

Redevelopment potential of landfills. A case study of six New Jersey projects

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Abstract

The paper will compare and contrast the experience of six landfill redevelopment projects engineered by Sadat Associates, Inc., where the authors, Messrs. Wiley and Assadi, have each worked for over 14 years.

The projects include one community college, the largest mall in the region, an office development, an 18-hole golf course and two housing developments. A total of 378 acres of waste have been properly closed and redeveloped in these projects. The construction value of the projects currently exceeds \$500 million, and when completed, will exceed \$1 billion.

Some of the projects involved constructing major building and site improvements, such as parking areas on top of old waste. Some projects involved waste consolidation/ relocation on site. Two of the projects involved beneficial use of over 7 million cubic yards of recycled materials and stabilized, contaminated dredge as part of the site development.

The paper will provide a comparison of the study, design and construction process at these six sites and will address relevant environmental and geotechnical factors. The paper will also address regulatory issues, including site contamination/remediation, and other environmental permit needs. In addition, the paper will explore the financial incentives and economic factors that made the projects feasible as well as institutional arrangements and community relations aspects.

The paper provides an evaluation of the many factors that make landfill redevelopment feasible in order to encourage practitioners in the field to consider the widest range of options for end uses of closed landfills.

The main factors that affect landfill redevelopment are: size of site, degree of contamination, type of waste, depth of waste, location, wetlands and open water bodies, use of recyclable materials for remediation and development purposes, land value, willing developer, regulatory agency policy/rules, engineering solutions, and financial initiatives.

1 Introduction

1.1 General

This paper provides a summary of technical, regulatory, institutional and economic aspects of redevelopment of six former landfill sites in New Jersey. These projects were permitted and designed by SAI for various clients over a period from 1988 to the present. The end uses of the sites range from commercial/retail to institutional and residential uses. In addition to compliance with landfill closure requirements, several of the sites (which had a history of industrial waste disposal) were characterized in accordance with site remediation rules and received (or will receive) a No Further Action Determination under a State remediation program (N.J.A.C. 7:26B).

1.2 Background

New Jersey has a legacy of improperly closed landfills. The New Jersey Department of Environmental Protection (NJDEP had historically) registered 387 landfills, most of which are currently closed. The State estimates that the total number of landfills (registered and unregistered) may approach 600. Most of the unregistered landfills were never properly closed. A handful of those landfills were properly closed and received a Closure and Post Closure Plan Approval pursuant to the Amended State Solid Waste Management Act of 1975 and/or the Sanitary Landfill Facility Closure and Contingency Fund Act of 1992. Hundreds of registered landfills were never properly closed because the owners lacked the resources to conform with regulatory closure requirements. While the Sanitary Landfill Facility Closure and Contingency Fund Act provides a revenue source through a tax on operating landfills, the State has historically not utilized these funds for closure of abandoned landfills and reserved the public funds for emergency actions, such as extinguishing a landfill fire or remediating methane migration. The State has also used the Spill Fund (Spill Compensation and Control Act) to study and remediate landfill sites which had a clear record of industrial waste disposal. Another group of large landfills were closed utilizing the Superfund. Nevertheless, hundreds of essentially orphaned landfill sites remain a problem with no plan for remediation being pursued either by current owners or the State. At one time, the NJDEP had worked on a Statewide Landfill Closure Plan. In the late 1980s, this plan estimated the unfunded capital costs to implement a program for closure of the registered landfills would have exceeded \$1.2 billion. Clearly the current capital costs of closure of registered and unregistered landfills would probably exceed \$2.0 billion. No coherent program to provide public funding for closure for the large number of unclosed sites has been developed.

The authors first became familiar with the problem of improperly closed landfills when they worked at the NJDEP. Mr. Wiley's last government position was Deputy Director of the Division of Solid Waste Management, where he had also served as Assistant Director for Planning. Mr. Assadi served as a Review Engi-

neer in the same division in the Landfill Bureau.

Sadat Associates, Inc. is a 55 person environmental engineering firm which specializes in site investigation and remediation, and has developed unique expertise in landfill redevelopment.

While the case studies of landfill redevelopment covered herein are for New Jersey sites, the technical issues are relevant to sites in other jurisdictions. Environmental conditions in New Jersey are very sensitive (the state has the highest population density in the country). Therefore, the case studies represent a model for both redevelopment potential of old landfills and proper remediation to meet the strictest environmental standards likely to be encountered in any jurisdiction.

