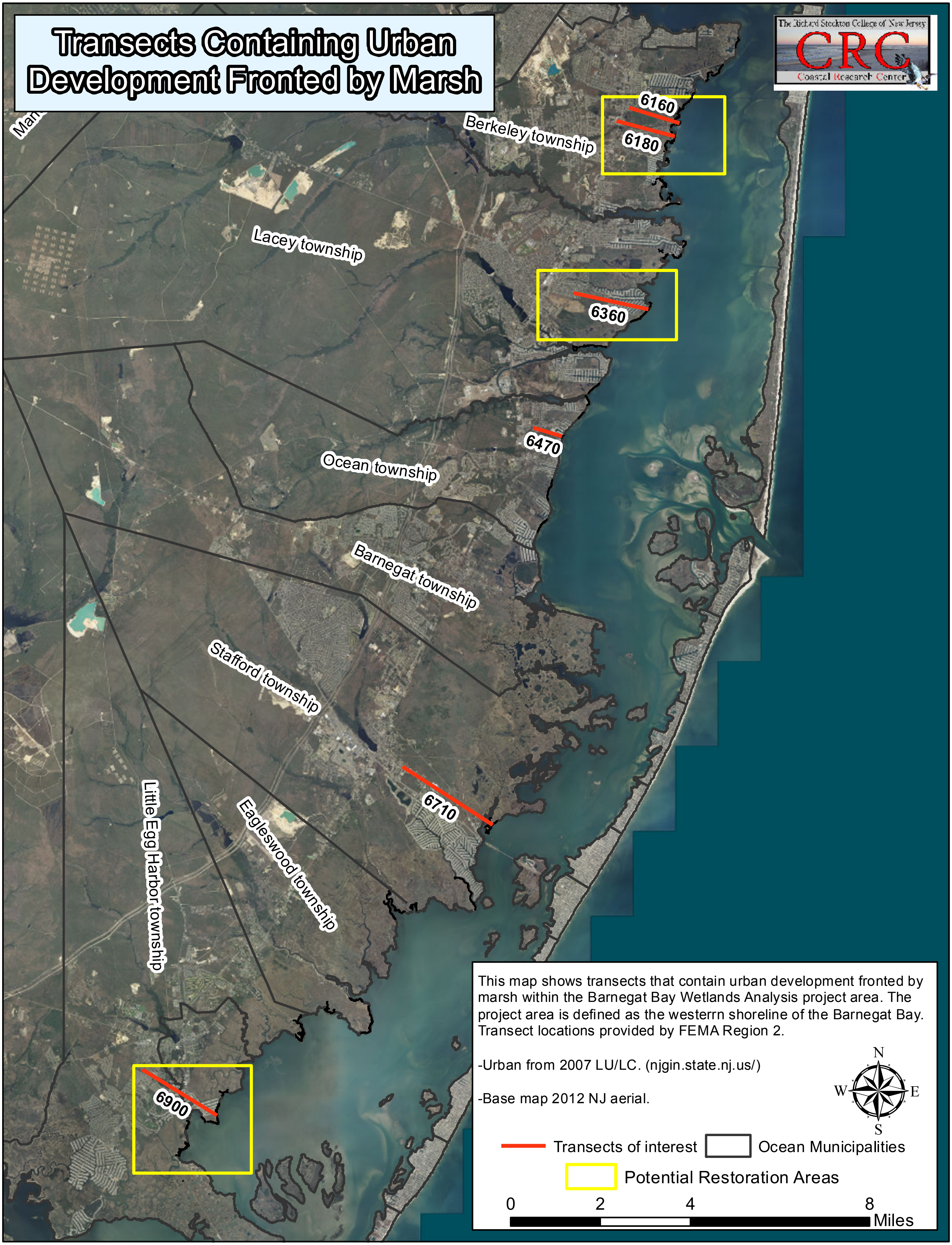
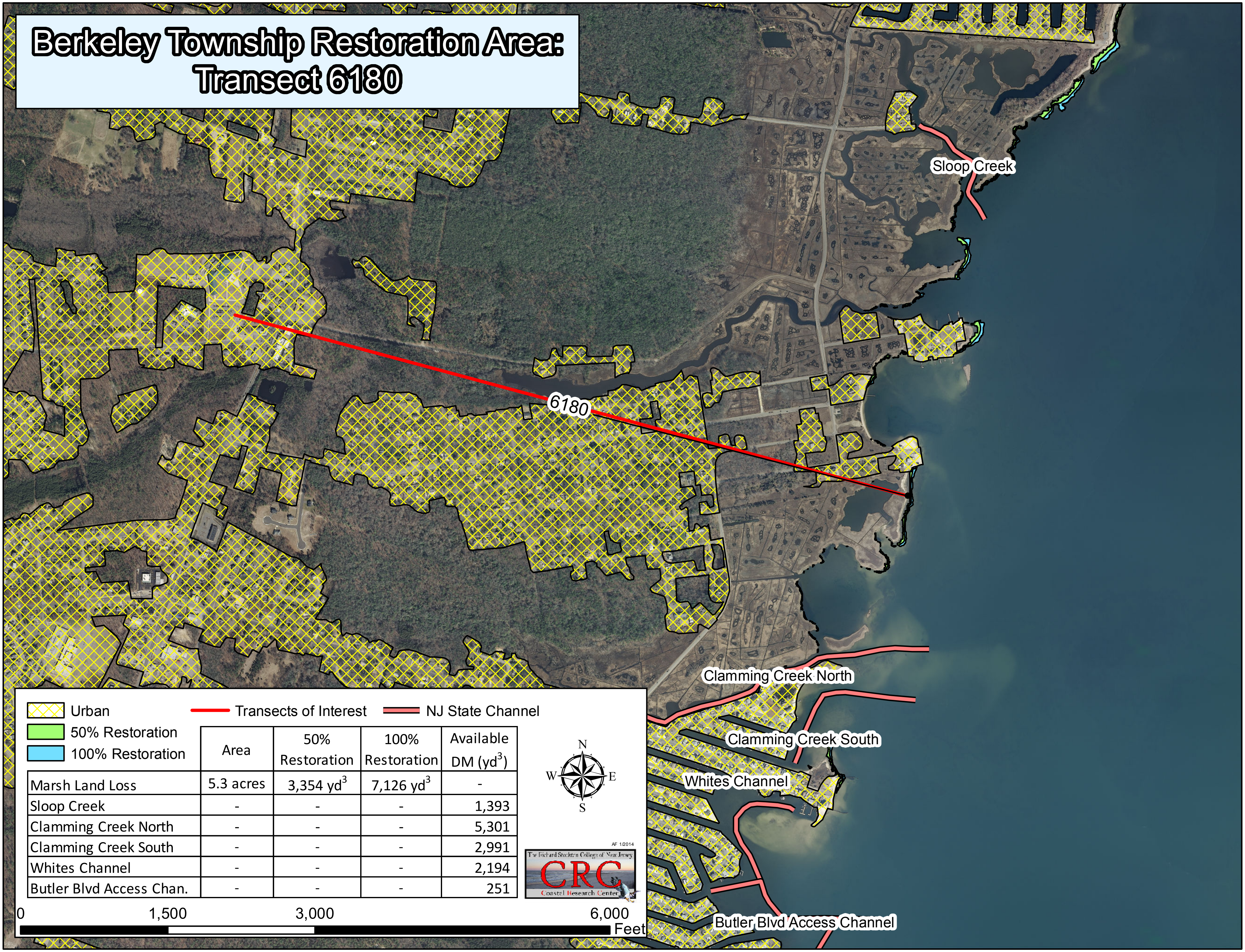
# Appendices

# Maps



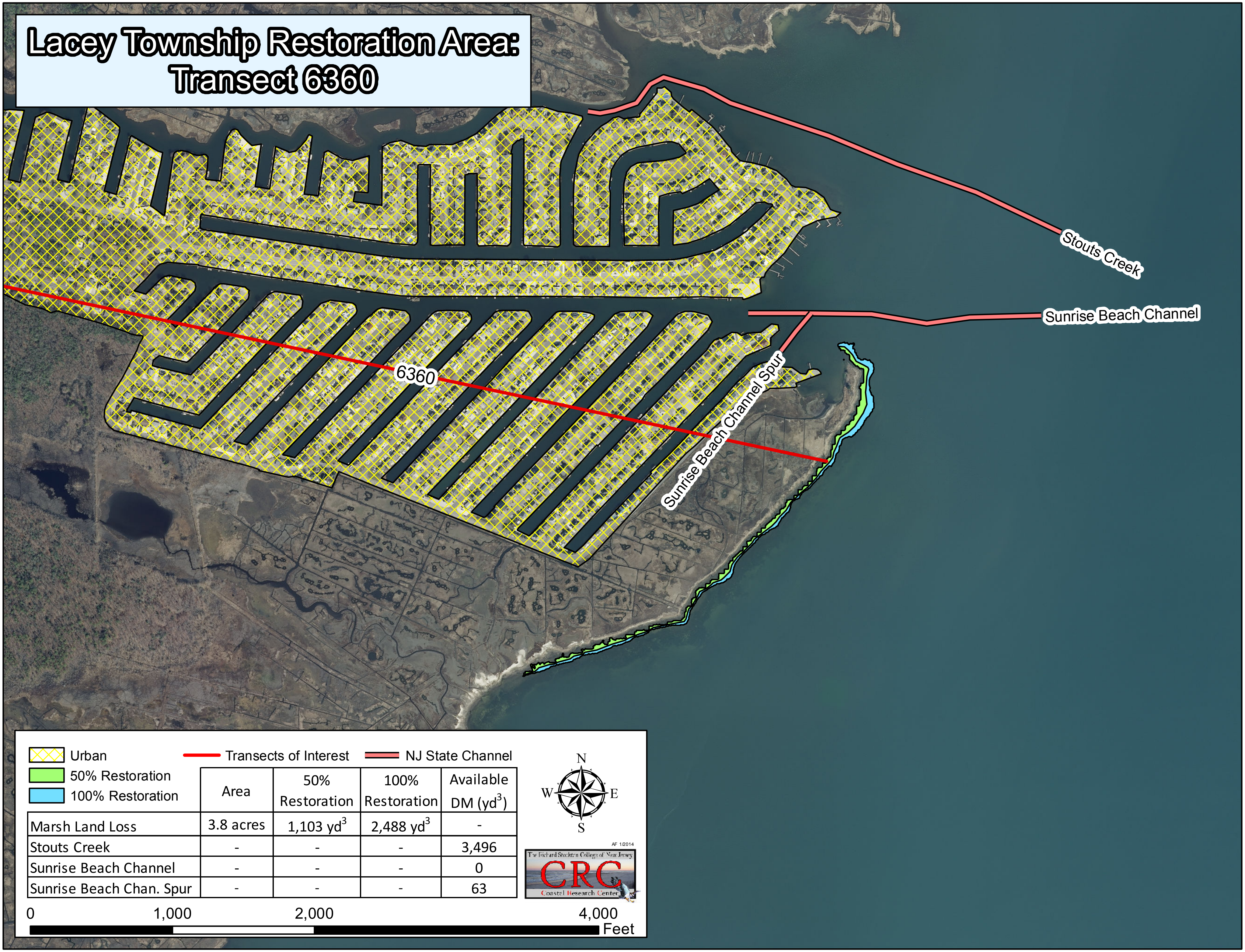
Transects Containing Urban Development Fronted by Marsh
The Richard Stockton College of New Jersey
CRC
Coastal Research Center
6160
6180
Berkeley township
Lacey township
6360
6470
Ocean township
Barnegat township
Stafford township
6710
Little Egg Harbor township
Eagleswood township
6900
This map shows transects that contain urban development fronted by marsh within the Barnegat Bay Wetlands Analysis project area. The project area is defined as the westerrn shoreline of the Barnegat Bay. Transect locations provided by FEMA Region 2.
-Urban from 2007 LU/LC. (njgin.state.nj.us/)
-Base map 2012 NJ aerial.
N
W
E
S
Transects of interest
Ocean Municipalities
Potential Restoration Areas
0
2
4
8
Miles

