WASTEWATER LAGOON CLOSURE AND BIOREMEDIATION OF HYDROCARBON CONTAMINATED SOIL AND WATER

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INTRODUCTION

Contamination of Georgia's waters by hazardous substances has become a frequent topic of discussion in the media and among our citizens. These concerns have resulted in passage of numerous laws and regulations to remedy the results of past environmentally damaging practices and to deter their recurrence. In past decades, prior to our current understanding of the negative consequences to human health and the environment, many of these practices were standard operating procedures in industry.

The consequences of formerly acceptable practices include significant financial liability for remediation imposed by the law on the owner of an environmentally impaired property. If owners of such properties wish to offer them for sale, they have two choices. They can sell the property "as is" for a significantly reduced price, or they can remedy the impairment in the hopes of a sale price higher than the cost of the remedy.

In this case study, the original operator of a truck terminal had caused the site to become environmentally impaired. The source of impairment was a wastewater lagoon receiving runoff from the truck wash and fuel island areas. The new owner of the property decided to remedy the site, anticipating a higher sale price.

The new owner contracted to remedy the impairment by a properly engineered closure of the lagoon. An on-site bioaugmentation and landfarming procedure was recommended as a cost-effective remedy for treating hydrocarbon contaminated sediments, water, and soils resulting from the lagoon closure.

SITE DESCRIPTION

The subject of this case study is a property developed for use as a truck terminal along a major highway in northeast Georgia. The site was originally developed in the late 1960's. Figure 1 depicts the site location.

Soils and Drainage

The site lies in the Piedmont Region of northeast Georgia. The regional groundwater flow parallels the surface water drainage flowing to the east and southeast, eventually joining Lake Hartwell or the Savannah River, and thence to the Atlantic Ocean.

Soils at the site are mostly the residual product of weathering of the underlying igneous and metamorphic rocks. They are classified as a Cecil Sandy Loam: deep, well-drained, moderately permeable, red soils, formed on ridge tops and side slopes (USDA, 1979). They typically are underlain by a clayey subsoil, limiting subsurface contaminant migration potential.

Source of Contamination

Environmental impairment on the site occurred as a result of the wastewater management practices of the original operator. The present owner acquired the property in a court-mediated bankruptcy settlement. The new owner decided to remedy the environmental impairment and then offer the property for sale.

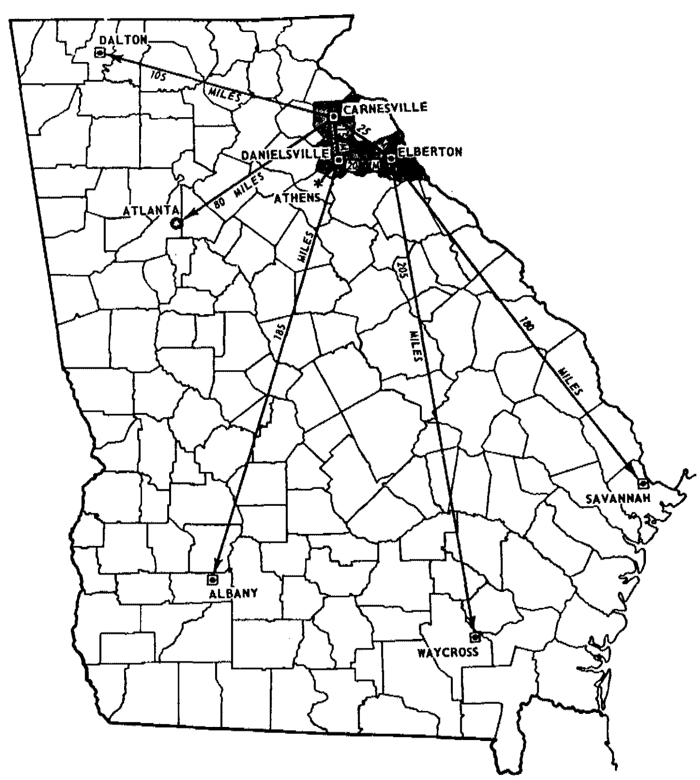

Figure 1. Site location (shaded area) in northeast Georgia

The previous owner had constructed a wastewater lagoon by building a 12-foot semi-circular berm at the foot of a small hill, located at the eastern corner of the site. Figure 2 is a site plan depicting the location of the lagoon (retention pond).

The lagoon received hydrocarbon-contaminated runoff for more than twenty years from the truck wash floor drains and a stormwater catch basin located at the fuel island. Wastewater was routed to the lagoon via six-inch underground PVC pipes. The lagoon had no outlet. The lagoon wastewater either infiltrated the underlying soils or evaporated.

