



University Transportation Research Center - Region 2

Final Report

Landfill Closure with Dredged Materials - Desktop Analysis

Performing Organization: Rutgers University

August 2014



Sponsors:

New Jersey Department of Transportation (NJDOT)

University Transportation Research Center - Region 2

University Transportation Research Center - Region 2

The Region 2 University Transportation Research Center (UTRC) is one of ten original University Transportation Centers established in 1987 by the U.S. Congress. These Centers were established with the recognition that transportation plays a key role in the nation's economy and the quality of life of its citizens. University faculty members provide a critical link in resolving our national and regional transportation problems while training the professionals who address our transportation systems and their customers on a daily basis.

The UTRC was established in order to support research, education and the transfer of technology in the field of transportation. The theme of the Center is "Planning and Managing Regional Transportation Systems in a Changing World." Presently, under the direction of Dr. Camille Kamga, the UTRC represents USDOT Region II, including New York, New Jersey, Puerto Rico and the U.S. Virgin Islands. Functioning as a consortium of twelve major Universities throughout the region, UTRC is located at the CUNY Institute for Transportation Systems at The City College of New York, the lead institution of the consortium. The Center, through its consortium, an Agency-Industry Council and its Director and Staff, supports research, education, and technology transfer under its theme. UTRC's three main goals are:

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Landfill Closure with Dredged Materials - Desktop Analysis

**FINAL REPORT
September 2014**

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16. Abstract This report describes a Rutgers University project for the New Jersey Department of Transportation (NJDOT) designed to analyze the potential for closure of New Jersey landfills using dredge material from existing Confined Disposal Facilities (CDF). The project included an update of the existing New Jersey Department of Environmental Protection (NJDEP) landfill database, the development of a rating system to identify sites with the highest potential to utilize dredged material for their closure, and the identification and preliminary investigation of the top five candidate landfills based on this rating system. Due to information developed during the project it was determined that all but four of the landfills assessed or closure were considered unsuitable for closure as a result only four landfills were selected and investigate further. The results of this project can be used by the NJDOT to facilitate the efficient closure of selected landfills, the beneficial reuse of the materials in CDFs, and the continued use of the state's CDFs and dredging activities.			
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EXECUTIVE SUMMARY

The New Jersey Department of Transportation (NJDOT) has identified many confined disposal facilities (CDFs) as at or near capacity with dredged materials. Periodic dredging of channels and marinas is of significant importance to New Jersey's recreational and commercial marine transportation. Establishment of new CDFs has been deemed improbable, thus the most efficient solution to this problem is reuse of dredged materials to increase the longevity of existing CDFs. Rutgers University was contracted to investigate the potential for utilizing dredged material from these CDFs in the closure of New Jersey's uncapped landfills.

The investigation involved the update of the New Jersey Department of Environmental Protection's (NJDEP) existing landfill database to fill existing data gaps. Next, a numerical rating system was established to evaluate landfill/CDF pairs for potential closure of the landfill with dredged materials. The pairs with the greatest potential for closure were identified in collaboration with personnel from the NJDOT Office of Maritime Resources and the NJDEP Solid and Hazardous Waste Management Program. Phase I Environmental Site Assessments were then conducted for the selected landfills to determine their suitability for closure.

The project yielded several results, including the following:

- The NJDEP landfill database was updated and converted to GIS form.
- A ranking system was developed to identify landfill/CDF pairs with the greatest potential for closure.
- The ranking system was applied to the database and the top landfill/CDF pairs were identified.
- Phase I Environmental Assessments were completed for the selected landfills.

Due to the post-ranking identification of several of the highly ranked landfills as previously closed, redeveloped, or undergoing an active site remediation, as well as a shift in the NJDOT Office of Maritime Resources' CDF priorities following Hurricane Sandy, the four landfills ultimately selected for Phase I Assessment were not among the most highly ranked pairs. These landfills were the Tinton Falls Municipal Sanitary Landfill in Tinton Falls, Monmouth County; Winzinger Landfill in Hainesport, Burlington County; Elsinboro Township Sanitary Landfill in Elsinboro, Salem County; and Filmore Sanitary Landfill in Middle Township, Cape May County. Personnel from T&M Associates and a team of undergraduate Rutgers University BioEnvironmental Engineering students conducted the Phase I Environmental Site Assessments for these four landfills.