# Berkeley Township Restoration Area: Transect 6180

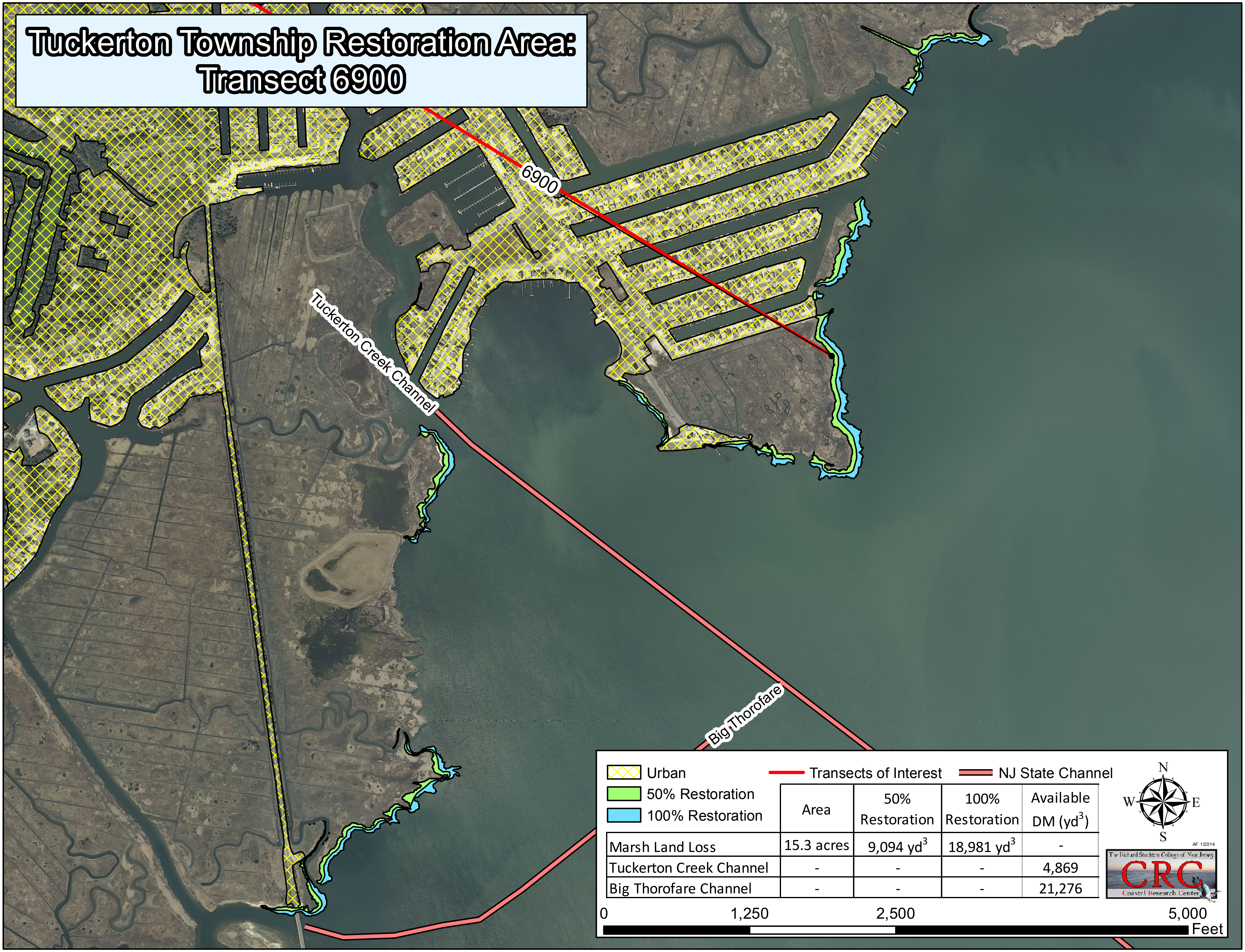



| | Area | 50% Restoration | 100% Restoration | Available DM ($yd^3$) |
|---|---|---|---|---|
| Marsh Land Loss | 5.3 acres | 3,354 $yd^3$ | 7,126 $yd^3$ | - |
| Sloop Creek | - | - | - | 1,393 |
| Clamming Creek North | - | - | - | 5,301 |
| Clamming Creek South | - | - | - | 2,991 |
| Whites Channel | - | - | - | 2,194 |
| Butler Blvd Access Chan. | - | - | - | 251 |

# Lacey Township Restoration Area: Transect 6360

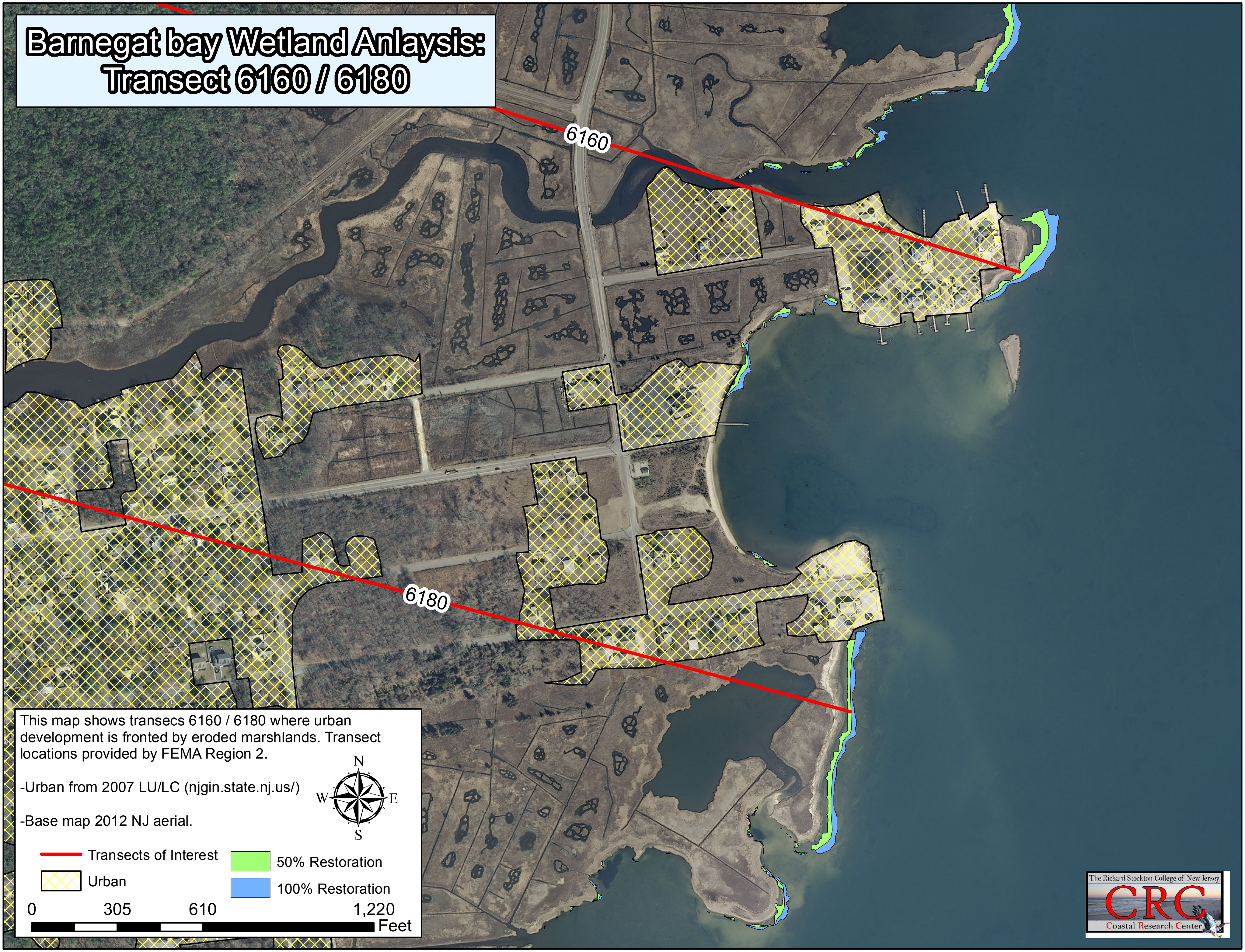



| | Area | 50% Restoration | 100% Restoration | Available DM ($yd^3$) |
|---|---|---|---|---|
| Marsh Land Loss | 3.8 acres | 1,103 $yd^3$ | 2,488 $yd^3$ | - |
| Stouts Creek | - | - | - | 3,496 |
| Sunrise Beach Channel | - | - | - | 0 |
| Sunrise Beach Chan. Spur | - | - | - | 63 |


Tuckerton Township Restoration Area:
Transect 6900
6900
Tuckerton Creek Channel
Big Thorofare
Urban
50% Restoration
100% Restoration
Transects of Interest
NJ State Channel

| | Area | 50% Restoration | 100% Restoration | Available DM ($yd^3$) |
|---|---|---|---|---|
| Marsh Land Loss | 15.3 acres | 9,094 $yd^3$ | 18,981 $yd^3$ | - |
| Tuckerton Creek Channel | - | - | - | 4,869 |
| Big Thorofare Channel | - | - | - | 21,276 |

0
1,250
2,500
5,000
Feet
N
E
S
W
AF 1/2014
The Richard Stockton College of New Jersey
CRC
Coastal Research Center


Barnegat bay Wetland Anlaysis:
Transect 6160 / 6180
6160
6180
This map shows transecs 6160 / 6180 where urban development is fronted by eroded marshlands. Transect locations provided by FEMA Region 2.
-Urban from 2007 LU/LC (njgin.state.nj.us/)
-Base map 2012 NJ aerial.
N
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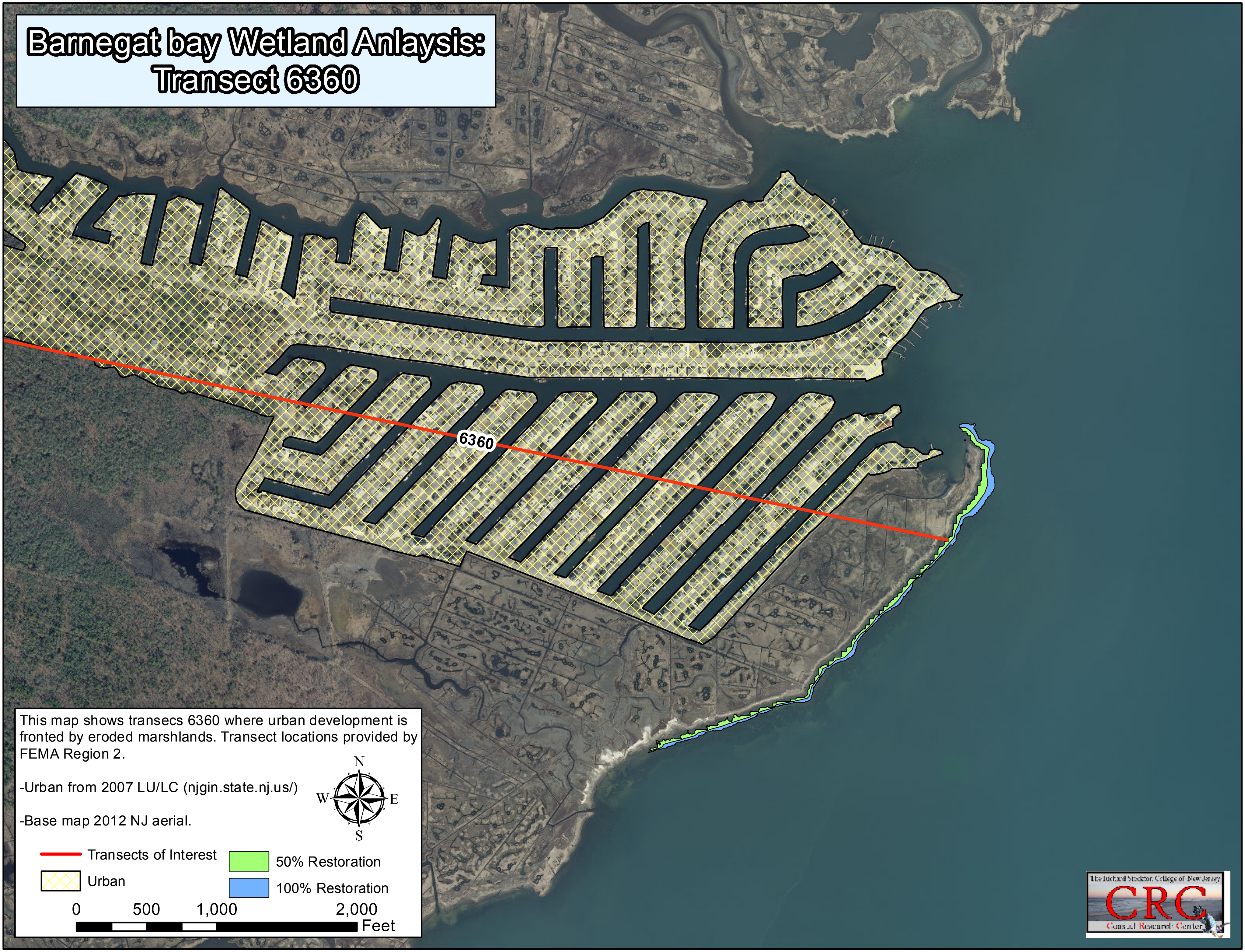
S
W
Transects of Interest
Urban
50% Restoration
100% Restoration
0
305
610
1,220
Feet
The Richard Stockton College of New Jersey
CRC
Coastal Research Center


