Interstate 287 Wetland Mitigation Project: Turning an Environmental Liability into an Environmental Asset

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As a condition of a U.S. Army Corps of Engineers Section 404 permit for the construction of a 9.5-km section of Interstate 287, the New Jersey Department of Transportation was required to create 4 ha of freshwater wetland. Finding a suitable site was difficult, resulting in a decision to buy a concrete pipe manufacturing plant along the Pequannock River and assuming the liability for contamination remediation. Site remediation was done during construction of the wetland replacement project and involved the excavation of 13,760 m^3 of petroleum hydrocarbon-contaminated soil, placement of 13 groundwater-monitoring wells, and development of a precedent-setting methodology for reuse of contaminated soil for the road embankment. To optimize the continued ecological viability of the newly created wetland, a hydrological model was developed and used in the design of the project. A shallow permanently flooded marsh planted with native emergent species was constructed and monitored for 3 years (from 1989 through 1991). An 80 percent success rate for planted vegetation was achieved, and the marsh now exhibits characteristics of a young developing wetland system with high degree of plant and wildlife diversity. The site, once a contaminated industrial facility, is now a thriving freshwater marsh contiguous to the Pequannock River that provides both functional and aesthetic values to the watershed.

The final 32 km of Interstate 287 in northern New Jersey was opened to traffic in November 1993. The entire project filled 31 ha of freshwater wetlands at 29 separate areas. In 1986 a U.S. Army Corps of Engineers Section 404 permit was issued for the "central section," a 9.5-km section within the limits of the overall project. About 3.2 ha of wetland was affected at eight separate areas, each ranging from 0.06 to 1.5 ha.

Nine potential mitigation sites were evaluated for the central section. A 4-ha concrete pipe manufacturing plant, whose access would be severed by the highway, was finally selected and converted to freshwater wetland. Mitigation for the rest of the project, a 12-ha site and a 16-ha site, is under construction. The goal of the mitigation designs approved by the U.S. Army Corps of Engineers and the advisory federal agencies was to provide high-value wildlife habitat and flood storage compensation at a 1:1 impact-to-mitigation ratio.

The conversion of the environmental liabilities associated with the 4-ha concrete pipe manufacturing plant site (Figure 1) into an environmental asset in the form of viable freshwater wetland (Figure 2) is described in the following sections.

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ENVIRONMENTAL LIABILITY: SITE CONTAMINATION

The site layout of the concrete pipe manufacturing company, which was in business for approximately 50 years, is shown in Figure 3. The operations on the site required the use and on-site storage of fuels (no. 2 heating oil, kerosine, and leaded gasoline), form-release oil (an oil composed of mineral and vegetable oil used to coat concrete molds to prevent the concrete from sticking), and hydraulic oil. The fuels were stored in two aboveground storage tanks (ASTs) and in four underground storage tanks (USTs).

As part of the property acquisition agreement the New Jersey Department of Transportation (NJDOT) assumed the responsibility for the investigation and cleanup of the site. The cleanup of the contamination was done as part of the wetland mitigation site construction and in close cooperation with the New Jersey Department of Environmental Protection and Energy (NJDEPE).

Soils

After acquisition of the site preliminary soil sampling was carried out in areas of the USTs and ASTs by the NJDOT during construction. The preliminary sampling detected petroleum hydrocarbons at concentrations of up to 45,552 ppm in the areas around

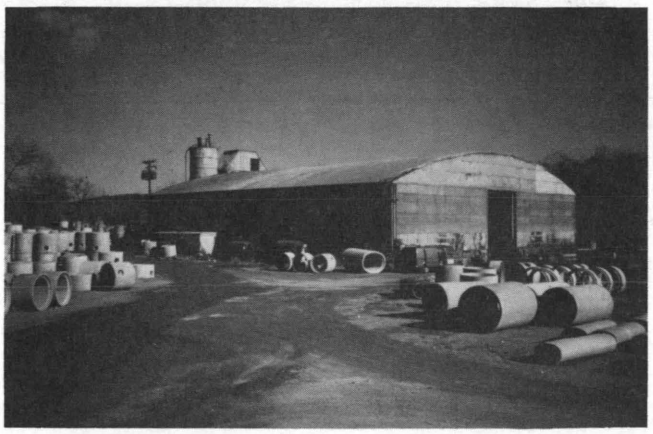

FIGURE 1 Concrete pipe manufacturing facility before construction (fall 1988).