BACKGROUND

Confined disposal facilities (CDFs) are facilities that accept and store dredged materials. CDFs are located throughout the coastal areas of New Jersey and are traditionally within a relatively short distance of the channels and marinas that require periodic dredging. The New Jersey Department of Transportation (NJDOT) has recently inventoried and sampled the existing CDFs and has determined that many are at or near capacity. The creation of new CDFs is unlikely due to high land prices in coastal regions of New Jersey and the environmental issues inherent with dredged material. A potential solution to this lack of storage space is to remove and reuse the dredged material for some beneficial use. Without reuse of at least portion of the dredged material, there is a potential for the reduction of dredging activities, which would negatively affect New Jersey's marine transportation of both recreational and commercial vessels.

The NJDOT has identified landfill closure with dredged material as a beneficial use option for the material stored in CDFs. Prior to this effort, the New Jersey Department of Environmental Protection (NJDEP) landfill database identified over 90% of the landfills in New Jersey's Cape May, Atlantic, Burlington, Ocean, and Monmouth Counties that stopped operating prior to 1982 as having not been officially closed. There is a potential to utilize significant amounts of dredged material in the capping of these landfills to aid in the viability of the CDFs.

OBJECTIVES

This project was completed to identify the best candidate pre-1982 landfills for closure with dredged material stored in CDFs. The project's objectives were defined as:

- Identification of existing pre-1982 landfills requiring closure in the southern half of the state that are potential candidates for closure with dredged material.
- Development of a rating system of potential landfill sites with the assistance and guidance of the NJDOT and NJDEP.
- Identification of landfills with the highest potential for closure with dredged materials via rating system.
- Investigation of the suitability for closure of identified landfills via Phase I Environmental Site Assessments.

INTRODUCTION

The project team utilized the existing NJDEP Bureau of Solid & Hazardous Waste and Permitting database to identify pre-1982 landfills that required closure in Cape May, Atlantic, Burlington, Ocean, and Monmouth Counties. This database contained several data gaps at the beginning of the project. In cooperation with the NJDEP and local government officials, the database has been updated to close data gaps. In addition, a landfill database shape file was developed in ArcGIS to geo-locate each of the landfills. The attribute table from the database containing all of the pertinent data for each landfill is tied to the locations.

Using the updated landfill database, the guidance of the NJDOT and NJDEP, and the analysis of material transport parameters, a rating system was created to analyze the characteristics of landfills and nearby CDFs. This rating system was used to prioritize landfills with the highest potential for closure with dredged materials. Parameters were identified that impacted closure activities. Each parameter in this rating system was appropriately weighted in order to reach the desired goals of the department. Once the rating system was developed and accepted by the NJDEP and NJDOT personnel, it was applied to the landfill database. The rating system identified landfill/CDF pairs that represented the highest potential for closure. However, further investigation of the identified landfill sites indicated that several of them were either redeveloped, undergoing site remediation, or otherwise not available for closure. As a result, the project team selected the four highest rated landfill/CDF pairs for further investigation via Phase I Environmental Site Investigations.

The four selected landfills were the Tinton Falls Municipal Sanitary Landfill in Tinton Falls, Monmouth County; Winzinger Landfill in Hainesport, Burlington County; Elsinboro Township Sanitary Landfill in Elsinboro, Salem County; and Filmore Sanitary Landfill in Middle Township, Cape May County. Each of these landfills was investigated by personnel from T&M Associates and a team of undergraduate Bio-Environmental Engineering students from Rutgers University. These Phase I Investigations have been conducted in accordance with the New Jersey Department of Environmental Protection (NJDEP) Preliminary Assessment procedure specified at NJAC 7:26E, 3.1, and 3.2.

SUMMARY OF LITERATURE REVIEW

Review/Update of Existing NJDEP Landfill Database

The project team used the existing NJDEP Landfill Database from August 2011 to identify candidate landfills for potential closure with CDF material. Only those landfills that ceased operation prior to 1982 were included in the analysis as directed by NJDOT guidance. The database contains several fields with pertinent information about the landfill. In several cases much of this data was incomplete or completely missing,

especially details regarding location. The project team then conducted a records search to obtain the missing data and to spatially delineate the landfills. The records search included review of the following sources:

- Public tax records subdivision maps.
- Exhaustive internet searches for government site reports, municipal meeting minutes, news articles, etc.
- Visits to county environmental health offices to speak with local solid waste experts and environmental health officers, including:
 - Atlantic County Division of Public Health.
 - Cape May County Municipal Utilities Authority.
 - Gloucester County Division of Environmental Services.
- Landfill history expertise provided by Mr. Bashar Assadi.
- Aerial photography.