Barnegat bay Wetland Anlaysis:
Transect 6360
6360
This map shows transecs 6360 where urban development is fronted by eroded marshlands. Transect locations provided by FEMA Region 2.
-Urban from 2007 LU/LC (njgin.state.nj.us/)
-Base map 2012 NJ aerial.
N
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Transects of Interest
Urban
50% Restoration
100% Restoration
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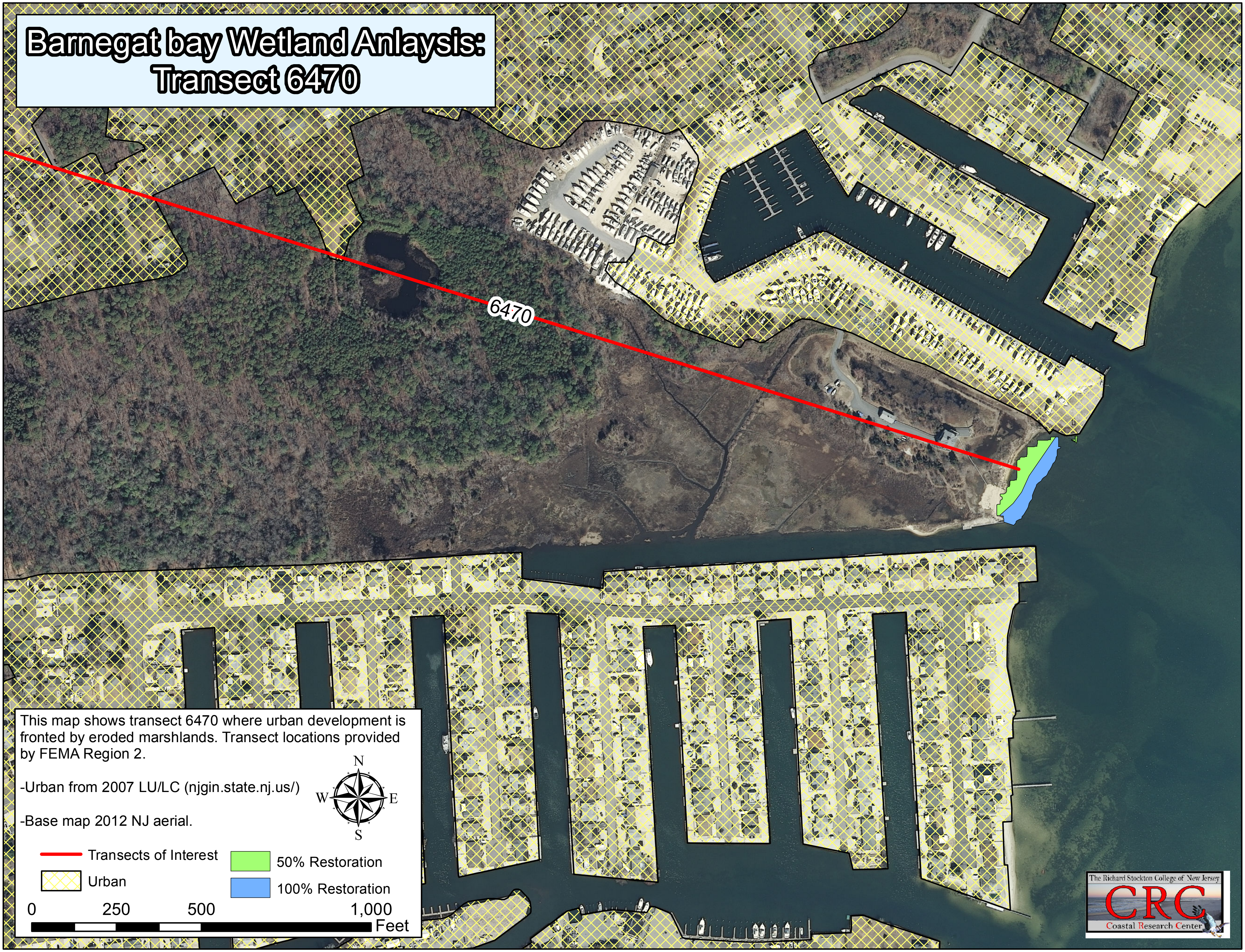
2,000
Feet


Barnegat bay Wetland Anlaysis:
Transect 6470
6470
This map shows transect 6470 where urban development is fronted by eroded marshlands. Transect locations provided by FEMA Region 2.
-Urban from 2007 LU/LC (njgin.state.nj.us/)
-Base map 2012 NJ aerial.
N
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Transects of Interest
Urban
50% Restoration
100% Restoration
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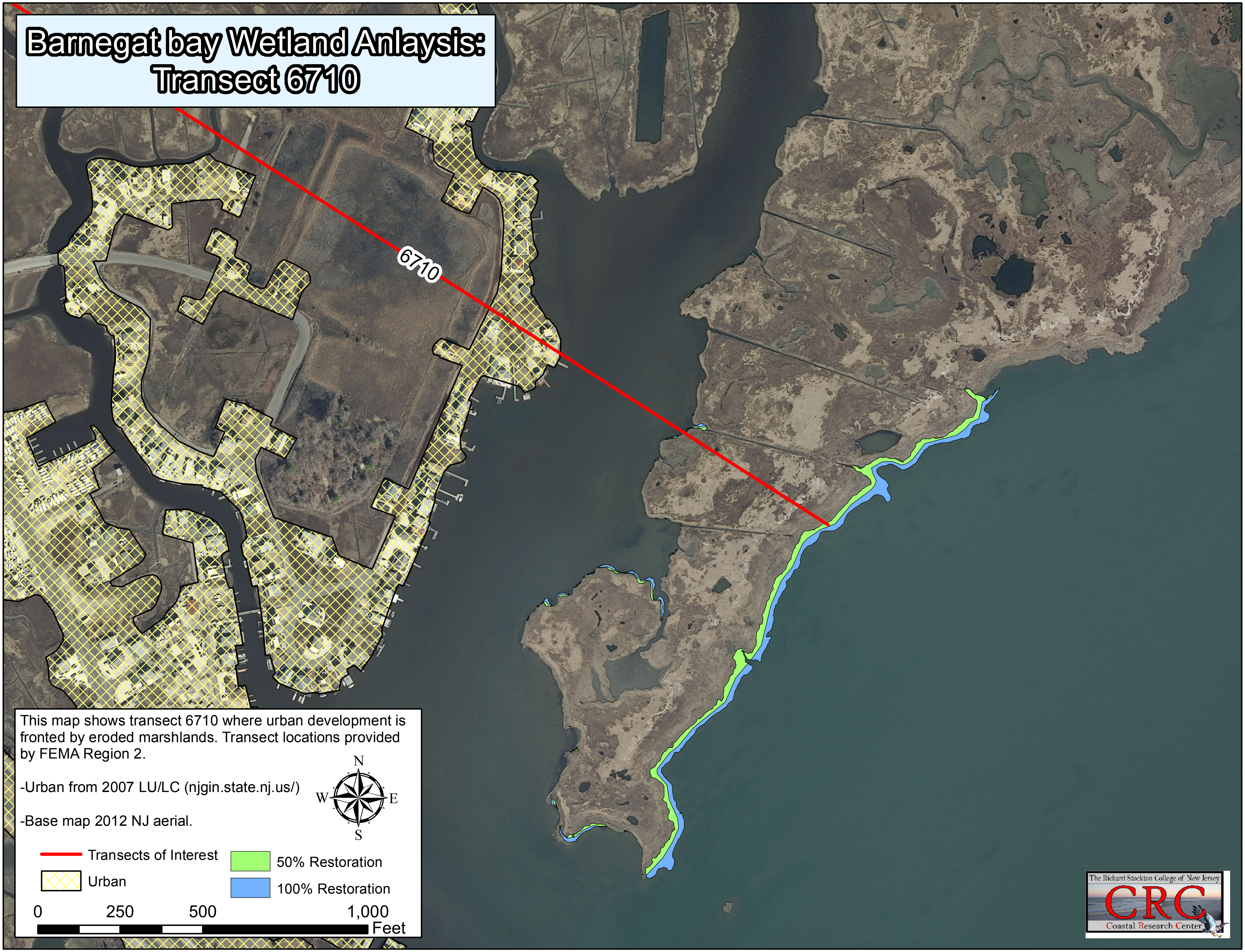
250
500
1,000
Feet
The Richard Stockton College of New Jersey
CRC
Coastal Research Center



Barnegat bay Wetland Anlaysis:
Transect 6710
6710
This map shows transect 6710 where urban development is fronted by eroded marshlands. Transect locations provided by FEMA Region 2.
-Urban from 2007 LU/LC (njgin.state.nj.us/)
-Base map 2012 NJ aerial.
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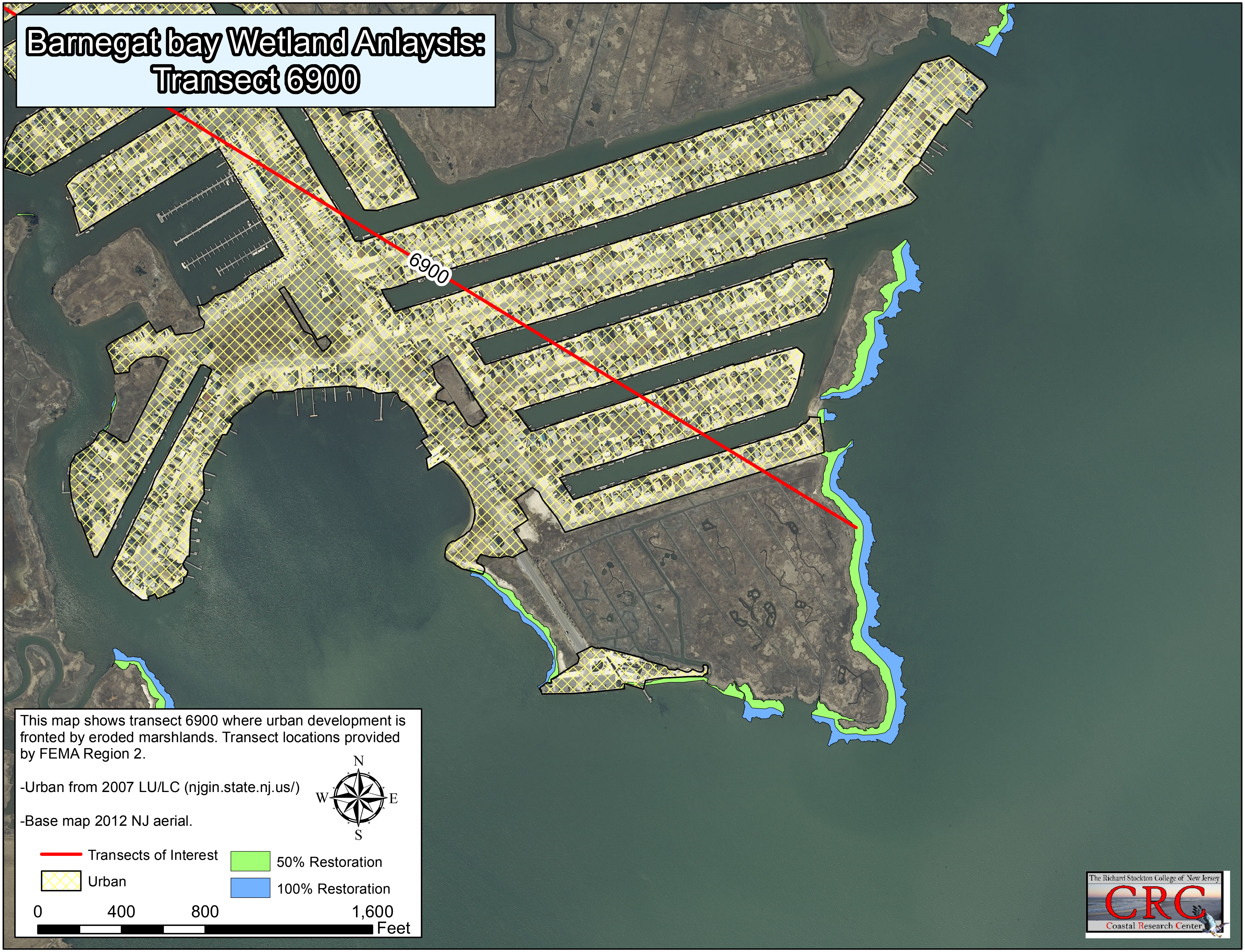
Transects of Interest
Urban
50% Restoration
100% Restoration
0
250
500
1,000
Feet
The Richard Stockton College of New Jersey
CRC
Coastal Research Center