FIGURE 2 Created deepwater marsh (August 1992).

the ASTs and the USTs. Additional soil sampling in the interiors of the buildings and drum storage areas identified the presence of other contaminants such as base/neutral organic compounds consisting primarily of polyaromatic hydrocarbons. No volatile organic compounds or PCBs were detected.

Groundwater

To monitor any potential impact to local groundwater quality resulting from the former operation of the concrete pipe company facility, NJDOT installed a groundwater-monitoring network consisting of 13 shallow monitoring wells. The results of sampling conducted after construction of the wetland were at or below the levels requiring NJDEPE action. It was therefore concluded that there was no further threat to the groundwater.

ENVIRONMENTAL ASSET: WETLAND MITIGATION SITE DESIGN

The approved mitigation design called for the construction of a shallow, permanently flooded marsh that would be planted with native emergent species. Among the first steps in the design process was development of a hydrologic model for the marsh system. The basis of the hydrologic model is shown in Figure 4. The model, which is basically a mass balance model, compared inflows to the wetland system with outflows from the wetland system to determine water levels in the marsh over a period of record. Inflows to the wetland system included precipitation, riverine inflow, groundwater inflow, and watershed runoff. Outflows from the system included evapotranspiration, exfiltration, and surface water outflow. Input data for precipitation and evapotranspiration were based on daily rainfall gauge data and pan data at nearby weather stations. Inflow data from the Pequannock River were developed by using discharge information from nearby U.S. Geological Survey gauge stations, and rating curve information was calculated by using the U.S. Army Corps of Engineers stepped backwater model HEC-2. Watershed runoff from tributary drainage areas was determined by the Rational Method. A rating curve for exfiltration rates was developed on the basis of the permeability of the proposed clay liner and the variable heads within the marsh system. Variable characteristics of the model included the elevations/heights and lengths of the proposed inlet and outlet control structures. The model is adaptable to most freshwater marsh systems.