At the onset of this project, 387 landfills were identified in the focus area (Monmouth County and areas south). Prior to our records search only 142 of these had Block/Lot information. After the records search this number increased to 279 landfills. In addition, four new fields were added to those in the existing landfill database through the records search. These include:

- Year operation ceased
- Acreage
- Waste type
- Ownership

Once the spatial extent of each landfill was determined, a shapefile was developed in ArcGIS of each delineated landfill. Each parameter included in the database was included in the attributes for each delineated landfill. A digital version of the database is included on a CD-ROM as appendix A.

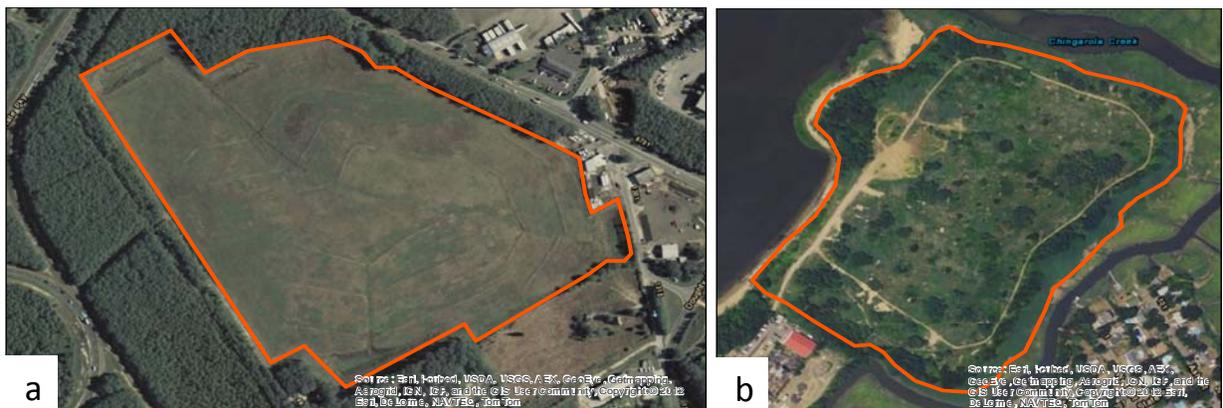


Figure 1. Landfill delineation shapefile polygons (a) Delilah Road Landfill, Atlantic County, (b) Waste Disposal Inc./Aero Marine Landfill, Monmouth County

A total of 243 landfill polygons were developed during the project. (See figure 2.) Each polygon has corresponding data in its attribute table corresponding to the fields in the appended landfill database. These fields are:

- Estimated quantity of material needed for closure.
- Proximity to CDFs appropriate for providing material for closure.
- Landfill size.
- Demand for fill in addition to cover.
- Degree of contamination per NJDEP data base.
- Proximity to major highways, ports and waterways.
- Proximity to power facility or electric grid.
- Owner(s) willingness to close landfill.
- Costs.
- Site conditions.
- Potential site redevelopment.
- Environmental habitat concerns using LANDSCAPE.
- Possible remediation action required.

