LANDFILLING: 
FACING THE CHALLENGES OF THE 21ST CENTURY

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SUMMARY
Implementing new landfill sites is becoming increasingly difficult from a public and regulatory perspective. For this reason many municipalities and agencies are seeking to implement innovative strategies to manage solid wastes, and return old landfill sites to a productive use. Some of the strategies implemented include utilizing an existing landfill site to create additional landfill capacity by expansion vertically in a “piggyback” fashion, or by horizontally and vertically overtopping the side slopes of an existing landfill mound. The municipalities of Islip and Colonie in New York are two towns who have implemented these expansion techniques at savings that include avoided costs of greater than $100 million. Other strategies to return old dump sites to a productive use include closing the facilities and constructing parks or creating wildlife habitats on top of the closed landfill. The City of Norwalk, Connecticut has designed and is currently constructing a 15 acre park above their closed landfill that includes a riverwalk, fishing pier, amphitheatre, gravel beach, sledding hill, and skating pond.

Key Words: Landfill, Expansion, Piggyback, Closure, Park Development

INTRODUCTION
As municipalities prepare to move into the 21st century, they must develop strategies for dealing with the many challenges they will face and how to deliver services. The challenges with regard to solid waste management, and specifically solid waste disposal, will be minimizing the environmental impacts associated with the older “dumps” while providing new facilities that will allow for the disposal of solid wastes in an environmentally safe and effective manner.

On the surface, the options for dealing with these challenges appear relatively straightforward. Old sites can be closed by installing a final cap and a new site located, permitted, and constructed to safely manage wastes into the future. In concept this somewhat simplified approach would achieve the goal of managing solid wastes in a safe and environmentally sound fashion while closing and minimizing the impacts associated with the older sites. However, in many cases implementing this simplified approach is not as easy as it may sound. Nobody can argue about cleaning up and safely closing existing dump sites, but implementing the second half of the approach to site a new landfill will be much more difficult and come under much greater scrutiny by the regulators and the public. And what should be done with that now inactive land area that was once a landfill, and perhaps costly, “old dump” site?

The difficulties in providing a new landfill are twofold. The first difficulty is to find a site that has the engineering and hydrogeologic characteristics suitable to construct a landfill and satisfy applicable regulations. Recent Federal RCRA Part 258 Subtitle D regulations stipulate location criteria that
address airport safety, and restrict development in floodplains, wetlands, seismic impact zones, earthquake producing fault areas, and unstable areas. In addition to these mandated siting criteria, the site must have, as a practical matter, geologic characteristics such that it is capable of high soil bearing capacity, resisting movement from static landfill loads, and accommodating earthquake ground movements, and the groundwater must be capable of being monitored and groundwater corrective actions implemented if necessary. Sites satisfying all these criteria are not easy to find, especially in densely populated areas. However, once a municipality or agency locates a potential site that meets the siting criteria, the second, and often more onerous difficulty will inevitably unfold: public opposition.

Nowadays, the public by and large is against the siting and permitting of new landfills, regardless of their value to the community. This position, often referred to as the NIMBY (Not In My Back Yard syndrome), is nearly universal and will be a factor that any municipality or agency will have to deal with if they plan to implement a new landfill. As a result, permitting new landfills (and any other solid waste management facility, for that matter), is an expensive, time consuming process that will likely involve the preparation of detailed environmental impact statements and extensive site geologic, hydrogeologic, and engineering evaluations in order to demonstrate to the regulators and to the public that any potential environmental impacts are being mitigated to the greatest extent practicable. Closure of old landfill sites, although more likely to be embraced by the community, still presents a long term management challenge.

Often the solution to these problems are not obvious, and a municipality or agency has no alternative other than to endure these difficulties and site a new landfill. However, this is not always the case. Some municipalities and agencies have opted to implement innovative strategies that focus on maximizing the use of existing site resources while still providing a solution to long term solid waste disposal. Some of these strategies include maximizing the disposal capacity of existing landfill sites by using high tech methods to expand horizontally, vertically, or both; closing old out-of-compliance landfills not suitable for expansion; and restoring closed landfills to a productive uses for passive and active recreation and environmental improvement, all of which are beneficial to the local and regulatory communities, and are much less likely to run into the opposition a new site would produce.

The techniques that can be implemented at a given landfill site are dependent upon the characteristics of that site. Not all sites possess the right characteristics to expand vertically or horizontally, and similarly, not all sites are suited for developing an end use such as a park. Some sites have served their purposes and are best suited for only closure by installing a final cap. For this reason, each site must be reviewed on an individual basis to determine how the site fits into the overall solid waste management plan, a determination made of the potential of each site to help achieve the management goals, and which techniques may be appropriate to achieve those goals for the benefit of the municipality.