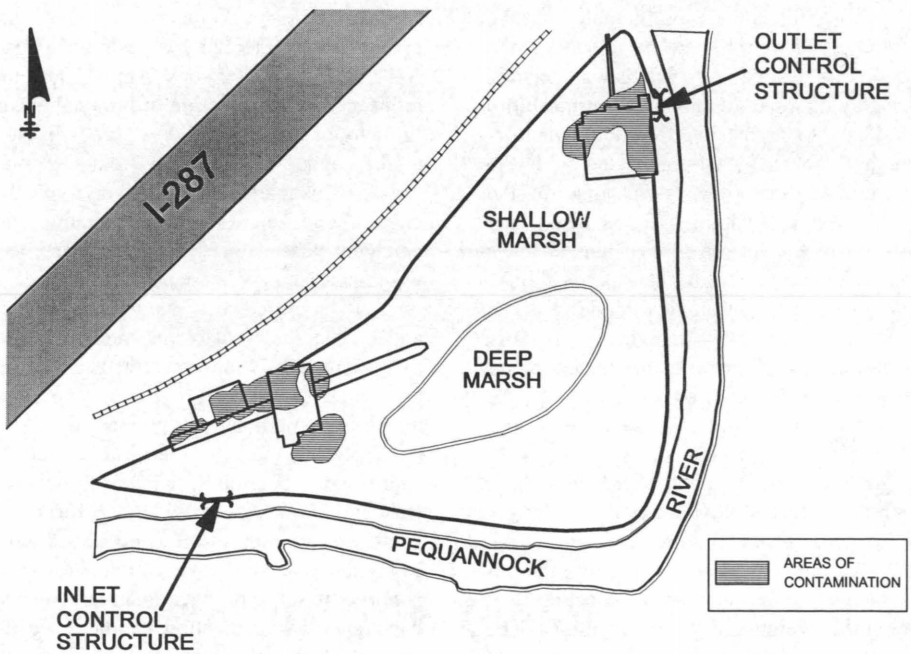

FIGURE 3 Project site map.

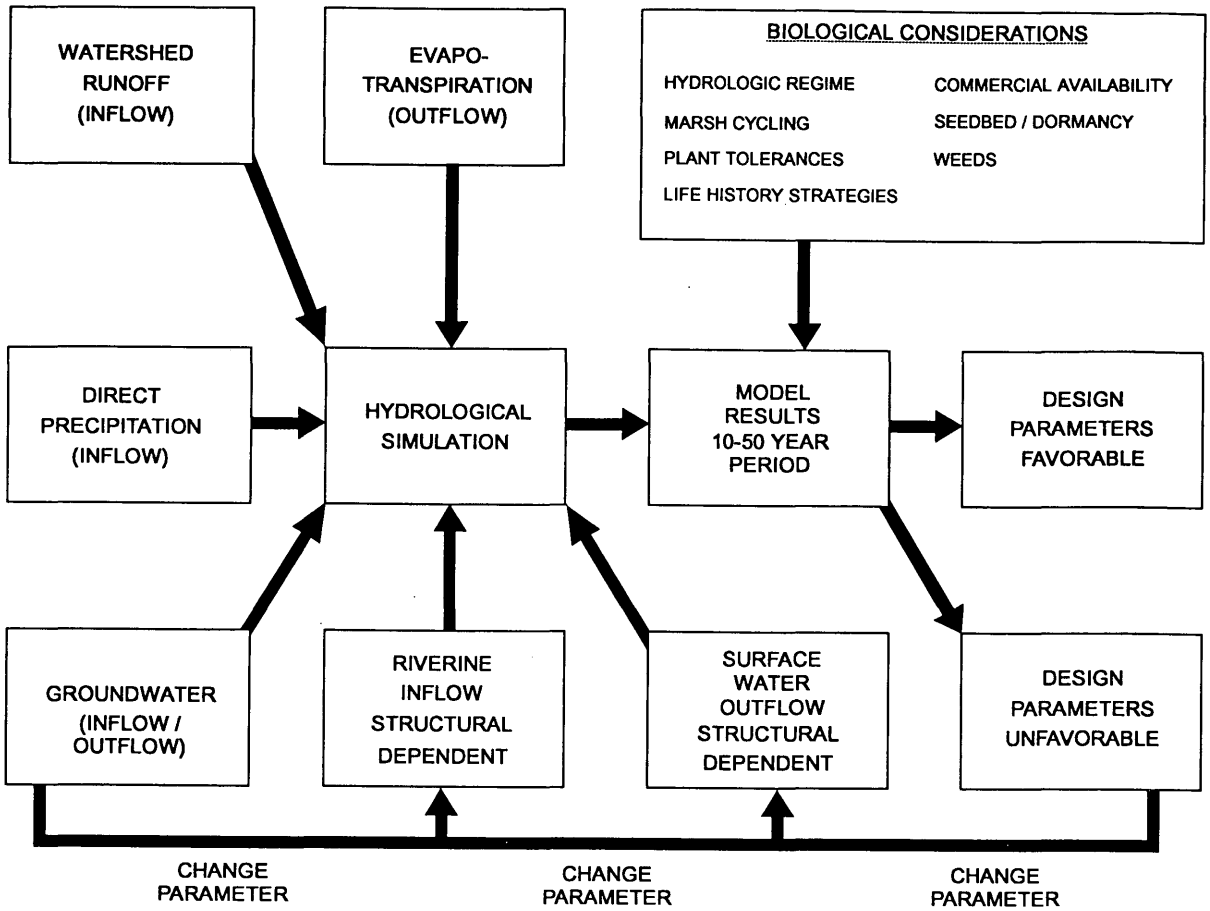

FIGURE 4 Hydrologic model flow chart.