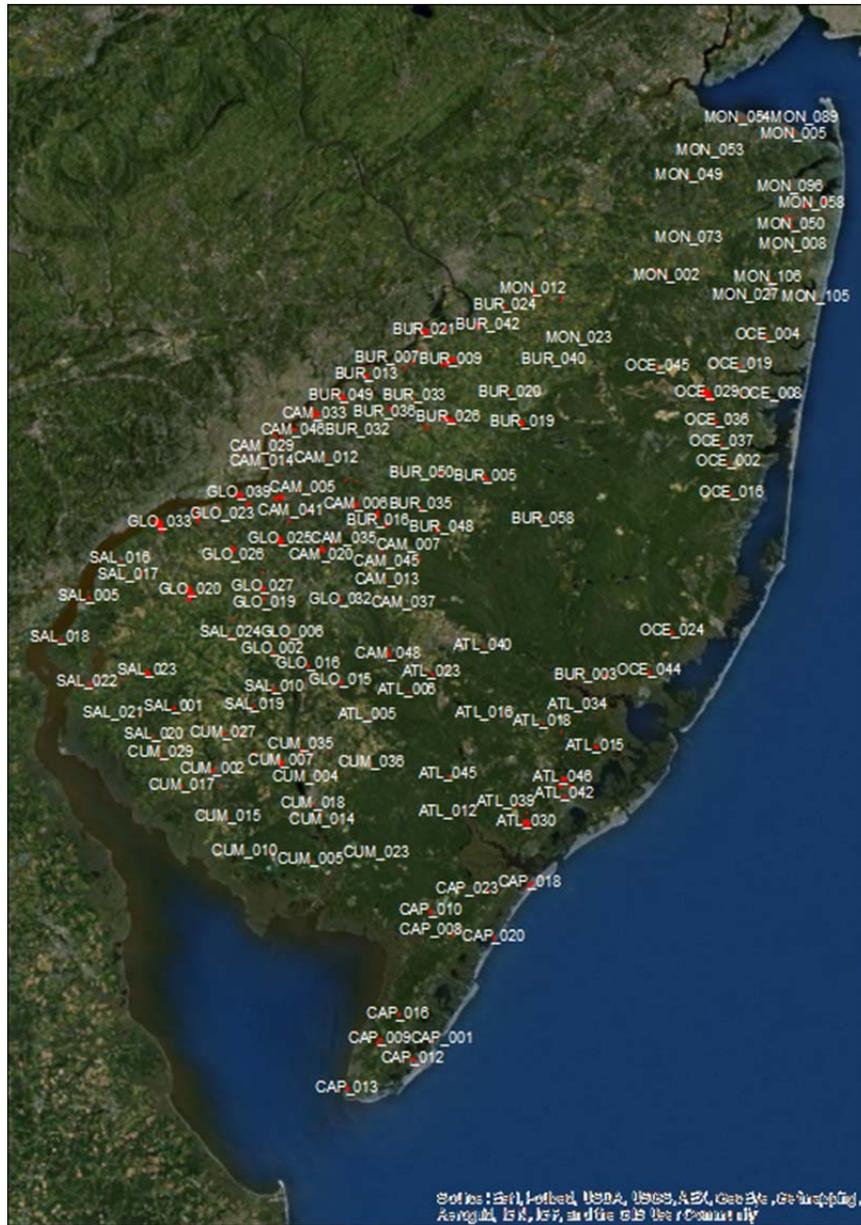


Figure 2. Location of delineated landfills statewide

SUMMARY OF WORK PERFORMED

In order to assess the potential success of closure of a landfill with material from a CDF, the characteristics of material transport between the landfills and CDFs are required in addition to the characteristics of the landfills and CDFs. Thus landfill/CDF pairs were identified. This was completed by analyzing the surrounding road network and determining the three closest CDFs to each landfill. This analysis was completed using the existing CDF database developed by the Richard Stockton College, Coastal Research Center for the NJDOT (Farrell et al, 2009), the existing New Jersey GIS road

network geodatabase (NJDOT GIS Data, 2013), and the geo-located landfill database developed for this project.

The characteristics of three landfill/CDF pairs for each pre-1982 landfill were then compiled for the ranking system. The ranking system that was developed for this project required a numerical score for each assessed parameter. These scores were normalized and weighted according to the relative importance of the parameter. An aggregate score was then compiled to determine the landfill/CDF pair that represented the highest potential for successful closure with dredged material. The weighting factors for each parameter were determined in cooperation with the NJDOT Office of Maritime Resources, the NJDEP Solid and Hazardous Waste Management Program and NJDEP Site Remediation Program, and the project team. The parameters that were decided upon for the final ranking system were:

- CDF Ownership (Public or Private)
- Landfill Ownership (Public or Private)
- Volume of CDF greater than required to cover landfill (Y/N)
- Aggregate Distance Score
- Average Landfill Slope Score
- Distance to Residential Development
- Clearing Type (Trees, Brush, None)
- CDF Area in acres (<5 =0.1, 5 < n < 22 = 0.5, >22=1)
- Landfill Area in acres (Normalized to second largest to avoid skewing by outlier)
- Landfill Topography Standard Deviation
- At Capacity (Yes=1, No=0.1, Could be with work = 0.5)
- CDF within 3 miles of channel

The first two parameters involved ownership of the CDFs and landfills. It was decided that publicly owned facilities were far superior to privately owned facilities with respect to accessibility and funding methods. As a result, publicly owned facilities were given a score of 1 and privately owned facilities were given a score of 0.1. The third parameter involved the ability of a CDF to provide enough material to close the landfill. The use of a single CDF of higher capacity would be advantageous due to the avoided added costs associated with establishing more than one transfer operation for a single landfill. This benefit was viewed as limited, however, thus the score of 1 was given to a CDF that contained sufficient material to cover a target landfill and 0.8 to one that was not. These first three scores were used to create an operational multiplier, M. All landfill/CDF pairs were analyzed with and without the multiplier in order to determine rank based solely on the physical properties, and with the anticipated operational limitations imposed via these parameters.