Barnegat bay Wetland Anlaysis:
Transect 6900
6900
This map shows transect 6900 where urban development is fronted by eroded marshlands. Transect locations provided by FEMA Region 2.
-Urban from 2007 LU/LC (njgin.state.nj.us/)
-Base map 2012 NJ aerial.
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Transects of Interest
Urban
50% Restoration
100% Restoration
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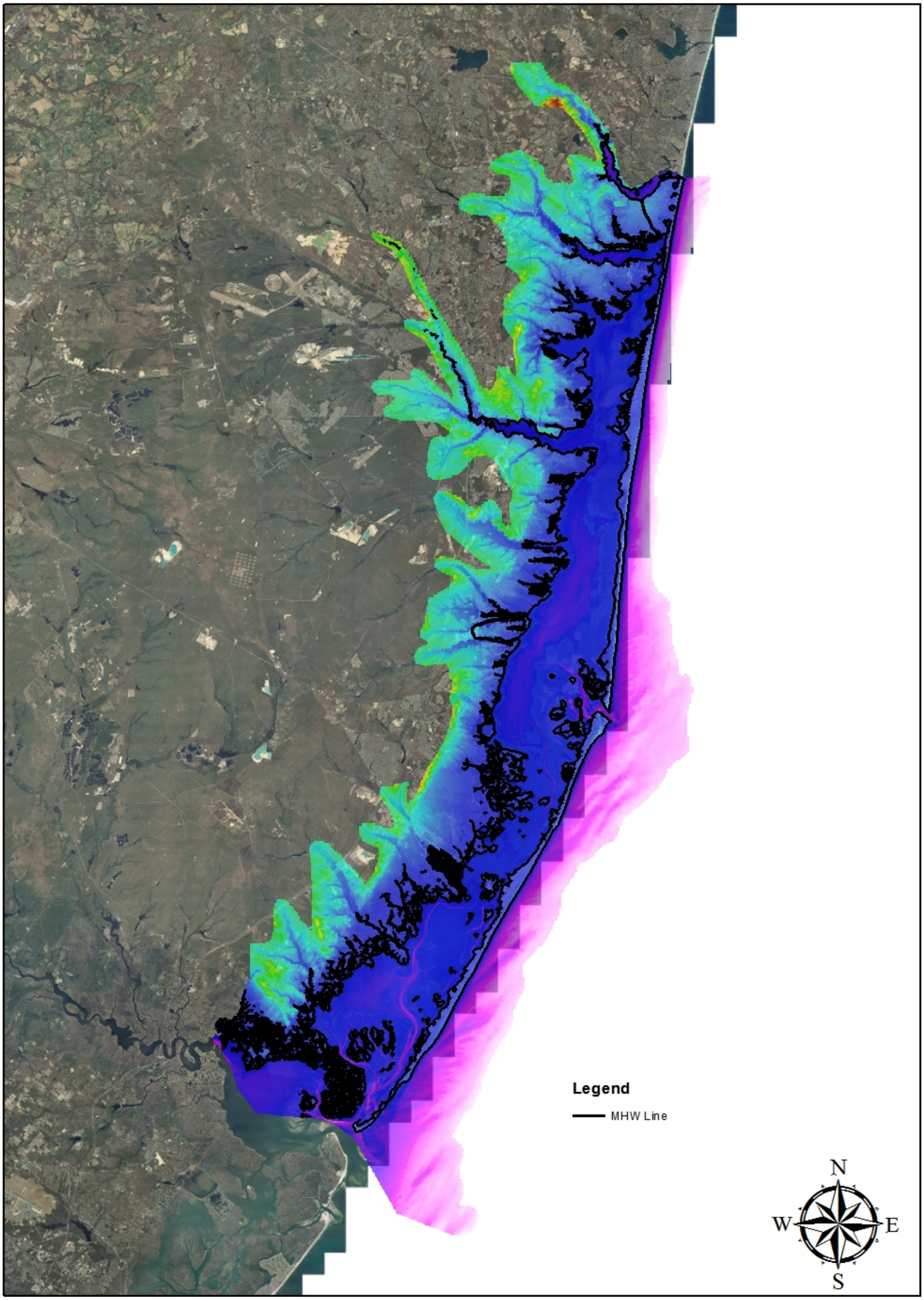
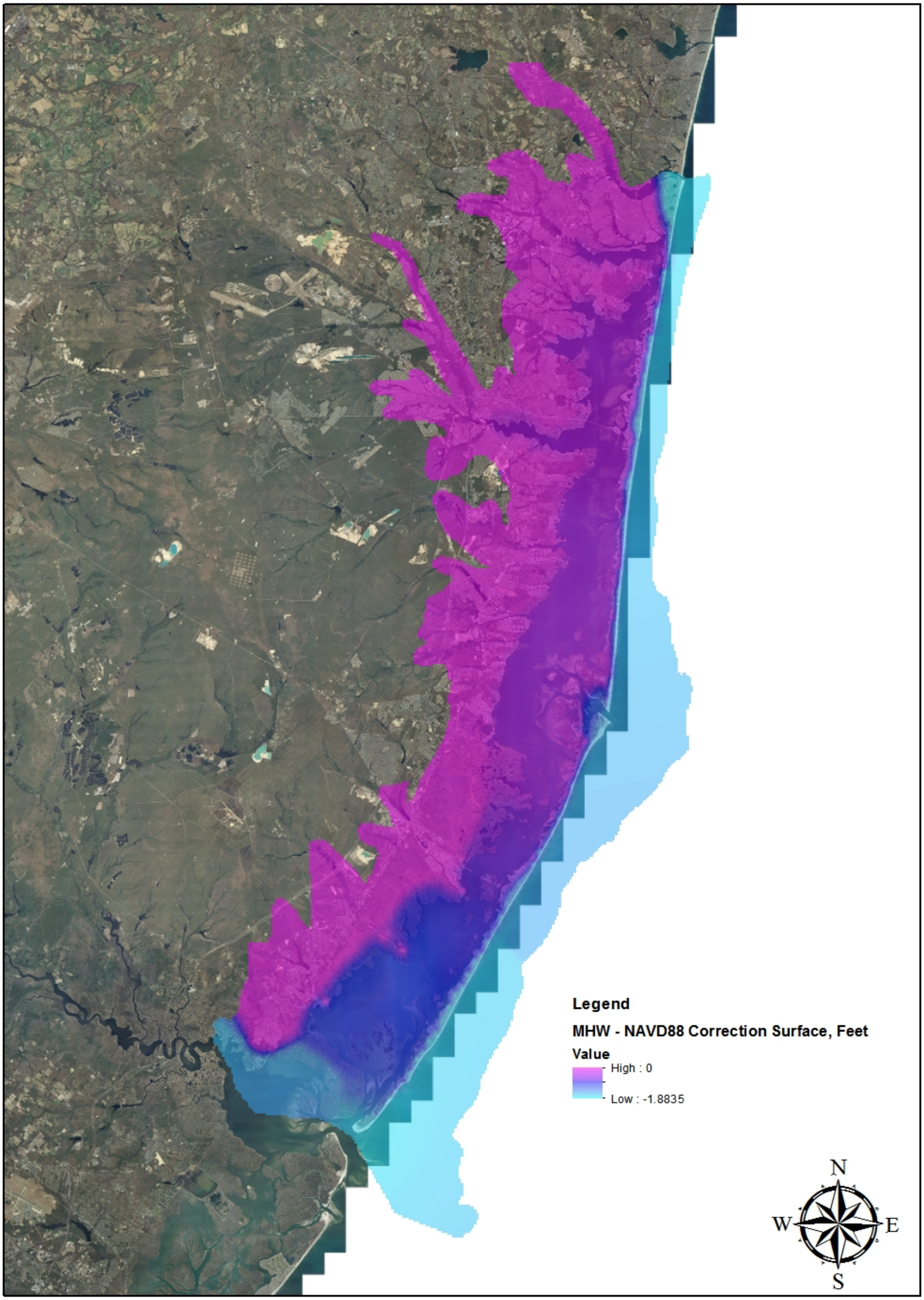
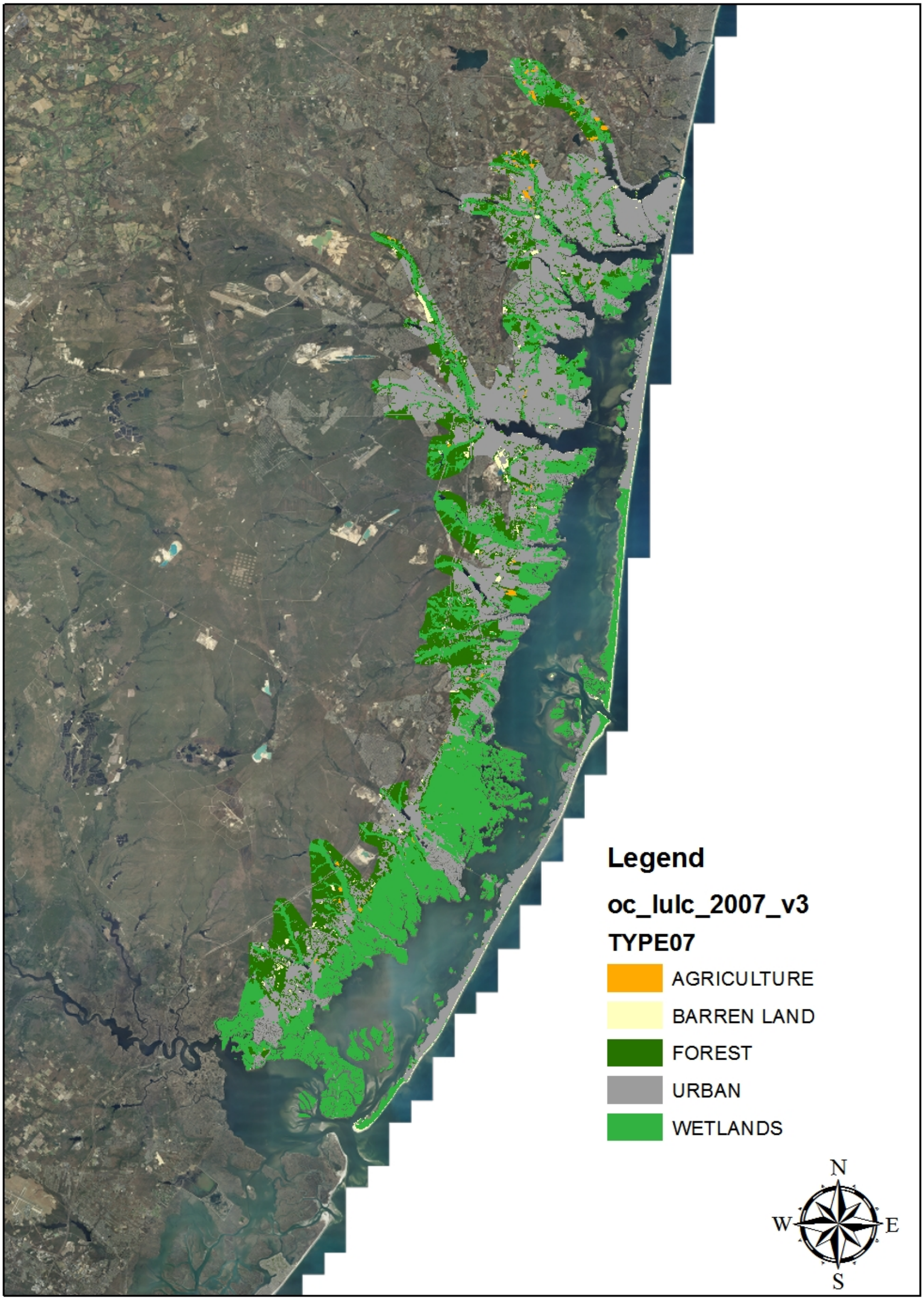
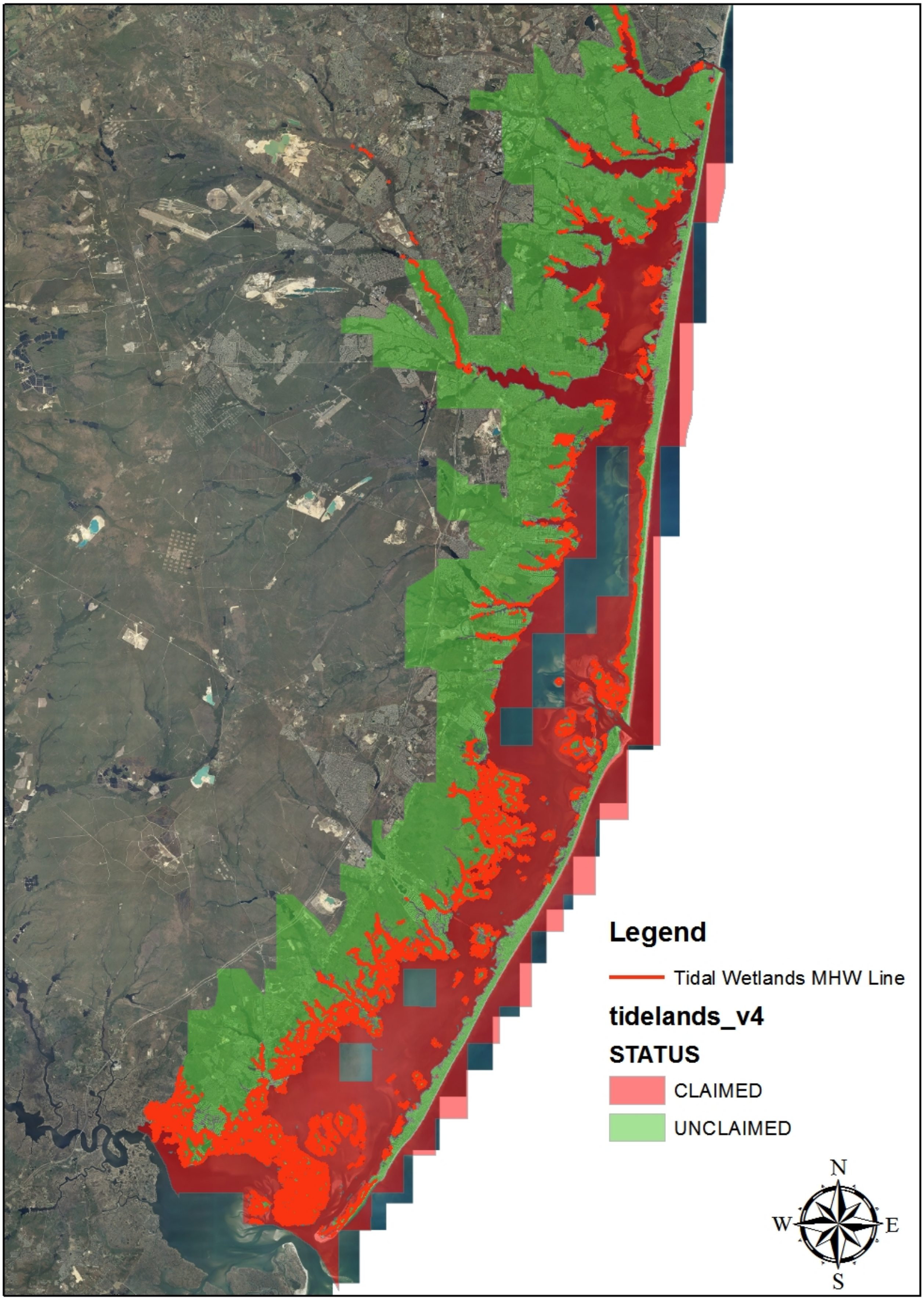
400
800
1,600
Feet
The Richard Stockton College of New Jersey
CRC
Coastal Research Center