2 Project summary descriptions

2.1 Overview

The six projects included a wide range of and uses including residential, commercial and institutional uses. Table 1 summarizes the key features of the projects including name/location, waste acreage, end use, remediation techniques, remedial costs, value of land uses constructed and beneficial use of recyclables.

2.1.1 Location and environmental setting

Most of the projects were located in the central/northern part of New Jersey where land is scarce and real estate values can range from \$100-300,000 /acre and more for developable land. One project was located along the Southern Jersey shore in an area of high real estate value.

2.1.2 Waste acreage/thickness

The projects ranged from 12 to 165 acres of waste. In all cases the waste was identified as municipal solid waste (MSW). However, both the Elizabeth and Bayonne sites had a history of industrial waste disposal as part of the MSW disposal operations. Waste thickness ranged from 10 to 30 feet.

2.1.3 Previous contamination

Previous contamination at the sites included typical parameters associated with general municipal solid waste (MSW). Sites such as Ashbrook Farms, Federal Business Centers, Wanaque/Passaic Co. Community College and North Wildwood had some heavy metals such as Arsenic, Lead or Beryllium above the State's industrial cleanup criteria. However, these parameters are related to typical urban soils and/or coal ash and are not unexpected in MSW. Two of the sites, Elizabeth and Bayonne, had a history of industrial dumping in portions of the sites. As a result, parameters such as petroleum, hydrocarbons and PCBs above the State's 2 PPM Nonresidential Cleanup Criterion, were encountered on portions of those sites. These sites required more intensive sampling to delineate Areas of Concern (AOC) within the landfills and to design limited removal of hazardous waste drums.

Groundwater was a potential concern at all of the sites because they were not

designed as contained facilities with liners or leachate collection systems. In the case of all of the landfills, except Wanaque, the sites were located on naturally impermeable formations (either clay or meadow mat). SAI conducted detailed groundwater studies for the Bayonne and Elizabeth sites (which were large and had a history of receiving industrial wastes) to confirm that the aquifer beneath the meadow mat had not been contaminated. For Ashbrook and Federal Business Centers, the landfills were relatively small and were sited on deep natural clay. Therefore, there was no concern of deeper aquifer contamination. In the case of Wanaque, a number of monitoring wells were placed in the rock aquifer. While there was slight landfill-related contamination (i.e. ammonia and TDS), the aquifer had a very low yield. No groundwater remediation was required.

2.1.4 End uses

The end uses varied widely. In an earlier project, such as Ashbrook Farms, the waste was moved, consolidated and capped so that the end use could be built on remediated areas of the site. The same occurred in the case of Federal Business Centers, except that parking areas were constructed over the re-encapsulated waste. The most recent project, North Wildwood, involves construction of elevated residential units on pile structures over the capped waste.

In some cases, the project owner had a well identified end use at the start of the project (North Wildwood, Bayonne). In the four other cases, a lengthy process of exploring alternatives for end use took place before the final use was selected. In three cases (Passaic, Ashbrook and Federal Business), the landfill was part of a larger property that was owned or acquired to develop the usable land. The landfill portion was an impediment to proper and complete use of the property.

2.1.5 Remediation techniques

A wide variety of remediation techniques were utilized. In the simplest case, waste was capped in place with one foot of silty, clayey material and one and one-half feet soil cover. In the most complex case, a slurry wall/sheet pile wall was used to contain leachate from outflow from the site and an interior leachate system was installed. The degree of capping, containment and leachate collection was influenced by the underlying geology, leachate strength and site specific cap design.

2.1.6 Remedial costs

Remedial costs ranged from \$0.3 to \$11 million. The cost per acre of closure/remediation ranged from \$10,000 to \$100,000. In addition to remedial costs, additional costs were incurred for the Elizabeth and Passaic projects for improving the geotechnical conditions of the waste to make it possible to build parking areas on the closed waste.

2.1.7 Value of end uses

The value of the constructed end uses varied from \$3 million to over \$500 million. The value of the end uses reflected in Table 1 only represents the approxi-

mate investment costs for building the end use and does not include the value of the property after remediation. Except for Passaic, all the projects were undertaken by private owners/developers. It is understood that in all the cases, the development project was profitable. That is the value of the property after remediation/approvals for development exceeded the property acquisition costs, all remediation costs, all soft costs and carrying costs.