The remaining parameters were obtained via overlays created from the identified attributes in GIS. The values determined for each parameter were then normalized to a

score from 1 to 0 with the most favorable score being 1 and the least favorable being 0. For example the landfill/CDF pair that had the least distance between them scored a one and the greatest scored a zero. Certain parameters were identified that skewed the data towards certain CDFs. It was determined that categorical scores would be more appropriate so CDF Area was scored using three categories (<5 =0.1, 5 < n < 22 = 0.5, >22=1) and the percent-filled capacity of the CDF was also scored using three categories (Yes=0.1, N=1, Could be with work = 0.5). The weights determined for these parameters were:

Table 1 - Ranking Procedure Parameter Weights

Parameter	Weight
Aggregate Distance Score	8
Average Landfill Slope Score	2
Distance to Residential Development	4
Clearing Type	6
CDF Area	7
Landfill Area (Normalized to second largest to avoid skewing by outlier)	7
Landfill Topography Standard Deviation	4
At Capacity	7
Within 3 miles of channel	7

The aggregate distance score was determined using a weighting procedure that favored major roads (State or interstate roads, identified as Road I) over local roads (identified as Road II). This was quantified using a weight for Road II that was twice that of Road I, thus one mile on a local road was the equivalent of two on a major road.

$$Distance\ Score = (1.0)Dist_{Road\ I} + (2.0)Dist_{Road\ II} \quad (1)$$

Once all of the parameters were normalized and the weighting factors determined, a total score of a landfill/CDF pair was determined as the aggregate of all parameters adjusted by their weights.

$$Total\ Score_i = M_i * \sum_{all\ j} W_j * P_{ij} \quad (2)$$

Where M_i is the landfill/CDF pair specific operational multiplier, W_j is the parameter specific weighting factor, and P_{ij} is the normalized value of each parameter, j , for each

landfill/CDF pair, i. Of the 172 landfill/CDF pairs analyzed the highest score was a 36.44 and lowest was < 1. The landfill/CDF pairs identified in table 2 are the highest 20 scores identified by this analysis.

Table 2 - Landfill/CDF Scores (Twenty Highest Total Scores)

Landfill	CDF	Operational Multiplier	Raw Score	Total Score
'CAP_020	Devil's Island'	1	34.66	34.66
'CAM_023	Cinnaminson CDF'	1	33.66	33.66
'MON_027	Lightning Jacks Marina'	1	28.58	28.58
'OCE_016	High Bar Harbor'	1	28.27	28.27
'BUR_011	Enterprise Range'	1	25.46	25.46
'OCE_024	Long Point Thorofare'	0.8	31.51	25.21
'BUR_011	Devlin Channel'	1	24.91	24.91
'CUM_023	Clubhouse Lagoon #1'	1	24.77	24.77
'OCE_024	Tuckerton Creek #1'	0.8	30.88	24.71
'OCE_004	Lightning Jacks Marina'	0.8	29.22	23.38
'CAP_020	Ludlam Thorofare #1'	0.8	29.15	23.32
'OCE_008	Lightning Jacks Marina'	0.8	29.00	23.20
'CAM_022	Fisher Point'	0.8	28.55	22.84
'CAM_041	Fisher Point'	0.8	28.52	22.82
'CUM_023	All Seasons Marina'	0.8	28.09	22.47
'OCE_024	Story Island'	0.8	28.04	22.43
'MON_005	Leonardo Harbor'	0.8	28.02	22.42
'MON_021	Atlantic Highlands Harbor'	1	22.27	22.27
'MON_059	Atlantic Highlands Harbor'	1	22.21	22.21
'BUR_040	Newbold Island'	1	22.08	22.08

A second analysis was completed that was independent of the operational multiplier; this was done to identify landfill/CDF pairs that represented the greatest potential for closure based solely on the physical parameters of the pair. This was identified as the raw score. Table 3 presents the twenty highest landfill/CDF pairs identified by the raw score.

Table 3 - Landfill/CDF Scores (Twenty Highest Raw Scores)

Landfill	CDF	Operational Multiplier	Raw Score	Multiplier Adjusted Score
'BUR_049	Cinnaminson CDF'	0.1	41.47	4.15
GLO_033*	Logan Plant'	0.4	36.35	14.54
'MON_054	Keansburg CDF'	0.08	36.29	2.90
'CAP_020	Devil's Island'	1	34.66	34.66
'CAM_046	Cinnaminson CDF'	0.1	34.58	3.46
'BUR_049	Dredge Harbor'	0.08	33.67	2.69
'CAM_023	Cinnaminson CDF'	1	33.66	33.66
'GLO_026	Logan Plant'	0.04	33.48	1.34
'CAM_020	Fisher Point'	0.08	33.45	2.68
'GLO_039	Fisher Point'	0.4	33.40	13.36
'ATL_037	Broad Thorofare #2'	0.008	31.54	0.25
'OCE_024	Long Point Thorofare'	0.8	31.51	25.21
'BUR_017	Burlington Island Cell B'	0.01	31.42	0.31
'BUR_017	Newbold Island'	0.01	31.34	0.31
'CAM_018	Fisher Point'	0.08	31.03	2.48
'OCE_024	Tuckerton Creek #1'	0.8	30.88	24.71
'CAM_006	Fisher Point'	0.08	30.52	2.44
'BUR_011	Burlington Island Cell B'	0.1	30.45	3.05
'ATL_009	Broad Thorofare #2'	0.01	30.27	0.30
'GLO_023	Logan Plant'	0.4	29.98	11.99