Legend
MHW Line
N
W
E
S


Legend
MHW - NAVD88 Correction Surface, Feet
Value
High : 0
Low : -1.8835
N
W
E
S


Legend
oc_lulc_2007_v3
TYPE07
AGRICULTURE
BARREN LAND
FOREST
URBAN
WETLANDS
N
W
E
S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Tidal Wetlands MHW Line
tidelands_v4
STATUS
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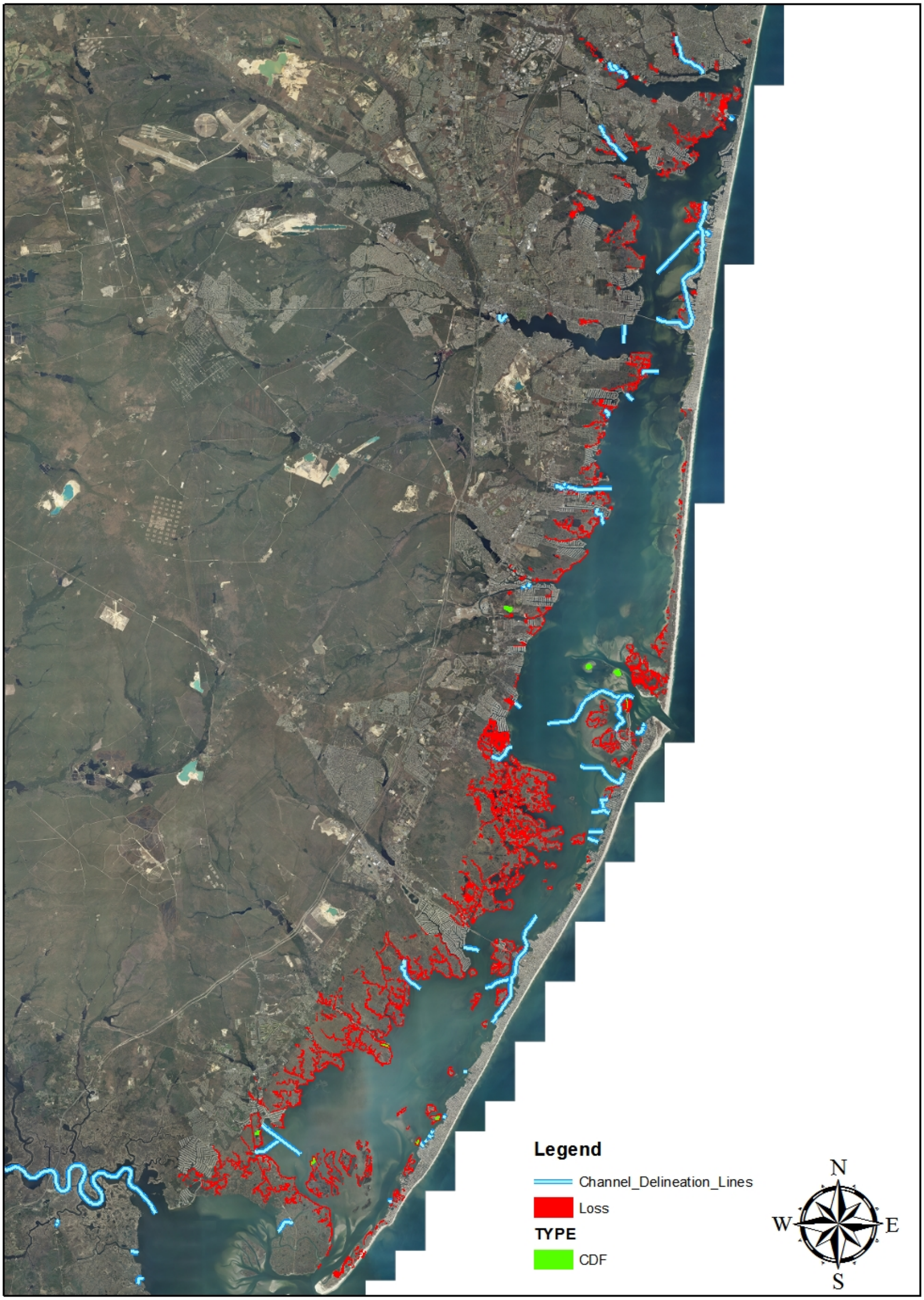
UNCLAIMED
N
W
E
S



Legend
Channel_Delineation_Lines
Loss
TYPE
CDF
N
W
E
S

# HAZUS-MH
# RESULTS

# HAZUS-MH: Flood Event Report

**Region Name:** Berkeley_0pc_test

**Flood Scenario:** berk_0pc

**Print Date:** Friday, May 09, 2014

***Disclaimer:***

*Totals only reflect data for those census tracts/blocks included in the user's study region.*

*The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Flood. These results can be improved by using enhanced inventory data and flood hazard information.*

# Table of Contents

## General Description of the Region

HAZUS is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of HAZUS is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The flood loss estimates provided in this report were based on a region that included 1 county(ies) from the following state(s):

- New Jersey

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 10 square miles and contains 182 census blocks. There are over 3 thousand households in the region and has a total population of 6,708 people (2000 Census Bureau data). The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 3,596 buildings in the region with a total building replacement value (excluding contents) of 589 million dollars (2006 dollars). Approximately 94.72% of the buildings (and 89.56% of the building value) are associated with residential housing.

# Building Inventory

## General Building Stock

HAZUS estimates that there are 3,596 buildings in the region which have an aggregate total replacement value of 589 million (2006 dollars). Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

**Table 1**
**Building Exposure by Occupancy Type for the Study Region**

| Occupancy | Exposure ($1000) | Percent of Total |
|---|---|---|
| Residential | 527,663 | 89.6% |
| Commercial | 43,430 | 7.4% |
| Industrial | 11,152 | 1.9% |
| Agricultural | 1,750 | 0.3% |
| Religion | 2,903 | 0.5% |
| Government | 0 | 0.0% |
| Education | 2,292 | 0.4% |
| **Total** | **589,190** | **100.00%** |

**Table 2**
**Building Exposure by Occupancy Type for the Scenario**

| Occupancy | Exposure ($1000) | Percent of Total |
|---|---|---|
| Residential | 448,252 | 89.7% |
| Commercial | 36,590 | 7.3% |
| Industrial | 9,966 | 2.0% |
| Agricultural | 1,750 | 0.4% |
| Religion | 962 | 0.2% |
| Government | 0 | 0.0% |
| Education | 2,292 | 0.5% |
| **Total** | **499,812** | **100.00%** |

## Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 2 schools, no fire stations, no police stations and no emergency operation centers.

## Flood Scenario Parameters

HAZUS used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

| | |
|---|---|
| **Study Region Name:** | Berkeley_0pc_test |
| **Scenario Name:** | berk_0pc |
| **Return Period Analyzed:** | 100 |
| **Analysis Options Analyzed:** | No What-Ifs |

## Building Damage

### General Building Stock Damage

HAZUS estimates that about 1,064 buildings will be at least moderately damaged. This is over 18% of the total number of buildings in the scenario. There are an estimated 145 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS Flood technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

**Table 3: Expected Building Damage by Occupancy**

| | 1-10 | | 11-20 | | 21-30 | | 31-40 | | 41-50 | | Substantially | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Occupancy** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** |
| Agriculture | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Commercial | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Education | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Government | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Industrial | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Religion | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Residential | 12 | 1.12 | 110 | 10.22 | 200 | 18.59 | 332 | 30.86 | 277 | 25.74 | 145 | 13.48 |
| **Total** | **12** | | **110** | | **200** | | **332** | | **277** | | **145** | |

**Table 4: Expected Building Damage by Building Type**

| **Building Type** | 1-10 | | 11-20 | | 21-30 | | 31-40 | | 41-50 | | Substantially | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** |
| Concrete | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| ManufHousing | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Masonry | 0 | 0.00 | 2 | 3.77 | 11 | 20.75 | 19 | 35.85 | 15 | 28.30 | 6 | 11.32 |
| Steel | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Wood | 12 | 1.17 | 108 | 10.56 | 189 | 18.48 | 313 | 30.60 | 262 | 25.61 | 139 | 13.59 |

## Essential Facility Damage

Before the flood analyzed in this scenario, the region had  hospital beds available for use.  On the day of the scenario flood event, the model estimates that 0 hospital beds are available in the region.

**Table 5: Expected Damage to Essential Facilities**

| | | # Facilities | | |
|---|---|---|---|---|
| **Classification** | Total | At Least Moderate | At Least Substantial | Loss of Use |
| Fire Stations | 0 | 0 | 0 | 0 |
| Hospitals | 0 | 0 | 0 | 0 |
| Police Stations | 0 | 0 | 0 | 0 |
| Schools | 2 | 2 | 0 | 0 |

If this report displays all zeros or is blank, two possibilities can explain this.

(1)  None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2)  The analysis was not run.  This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

## Induced Flood Damage

### Debris Generation

HAZUS estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 8,491 tons of debris will be generated. Of the total amount, Finishes comprises 71% of the total, Structure comprises 18% of the total. If the debris tonnage is converted into an estimated number of truckloads, it will require 340 truckloads (@25 tons/truck) to remove the debris generated by the flood.

## Social Impact

### Shelter Requirements

HAZUS estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. HAZUS also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 1,366 households will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 3,573 people (out of a total population of 6,708) will seek temporary shelter in public shelters.

## Economic Loss

The total economic loss estimated for the flood is 151.41 million dollars, which represents 30.29 % of the total replacement value of the scenario buildings.

### Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the flood.

The total building-related losses were 150.60 million dollars. 0% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 83.92% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

**Table 6: Building-Related Economic Loss Estimates**

(Millions of dollars)

| Category | Area | Residential | Commercial | Industrial | Others | Total |
|---|---|---|---|---|---|---|
| Building Loss | | | | | | |
| | Building | 83.09 | 4.71 | 2.13 | 0.28 | 90.21 |
| | Content | 43.72 | 11.82 | 2.84 | 1.22 | 59.61 |
| | Inventory | 0.00 | 0.24 | 0.48 | 0.06 | 0.78 |
| | **Subtotal** | **126.82** | **16.77** | **5.45** | **1.56** | **150.60** |
| Business Interruption | | | | | | |
| | Income | 0.00 | 0.08 | 0.00 | 0.01 | 0.09 |
| | Relocation | 0.19 | 0.01 | 0.00 | 0.00 | 0.20 |
| | Rental Income | 0.05 | 0.01 | 0.00 | 0.00 | 0.06 |
| | Wage | 0.00 | 0.06 | 0.00 | 0.04 | 0.10 |
| | **Subtotal** | **0.25** | **0.15** | **0.00** | **0.05** | **0.45** |
| ALL | **Total** | **127.07** | **16.92** | **5.45** | **1.61** | **151.04** |

## Appendix A: County Listing for the Region

New Jersey

- Ocean

## Appendix B: Regional Population and Building Value Data

| | | Building Value (thousands of dollars) | | |
|---|---|---|---|---|
| | Population | Residential | Non-Residential | Total |
| **New Jersey** | | | | |
| Ocean | 6,708 | 527,663 | 61,527 | 589,190 |
| **Total** | **6,708** | **527,663** | **61,527** | **589,190** |
| **Total Study Region** | **6,708** | **527,663** | **61,527** | **589,190** |

# HAZUS-MH: Flood Event Report

**Region Name:** Berkeley_100pc_test

**Flood Scenario:** berkeley_100pc

**Print Date:** Monday, May 12, 2014

***Disclaimer:***

*Totals only reflect data for those census tracts/blocks included in the user's study region.*

*The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Flood. These results can be improved by using enhanced inventory data and flood hazard information.*

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## General Description of the Region

HAZUS is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of HAZUS is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The flood loss estimates provided in this report were based on a region that included 1 county(ies) from the following state(s):

- New Jersey

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 10 square miles and contains 182 census blocks. There are over 3 thousand households in the region and has a total population of 6,708 people (2000 Census Bureau data). The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 3,596 buildings in the region with a total building replacement value (excluding contents) of 589 million dollars (2006 dollars). Approximately 94.72% of the buildings (and 89.56% of the building value) are associated with residential housing.