Table 1: Summary of Six Landfill Redevelopment Projects

Project Name	Location	Owner/Developer	Acres	End Use Type	Remediation Technique	Value of Development	Use of Recyclables/Dredge
Jersey Gardens Mall	Elizabeth, NJ	OENJ Corporation	166	Mall, Hotels, Commercial, Ferry Service	L,V,C,H,G	\$700M Constructed \$300M Planned	2.5 MCY
Bayonne Golf Course	Bayonne, NJ	OENJ-Cherokee Corporation	120	Golf Course	L,S,C,H,G	\$10M Planned	5.0MCY+
Seaboard Point Resort	North Wildwood, NJ	Seaboard Development	12	Residential Condominiums	C, G	\$50M+	50,000 cy
Passaic County Comm. College	Wanaque, NJ	Passaic County Community College	12	Community College	L,C,W,G	\$10M	--
Ashbrook Farm	Edison, NJ	W&F Developers	30	Residential	W,C,L,G	\$3M	--
Federal Business Center	Woodbridge, NJ	Federal Business Centers	38	Office/Warehouse Development	W,C,L,G	\$9M	--
Totals			378			\$1 Billion+	7.5 MCY+

L = Leachate Collection & Treatment
 V = Vertical Membrane Wall

C = Capping
 W = Waste Relocation

S = Slurry Wall

H = Hazardous Waste Removal
 G = Landfill Gas Controls

2.1.8 Associated permits

In addition to a Landfill Disruption and Closure/Post Closure Care Plan, each of the sites required a variety of other State environmental permits.

Three of the sites (Elizabeth, Bayonne and North Wildwood), included preparation of a Remedial Investigation/Remedial Action Workplan (RI/RAWP) under the State of New Jersey Industrial Site Remediation Act (ISRA, N.J.S.A. 13:1K). In order to receive a letter of No Further Action (NFA), which addresses remediation of past releases of hazardous materials, it is necessary to complete the RI/RAWP. While MSW landfills are not required generally to undergo the ISRA process, in the case of sites with a listing of hazardous materials and/or sensitive end use issues, it is prudent for the site developer to receive an NFA. This also assists the developer in obtaining bank financing. Finally, compliance with ISRA

is a pre-requisite for financial incentives available under the State's Brownfields Redevelopment Act.

2.1.9 Beneficial uses of recyclables

Two of the projects (Elizabeth and Bayonne) utilized large amounts of recyclable materials to prepare the land for end use development. In Elizabeth, approximately 2.2 mcy of contaminated dredge spoils and recyclables were used to re-contour the site for development and surcharge the old waste to provide adequate foundation conditions. In the case of Bayonne, over 5 mcy of contaminated dredge spoils and recyclable are being used to create a rolling topography for use in golf course construction.

3 End use planning approaches

3.1 Historical overview

MSW landfills have been redeveloped historically without necessarily following the technical or regulatory approaches described in this paper. The Wanaque Landfill (now redeveloped as Passaic County Community College) had a Vo-Tech School built within the waste area after only the waste under the building footprint was relocated. The Vo-Tech School project was abandoned around 1985 before construction of the building was completed due to reports of methane migration as well as state enforcement action for lack of proper state permits to construct on the landfill.

A new era of proper planning design and remediation to allow landfill redevelopment was pioneered in the late 1980s in New Jersey by SAI, when it undertook the first projects described in this paper.

3.2 Planning approaches

Some of SAI's early projects were the result of owners "discovering" old MSW on their properties in the process of developing other portions of their sites. In these cases, SAI was retained to determine how to best "work around" the old waste and still maximize the use of the property. The solution in two cases was to move and consolidate the waste on site into a smaller controlled area with leachate collection on natural clay and capping with clay or development.

In other projects, the owners started their activities with the full knowledge that the MSW was a major constraint in use of the site.