Often helpful direction on future problems and challenges for one community can be found by evaluating what other communities have done in similar circumstances. The following sections of this paper will present a series of case studies describing the difficulties encountered by some municipalities, and the techniques that were used to overcome these difficulties when closing old landfills, expanding old landfill sites to provide new disposal capacity, and developing end-use plans above a closed landfill to benefit the community with a new resource.
**Landfill Expansion**

In the late 1980’s as available landfill space was dwindling on Long Island due to new regulations, many Long Island municipalities were forced to haul their municipal solid waste off the Island, often as far west as Ohio and Wisconsin. Unlike many of its neighboring communities, which were paying as much as $140 per ton to ship their refuse, the Town of Islip faced with the closure of the remaining portion of their landfill in 1988, chose to “piggyback” a vertical landfill expansion on top of an adjacent unlined 45-acre portion of the landfill previously closed and capped with a 20-mil PVC liner.

At that time the concept of “piggybacking” was never utilized for expanding a landfill, and as a result the Islip’s piggyback at the Blydenburgh Landfill was the first of its kind. Although the Town recognized that “piggybacking” would require a unique combination of landfill elements for gas and leachate control, Islip determined that an expansion would be significantly less expensive than trucking the Town’s waste to distant, off-island disposal sites, even if for a short amount of time. This would also allow precious time for readjustment of the Town’s entire solid waste program.

Design of the vertical expansion was initiated by Malcolm Pirnie in May 1987 and construction began in September 1987. Construction was completed in August 1988 and the facility began receiving waste that month. As described later in this section, the piggyback ceased accepting waste in December of 1990 and was closed.
The vertical expansion was designed to maximize the available volume for waste disposal while meeting the stringent requirements of the New York State Department of Environmental Conservation. To account for existing landfill grades of up to 3:1 and settlement of the existing waste, Malcolm Pirnie's award winning design incorporated various synthetic materials to form a leachate collection and transport system, including:

- uniaxial geogrids for structural support of liner components,
- drainage nets for lateral leachate flow,
- filter fabric, and
- an 80-mil HDPE liner.

In addition to extensive use of synthetic materials, the other major features of the piggyback design include: use of the existing cap, and continued operation of the existing gas and leachate collection systems.

The cost to design and construct the piggyback expansion over the 25 acre footprint was less than $7 million, a fraction of the $174 million estimated to haul Islip’s garbage off Long Island. The Town realized this savings in avoided costs over the three year period that the facility operated prior to its closure.

Closure and Environmental Benefit

As part of the closure activities for the “piggyback” site, the Town of Islip sought to implement an Environmental Benefit Plan (Plan) to enhance the aesthetics of the Blydenburgh Landfill while creating new habitat for local wildlife. The development of the Plan was a challenge for several reasons, in that planting on a landfill presents unique problems, and creating wildlife habitat on a landfill is a relatively new concept. A number of biological, economic, and engineering concerns had to be incorporated into the overall design in order to achieve the Plan's goals for a biodiverse ecosystem that would provide habitat and life needs for wildlife while creating visually pleasing aesthetics.

The main design issues for developing a suitable habitat plan included weather patterns, grades on the landfill slopes, soil composition, drainage patterns, and selection of native plants suitable for establishing plant communities that would benefit wildlife and be tolerant of the more extreme weather conditions typical to landfills.

Local weather patterns were researched to determine temperature ranges and prevailing wind patterns. The Blydenburgh landfill is the highest point in the eastern end of Long Island. Both Long Island Sound and the Atlantic Ocean can be seen from its summit. Because of its height and location, the north and west slopes are exposed to prevailing northwest winds which have a drying, erosive effect on the soils, and a potentially damaging effect on plantings. The south slopes are also prone to droughty conditions during the summer season. Consequently, plants selected for the north, west, and south slopes must be tolerant of dry conditions and seasonal high and low temperatures.
Landscape design included plans for creating open field habitat on the upper slopes by using a variety of native grasses selected for landfill conditions. A variety of deciduous trees and shrubs were selected for the lower landfill slopes to create a hedgerow effect. Tree and shrub species selected for habitat restoration met the criteria for native species that are indigenous to the area. The plants have a shallow spreading root system, and are adaptable to the climate typical to landfills. Furthermore, the plant community provided wildlife habitat, and wildlife requisites such as a food, and nesting and roosting habitat for resident and migratory wildlife. Many of the species selected produce a fruit or seed that provides a food source for a number of bird species and small mammals. The plan provided a vegetated corridor and an edge ecotone for maximum wildlife protection and utilization.

Early in the planning stage, NYSDEC had reservations about the use of woody plant species relative to maintaining the integrity of the landfill cap, but research by Rutgers University indicated that landfill caps engineered with hydraulic conductivities of $10^{-7}$ cm/sec, after compaction are a deterrent to root penetration. This research and expected shallow root penetration was sufficient to demonstrate to the regulators that woody vegetation would not damage the cap.