The entire ranked dataset, including parameter specific scores, is included as appendix B.

Subsequent to the ranking analysis, findings were shared with the personnel from the NJDOT Office of Maritime Resources and the NJDEP Solid and Hazardous Waste Management Program to determine their priorities for CDF excavation and landfill closure. Upon further investigation, several of the highly ranked landfills in the pairs were identified as previously closed, redeveloped, or undergoing and active site remediation. In addition, the occurrence of Hurricane Sandy in October 2012 changed the CDF priorities of the NJDOT Office of Maritime Resources. As a result, the landfills selected for Phase I Environmental Site Investigation are not from the landfill/CDF pairs identified as those with the highest potential for closure with dredged material.

The four selected landfills were the Tinton Falls Municipal Sanitary Landfall in Tinton Falls, Monmouth County; Winzinger Landfill in Hainesport, Burlington County; Elsinboro

Township Sanitary Landfill, Elsinboro, Salem County; and Filmore Sanitary Landfill, Middle Township, Cape May County. Each of these were identified as part of a landfill/CDF pair with a relatively high total score determined by the ranking system developed for this project. The landfill/CDF pairs were:

Table 4 - Final Landfill/CDF Pairs

Landfill	CDF	Raw Score	Multiplier Adjusted Score
Winzinger	Burlington Island Cell B'	25.42	2.54
Winzinger	Hawk Island'	23.03	2.30
Winzinger	Castle Harbor'	16.92	0.17
Filmore	Richardson Channel #5'	28.63	0.23
Filmore	Linger Pt #1'	22.67	0.23
Filmore	Dickenson Creek'	26.96	0.22
Tinton Falls	Belmar Marina'	26.52	21.22
Tinton Falls	Leonardo Harbor'	24.43	19.55
Tinton Falls	Atlantic Highlands Harbor'	22.39	1.79
Elsinboro	Penns Neck'	19.77	9.89
Elsinboro	Killcohook #1'	18.73	9.36
Elsinboro	Artificial Island'	17.86	8.93

The landfills that were investigated were parts of landfill/CDF pairs that scored relatively high in raw score, but lower when adjusted for the operational multiplier. The reasons for these low scores are: Winzinger is a privately owned landfill, Filmore is a privately owned landfill and the three associated CDFs are also private, the CDFs that are paired with Tinton Falls are small and have insufficient volume to close the landfill alone, and the CDFs paired with Elsinboro are all federal facilities.

Each of these landfills was investigated by personnel from T&M Associates and a team of undergraduate Bio-Environmental Engineering students from Rutgers University. These Phase I Investigations have been conducted in accordance with the New Jersey Department of Environmental Protection (NJDEP) Preliminary Assessment procedure specified at NJAC 7:26E, 3.1, and 3.2. The Phase I Reports for each of the sites are contained in appendices C, D, E, and F.

SITE ASSESSMENTS RESULTS

Each of the four selected landfills was investigated to determine the presence of potential issues associated with closure of the landfills. The following potential issues materials were identified by T&M Associates:

Tinton Falls Municipal Sanitary Landfill

“The file reviews conducted for the PA have not identified any formal NJDEP Solid Waste Program closure approval for the greater TFLS landfill including the Route 18 Portion which encompasses the majority of the greater, historic area of landfilling. However, the Route 18 Portion is currently capped and encumbered by the NJDOT Route 18 freeway lanes and exit ramps which presumably would not be available for capping with dredge materials due to completed engineering profiles achieved for the roadway project. The balance of the historic landfill area referred to here as the TFLS Site is approximately 2.50 acres in area with 2 foot thick cap of clean material placed in 1982. The TFLS Site receives stormwater sheet flow from the developed lands to the south as well as point-discharge flow from the GSP and Route 18 stormwater drainage systems. During the Site visit conducted for this PA, T&M identified area of ponding with phragmites growth indicating the potential presence of wetland areas at the TFSL Site. The NJDEP GeoWeb program mapping depicts “Managed Wetlands” area intersecting the south edge of the TFSL Site.