In these cases, in order to justify the costs of remediation, it was necessary to consider a variety of alternative end uses. In the case of Elizabeth Landfill, several years of alternative use analysis took place in which a real estate expert (Eli Cohen Realty of Paramus, NJ) explored the real estate value of a wide range of uses. Some of the uses considered included container storage, car staging for imported vehicles arriving by ship, rail yard expansion and various types of retail. The alternative finally chosen to begin development was a 100 acre regional mall with a 1.2M ft² two story mall (largest in the region). Four smaller parcels

in the 100 acres were reserved for other commercial uses. Eventually four hotels were sited and are being completed on the original 100 acres. An additional 25 acres "waterfront" parcel has been approved for office development, a ferry service and a marina. At another site (North Wildwood), the original plan was development of a minor league baseball stadium. After this project was abandoned for financial reasons, a new developer acquired the site with the objective of developing five story, high rise condominiums. The Wanaque Landfill, where the Vo-Tech School project was abandoned in the mid-1980s, was evaluated by the owners by default (Passaic County Board of Chosen Freeholders) in the late 1980s. After many alternatives were considered for end use, ranging from open space to public works garage, the alternative of redevelopment as a satellite community college was selected.

As more experience has been gathered and successful projects completed, developers are now acquiring old landfill sites with the express intention of redevelopment.

4 Regulatory issues

New Jersey has had statutes and regulations related to landfill closure since 1970. The Solid Waste Management Act of 1970 and regulations N.J.A.C. 7:26 et seq. require approval by NJDEP for "disruption" of a landfill. The Landfill Closure and Contingency Fund Act of 1987 requires landfills closed after January 1, 1982 to have a Closure and Post Closure Plan and Financial Plan to ensure proper closure. Therefore, a long standing program has been in effect, whereby NJDEP must approve landfill closure and development.

In the mid-1980s, the NJ Legislature passed the ECRA law which required NJDEP approval of property transactions involving certain prior industrial uses, MSW landfills were not included. When the ECRA law was amended by the ISRA Law in 1993, discharge of hazardous materials from any property became the subject of additional regulation. This resulted in a situation in which old MSW landfills became the subject of state cleanup requirements, assuming they had received hazardous substances, which required control /remediation.

ISRA and the State Spill Fund Act was amended in 1998 under the Brownfields Act, which offered liability protection for innocent purchasers in the form of a covenant not to sue. Financial incentives for remediation were also provided in the 1998 Brownfields Law, including provisions for grants to municipalities to study cleanup needs, up to \$2 million in grants to municipalities for actual cleanup and loans for private innocent purchasers. Also included is a 75% state tax credit program for remediation by private innocent purchasers.

After the ISRA, it became necessary for landfill redevelopment projects to explicitly address contamination of soil and migration of hazardous materials to receiving media. Prior to ISRA, the issue of migration was addressed under the Solid Waste Management Act and the State Water Quality Management Act. ISRA has extensive rules regarding site investigation which require that the waste itself be characterized through Priority Pollutant +40 testing.

5 Technical issues

The redevelopment of old landfills involves a multitude of technical factors: remedial investigations, natural constraints, contamination, safety, and serviceability. Each site may have some of all of these factors with varying degrees of difficulty.

5.1 Remedial investigations

Remedial investigations at old landfills that are considered for redevelopment usually take a different approach from those conducted for landfills that are investigated to be remediated without being considered for redevelopment. The limited or intensive use of the redeveloped sites by human beings raises the concerns of the regulator, the developer/owner, and the professionals involved in the contaminated site redevelopment to a much higher level. Whence a new and more important objective of the remedial investigations becomes making sure that the health and safety of the short and long-term users of the redeveloped site are protected. This new objective requires more extensive investigations. This means additional cost to the owner/developer.

In two of the six cases presented in this paper (Elizabeth & Bayonne), SAI had to develop sampling plans with the cooperation of the New Jersey Department of Environmental Protection (NJDEP) to address human exposure, and characterize onsite contamination. Geostatistical models were employed to optimize the number and the location of samples to be collected and analyzed. In certain cases, the sampling had to be biased towards areas of concern where easily discernable contamination was encountered, or where sensitive environmental resource was present (wetlands, mudflats...).

In some cases, remedial investigations were limited to collecting information about the degree of waste decomposition using test programs, the presence of landfill gas, the strength of landfill leachate, and collecting few samples for chemical analysis. In other cases, extensive investigation of the waste, groundwater (deep and shallow), surface water, sediment, landfill gas, tidal influence and the impact on the ecological receptors.