Unique to the project was the integration of specifications for the Plan with Malcolm Pirnie's engineering design for storm water drainage control structures. The integration of the plans allowed for the utilization of surface water flow for plant irrigation. A system of tiered, horizontal drainage swales located upslope of the planted benches allowed storm water flow from the swales to irrigate the down-gradient of benches during rainfall events. The Plan also managed storm water flow to provide water for plantings on the slopes between the swales and benches. Overall, the Plan provided benefits for landfill vegetation and storm water control and water quality.

After landfill backfilling and grading were complete, the selected plants were installed by an experienced landscaping contractor. The trees and shrubs were true to name and variety as established by the American Joint Committee on Horticultural Nomenclature, Standardized Plant Names. In addition to Malcolm Pirnie specifications, the plant material also complied with the recommendations and requirements of ANSI-Z60.1-90 relative to overall size, caliper, and branching according to species and type. The tree and shrub species installed to form the hedgerow plant community and the total acres planted are presented in Table 1.

<table>
<thead>
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<th>TABLE 1</th>
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<tr>
<td>Latin Name</td>
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<tr>
<td>Rubus allegheniensis</td>
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<tr>
<td>Myrica pensylvanica</td>
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<tr>
<td>Rhus copallina</td>
</tr>
<tr>
<td>Rosa rugosa</td>
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<tr>
<td>Juniperus communis</td>
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<tr>
<td>Betula populifolia</td>
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<tr>
<td>Prunus serotina</td>
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<td>Eleagnus umbellata</td>
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Deciduous shrubs of various sizes, 0.3 meters (1 foot) to 1.1 meters (4 feet) were planted to be more representative of conditions in nature rather than to give the appearance of planted rows of single-aged plants. The height of the trees was less varied than that of the shrubs, and ranged from 1.0-1.1 meters (3-4 feet). Cost was the primary factor in selecting the height of the trees; larger trees being more costly. Shrubs were planted 2.0 meters (6 foot) on center. Trees and evergreen shrubs were planted 2.6 meters (8 foot) on center. At the time of planting, each of the plantings was fertilized with Agriform 20-10-5 and mulched. The area planted with trees and shrubs varied in length from 129 meters (400 feet) to 258 meters (800 feet). The width of the hedgerow was determined by the width of the landfill bench, approximately 6.45 meters (20 feet).

The field habitat on the upper slopes and the areas between the benches was hydroseeded with a mixture of turf grasses which included a variety of tall fescues. A list of the grass species is shown in Table 2. The small area, approximately 0.8 meters (2.5 feet) wide, adjoining the length of the downchutes was hydroseeded with a seed mixture more suitable to steep slopes. The mixture consisted of 33 percent *Coronilla varia* (Crownvetch) and 67 percent *Festuca arundinacea* (Tall Fescue). Although *C. varia* is not a native species, it produces vigorous growth on steep embankments where grasses fail.

<table>
<thead>
<tr>
<th>TABLE 2</th>
<th>GRASS MIXTURE FOR FIELD HABITAT</th>
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<tbody>
<tr>
<td>Percent Mix</td>
<td>Latin Name</td>
</tr>
<tr>
<td>15%</td>
<td>Eragrostis curvula</td>
</tr>
<tr>
<td>30%</td>
<td>Festuca arundinacea &quot;Clemfine&quot;</td>
</tr>
<tr>
<td>10%</td>
<td>Festuca longifolia &quot;Relient&quot;</td>
</tr>
<tr>
<td>10%</td>
<td>Festuca rubra &quot;Jamestown&quot;</td>
</tr>
<tr>
<td>25%</td>
<td>Lolium perenne &quot;Palmer&quot;</td>
</tr>
<tr>
<td>5%</td>
<td>Panicum virgatum &quot;Blackwell&quot;</td>
</tr>
<tr>
<td>5%</td>
<td>Trifolium repens</td>
</tr>
</tbody>
</table>

At the conclusion of the first growing season in 1994, the plantings exhibited a high rate of success. Trees and shrubs had a greater than 90 percent survival rate, and turf grasses established successfully on greater than 75 percent of the slopes. A degree of success can be attributed to the selection of plant species, but the primary reasons for success can be attributed to the high quality of the plant material installed to specifications, and to regular maintenance visits.

During the first growing season, the landscapers routinely pruned dead or damaged branches, and replaced planting that had not survived. They watered and refertilized the plantings as needed. The northwest winds proved to be particularly damaging to the *R. coppalina* (winged sumac) plantings causing several of them to snap and others to be windthrown. Landscapers replanted or replaced the plantings as needed. Grasses on the northwest slope also had difficulty becoming established. The prevailing winds caused excessive drying and soil erosion on the corner of the
northwest slope. This area and several small areas on the landfill were reseeded.