The NJDOT installed and sampled five (5) groundwater monitoring wells at the greater landfill area as part of the NJPDES Permit required for the development of the Route 18 Freeway in 1984. Monitoring well “MW-1” is situated at the TFSL Site and was located by T&M. The remainder of the monitoring wells installed and sampled by the NJDOT are/were located to the north, south and east of the TFSL Site. The groundwater analysis reporting reviewed for this PA has not identified any groundwater exceedances or contaminants in the groundwater at the TFSL Site MW-1 with the exception of dissolved iron. No NJDEP Spill Case Numbers indicating the reporting of or documentation of soil and/or groundwater contamination at the TFSL Site were identified for this PA.”

Winzinger Landfill

“The Baseline Ecological Evaluation dated February 2012 (the 2012 BEE) indicates that groundwater sampling conducted in April 2008 has indicated exceedances of the NJDEP Groundwater Quality Standards (GWQS) for Arsenic; sediment sampling data shows one sediment sample location with a concentration of arsenic above the residential direct contact soil remediation standard (RDCSRS) and polycyclic aromatic hydrocarbons (PAHs) below the RDCSRS; and PAHs were detected above the RDCSRS at the base of the fill material during sampling at test pits.”

Elsinboro Township Sanitary Landfill

“The July 20, 1989 NJDEP Discharge Surveillance Report for the Discharge To Groundwater NJPDES Permit for the ETSL Site indicates that there is one (1) permitted discharge to groundwater at the Site. The DSR Comments and attached Discharge Data table state that the following analytes exceeded the discharge limits during the 3rd and 4th quarters of 1988 and the 1st and 2nd quarters of 1989 at “some of the wells”: Cadmium, chlorides, coliform, Iron, Manganese, Selenium, Total Dissolved Solids, Ammonia, Nitrogen, Color, Sodium and Arsenic.

T&M’s comparison of the 1988 and 1989 discharge sampling event results with the current NJDEP Groundwater Quality Standards (GWQS) indicates that several of the listed parameters exceeded the current GWQS. The Discharge Report includes a sketch of the ETSL with locations of the four (4) on-Site monitoring wells. The correspondence provided by the Township indicates that groundwater monitoring at the ETSL was discontinued in 1990.

According to the NJDEP Case Transfer Report, the contamination case for the ETSL was transferred from the Bureau of Aquifer Restoration to the Bureau of Site Case Management for the “uncontrolled source” of groundwater contamination. The “Media Affected” is Groundwater which was sampled in 1987, 1988, 1989 and 1990. The Pollutants listed are Arsenic, Lead and Ammonia which were reported above the current NJDEP GWQS.”

Filmore Sanitary Landfill

“Based on the presence of permanent groundwater monitoring wells and temporary well sampling points throughout the FSL Site, T&M presumes that contaminated groundwater is being monitored and remediated at the Site. In addition, an approximately 11.6 acre portion of the original landfill area is developed with gasoline filling station/auto repair facility and family fun park. The developed areas may not be available for capping with dredge materials under the current conditions.”

More information regarding the potential issues and areas of concern for the four landfills can be found in T&M Associates’ Phase I Reports, included in appendices C, D, E, and F. Based on these results, it is recommended that prior to initiation of any closure activities, additional investigation of the identified potential issues be conducted at these sites.

The topography of the four landfill sites are either flat or sloping in one direction. As a result there are no apparent depressions that require filling which would expand the capacity of the landfills need to be filled up. This means you could use dredge mainly for the capping. It would be safe to assume 3,200 CY per acre. The site in Tinton Falls might be extended beyond where the contours are. I think the clover leaf and other

surrounding areas are in what used to be the landfill. Please refer to the historical aerial photographs included in the PA for Tinton Falls. So the area is bigger and would require more material.”