5.2 Natural constraints

In general, site development is challenged by natural constraints: wetlands, open water bodies, streams, irregular topography. At old landfills, this factor is compounded by the presence of contamination that exacerbates the impact on development.

In three of the cases (Elizabeth, Bayonne & North Wildwood), wetlands were present at the site. These wetlands were for the most part degraded; however, they provided habitats for animals or birds. In order to develop these sites, the impact of the site redevelopment on the wetlands had to be addressed. In one case (North Wildwood), the wetlands were completely avoided, but the wetlands transition area was used for development related permitted uses such as storm

water basins. In another case (Bayonne), the existing wetlands were partially filled, and higher quality mitigated wetlands were created. The filling of existing wetlands was necessary for the remediation and the redevelopment of the site. The remediation of the site included the containment of the onsite waste, which in some areas existed in wetlands. In the case of the Elizabeth site, the wetlands were filled in the process of installing a ten-foot RCP to pipe a one mile long ditch that bisected the site. Previously the ditch acted as a conduit for leachate from the landfill allowing it to discharge into the Newark Bay. Filling of the wetlands was not only required for the proper remediation of the environmental impact, but also enhanced the potential for site redevelopment.

The landfill redevelopment in North Wildwood has been impacted by the extent of the wetlands' transition area and the presence of a bird habitat. Discussions with the NJDEP are underway to mitigate this impact.

Another natural restriction to site redevelopment are drainage ditches. In two of the six sites (Elizabeth and Bayonne), large drainage ditches had to be filled to accommodate redevelopment. However, they would not have been permitted to be filled without the special justification provided by the need to prevent leachate from discharging into the surface water bodies of the state. The main justification for piping these ditches was preventing contaminants (leachate or contaminated sediments) from being transported via these ditches to the surface water bodies of the State.

5.3 Contamination

Contamination at old landfills varies from one site to another. There are common contaminants that are present at most landfills at varying levels and are considered landfill indicators: BOD, COD, Ammonia, some heavy metals, and chlorinated organic compounds. However, other contaminants are encountered at old landfills due to uncontrolled dumping. This especially true for old landfills, which are the majority of landfill sites considered for redevelopment. These contaminants include PCBs, tar, paint sludge, waste oils, drummed industrial waste, medical waste, and others. At the two larger sites (Elizabeth and Bayonne) of the sites under study, there were several examples of these types of contaminants, which required special types of treatment. Some required removal and offsite disposal: drums (Bayonne), and paint sludge and tar (Elizabeth). Some required in-situ treatment: oil sludge (Bayonne). Some required complete encapsulation due to the large volume and high cost of removal and disposal: PCB contaminated waste (Elizabeth).

5.4 Remedial action

Remedial action at old landfills normally includes capping of the waste, managing landfill leachate and gas, and monitoring the impact on the environment.

For the six cases that are considered here, some or all of the landfill remediation elements were implemented to prepare the sites for redevelopment. The least remedial action involved: capping, landfill gas management, and maintenance

and monitoring program (North Wildwood). The earliest remediated site (Edison) involved: partial relocation of waste to accommodate redevelopment, capping the relocated waste with one foot of clay and one and a half foot of soil to promote vegetative growth, landfill gas control and venting system, leachate collection and disposal system. The second earliest remediated site (Woodbridge) involved: excavation and relocation of the entire waste, the construction of a state-of-the-art small landfill on a two acre lot (clay liner, leachate collection and disposal system, passive gas venting system). Thirty six acres of this thirty eight acre site became available for development after implementing the remedial action/closure. The closed and capped two acre new landfill has also been used for parking purposes.

The waste relocation and consolidation approach was later enhanced. During the implementation of a test pit program at the Wanaque landfill site, it was observed that the majority of the waste (70%) had decomposed and was reduced to soil like material. The excavation and relocation was augmented with a screening process prior to relocation and encapsulation. The material passing the screen was tested and found suitable for use as backfill for redeveloping portions of the site.

At the three more recent remediated landfill sites, the costliest element of the remediation, capping, was incorporated into the redevelopment. The two main purposes of capping are: creating a physical barrier between the waste and the environment, and reduce the potential for precipitation entering the waste fill and producing more leachate. Therefore, buildings, paved roadways and parking areas were used for achieving these two objectives (Elizabeth and North Wildwood). In Bayonne, the fill material for shaping the site to accommodate the construction of a golf course was also used as a cap, using low permeability recyclable materials such as stabilized dredge material.