## Building Inventory

### General Building Stock

HAZUS estimates that there are 3,596 buildings in the region which have an aggregate total replacement value of 589 million (2006 dollars). Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

**Table 1**
**Building Exposure by Occupancy Type for the Study Region**

| Occupancy | Exposure ($1000) | Percent of Total |
|---|---|---|
| Residential | 527,663 | 89.6% |
| Commercial | 43,430 | 7.4% |
| Industrial | 11,152 | 1.9% |
| Agricultural | 1,750 | 0.3% |
| Religion | 2,903 | 0.5% |
| Government | 0 | 0.0% |
| Education | 2,292 | 0.4% |
| **Total** | **589,190** | **100.00%** |

**Table 2**
**Building Exposure by Occupancy Type for the Scenario**

| Occupancy | Exposure ($1000) | Percent of Total |
|---|---|---|
| Residential | 448,252 | 89.7% |
| Commercial | 36,590 | 7.3% |
| Industrial | 9,966 | 2.0% |
| Agricultural | 1,750 | 0.4% |
| Religion | 962 | 0.2% |
| Government | 0 | 0.0% |
| Education | 2,292 | 0.5% |
| **Total** | **499,812** | **100.00%** |

### Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 2 schools, no fire stations, no police stations and no emergency operation centers.

## Flood Scenario Parameters

HAZUS used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

| | |
|---|---|
| **Study Region Name:** | Berkeley_100pc_test |
| **Scenario Name:** | berkeley_100pc |
| **Return Period Analyzed:** | 100 |
| **Analysis Options Analyzed:** | No What-Ifs |

## Building Damage

### General Building Stock Damage

HAZUS estimates that about 1,064 buildings will be at least moderately damaged. This is over 18% of the total number of buildings in the scenario. There are an estimated 145 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS Flood technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

**Table 3: Expected Building Damage by Occupancy**

| | 1-10 | | 11-20 | | 21-30 | | 31-40 | | 41-50 | | Substantially | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Occupancy** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** |
| Agriculture | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Commercial | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Education | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Government | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Industrial | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Religion | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Residential | 12 | 1.12 | 110 | 10.22 | 200 | 18.59 | 332 | 30.86 | 277 | 25.74 | 145 | 13.48 |
| **Total** | **12** | | **110** | | **200** | | **332** | | **277** | | **145** | |

**Table 4: Expected Building Damage by Building Type**

| **Building Type** | 1-10 | | 11-20 | | 21-30 | | 31-40 | | 41-50 | | Substantially | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** |
| Concrete | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| ManufHousing | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Masonry | 0 | 0.00 | 2 | 3.77 | 11 | 20.75 | 19 | 35.85 | 15 | 28.30 | 6 | 11.32 |
| Steel | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Wood | 12 | 1.17 | 108 | 10.56 | 189 | 18.48 | 313 | 30.60 | 262 | 25.61 | 139 | 13.59 |

## Essential Facility Damage

Before the flood analyzed in this scenario, the region had  hospital beds available for use.  On the day of the scenario flood event, the model estimates that 0 hospital beds are available in the region.

**Table 5: Expected Damage to Essential Facilities**

| | | # Facilities | | |
|---|---|---|---|---|
| **Classification** | Total | At Least Moderate | At Least Substantial | Loss of Use |
| Fire Stations | 0 | 0 | 0 | 0 |
| Hospitals | 0 | 0 | 0 | 0 |
| Police Stations | 0 | 0 | 0 | 0 |
| Schools | 2 | 2 | 0 | 0 |

If this report displays all zeros or is blank, two possibilities can explain this.

(1) None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2) The analysis was not run. This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

## Induced Flood Damage

### Debris Generation

HAZUS estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 8,421 tons of debris will be generated. Of the total amount, Finishes comprises 72% of the total, Structure comprises 17% of the total. If the debris tonnage is converted into an estimated number of truckloads, it will require 337 truckloads (@25 tons/truck) to remove the debris generated by the flood.

## Social Impact

### Shelter Requirements

HAZUS estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. HAZUS also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 1,366 households will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 3,573 people (out of a total population of 6,708) will seek temporary shelter in public shelters.

## Economic Loss

The total economic loss estimated for the flood is 151.39 million dollars, which represents 30.29 % of the total replacement value of the scenario buildings.

### Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the flood.

The total building-related losses were 150.57 million dollars. 0% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 83.92% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

**Table 6: Building-Related Economic Loss Estimates**

(Millions of dollars)

| Category | Area | Residential | Commercial | Industrial | Others | Total |
|---|---|---|---|---|---|---|
| Building Loss | | | | | | |
| | Building | 83.08 | 4.71 | 2.13 | 0.28 | 90.19 |
| | Content | 43.72 | 11.82 | 2.84 | 1.22 | 59.60 |
| | Inventory | 0.00 | 0.24 | 0.48 | 0.06 | 0.78 |
| | **Subtotal** | **126.80** | **16.76** | **5.45** | **1.56** | **150.57** |
| Business Interruption | | | | | | |
| | Income | 0.00 | 0.08 | 0.00 | 0.01 | 0.09 |
| | Relocation | 0.19 | 0.01 | 0.00 | 0.00 | 0.20 |
| | Rental Income | 0.05 | 0.01 | 0.00 | 0.00 | 0.06 |
| | Wage | 0.00 | 0.06 | 0.00 | 0.04 | 0.10 |
| | **Subtotal** | **0.25** | **0.15** | **0.00** | **0.05** | **0.45** |
| ALL | **Total** | **127.05** | **16.92** | **5.45** | **1.61** | **151.02** |

## Appendix A: County Listing for the Region

New Jersey

- Ocean

## Appendix B: Regional Population and Building Value Data

| | | Building Value (thousands of dollars) | | |
|---|---|---|---|---|
| | Population | Residential | Non-Residential | Total |
| **New Jersey** | | | | |
| Ocean | 6,708 | 527,663 | 61,527 | 589,190 |
| **Total** | **6,708** | **527,663** | **61,527** | **589,190** |
| **Total Study Region** | **6,708** | **527,663** | **61,527** | **589,190** |

# HAZUS-MH: Flood Event Report

**Region Name:** Lacey_0pc_test

**Flood Scenario:** Lacey 0pc

**Print Date:** Friday, May 09, 2014

***Disclaimer:***

*Totals only reflect data for those census tracts/blocks included in the user's study region.*

*The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Flood. These results can be improved by using enhanced inventory data and flood hazard information.*

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## General Description of the Region

HAZUS is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of HAZUS is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The flood loss estimates provided in this report were based on a region that included 1 county(ies) from the following state(s):

- New Jersey

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 8 square miles and contains 342 census blocks. There are over 5 thousand households in the region and has a total population of 12,592 people (2000 Census Bureau data). The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 6,368 buildings in the region with a total building replacement value (excluding contents) of 1,103 million dollars (2006 dollars). Approximately 94.11% of the buildings (and 88.18% of the building value) are associated with residential housing.

## Building Inventory

### General Building Stock

HAZUS estimates that there are 6,368 buildings in the region which have an aggregate total replacement value of 1,103 million (2006 dollars). Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

**Table 1**
**Building Exposure by Occupancy Type for the Study Region**

| Occupancy | Exposure ($1000) | Percent of Total |
|---|---|---|
| Residential | 972,546 | 88.2% |
| Commercial | 91,573 | 8.3% |
| Industrial | 25,333 | 2.3% |
| Agricultural | 1,227 | 0.1% |
| Religion | 7,391 | 0.7% |
| Government | 268 | 0.0% |
| Education | 4,582 | 0.4% |
| **Total** | **1,102,920** | **100.00%** |

**Table 2**
**Building Exposure by Occupancy Type for the Scenario**

| Occupancy | Exposure ($1000) | Percent of Total |
|---|---|---|
| Residential | 884,376 | 88.6% |
| Commercial | 80,384 | 8.1% |
| Industrial | 23,008 | 2.3% |
| Agricultural | 1,071 | 0.1% |
| Religion | 4,984 | 0.5% |
| Government | 268 | 0.0% |
| Education | 4,032 | 0.4% |
| **Total** | **998,123** | **100.00%** |

### Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are no schools, no fire stations, no police stations and no emergency operation centers.

## Flood Scenario Parameters

HAZUS used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

| | |
|---|---|
| **Study Region Name:** | Lacey_0pc_test |
| **Scenario Name:** | Lacey 0pc |
| **Return Period Analyzed:** | 100 |
| **Analysis Options Analyzed:** | No What-Ifs |

## Building Damage

### General Building Stock Damage

HAZUS estimates that about 1,424 buildings will be at least moderately damaged. This is over 14% of the total number of buildings in the scenario. There are an estimated 218 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS Flood technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

**Table 3: Expected Building Damage by Occupancy**

| | 1-10 | | 11-20 | | 21-30 | | 31-40 | | 41-50 | | Substantially | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Occupancy** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** |
| Agriculture | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Commercial | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Education | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Government | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Industrial | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Religion | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Residential | 9 | 0.63 | 169 | 11.79 | 265 | 18.49 | 387 | 27.01 | 385 | 26.87 | 218 | 15.21 |
| **Total** | **9** | | **169** | | **265** | | **387** | | **385** | | **218** | |

**Table 4: Expected Building Damage by Building Type**

| **Building Type** | 1-10 | | 11-20 | | 21-30 | | 31-40 | | 41-50 | | Substantially | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** |
| Concrete | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| ManufHousing | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 2 | 100.00 |
| Masonry | 0 | 0.00 | 2 | 3.08 | 12 | 18.46 | 18 | 27.69 | 19 | 29.23 | 14 | 21.54 |
| Steel | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Wood | 9 | 0.66 | 167 | 12.23 | 253 | 18.52 | 369 | 27.01 | 366 | 26.79 | 202 | 14.79 |

## Essential Facility Damage

Before the flood analyzed in this scenario, the region had  hospital beds available for use.  On the day of the scenario flood event, the model estimates that 0 hospital beds are available in the region.

**Table 5: Expected Damage to Essential Facilities**

| | | # Facilities | | |
|---|---|---|---|---|
| **Classification** | Total | At Least Moderate | At Least Substantial | Loss of Use |
| Fire Stations | 0 | 0 | 0 | 0 |
| Hospitals | 0 | 0 | 0 | 0 |
| Police Stations | 0 | 0 | 0 | 0 |
| Schools | 0 | 0 | 0 | 0 |

If this report displays all zeros or is blank, two possibilities can explain this.

(1) None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2) The analysis was not run. This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

## Induced Flood Damage

### Debris Generation

HAZUS estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 4,512 tons of debris will be generated. Of the total amount, Finishes comprises 90% of the total, Structure comprises 6% of the total. If the debris tonnage is converted into an estimated number of truckloads, it will require 180 truckloads (@25 tons/truck) to remove the debris generated by the flood.

## Social Impact

### Shelter Requirements

HAZUS estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. HAZUS also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 2,839 households will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 6,874 people (out of a total population of 12,592) will seek temporary shelter in public shelters.

## Economic Loss

The total economic loss estimated for the flood is 261.00 million dollars, which represents 26.15 % of the total replacement value of the scenario buildings.

### Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the flood.