Early in the development of the mitigation design it was realized that the on-site soil permeabilities were too high and that the groundwater fluctuations observed were too severe to support the permanently flooded conditions desired. As such it was decided that a buried 15-cm-thick clay liner with a maximum permeability of 1×10^{-6} cm/sec would have to be installed to provide the low-permeable soils. Although there is a cost associated with the placement of clay liners, in many cases the cost is offset by the shallower excavation and lower excavation quantities that clay liners allow. The installation of the liner has been judged to be highly successful and has achieved the desired soil permeability.

For the Pequannock River site the hydrological model was run for a continuous 20-year period by using both historical daily precipitation data and historical daily stream gauge data. Among the outputs of the model was a prediction of the daily water height at a reference point in the created wetland. The model was conducted for dozens of different possible design configurations, with the inlet height, inlet length, outlet height, and outlet length being among the parameters with the greatest flexibilities in the design.

The interpretation of the model results required expertise in the fields of both hydrological and biological sciences. From the engineering standpoint the model is a key element in selecting final elevations and determining the overall excavation quantities. The biological interpretation of the model's output takes into account a number of biological parameters, including life history strategies of the targeted plants, plant tolerances to designed water depths, seedbed and plant dormancies, the potential for obnoxious weeds invasion, the potential for desirable plant invasion, and various soil-related characteristics. Among the most important biological influences in the selection of the final elevations is marsh cycling. In many of the productive wetlands in North America the hydrological regime varies widely from season to season and from year to year. This marsh cycling is very typical in the Midwest and the Great Plains, where marshes cycle through the sequence of dense emergent phase, open emergent phase, submergent phase, open-water phase, drawdown phase, and back to the dense emergent phase. Therefore when deciding on the inlet and outlet heights and lengths, the goal of the modeling was to select an elevation that would allow for a natural periodic drawdown of the marsh on a cycle of between 5 and 10 years, but that would allow the marsh to be permanently ponded in most of the years.

Another of the key biological considerations on the marsh design was the potential for invasion by obnoxious weeds, particularly *Phragmites australis* and *Lythrum salicaria*. Both of these plants are common in the Pequannock River watershed and could easily invade a wetland creation site. As such the outlet structure is normally set to produce relatively deep water levels that are not conducive to colonization by these weeds. A depth of approximately 30 cm over most of the emergent marsh was chosen for the project described here, with the central pond area having a

depth of 75 cm. The drawback to this setting is that the planted species are stressed and there is a reduction in the overall emergent vegetative cover.

A final consideration is determining weir heights in relation to nutrient loadings. In an urbanized or agricultural watershed, approximately 90 percent of the pollutant nutrient loading is contained in the runoff derived from the first 2.5 cm of rain. To reduce the pollutant loading entering the wetland, inflows from the Pequannock River do not occur for storm events that produce less than 2.5 cm of precipitation. This was done to limit the potential for nuisance algal blooms.

CONSTRUCTION OF MITIGATION SITE

Site Remediation: Removal of Liability

The NJDOT commenced through a single contractor the remediation and construction of the wetland mitigation site in April 1988. The excavated soils from the remedial activities were analyzed for the federal Resource Conservation Recovery Act (RCRA) waste classification parameters of Extraction Procedure (EP) toxicity metals, corrosivity, ignitability, total petroleum hydrocarbons (TPHCs), and reactivity to cyanide and sulfide. The results of these analyses found TPHC concentrations ranging from 340 to 23,000 ppm in all samples except the interior sample from the circular pipe building (Building 1), which contained TPHCs at 74,000 ppm. The stockpile from the Building 1 interior (25 m^3) was manifested, transported, and disposed of as a hazardous waste.