Contamination Assessment

No recorded instance of wastewater overtopping the berm was noted during a contamination assessment performed under contract to the present owner in September 1991. The assessment included installation of three monitoring wells around the lagoon.

The three wells defined a piezometric surface indicating groundwater flow under the lagoon toward the east and a nearby drainage ditch. The drainage ditch was a wet weather feature, hydraulically well above the groundwater, but below the lagoon water surface.

The lagoon water surface was a maximum of about four feet above the bottom of the bermed area, as indicated by lines of discoloration on the inside surface of the berm. The groundwater table was observed at a depth approximately 18 feet below the average lagoon water surface elevation.

Groundwater and soil samples were collected from the wells and associated borings during the assessment and analyzed in the laboratory for aromatic hydrocarbons. Results from both upgradient and downgradient wells indicated no significant contamination.

Samples were also collected from the lagoon sediments and analyzed for several parameters of environmental concern. The laboratory analyses confirmed total petroleum hydrocarbon (TPH) levels in excess of 16,000 parts per million (ppm). Analyses for toxicity characteristics leaching procedure (TCLP) metals, organic solvents, and other pollutants, indicated no other contamination requiring corrective action.

CLOSURE PROCEDURES

The assessment had confirmed the only contaminant of concern was TPH. The hydrocarbons were believed to be an amalgam of diesel fuel, and waste oil and grease. This inference was drawn from the nature of the wastewater sources.

To remedy the environmental impairment on site, the wastewater had to be pumped out, then the contaminated soils excavated and treated to below corrective action levels, and finally the lagoon excavation backfilled with the treated soils to complete the closure.

A 15,000 gallon temporary holding tank was constructed on the asphalt parking lot above the lower gravel lot where the contaminated soils were planned to be treated. Refer to Figure 2 for the site layout. The lagoon waters were pumped into this holding tank, along with some contaminated sediments.

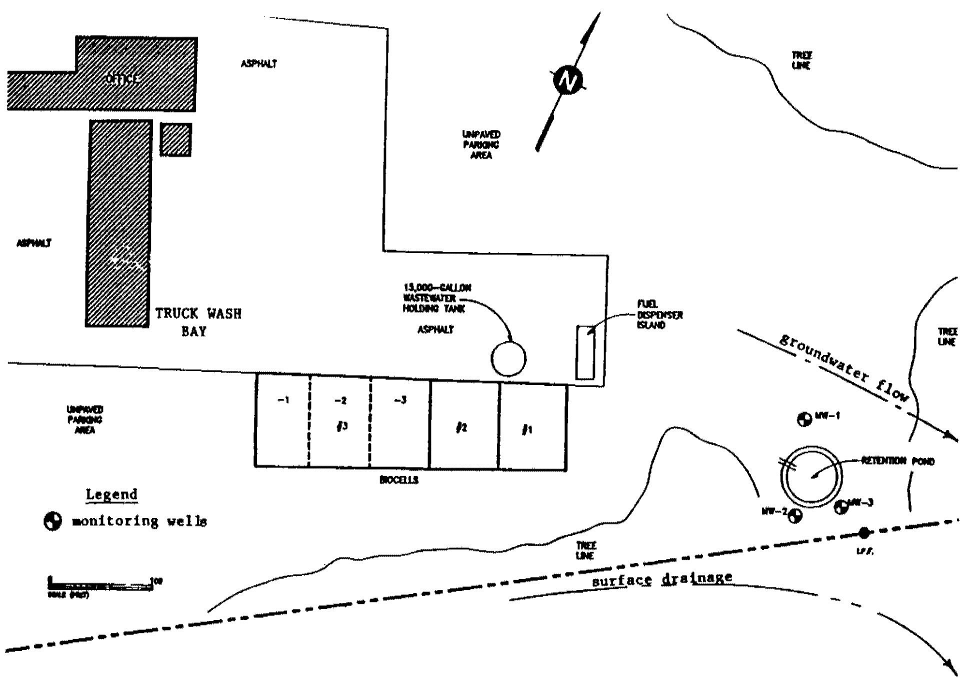

Figure 2. Site plan indicating major site features; including truck wash bay, fuel island, former wastewater lagoon, site hydrology, and biocell layout.

After the lagoon was dewatered, the berm was removed down to just above the former water level, providing access for the track-hoe excavator to remove the contaminated sediments and underlying soils. The relatively clean berm soils were stockpiled for use in construction of the biocells for contaminated soil treatment.

Continued excavation revealed TPH contamination extending laterally a few feet into the lower berm, and vertically down to the groundwater table. Zones of varying permeability in the saprolitic soil structure underlying the lagoon created a feathery hourglass-shaped cross-sectional pattern. Figure 3 illustrates the contaminant migration.