The total building-related losses were 259.32 million dollars. 0% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 77.74% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

**Table 6: Building-Related Economic Loss Estimates**

(Millions of dollars)

| Category | Area | Residential | Commercial | Industrial | Others | Total |
|---|---|---|---|---|---|---|
| Building Loss | | | | | | |
| | Building | 131.37 | 11.39 | 4.74 | 0.63 | 148.12 |
| | Content | 71.06 | 26.85 | 7.70 | 3.70 | 109.30 |
| | Inventory | 0.00 | 0.50 | 1.37 | 0.03 | 1.90 |
| | **Subtotal** | **202.42** | **38.73** | **13.81** | **4.36** | **259.32** |
| Business Interruption | | | | | | |
| | Income | 0.01 | 0.17 | 0.00 | 0.02 | 0.19 |
| | Relocation | 0.37 | 0.03 | 0.00 | 0.00 | 0.40 |
| | Rental Income | 0.07 | 0.02 | 0.00 | 0.00 | 0.09 |
| | Wage | 0.02 | 0.13 | 0.00 | 0.15 | 0.30 |
| | **Subtotal** | **0.47** | **0.35** | **0.00** | **0.16** | **0.99** |
| ALL | **Total** | **202.89** | **39.09** | **13.81** | **4.52** | **260.31** |

## Appendix A: County Listing for the Region

New Jersey
- Ocean

## Appendix B: Regional Population and Building Value Data

| | Population | Building Value (thousands of dollars) | | |
|---|---|---|---|---|
| | | Residential | Non-Residential | Total |
| **New Jersev** | | | | |
| Ocean | 12,592 | 972,546 | 130,374 | 1,102,920 |
| **Total** | **12,592** | **972,546** | **130,374** | **1,102,920** |
| **Total Study Region** | **12,592** | **972,546** | **130,374** | **1,102,920** |

# HAZUS-MH: Flood Event Report

**Region Name:** Lacey_100pc_test

**Flood Scenario:** lacey100pc_v2

**Print Date:** Thursday, May 08, 2014

***Disclaimer:***

*Totals only reflect data for those census tracts/blocks included in the user's study region.*

*The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Flood. These results can be improved by using enhanced inventory data and flood hazard information.*

# Table of Contents

## General Description of the Region

HAZUS is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of HAZUS is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The flood loss estimates provided in this report were based on a region that included 1 county(ies) from the following state(s):

- New Jersey

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 8 square miles and contains 342 census blocks. There are over 5 thousand households in the region and has a total population of 12,592 people (2000 Census Bureau data). The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 6,368 buildings in the region with a total building replacement value (excluding contents) of 1,103 million dollars (2006 dollars). Approximately 94.11% of the buildings (and 88.18% of the building value) are associated with residential housing.

## Building Inventory

### General Building Stock

HAZUS estimates that there are 6,368 buildings in the region which have an aggregate total replacement value of 1,103 million (2006 dollars). Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

**Table 1**
**Building Exposure by Occupancy Type for the Study Region**

| Occupancy | Exposure ($1000) | Percent of Total |
|---|---|---|
| Residential | 972,546 | 88.2% |
| Commercial | 91,573 | 8.3% |
| Industrial | 25,333 | 2.3% |
| Agricultural | 1,227 | 0.1% |
| Religion | 7,391 | 0.7% |
| Government | 268 | 0.0% |
| Education | 4,582 | 0.4% |
| **Total** | **1,102,920** | **100.00%** |

**Table 2**
**Building Exposure by Occupancy Type for the Scenario**

| Occupancy | Exposure ($1000) | Percent of Total |
|---|---|---|
| Residential | 884,376 | 88.6% |
| Commercial | 80,384 | 8.1% |
| Industrial | 23,008 | 2.3% |
| Agricultural | 1,071 | 0.1% |
| Religion | 4,984 | 0.5% |
| Government | 268 | 0.0% |
| Education | 4,032 | 0.4% |
| **Total** | **998,123** | **100.00%** |

### Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are no schools, no fire stations, no police stations and no emergency operation centers.

## Flood Scenario Parameters

HAZUS used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

| | |
|---|---|
| **Study Region Name:** | Lacey_100pc_test |
| **Scenario Name:** | lacey100pc_v2 |
| **Return Period Analyzed:** | 100 |
| **Analysis Options Analyzed:** | No What-Ifs |

## Building Damage

### General Building Stock Damage

HAZUS estimates that about 1,425 buildings will be at least moderately damaged. This is over 14% of the total number of buildings in the scenario. There are an estimated 218 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS Flood technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

**Table 3: Expected Building Damage by Occupancy**

| | 1-10 | | 11-20 | | 21-30 | | 31-40 | | 41-50 | | Substantially | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Occupancy** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** |
| Agriculture | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Commercial | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Education | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Government | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Industrial | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Religion | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Residential | 9 | 0.63 | 169 | 11.79 | 266 | 18.55 | 387 | 26.99 | 385 | 26.85 | 218 | 15.20 |
| **Total** | **9** | | **169** | | **266** | | **387** | | **385** | | **218** | |

**Table 4: Expected Building Damage by Building Type**

| **Building Type** | 1-10 | | 11-20 | | 21-30 | | 31-40 | | 41-50 | | Substantially | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** |
| Concrete | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| ManufHousing | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 2 | 100.00 |
| Masonry | 0 | 0.00 | 2 | 3.08 | 12 | 18.46 | 18 | 27.69 | 19 | 29.23 | 14 | 21.54 |
| Steel | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Wood | 9 | 0.66 | 167 | 12.22 | 254 | 18.58 | 369 | 26.99 | 366 | 26.77 | 202 | 14.78 |

## Essential Facility Damage

Before the flood analyzed in this scenario, the region had  hospital beds available for use.  On the day of the scenario flood event, the model estimates that 0 hospital beds are available in the region.

**Table 5: Expected Damage to Essential Facilities**

| | | # Facilities | | |
|---|---|---|---|---|
| **Classification** | Total | At Least Moderate | At Least Substantial | Loss of Use |
| Fire Stations | 0 | 0 | 0 | 0 |
| Hospitals | 0 | 0 | 0 | 0 |
| Police Stations | 0 | 0 | 0 | 0 |
| Schools | 0 | 0 | 0 | 0 |

If this report displays all zeros or is blank, two possibilities can explain this.

(1)  None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2)  The analysis was not run.  This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

## Induced Flood Damage

### Debris Generation

HAZUS estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 4,509 tons of debris will be generated. Of the total amount, Finishes comprises 90% of the total, Structure comprises 6% of the total. If the debris tonnage is converted into an estimated number of truckloads, it will require 180 truckloads (@25 tons/truck) to remove the debris generated by the flood.

## Social Impact

### Shelter Requirements

HAZUS estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. HAZUS also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 2,839 households will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 6,874 people (out of a total population of 12,592) will seek temporary shelter in public shelters.

# Economic Loss

The total economic loss estimated for the flood is 260.96 million dollars, which represents 26.14 % of the total replacement value of the scenario buildings.

## Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the flood.

The total building-related losses were 259.28 million dollars. 0% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 77.73% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

**Table 6: Building-Related Economic Loss Estimates**

(Millions of dollars)

| Category | Area | Residential | Commercial | Industrial | Others | Total |
|---|---|---|---|---|---|---|
| Building Loss | | | | | | |
| | Building | 131.34 | 11.39 | 4.74 | 0.63 | 148.10 |
| | Content | 71.04 | 26.84 | 7.70 | 3.70 | 109.28 |
| | Inventory | 0.00 | 0.50 | 1.37 | 0.03 | 1.90 |
| | **Subtotal** | **202.38** | **38.73** | **13.81** | **4.36** | **259.28** |
| Business Interruption | | | | | | |
| | Income | 0.01 | 0.17 | 0.00 | 0.02 | 0.19 |
| | Relocation | 0.37 | 0.03 | 0.00 | 0.00 | 0.40 |
| | Rental Income | 0.07 | 0.02 | 0.00 | 0.00 | 0.09 |
| | Wage | 0.02 | 0.13 | 0.00 | 0.15 | 0.30 |
| | **Subtotal** | **0.47** | **0.35** | **0.00** | **0.16** | **0.99** |
| ALL | **Total** | **202.85** | **39.09** | **13.81** | **4.52** | **260.27** |

## Appendix A: County Listing for the Region

New Jersey

- Ocean

## Appendix B: Regional Population and Building Value Data

| | Population | Building Value (thousands of dollars) | | |
|---|---|---|---|---|
| | | Residential | Non-Residential | Total |
| **New Jersey** | | | | |
| Ocean | 12,592 | 972,546 | 130,374 | 1,102,920 |
| **Total** | **12,592** | **972,546** | **130,374** | **1,102,920** |
| **Total Study Region** | **12,592** | **972,546** | **130,374** | **1,102,920** |

# HAZUS-MH: Flood Event Report

**Region Name:** Tuckerton_Test_2

**Flood Scenario:** tuck100yr3

**Print Date:** Friday, January 24, 2014

***Disclaimer:***

*Totals only reflect data for those census tracts/blocks included in the user's study region.*

*The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Flood. These results can be improved by using enhanced inventory data and flood hazard information.*

# Table of Contents

## General Description of the Region

HAZUS is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of HAZUS is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The flood loss estimates provided in this report were based on a region that included 1 county(ies) from the following state(s):

- New Jersey

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 8 square miles and contains 149 census blocks. There are over 4 thousand households in the region and has a total population of 9,256 people (2000 Census Bureau data). The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 4,357 buildings in the region with a total building replacement value (excluding contents) of 844 million dollars (2006 dollars). Approximately 93.55% of the buildings (and 67.84% of the building value) are associated with residential housing.

## Building Inventory

### General Building Stock

HAZUS estimates that there are 4,357 buildings in the region which have an aggregate total replacement value of 844 million (2006 dollars). Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

**Table 1**
**Building Exposure by Occupancy Type for the Study Region**

| Occupancy | Exposure ($1000) | Percent of Total |
|---|---|---|
| Residential | 572,461 | 67.8% |
| Commercial | 235,650 | 27.9% |
| Industrial | 15,271 | 1.8% |
| Agricultural | 2,273 | 0.3% |
| Religion | 8,985 | 1.1% |
| Government | 6,484 | 0.8% |
| Education | 2,680 | 0.3% |
| **Total** | **843,804** | **100.00%** |

**Table 2**
**Building Exposure by Occupancy Type for the Scenario**

| Occupancy | Exposure ($1000) | Percent of Total |
|---|---|---|
| Residential | 438,142 | 87.8% |
| Commercial | 44,221 | 8.9% |
| Industrial | 9,523 | 1.9% |
| Agricultural | 1,379 | 0.3% |
| Religion | 2,708 | 0.5% |
| Government | 1,007 | 0.2% |
| Education | 2,141 | 0.4% |
| **Total** | **499,121** | **100.00%** |

### Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 4 schools, 2 fire stations, 2 police stations and 1 emergency operation center.

## Flood Scenario Parameters

HAZUS used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

| | |
|---|---|
| **Study Region Name:** | Tuckerton_Test_2 |
| **Scenario Name:** | tuck100yr3 |
| **Return Period Analyzed:** | 100 |
| **Analysis Options Analyzed:** | No What-Ifs |

## Building Damage

### General Building Stock Damage

HAZUS estimates that about 1,003 buildings will be at least moderately damaged. This is over 8% of the total number of buildings in the scenario. There are an estimated 440 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS Flood technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

**Table 3: Expected Building Damage by Occupancy**

| | 1-10 | | 11-20 | | 21-30 | | 31-40 | | 41-50 | | Substantially | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Occupancy** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** |
| Agriculture | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Commercial | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Education | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Government | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Industrial | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Religion | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Residential | 0 | 0.00 | 11 | 1.10 | 83 | 8.28 | 209 | 20.84 | 260 | 25.92 | 440 | 43.87 |
| **Total** | **0** | | **11** | | **83** | | **209** | | **260** | | **440** | |

**Table 4: Expected Building Damage by Building Type**

| **Building Type** | 1-10 | | 11-20 | | 21-30 | | 31-40 | | 41-50 | | Substantially | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** |
| Concrete | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| ManufHousing | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 24 | 100.00 |
| Masonry | 0 | 0.00 | 0 | 0.00 | 3 | 4.23 | 15 | 21.13 | 20 | 28.17 | 33 | 46.48 |
| Steel | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Wood | 0 | 0.00 | 11 | 1.21 | 80 | 8.80 | 194 | 21.34 | 241 | 26.51 | 383 | 42.13 |

## Essential Facility Damage

Before the flood analyzed in this scenario, the region had  hospital beds available for use.  On the day of the scenario flood event, the model estimates that 0 hospital beds are available in the region.

**Table 5: Expected Damage to Essential Facilities**

| | | # Facilities | | |
|---|---|---|---|---|
| **Classification** | Total | At Least Moderate | At Least Substantial | Loss of Use |
| Fire Stations | 2 | 0 | 0 | 0 |
| Hospitals | 0 | 0 | 0 | 0 |
| Police Stations | 2 | 1 | 0 | 0 |
| Schools | 4 | 0 | 0 | 0 |

If this report displays all zeros or is blank, two possibilities can explain this.

(1) None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2) The analysis was not run. This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

## Induced Flood Damage

### Debris Generation

HAZUS estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 13,963 tons of debris will be generated. Of the total amount, Finishes comprises 51% of the total, Structure comprises 29% of the total. If the debris tonnage is converted into an estimated number of truckloads, it will require 559 truckloads (@25 tons/truck) to remove the debris generated by the flood.

## Social Impact

### Shelter Requirements

HAZUS estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. HAZUS also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 937 households will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 2,485 people (out of a total population of 9,256) will seek temporary shelter in public shelters.

## Economic Loss

The total economic loss estimated for the flood is 124.72 million dollars, which represents 24.99 % of the total replacement value of the scenario buildings.

### Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the flood.