5.5 Safety

One of the main concerns of redeveloping landfill sites is the safety of the eventual users of the sites: residents, shoppers, workers, or golfers.

Providing sufficient physical barrier (cap) between the waste and the users, coupled with institutional controls, proved to be an effective means of protection against human exposure to onsite contaminants. To enhance this protection, SAI with the direction of NJDEP, made it a practice to design backfill for all utility trenches with clean fill to prevent the exposure of maintenance crews to any contaminants at the landfill. Also SAI developed operating procedures for maintenance crews for areas where the potential for exposure still exists, such as leachate pump stations or valve chambers.

The second biggest concern at landfill sites is landfill gas, due to its explosive potential at certain concentrations. At each of the six sites under study, a landfill gas management system was installed or is planned to be installed. These systems are at varying degrees of sophistication depending on the level of exposure and the levels of methane gas encountered during site investigations. The system range from simple passive gas vents (Woodbridge), to synthetic barrier wall with

venting trench and passive vents (Wanaque & Edison), to the more advanced active venting system under commercial or residential buildings (Elizabeth and North Wildwood). For residential development on landfills, the regulatory agencies have been more stringent. In the earlier residential development (Edison), the NJDEP allowed the construction of the houses after the waste was relocated and a passive gas barrier was installed between the housing development and the waste. In the more recent residential development, the NJDEP permitted the construction of the condominium building on top of the waste, but with an open-air first floor used for parking and an active gas venting system under the first floor.

In commercial developments, the NJDEP permitted the construction of buildings with an active gas venting system under the first floor, with explosive gas sensors in the first floor.

5.6 Stability

Another safety concern at landfills is stability of the developed structures. Stability can be compromised by differential settlement in the waste fill and the underlying soils. This can be controlled by engineered improvement of the characteristics of the waste fill and the underlying soils. For the Elizabeth site, fill surcharge and deep dynamic compaction were employed to improve the characteristics of the waste fill and the underlying soil to accommodate the construction of roadways and parking lots. However, the mall building and the hotels were built on pile foundations. The waste and underlying soft soil layer could not have been improved to accommodate the loads from these structures in time for the opening of the mall. The additional cost of pile foundation was justified by having high returns from development. Similarly, at the North Wildwood site, the waste will be surcharged with fill to mitigate the potential for differential settlement in the waste and underlying soft soils in the roadways, parking areas, and the landscape areas, while the high rise residential buildings will be constructed on piles.

At the Bayonne site, the clubhouse for the golf course is located in an area that was originally at much lower grade. Therefore, imported fill to bring the site to grade at that location to final grade needed to be select fill, to provide a competent foundation. The clubhouse location will also be surcharged to mitigate future settlement in the thin layer of waste and underlying organic clay layer. The small thickness of the waste layer and the less aggressive schedule for constructing the golf course, due to the need for bringing large volume of recycled fill, permitted implementing geotechnical improvements with a less expensive foundation solution.

Like any other sloped fill structure, redeveloped landfills should be analyzed for slope stability whenever the conditions warrant. At the Bayonne site, the stability of the side slopes was analyzed to ensure against failure. In certain areas of the site, the proposed slopes could have proven unsafe to accommodate the proposed golf course. Engineered retaining walls (sheet piling) had to be installed to prevent unsafe conditions from developing. At the North Wildwood site, the side slopes face the Atlantic Ocean and have to be protected against wave action. The

slopes are designed to be planted with types of vegetation that provide protection against erosion.

5.7 Serviceability

In addition to the above challenges, redeveloping old landfills does have its limitations: potential settlement due to decomposition and consolidation of the waste and the underlying soils, and the non-homogeneity of the waste causing differential settlement as discussed above. The impact of differential settlement on the stability of structures is one effect of potential settlement, serviceability is another. Settlement may cause the surfaces of roadways and parking areas to be uneven, or it may cause damage to utility lines. In one case (Elizabeth), the pavement settled evenly, but the lighting poles were constructed on piles and which did not settle. This caused the base of the pole to project above the pavement. Such an occurrence can be problematic if the differential settlement is high. Luckily this has not been the case, since the waste was dynamically compacted or preloaded prior to development. In order to avoid settlement in the different imported recyclable materials, SAI developed a laboratory and field-testing Protocol (Protocol for Review and Certification of Recyclable Material at the OENJ Elizabeth Site, copyright 1995, Princeton Recycling Technologies, Inc.) for all imported recyclable materials. The laboratory testing Protocol focused on providing on the density and strength of the recyclable material. These parameters were then verified in the field by an SAI representative for the actual material imported to the site.