The track-hoe removed all the TPH contaminated soils. Laboratory analyses of soil samples, collected from the sides and bottom of the excavation, verified successful removal of all soils contaminated above 100 ppm TPH. At completion, the excavation was 50 feet in diameter at the top, narrowing to about 40 feet at the bottom. 1000 cubic yards of contaminated soils (ca. 1500 tons) were removed.

Biocell Construction

Biocells for treatment of the contaminated soils were constructed concurrent with the excavation. Excavated soils were homogenized within the excavation by the track-hoe and then moved by dumptruck to the biocells under construction.

The biocells were constructed by first preparing a level subgrade with a backhoe. Sides were formed with hay bales. A plastic liner was then laid on the subgrade and over the top of the bales. The plastic was placed to prevent contaminant leaching into the subgrade.

Two to three inches of clean sandy soil were placed on top of the plastic for its protection and levelled by hand. A layer of hay was spread on the clean soil for a depth indicator. One foot of contaminated soil was placed on the hay layer. Figure 4 shows a cross-section of the biocell construction.

The completed biocells covered nearly 27,000 square feet (ca. 2/3 acre). A plan view of the completed biocells is shown on Figure 2.

Biocell Operations

The contaminated sediments and soils in the biocells were conditioned with lime, phosphorous and nitrate salts, then inoculated with a proprietary hydrocarbon-degrading bacterial culture on May 15, 1992. The wastewater was to be treated by irrigation onto the biologically active soils.

The soils were to be tilled every few days to mix the conditioning agents and bioculture, and to favor the faster process or aerobic biodegradation. We monitored progress of the treatment by collecting composite soil samples for TPH, nutrient, and pH analyses. Aliquots for the composite samples were collected on a specified grid for consistency between sampling events.

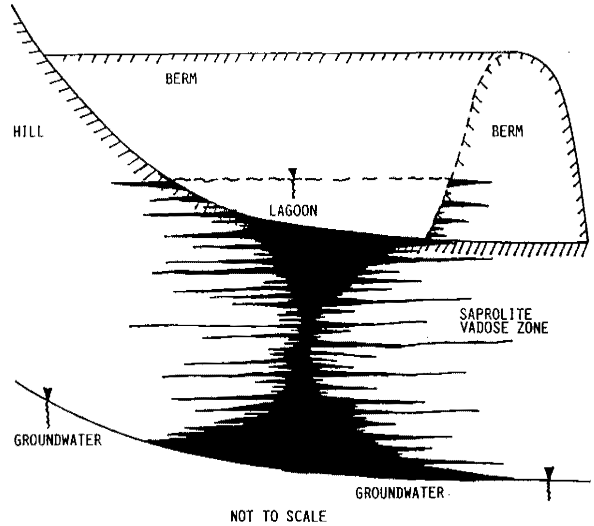

Figure 3. Vertical cross-section of contaminant migration below the wastwater lagoon.

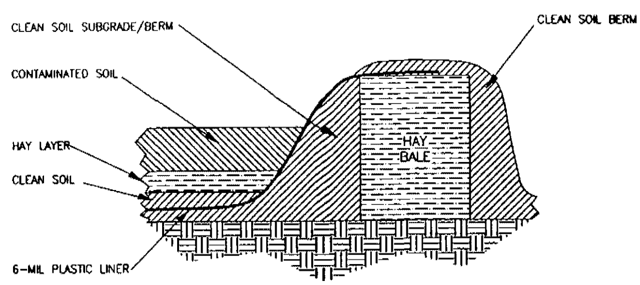

Figure 4. Biocell vertical cross-section showing construction.

Treatment was expected to last five months.

The target level for completion of treatment was 100 ppm TPH. This level was set by extrapolation from the Georgia Environmental Protection Division (EPD) regulations governing corrective actions at underground storage tank (UST) sites (Chapter 391-3-15). The UST regulations were selected as the closest applicable guidelines as to future environmental liability concerns.

Stormwater Management

The biocells were not covered to control stormwater infiltration. Because of the large area to be covered, we felt the additional labor required to uncover and recover the biocells each time they were tilled would be cost prohibitive.

A review of the *Climatic Atlas of the United States* (1968) for the site location indicated the normal May to October precipitation was 26 inches. Normal evaporation during this same period was reported to be 36 inches.

The statistical norms suggested maintaining sufficient moisture in the biocells was going to be our greatest concern. Fortunately, the predicted moisture deficit would offer the opportunity to biologically treat the wastewater in the holding tank by using it for irrigation.