Demolition of structures and the removal of building foundations was completed in August 1988. During the demolition all stained soils were excavated and stockpiled on site on plastic sheeting. Soil samples were taken from the excavations and analyzed for the RCRA waste classification parameters. Soil samples found to exceed NJDEPE cleanup levels resulted in an additional 1.5 m of soil being excavated from the bottom and stockpiled. No further sampling was carried out on the additional excavation. An estimated total of 13,760 m^3 of contaminated material was generated as a result of remedial activities at the site.

Wetland Mitigation

Upon completion of the demolition of the existing buildings, ASTs, and USTs and removal of contaminated soils, the proposed 4-ha wetland mitigation area was constructed. The emergent marsh zone of the created wetland was planted with a total of 90,000 individuals on approximately 60-cm centers, including *Peltandra virginica, Sparganium eurycarpum, Pontederia cordata, Sagittaria latifolia, Scirpus validus*, and *Scirpus americanus*. The deeper, central pond area was planted less densely with *Nymphaea odorata, Vallisneria* sp., and *Potamogeton pectinatus*.

Soil Reuse: Establishing a Statewide Precedent

The NJDOT presented to the NJDEPE's Bureau of Hazardous Waste Classification and Regulation a waste classification sampling plan in November 1988 to characterize the 13,760-m^3 soil stockpile. NJDEPE accepted a modified form of the sampling plan because of the large volume of soil to be sampled. The NJDOT plan modified NJDEPE's standard sampling protocol of one five-part composite sample per 75 m^3 to one five-part composite sample per 200 m^3. The soil stockpile was systematically divided into 72 sampling units, with each unit representing 200 m^3 in accordance with the modified sampling plan.

The 72 composite samples were analyzed for EP toxicity metals, TPHCs, reactivity tests for sulfide and cyanide, and PCBs. No values in excess of the maximum concentration for EP toxicity metals, reactivity to cyanide or sulfide, or PCBs were found in any of the 72 composite samples. TPHC concentrations ranged from less than 11.5 to 5,240 ppm. Upon completion of the waste classification testing the NJDEPE reviewed the results of the testing and classified the soil as ID-27 material, which is a contaminated but nonhazardous dry industrial waste.

In New Jersey ID-27 soils that are disturbed as a function of construction must be stabilized so that there is no threat to the general public or to the environment. Various methods of reusing or disposing of the soils were evaluated with respect to cost, implementability, and long-term liability, including (a) landfilling at a licensed landfill facility ($230/$m^3$), (b) reusing the material in the roadway embankment ($9/$m^3$), (c) recycling the contaminated soils at an asphalt recycling facility ($145/$m^3$), and (d) treating the contaminated soils by washing, biologic, or incineration methods.

It was determined that reuse of the 13,760 m^3 of contaminated soils as highway embankment material was the most cost-effective solution that would not have a significant impact on the construction schedule of the roadway, the wetland mitigation permit goals, and ultimately the opening of the highway. The contaminated soil was to be placed directly beneath the 70-cm-thick roadway pavement box, which eliminated the potential for infiltration and resultant leaching of contamination into the environment. A soil reuse plan was then prepared. The plan addressed the types of soil contamination present, proposed method of reuse, proposed construction methods, and health and safety requirements during construction. A qualitative risk analysis was also prepared as part of the soil reuse plan. The analysis evaluated short-term and long-term pathways and exposure rates of the contaminants in relation to the guidelines of the National Institute for Occupational Safety and Health and the American Conference of Governmental Industrial Hygienists.