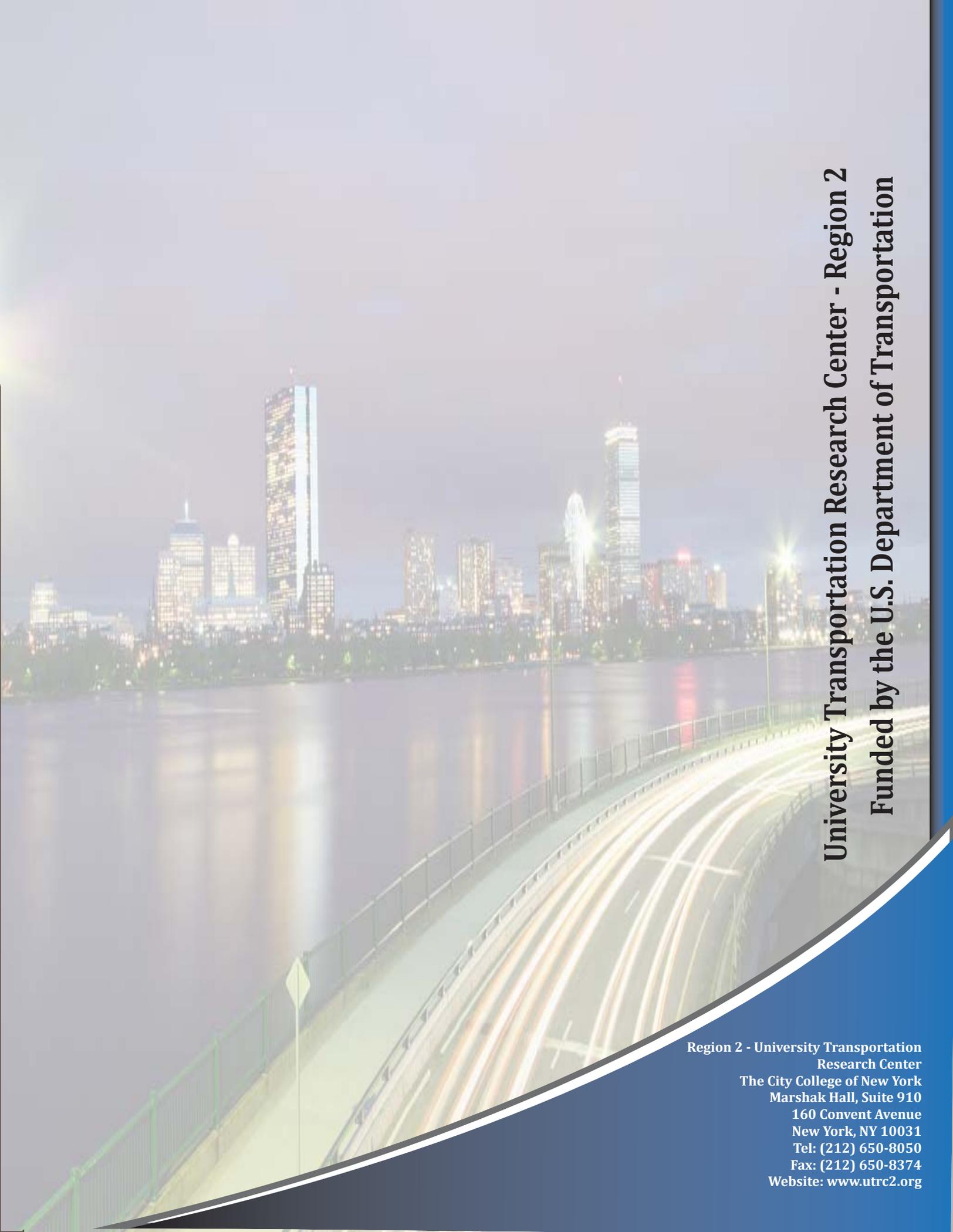
Initial calculations to determine the volume of dredged materials necessary to cap each of the four landfills produced the following results:

Table 5 - Volume of Dredged Materials Required for the Selected Landfills

Landfill	Volume required for a 2-foot cover (yd³)	Volume required for a 4-foot cover (yd³)
Tinton Falls Municipal Sanitary Landfill	8,067	16,134
Winzinger Landfill	70,987	141,974
Elsinboro Township Sanitary Landfill	38,720	77,440
Filmore Sanitary Landfill	51,627	103,254

REFERENCES

- Farrell, S. C., Barone, D. A., McKenna, K. K., Gorleski, E., Robine, C. M., & Koch, R. V. (2008). *Sediment Characterization and Management of Coastal Waterways, Atlantic County, New Jersey* (Technical Report No. 1). New Jersey Department of Transportation - Office of Maritime Resources, Trenton, New Jersey: The Richard Stockton College of New Jersey, Coastal Research Center. Retrieved from <http://crcgis.stockton.edu/iboat/atlanticcounty/index.htm>
- Geographic Information Systems: GIS Data. (2013). *New Jersey Department of Transportation (NJDOT)*. Retrieved June 10, 2014, from <http://www.state.nj.us/transportation/gis/data.shtm>

A long-exposure photograph of a city skyline at night, reflected in a body of water. In the foreground, a bridge or highway has light trails from moving vehicles. The sky is dark, and the city lights are bright and colorful.

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