Actual precipitation during May to October 1992, as recorded using an on-site rain gauge, was 38.8 inches. This was 50 per cent above normal. More-frequent-than-normal cloudy days also limited drying conditions to less than 36 inches of evaporation for the specified period. The resulting moisture surplus seriously affected biocell operations.

Because of saturated soil conditions, the tractor was not able to enter the biocells to till the soils according to schedule. We averaged only about 50 percent of our planned tilling schedule.

RESULTS AND DISCUSSION

Biocell #1 received soils from the upper levels of the lagoon excavation where contaminants were most concentrated. Among all three biocells, it consistently indicated the highest concentrations of TPH.

Figure 5 compares our actual sampling results in Biocell #1 to those predicted by a first-order linear biodegradation model. The bioculture vendor recommended using a half-life of 30 to 45 days. Our model conservatively assumed a 45-day half-life.

Samples collected on August 31, 1992, (90 days elapsed time after the baseline sampling June 2) indicated a half-life of 22 days, despite failure to meet our planned tilling schedule. We assumed that dissolved oxygen in the rains had allowed aerobic biodegradation to continue at an efficient rate. This seemed reasonable given the near-optimal temperatures of mid-summer.

Site inspections in August 1992 revealed significant contaminant migration into the hay layer; a result of leaching during the heavy rains. Biological surfactants produced by the bacterial metabolism probably allowed leaching to occur easily.

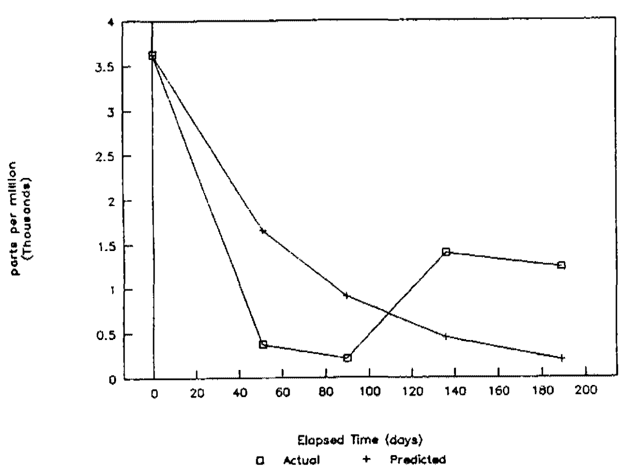

Figure 5. Comparison of actual versus predicted TPH levels in Biocell #1.

We had not tilled into the hay layer since this was our depth indicator to protect the plastic liner. Decay of the hay and lack of tilling likely resulted in near anoxic conditions in the hay layer, severely limiting the rate of hydrocarbon biodegradation.

The farmer was instructed in late August 1992 to till into the hay layer. This succeeded in incorporating organics from the hay layer into the larger biocell mass.

By early September 1992 it was obvious that moisture application was not going to be required in time to bioremediate the wastewater in the holding tank. It was pumped into Biocell #3 where TPH contaminant levels had already declined to significantly less than 100 ppm. This caused Section -3 to increase above 100 ppm. The other sections of Biocell #3 remained below the corrective action level.

By mid-October 1992 (elapsed time = 136 days), we had lost our temperature advantage and continued to experience more-frequent-than-normal cloudy days and heavy rains. Saturated conditions limited the oxygen availability and diffusion rate in the soils, and the biodegradation rate.

Sampling results in October and December 1992 indicated increased TPH levels, reflecting incorporation of the hay layer into the upper biocell mass and limited biodegradation rates due to cooler temperatures. This situation has had a negative effect on project schedule and budget.

Applying the biodegradation model to analytical results through December 1992 (elapsed time = 189 days), we calculated a half-life of 122 days. Given the previously described operational setbacks and optimal half-life of 30 to 45 days, a 122 day half-life was probably representative of actual conditions in the biocells averaged over the project life.

A plastic cover and drainpipes were added in November 1992 for stormwater control. However, drying conditions were not favorable in the fall of 1992 and the soils remained saturated. Therefore, the project was shut down until more favorable climatic conditions arrive in the spring of 1993.

RECOMMENDATIONS

- Do not assume stormwater control can be neglected during bioremediation operations. Consider the possibility of experiencing 30-year rainfalls.

- Regularly inspect down the entire depth of each biocell to the liner for evidence of contaminant leaching due to the action of biosurfactants. Adjust the tilling process accordingly.

- Collect samples for microbiological plate counts along with nutrient analyses, etc. Correlate these results with contaminant analyses and biodegradation model predictions. Be suspicious of better-than-expected results as well as worse-than-expected results.

- Consider alternative processes for managing the bioremediation with better control; e.g., static pile or cells with forced-air aeration, etc.

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