SAI monitored the compaction of the different recyclable materials, and used a nuclear density instrument to check the field density. This became part of the record and was shared with the geotechnical engineer for the mall developer.

6 Economic/financial Issues

6.1 Economics of remediation/closure

As mentioned earlier, the remediation and proper closure of old landfills is a costly proposition. This is perhaps one reason why there are many landfills that have not been properly closed. Redeveloping old landfills provides the resources for implementing proper closure and rendering uncontrolled old landfill sites valuable, job generating and tax paying. Incentives described elsewhere in this paper helped create a success story for developers and the State and local governments. However, landfill redevelopment projects have to make economic sense to developers to embark on them. In four out of the five privately owned projects (those are the ones that have been completed), the developers were able to achieve reasonable profits.

At the Woodbridge site, the developer spent approximately \$200,000 in engineering and construction oversight costs, and approximately \$800,000 in construction costs. The end results were: the site no longer had scattered waste, and thirty six acres of developable property became available for development with a

value of \$9M at the time of completion.

At the Elizabeth site, the site was uncontrolled contaminated dump with a lot of surficial dumping, overgrown vegetation, and a large open ditch that bisected the site. The value of the land was less than \$100,000/acre. However the location was highly attractive (next to the New Jersey Turnpike and near Newark Airport), which attracted a Danish redevelopment company to pursue developing the site. The Danish company spent approximately \$3M in engineering and construction oversight costs and \$8M in construction costs to remediate the site without applying a cap. The redevelopment of the site required importing approximately 2.2 million cubic yards of fill. This would have cost the developer approximately \$13M. Instead, the developer, with the assistance of SAI, developed a program for using recyclable materials as fill to accommodate the development and cap the landfill. SAI also developed a closure plan that incorporated the capping into the development plan. The buildings, the roadway pavement and the parking lot pavement became part of the cap. Only in landscape areas did the developer have to install a two-foot soil cap, which was also part of the development cost. The value of the property increased to \$400,000/acre for 100 acres of upland, and to \$1M/acre for eighteen acres of waterfront upland parcel.

The Bayonne site has 120 acres including an old municipal dump and a contaminated former industrial site. The remediation cost of this site is estimated at \$3M in engineering and construction oversight costs and \$11M in construction costs. For the site to be developed as an 18-hole golf course, which is the intended use of the site, 6 million cubic yards of fill material were needed. This fill would have cost \$30M. Instead, SAI developed a program with the NJDEP for accepting recyclable materials as fill. To date, the site has received approximately 4 million cubic yards of recyclable materials. The contaminated site has been transformed into a valuable piece of property in the middle of urban area.

The site in North Wildwood is a twelve-acre old municipal landfill that is being developed into a high-end apartment complex. The unremediated site would have little to no value. The remediation cost is limited to the installation of gas venting systems for the different buildings. The estimated cost of construction for these systems is \$300,000, and the estimated engineering and construction oversight costs for obtaining the necessary approvals are \$300,000-\$500,000.

The cost of remediation/closure for the sites under study can be plotted against the acreage of the sites. The curve generated presents the trend of the cost of remediation/closure versus the acreage of the landfill site. It is clear that the larger the site, the higher the cost of the remediation/closure. The best fitting curve of the available data is linear (see Figure 1, next page). However, inspection of the data points indicates that costs per acre appear to reach a plateau at landfill sites of the size 130 acres or more. This trend makes sense since the larger sites are more likely to have more difficult natural constraints, more illegal dumping, more hazardous waste to deal with, which drive the cost higher. The Wanaque site cost per acre probably an outlier since the excavation, screening and re-deposition of waste increased the cost of remediating the site and preparing for closure and development. This site topography, geology and size required

such a solution for dealing with the on site waste, and caused the cost to be higher than the other sites evaluated in this paper.