During a visit to the landfill in October 1994, aerial coverage of the vegetation was greater than 90 percent with no signs of soil erosion. Wildlife species appeared to be moving into the new plant communities. A number of ground-nesting sparrows were observed in the field habitat on the upper slopes. Several birds of prey (northern harrier and American kestrel) were observed hunting the slopes. Employees at the landfill site have enjoyed the renaissance from landfill to open space habitat and report that a red fox has taken up residence on the lower portion of the southern slope.

Severe drought conditions in the summer of 1995 did however cause die off of selected shrubs, but not enough to disrupt the overall enhancement effects.

Based on the results to date, the Town and its residents consider the Environmental Benefit Plan a success. The high rate of survival of the hedgerow and field plantings has contributed to the attraction of wildlife to the habitats and to the overall pleasing appearance of the now closed landfill. The landfill personnel often congregate on top of the landfill to observe the wildlife. The site which could have wound up as an unusable, unproductive space is now flourishing, and wildlife and the community are once again enjoying and benefiting from its presence.

Colonie Landfill
Colonie, New York
Vertical and Horizontal Landfill Expansion

In 1994 the Town of Colonie was faced with dwindling permitted landfill disposal capacity, and a landfill permit that was to expire in April of that year. The Town's Solid Waste Management Plan (SWMP) called for the long-term development of a sanitary landfill on an adjacent parcel of land owned by the Town. The proposed development was going to require a permit from the New York State Department of Environmental Conservation (NYSDEC) and compliance with the State Environmental Quality Review Act (SEQRA). The expected delays associated with the SEQRA process and the permit from NYSDEC would leave the Town of Colonie without disposal capabilities for two or more years. To solve their solid waste management crisis, the Town engaged Malcolm Pirnie to follow the lead of the Town of Islip to expand their existing landfill and develop additional disposal capacity to meet their disposal needs.

Because the expansion was proposed for the existing site, a full EIS was not required under SEQRA and the action was deemed a minor additional environmental impact based on completion of an environmental assessment form. This distinction was the key to the timely permitting and construction of the facility, and the reason why the Town was able to maintain uninterrupted disposal capacity on-site.
Similar to Islip’s vertical piggyback, the Colonie landfill was expanded vertically and also horizontally. The vertical expansion consists of a geosynthetically reinforced subbase and composite barrier layer over a 10-acre area of the existing landfill. The barrier layer consists of two layers of geogrids, 24 inches of low-permeability soil and a 60-mil high-density polyethylene (HDPE) geomembrane placed directly above the intermediate cover layer and waste. The horizontal expansion is a 15-acre double composite-lined landfill.

To increase landfill capacity, a portion of the double composite liner system was constructed below the water table. A pore pressure relief layer relieves the hydrostatic forces associated with the groundwater during both construction and operation. The double composite liner system consists of (from bottom to top): a pore pressure relief layer, a 24-inch low-permeability soil layer, a 60-mil textured HDPE geomembrane, a double-sided geocomposite drainage net, a 12-inch structural soil layer, a 6-inch low-permeability soil layer, a 60-mil textured HDPE geomembrane, a double-sided geocomposite drainage net, and a 24-inch drainage soil layer.

The expansion increased the operational life of the facility by approximately 15 years and saved the Town the expense of permitting the adjacent parcel of land for 10 to 12 years. The Colonie landfill expansion was constructed in 1996 and is currently operating with great success. The Town of Colonie estimates that constructing the facility at their existing landfill site saved them more than $10 million while preserving the adjacent parcel of land.

Norwalk Landfill
Norwalk, Connecticut
Development of Oyster Shell Park

The City of Norwalk owned and operated a 15-acre landfill into the 1970’s. With limited park space
within the community, and the proximity of the landfill to the Norwalk River, the City decided to pursue developing a park on the vacant land occupied by the landfill that had remained unused since its closure.

Malcolm Pirnie assisted the City in preparing a landfill closure plan that incorporated productive and diverse habitats emphasizing wildlife utilization to provide environmental education opportunities and recreational amenities for the community. Located along the tidal portion of the Norwalk River, the landfill closure provided an excellent opportunity for this type of reuse. The project has proceeded in a phased approach aimed at determining the appropriate closure requirements, obtaining regulatory concurrence from the Connecticut Department of Environmental Protection on closure criteria and methods, and then construction.

The aesthetic alternatives considered for this site reflect the recreational use desired by the City. Consideration was given to the state's master plan for this area of the State called the Heritage Park plan, tourism, harbor-related issues, and the public health and welfare in the final determination of the most beneficial reuse of the site. Alternative uses for the site will require the preparation of landscaping plans, protection of wetlands, and public access plans.

The park is currently under construction, and when completed will include unique features such as a riverwalk, fishing pier, ice skating pond, sleighing hill, gravel beach, and amphitheater.