This project was the largest soil reuse plan approved by NJDEPE and the first soil reuse plan prepared by NJDOT that laid the groundwork for other proposed on-site disposal and reuse applications. By reusing the contaminated soils within the project area a savings of approximately $2,000,000 in disposal costs was realized by NJDOT. Aside from the cost savings to NJDOT it had the added benefit of triggering the formation of a Soil Reuse Committee by NJDEPE and the development of a precedent-setting procedure to be used in future cases.

LONG-TERM MONITORING

Special Condition C of the U.S. Army Corps of Engineers Section 404 permit required that the created wetland exhibit an 80 percent success rate for planted vegetation. This was documented by three annual, written reports submitted by NJDOT to the U.S. Army Corps of Engineers in the fall of each year following completion of construction. Density of emergent and submerged vegetation was estimated and recorded as percent cover. Evidence or direct

sitings of fish and wildlife use of the marsh were also recorded during these and any other visits to the site during each of the 3 monitoring years.

The following plant species were observed in and around the shallow marsh during the 3-year monitoring period: *Echinochloa crusgalli, Typha* sp., *Acorus calamus, Cyperus* sp., *Eleocharis* sp., *Polygonum* sp., *Scirpus validus, Heteranthera reniformis, Ludwigia palustris, Alisma triviale, Pontederia cordata, Sparganium* sp., *Sagittaria latifolia, Leersia oryzoides, Juncus effusus, Salix nigra, Impatiens capensis, Bidens* sp., *Scirpus purshianus, Scirpus atrovirens, Phragmites australis, Setaria* sp., and *Peltandra virginica.*

The central pond area was vegetated by *Nymphaea odorata, Myriophyllum* sp., *Potamogeton* sp., and *Elodea canadensis.* Intermittent patches of *Sagittaria latifolia, Typha* sp., and *Eleocharis* sp. were also scattered throughout this area.

Wildlife observed over the 3-year monitoring period included large amounts of freshwater snails clinging to submerged portions of vegetation in the wetland. Minnows, sunfish, and young smallmouth bass were also observed. Waterfowl regularly used the marsh, with mallards and Canada geese almost always seen swimming or feeding when one visited the site. Other birds seen in or near the marsh included black duck, great blue heron, killdeer, chimney swift, great egret, green heron, snipe, and greater and lesser yellowlegs. Mammals seen using the marsh or surrounding the berm area include muskrats, raccoons, and whitetail deer.

At the end of the 3-year monitoring period, taking both emergent and submerged vegetation into consideration, the average plant cover requirement of 80 percent specified in the U.S. Army Corps of Engineers permit was determined to be satisfied.

Presently the created marsh exhibits several characteristics and functions of a young, developing wetland ecosystem. Plant diversity has been maintained at a high level, with *Scirpus* sp., *Pontederia cordata, Sparganium eurycarpum, Sagittaria latifolia,* and *Nymphaea odorata* dominating (Figure 2). Numerous small fish are present in the marsh, which provides a nursery area for them. Local anglers have reported taking game fish (bass) from the site. Wildlife habitat is also well established, and waterfowl have reproduced successfully at the site. Situated along the banks of the Pequannock River, the created wetland also provides additional flood storage and desynchronization, which are considered valuable to developed areas downstream.

SUMMARY

Under normal circumstances NJDOT attempts to avoid acquisition of potentially contaminated industrial sites for projects. However because of the limited availability of land for wetland mitigation, the need to expedite right-of-way negotiations, and the site's ideal location, NJDOT took a calculated risk. The concrete pipe manufacturing facility, located immediately adjacent to the Pequannock River, in the floodplain, was a source of environmental contaminants with direct pathways to both surface and groundwater. The NJDOT, by using the site for freshwater wetland mitigation, removed the sources of contamination and converted the environmental liability inherent to the site into a 4-ha environmental asset and an aesthetically pleasing, ecologically functional wetland habitat. In the course of doing so, a precedent-setting contaminated soil reuse process was developed. The process was significantly less expensive than previously used disposal methods.

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