The economics of redeveloping old landfill sites is impacted by many factors: type of development, intensity of development, schedule, site conditions and environmental setting. These factors are inter-related. For example, a shorter schedule may not allow for a less expensive option for resolving foundation issues. As mentioned earlier, the opening of a mall and the loading from the mall building required the use of pile foundation (more expensive), instead of pre-loading which would have taken much longer and would not have supported an aggressive development plan. At the Ashbrook Farms site, the development intensity and type were low and allowed for an inexpensive solution. The housing units were built on a small portion of the landfill, which allowed for waste relocation from the developed area to the undeveloped area. The residential units were low rise, which did not require expensive foundation improvements. At the North Wildwood site, the intensity of the development does not allow for waste relocation, and will require expensive foundation and landfill gas management solutions.

The additional costs for redeveloping landfills are partially compensated by the relatively low cost of land before development. However, this low cost of land usually is not sufficient to compensate for the high cost of remediation/closure. This prompted the legislature in the State of New Jersey to develop incentives for redeveloping contaminated sites, including landfill sites as discussed elsewhere in this paper.

6.2 Financial incentives

A number of significant financial incentives are available in New Jersey for landfill redevelopment.

In 1996, the Gormley Bill (Senate Bill 294 “ Municipal Landfill Site, Closure, Remediation and Redevelopment”) was enacted. That bill provided up to 75% in state tax credits for remediation costs for qualified landfill redevelopment projects. Typical state taxes that can be defrayed through the former bill include a six percent sales tax. Redevelopment projects that involve retail development provide an excellent opportunity for setting aside State taxes into a State administered fund to allow the developer to recoup the costs of remediation. Finally, special legislation has been used in the case of the Elizabeth Landfill to utilize the framework of the Gormley Bill to provide a funding source to pay for major infrastructure improvements. For the Elizabeth Landfill redevelopment project, the 3 percent sales tax from the mall project was allowed to be set aside to repay approximately \$80M in roadway improvements needed to provide a four lane connector road from a toll plaza on the New Jersey Turnpike directly to the mall property.

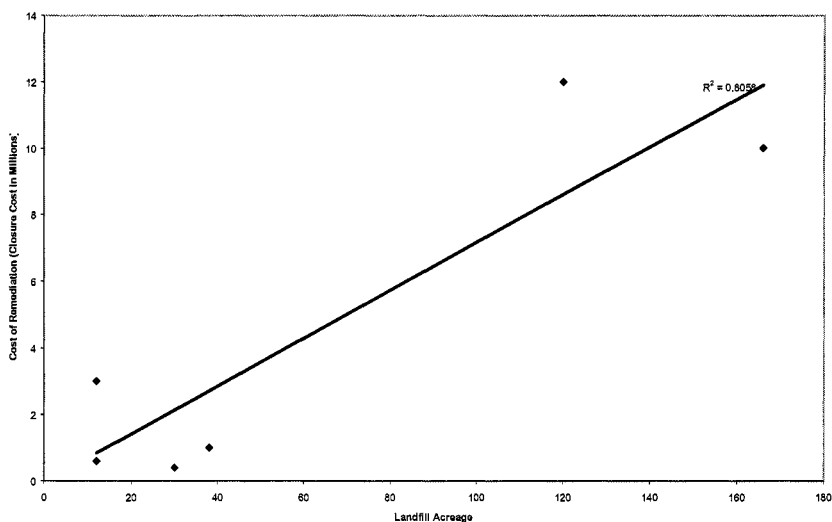


Figure 1: Landfill acreage vs. cost of remediation (closure cost in \$millions)

7 Community relations issues

The landfill closure and redevelopment program in New Jersey does not have a required community involvement component in state level permitting except insofar as certain state permits, such as Upland Waterfront Development (similar to a Coastal Zone Management Act approval) have prescribed public notice/hearing provisions.

Community input to the planning for site redevelopment for the projects discussed herein resulted either from the project developer's desire to involve local officials or from required local land use approvals for site development.

In the case of the Elizabeth Project, the developer took advantage of strong interest from the Regional Planning Association (RPA) to support the project. RPA assisted the developer in coordinating local, regional and state permits needed for the project. The involvement of RPA was helpful in obtaining local and legislative support needed to gain special legislation to provide financing for the transportation infrastructure needed for the project.