The total building-related losses were 124.15 million dollars. 0% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 84.21% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

**Table 6: Building-Related Economic Loss Estimates**

(Millions of dollars)

| Category | Area | Residential | Commercial | Industrial | Others | Total |
|---|---|---|---|---|---|---|
| Building Loss | | | | | | |
| | Building | 68.50 | 4.26 | 1.50 | 0.40 | 74.65 |
| | Content | 36.35 | 8.95 | 2.16 | 1.39 | 48.84 |
| | Inventory | 0.00 | 0.17 | 0.41 | 0.07 | 0.66 |
| | **Subtotal** | **104.85** | **13.38** | **4.07** | **1.86** | **124.15** |
| Business Interruption | | | | | | |
| | Income | 0.00 | 0.05 | 0.00 | 0.01 | 0.05 |
| | Relocation | 0.14 | 0.01 | 0.00 | 0.00 | 0.15 |
| | Rental Income | 0.04 | 0.01 | 0.00 | 0.00 | 0.05 |
| | Wage | 0.00 | 0.04 | 0.00 | 0.04 | 0.07 |
| | **Subtotal** | **0.18** | **0.10** | **0.00** | **0.04** | **0.32** |
| ALL | **Total** | **105.03** | **13.47** | **4.07** | **1.90** | **124.47** |

## Appendix A: County Listing for the Region

New Jersey

- Ocean

## Appendix B: Regional Population and Building Value Data

| | | Building Value (thousands of dollars) | | |
|---|---|---|---|---|
| | Population | Residential | Non-Residential | Total |
| **New Jersev** | | | | |
| Ocean | 9,256 | 572,461 | 271,343 | 843,804 |
| **Total** | **9,256** | **572,461** | **271,343** | **843,804** |
| **Total Study Region** | **9,256** | **572,461** | **271,343** | **843,804** |

# HAZUS-MH: Flood Event Report

**Region Name:** tuck100pc_test

**Flood Scenario:** tuck100pctest

**Print Date:** Friday, January 24, 2014

***Disclaimer:***

*Totals only reflect data for those census tracts/blocks included in the user's study region.*

*The estimates of social and economic impacts contained in this report were produced using HAZUS loss estimation methodology software which is based on current scientific and engineering knowledge. There are uncertainties inherent in any loss estimation technique. Therefore, there may be significant differences between the modeled results contained in this report and the actual social and economic losses following a specific Flood. These results can be improved by using enhanced inventory data and flood hazard information.*

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## General Description of the Region

HAZUS is a regional multi-hazard loss estimation model that was developed by the Federal Emergency Management Agency (FEMA) and the National Institute of Building Sciences (NIBS). The primary purpose of HAZUS is to provide a methodology and software application to develop multi-hazard losses at a regional scale. These loss estimates would be used primarily by local, state and regional officials to plan and stimulate efforts to reduce risks from multi-hazards and to prepare for emergency response and recovery.

The flood loss estimates provided in this report were based on a region that included 1 county(ies) from the following state(s):

- New Jersey

Note:
Appendix A contains a complete listing of the counties contained in the region.

The geographical size of the region is 8 square miles and contains 149 census blocks. There are over 4 thousand households in the region and has a total population of 9,256 people (2000 Census Bureau data). The distribution of population by State and County for the study region is provided in Appendix B.

There are an estimated 4,357 buildings in the region with a total building replacement value (excluding contents) of 844 million dollars (2006 dollars). Approximately 93.55% of the buildings (and 67.84% of the building value) are associated with residential housing.

# Building Inventory

## General Building Stock

HAZUS estimates that there are 4,357 buildings in the region which have an aggregate total replacement value of 844 million (2006 dollars). Table 1 and Table 2 present the relative distribution of the value with respect to the general occupancies by Study Region and Scenario respectively. Appendix B provides a general distribution of the building value by State and County.

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|---|---|---|
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| Industrial | 15,271 | 1.8% |
| Agricultural | 2,273 | 0.3% |
| Religion | 8,985 | 1.1% |
| Government | 6,484 | 0.8% |
| Education | 2,680 | 0.3% |
| **Total** | **843,804** | **100.00%** |

**Table 2**
**Building Exposure by Occupancy Type for the Scenario**

| Occupancy | Exposure ($1000) | Percent of Total |
|---|---|---|
| Residential | 438,142 | 87.8% |
| Commercial | 44,221 | 8.9% |
| Industrial | 9,523 | 1.9% |
| Agricultural | 1,379 | 0.3% |
| Religion | 2,708 | 0.5% |
| Government | 1,007 | 0.2% |
| Education | 2,141 | 0.4% |
| **Total** | **499,121** | **100.00%** |

## Essential Facility Inventory

For essential facilities, there are no hospitals in the region with a total bed capacity of no beds. There are 4 schools, 2 fire stations, 2 police stations and 1 emergency operation center.

## Flood Scenario Parameters

HAZUS used the following set of information to define the flood parameters for the flood loss estimate provided in this report.

| | |
|---|---|
| **Study Region Name:** | tuck100pc_test |
| **Scenario Name:** | tuck100pctest |
| **Return Period Analyzed:** | 100 |
| **Analysis Options Analyzed:** | No What-Ifs |

## General Building Stock Damage

HAZUS estimates that about 1,003 buildings will be at least moderately damaged. This is over 8% of the total number of buildings in the scenario. There are an estimated 440 buildings that will be completely destroyed. The definition of the 'damage states' is provided in Volume 1: Chapter 5 of the HAZUS Flood technical manual. Table 3 below summarizes the expected damage by general occupancy for the buildings in the region. Table 4 summarizes the expected damage by general building type.

**Table 3: Expected Building Damage by Occupancy**

| | 1-10 | | 11-20 | | 21-30 | | 31-40 | | 41-50 | | Substantially | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Occupancy** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** |
| Agriculture | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Commercial | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Education | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Government | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Industrial | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Religion | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Residential | 0 | 0.00 | 11 | 1.10 | 83 | 8.28 | 209 | 20.84 | 260 | 25.92 | 440 | 43.87 |
| **Total** | **0** | | **11** | | **83** | | **209** | | **260** | | **440** | |

**Table 4: Expected Building Damage by Building Type**

| **Building Type** | **1-10** | | **11-20** | | **21-30** | | **31-40** | | **41-50** | | **Substantially** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** | **Count** | **(%)** |
| Concrete | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| ManufHousing | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 24 | 100.00 |
| Masonry | 0 | 0.00 | 0 | 0.00 | 3 | 4.23 | 15 | 21.13 | 20 | 28.17 | 33 | 46.48 |
| Steel | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 | 0 | 0.00 |
| Wood | 0 | 0.00 | 11 | 1.21 | 80 | 8.80 | 194 | 21.34 | 241 | 26.51 | 383 | 42.13 |

## Essential Facility Damage

Before the flood analyzed in this scenario, the region had  hospital beds available for use.  On the day of the scenario flood event, the model estimates that 0 hospital beds are available in the region.

**Table 5: Expected Damage to Essential Facilities**

| | | # Facilities | | |
|---|---|---|---|---|
| **Classification** | Total | At Least Moderate | At Least Substantial | Loss of Use |
| Fire Stations | 2 | 0 | 0 | 0 |
| Hospitals | 0 | 0 | 0 | 0 |
| Police Stations | 2 | 1 | 0 | 0 |
| Schools | 4 | 0 | 0 | 0 |

If this report displays all zeros or is blank, two possibilities can explain this.

(1)  None of your facilities were flooded. This can be checked by mapping the inventory data on the depth grid.

(2)  The analysis was not run.  This can be tested by checking the run box on the Analysis Menu and seeing if a message box asks you to replace the existing results.

## Induced Flood Damage

### Debris Generation

HAZUS estimates the amount of debris that will be generated by the flood. The model breaks debris into three general categories: 1) Finishes (dry wall, insulation, etc.), 2) Structural (wood, brick, etc.) and 3) Foundations (concrete slab, concrete block, rebar, etc.). This distinction is made because of the different types of material handling equipment required to handle the debris.

The model estimates that a total of 13,965 tons of debris will be generated. Of the total amount, Finishes comprises 51% of the total, Structure comprises 29% of the total. If the debris tonnage is converted into an estimated number of truckloads, it will require 559 truckloads (@25 tons/truck) to remove the debris generated by the flood.

## Social Impact

### Shelter Requirements

HAZUS estimates the number of households that are expected to be displaced from their homes due to the flood and the associated potential evacuation. HAZUS also estimates those displaced people that will require accommodations in temporary public shelters. The model estimates 937 households will be displaced due to the flood. Displacement includes households evacuated from within or very near to the inundated area. Of these, 2,485 people (out of a total population of 9,256) will seek temporary shelter in public shelters.

## Economic Loss

The total economic loss estimated for the flood is 124.72 million dollars, which represents 24.99 % of the total replacement value of the scenario buildings.

### Building-Related Losses

The building losses are broken into two categories: direct building losses and business interruption losses. The direct building losses are the estimated costs to repair or replace the damage caused to the building and its contents. The business interruption losses are the losses associated with inability to operate a business because of the damage sustained during the flood. Business interruption losses also include the temporary living expenses for those people displaced from their homes because of the flood.

The total building-related losses were 124.15 million dollars. 0% of the estimated losses were related to the business interruption of the region. The residential occupancies made up 84.21% of the total loss. Table 6 below provides a summary of the losses associated with the building damage.

**Table 6: Building-Related Economic Loss Estimates**

(Millions of dollars)

| Category | Area | Residential | Commercial | Industrial | Others | Total |
|---|---|---|---|---|---|---|
| Building Loss | | | | | | |
| | Building | 68.50 | 4.26 | 1.50 | 0.40 | 74.65 |
| | Content | 36.35 | 8.95 | 2.16 | 1.39 | 48.84 |
| | Inventory | 0.00 | 0.17 | 0.41 | 0.07 | 0.66 |
| | **Subtotal** | **104.85** | **13.37** | **4.07** | **1.86** | **124.15** |
| Business Interruption | | | | | | |
| | Income | 0.00 | 0.05 | 0.00 | 0.01 | 0.05 |
| | Relocation | 0.14 | 0.01 | 0.00 | 0.00 | 0.15 |
| | Rental Income | 0.04 | 0.01 | 0.00 | 0.00 | 0.05 |
| | Wage | 0.00 | 0.04 | 0.00 | 0.04 | 0.07 |
| | **Subtotal** | **0.18** | **0.10** | **0.00** | **0.04** | **0.32** |
| ALL | **Total** | **105.03** | **13.47** | **4.07** | **1.90** | **124.47** |

## Appendix A: County Listing for the Region

New Jersey

- Ocean

## Appendix B: Regional Population and Building Value Data

| | Population | Building Value (thousands of dollars) | | |
|---|---|---|---|---|
| | | Residential | Non-Residential | Total |
| **New Jersey** | | | | |
| Ocean | 9,256 | 572,461 | 271,343 | 843,804 |
| **Total** | **9,256** | **572,461** | **271,343** | **843,804** |
| **Total Study Region** | **9,256** | **572,461** | **271,343** | **843,804** |

# WHAFIS
# PART 2*
# RESULTS

| Transect ID | 0% Restoration | | 50% Restoration | | 100% Restoration | |
|---|---|---|---|---|---|---|
| | Wave Height(ft) | Elevation | Wave Height(ft) | Elevation | Wave Height(ft) | Elevation |
| 6160 | 4.51 | 9.86 | 4.54 | 9.89 | 4.54 | 9.89 |
| 6180 | 4.48 | 9.80 | 4.18 | 9.59 | 4.18 | 9.59 |
| 6360 | 3.50 | 8.83 | 3.50 | 8.83 | 3.50 | 8.83 |
| 6470 | 4.47 | 9.84 | 3.14 | 8.90 | 3.14 | 8.90 |
| 6710 | 3.84 | 9.65 | 3.63 | 9.50 | 3.63 | 9.50 |
| 6900 | 4.79 | 11.24 | 3.86 | 10.59 | 3.83 | 10.57 |
| Average | 4.27 | 9.87 | 3.81 | 9.55 | 3.80 | 9.55 |

| Transect ID | 0% - 50% Restoration | | 0% - 100% Restoration | | 50% - 100% Restoration | |
|---|---|---|---|---|---|---|
| | Wave Height(ft) | Elevation | Wave Height(ft) | Elevation | Wave Height(ft) | Elevation |
| 6160 | 0.03 | 0.03 | 0.03 | 0.03 | 0.00 | 0.00 |
| 6180 | -0.30 | -0.21 | -0.30 | -0.21 | 0.00 | 0.00 |
| 6360 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 6470 | -1.33 | -0.94 | -1.33 | -0.94 | 0.00 | 0.00 |
| 6710 | -0.21 | -0.15 | -0.21 | -0.15 | 0.00 | 0.00 |
| 6900 | -0.93 | -0.65 | -0.96 | -0.67 | -0.03 | -0.02 |
| Average | -0.46 | -0.32 | -0.46 | -0.32 | 0.00 | 0.00 |

*Complete WHAFIS output reports can have lengths of 150 pages or greater. Wave conditions at the shorline are from the first line of output data from "Part 2" in WHAFIS output reports and the onl information referenced in report. Complete WHAFIS output can be provided upon request.