SOIL-COVER SUCCESS

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Information gleaned from instrumentation helped extend the life of a New Jersey landfill and convinced state regulators that a mandated clay cap ultimately would fail. Engineers were able to prove that a simple soil cover would get the job done and save $20 million.

After seven years of operation and extensive vertical and lateral expansions, owners of the Kingsland Park Sanitary Landfill, located in northern New Jersey's Meadowlands, were ready to close the facility. State environmental regulations required that the closure cover have a clay component to limit water percolation and leachate generation. But engineers at Converse Consultants East, Parsippany, N.J., the owner's geotechnical engineering consultant, feared the state-required cap would fail due to the ongoing settlements at the landfill. The cap, they claimed, would be a waste of money.

Officials from the New Jersey Department of Environmental Protection and Energy (NJDEPE) requested support for this argument. Converse engineers turned to data taken from piezometers and inclinometers, installed during the 1980s to ensure a stable site during expansions, to prove their point.

Geotechnical instrumentation has been long used for monitoring soil slopes. Few landfill owners, however, incorporated instrumentation as an integral part of a waste-management plan. This is the first time such a system has been used in New Jersey. The instrumentation extended the life of the landfill by two years and allowed the disposal of an additional 2.6 million tons of refuse. The savings to owners and taxpayers (compared to shipping the refuse out of state) is about $200 million.

The landfill's operators, the Bergen County Utilities Authority (BCUA), is a regional government agency located in the northeast corner of New Jersey. It operated the Kingsland Park Sanitary Landfill from January 1981 to February 1988. In the last few months of operation, officials accepted refuse from 500–600 hauling trucks per day. Workers would apply 6 in. of covered material (imported from outside sources) to compacted layers totaling 12 ft in lift height. Testing of this area indicated in-place densities of about 1,200 lb/cu yd.

Site constraints made waste disposal difficult. Along the northern perimeter, a high-speed passenger rail line parallels high-tension power-transmission towers. The southern boundary follows a major 3 ft diameter natural gas pipeline. Finally, the Hackensack Meadowlands Development Commission headquarters are located to the east. All of these would be impacted by a landfill foundation failure.

To meet the county's solid-waste-disposal needs, BCUA officials decided to expand the landfill vertically and horizontally. Clinton Bogert Associates, Englewood Cliffs, N.J., directed the various expansions, which were done from 1983 to 1987.

Expansion possibilities were limited due to the soft subsurface soils at the site and regulatory requirements. The 137 acre landfill is underlain by sand that varies from less than a foot thick on the east side to about 20 ft thick on the west side. Underlying the sand is a stratum of soft varved clay, more than 200 ft thick in some places. Soft organic silt and peat overlay the sand stratum along the toe. Near the center of the landfill, the organic layer is thin or nonexistent. This layer may have been excavated or mud-waved (pushed ahead of advancing refuse) during early landfill dumping.

Initially, in 1983, workers expanded the landfill vertically from an elevation of 85 ft to about 100 ft. But the need for more disposal area persisted, even though landfill settlement provided some extra storage volume.

In the summer of 1984, the southeast toe was extended 100 ft to the south to provide additional capacity using the wet excavation method. They removed soft organic soils and filled the void with stable materials. Converse engineers installed three soil inclinometers and two piezometers to ensure that there would be no adverse impacts due to the excavation. So, despite landfill loadings in the area to about 100 ft, and continued landfill operations, construction proceeded without incident.

The landfill was further expanded on the southwest corner in 1984–85. The area, next to the Kingsland Lagoon, had been under 6 ft of water. A 30 acre area was excavated after a soil bentonite wall was built along all but the north side, adjacent to the landfill. To provide additional landfill capacity, crews dewatered and excavated the lagoon and installed a system to collect and remove leachates. The clay excavated from the lagoon was stockpiled for different uses at other landfills. The lagoon leachate-collection system is now integrated with the collection system around the main body of the landfill, which incorporated the same soil bentonite wall and ingradient design. This ingradient design provides a hydraulic barrier to leachate migration. The lagoon-area development proved to be a critical addition to the BCUA solid-waste planning. It provides needed disposal capacity and will allow the remainder of the landfill to stabilize.

At this point, the north and south sides of the lagoon were instrumented with soil inclinometers and piezometers to monitor indications of instability during excavation. During construction, some deep-seated, potentially adverse movement developed at the north side of the lagoon (the southwest

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side of the landfill). The north slopes were redesigned to avert a failure.

As soon as the southeast expansion site was prepared, landfill operations were relocated to take advantage of the additional capacity. The area was located adjacent to the gas pipeline, and was monitored by inclinometers (see locations SL-1 and SL-2 in accompanying photo). In early April 1985, excessive soil movements were detected.

After SL-1, engineers suspended operations so the area could stabilize. Workers moved operations to the northeast side of the landfill, adjacent to the rail line and the electrical towers. Several inclinometers were used to monitor the area. At first the upper soft organic soil began to deform. This did not cause much concern. By early May 1985, however, Converse engineers had detected deep-seated movements at instrumentation site SL-4, so operations were moved to the central portion of the landfill. When the southwest expansion was completed in July 1985, operations were moved back to the lagoon area.

The southwest expansion provided BCUA with sufficient operating space for six months. During this time areas adjacent to the instrumentation at SL-1 and SL-4 stabilized. When the refuse elevation in the expansion area matched the original landfill top elevation, crews moved the filling activity to the west side, monitored by instrumentation at SL-3 and SL-18. In June 1985, inclinometers at SL-3 indicated significant movement about 100 ft below the toe. So operations were moved toward the middle of the landfill, monitored by instrumentation at SL-2 and SL-18. During this period, BCUA officials submitted a permit to NJDEPE for vertical expansion to elevation 135 ft. NJDEPE officials approved the expansion with the condition that a 200 ft wide setback, proposed by Converse engineers, be built around the landfill at or below elevation 110 ft, except on the more stable west side.

In early September 1987, the instrumentation at SL-2 experienced significant deep-seated movement at about 80 and 100 ft below grade. This forced workers to move landfill operations away from the instrumentation at SL-2 and closer to SL-18. The area around SL-2 was particularly sensitive in terms of stability because of the presence of the gas line.

During this period engineers conducted field investigations and stability analyses to obtain a permit for filling low areas on the west side. The landfill reached a peak elevation of 135 ft.

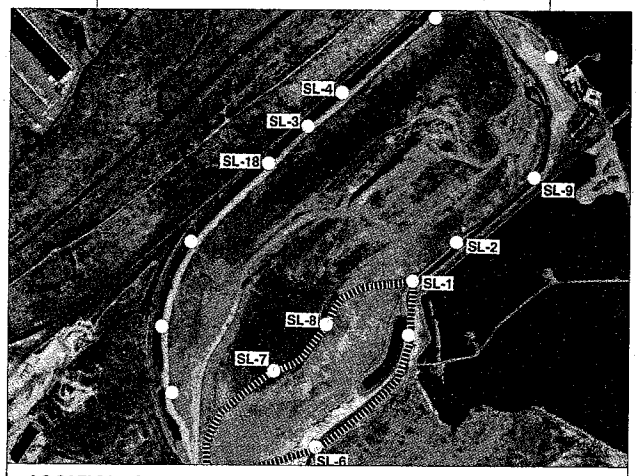
In early November 1987, instrumentation at SL-2 experienced additional large movements at the –100 ft level. By that time, operations were relocated to the southwest side. Once a transfer station was finished, landfill operations on this site ceased.

Following the termination of operations in 1988, BCUA officials proceeded to design a final cover in accordance with state regulatory requirements. The cover would include a clay component to limit water percolation and leachate generation. Engineers from Converse believed that, because of the ongoing settlements of the landfill, the regulated cap would fail. Instead the engineers recommended an ordinary soil cover. They conducted many analyses to demonstrate that the cap would structurally crack under the expected settlements. They proved that a cap constructed of material with a permeability of 1×10^{-7} cm/s, but an efficiency of only 60% (due to cracking of the cap), would have the same effectiveness as an ordinary soil cap with a permeability of 1×10^{-5} cm/s or higher.

The leachate-collection system continues to operate as a closed system conveying all leachate to treatment. Solute-transport modeling indicated negligible risk of off-site migration of contamination through the underlying varved clay. Using data taken from the many piezometers that had been installed, engineers were able to prove that the hydraulic head in the clay (due to refuse weight and slow consolidation) was higher than hydraulic heads in the refuse mound. This meant that the refuse would be recharged by the clay, and that an upward gradient would prevail for at least the next 50 years, which is the estimated consolidation time for the thick clay layer.

Based on the evidence presented this year, NJDEPE officials accepted the alternative design. Important ongoing elements to the success of the recently approved soil-cover alternative are surface grading to encourage surface runoff to perimeter swales, repair and maintenance of the swales, promotion of existing vegetation, and encouragement of new vegetation.

After landfill operations were terminated, BCUA officials applied for a permit to run a regional composting facility on the top of the site. The application initially was denied on grounds that loads generated by composting could destabilize the landfill and shear the cutoff wall now in place. NJDEPE officials finally granted a permit after inclinometer and piezometer data proved that the landfill was experiencing no adverse movements. The landfill is still monitored and data are being collected to demonstrate the feasibility of possible additional beneficial uses. Methane gas, for example, may be extracted in 1996.



LOCATION OF SOIL INCLINOMETERS AND PIEZOMETERS AT THE KINGSLAND PARK SANITARY LANDFILL IN BERGEN COUNTY, N.J.

The development of the Kingsland Lagoon expansion involved creating an ingradient system (hydraulic barrier), and placing refuse 25 ft below the level of the Hackensack River less than 1,500 ft away. The analysis and monitoring leading to the deletion of the standard-design cap requirement for this site is a new and innovative application of geotechnical engineering and hydrogeology.

The deletion of the cap saved an additional $20 million in capital costs that will be applied to BCUA's postclosure program to ensure that the facility is properly monitored as well as provide for a continued safe environment.

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