Expedited Remedial Action by Florida Department of Transportation at I-595 and Davie Boulevard Corridor Expansion Project: Case History

JON G. BERRY AND LUKE FRANTZ

The Florida Department of Transportation planned to begin construction of a portion of the I-595 corridor in Fort Lauderdale, a 2½-year project valued at $83.5 million. The designed storm water retention pond for the project spanned two parcels of land, which were discovered to contain petroleum-based contaminants. The pond was scheduled to be constructed early in the project to receive storm water runoff during construction and remain as a permanent storm water pond after completion of construction. The contaminated conditions prevented construction and use of the pond. It was therefore imperative that the site contamination be cleaned up quickly and effectively; otherwise, the construction schedule and budget would be hurt substantially. Site assessment and remedial planning were expedited, requiring close coordination between the involved regulatory agencies, other public agencies, general contractor, and remediation contractor. The design for the contaminated groundwater recovery system included high-recovery-rate horizontal drains, the first such application in Florida, as well as deep vertical wells. The groundwater treatment system employed filtration, clarification, and carbon adsorption treatment. Treated water was discharged into recharge ponds and infiltrated in designated site areas to flush the soils in the vadose zone. This action minimized the rebound effect typical of pump and treat operations that is caused by the interaction of the recovered water table and vadose zone soil contamination. This unique, large-scale groundwater remediation was effective, removing more than 99 percent of the benzene and 95 percent of total volatile organic aromatics in 3 months.

In September 1991 the Florida Department of Transportation (FDOT) acted on the discovery that construction of the I-595 corridor expansion project would be affected by the presence of petroleum-related contamination in the right of way. The project was due to be let in October 1991. Expeditious remediation of the contaminated property was imperative to prevent project delays.

From October 1991 to February 1992, the contaminated area was assessed and remediated. Working in close cooperation with the Florida Department of Environmental Protection (FDEP, formerly the Department of Environmental Regulation), a major groundwater remedial action was completed. A key factor contributing to the success of this remedial activity was the close coordination and cooperation among FDOT, FDEP, other public agencies, the general contractor, and the remedial contractor.

This paper presents a case history of the expedited groundwater remedial action. The remediation is believed to be the first and largest application of high-recovery-rate horizontal recovery drains (horizontal drains) in Florida. Initial estimates indicated that remediating this site using conventional pump and treat methods would have required 3 to 10 years to complete.

PROJECT BACKGROUND

I-595 Expansion Project

The Interstate highway I-595 expansion project involved widening I-595 throughout Broward County, Florida. In October 1991 FDOT let the construction contract to begin the 2½-year construction of the $83.5 million "last link" of the I-595 expansion project in Fort Lauderdale. The last link involved widening a 3.22-km (2-mi) stretch of Interstate 95 from north FL-84 to south of Sunrise Boulevard. The project scope also included construction of park-and-ride facilities, erection of noise barrier walls, and widening or relocating portions of Davie Boulevard, a local main east-west feeder route to I-95.

Remediation Site

The remediation site was part of the right-of-way acquisition required to complete the construction project. As is usually the case in roadway construction projects, the storm water retention/detention ponds were planned to be built first, so that they could be used to collect storm water runoff associated with construction. The storm water pond was designed to be located on two parcels of land, identified in this paper as Parcels 268 (P268) and 269 (P269). One parcel was occupied by an active gasoline station; the other was occupied by an insurance company, which was previously the site of a gasoline station. The two parcels were determined to affect construction because of preexisting petroleum contamination of soils and groundwater, which resulted from releases during present and past operations at the sites.

P268 and P269 are adjacent parcels separated by a dead end street (S.W. 19th Avenue). Petroleum contamination plumes from each parcel intersected, forming a mixed plume; therefore, from an environmental perspective, the area was treated as one site. Figure 1 presents a plan view indicating the principal physical features of the site area. Figures 2 and 3 show the delineation of the horizontal and vertical limits of the petroleum contamination plume. The site is bordered to the west by I-95 and to the north, south, and east by residential com-

J. G. Berry, Florida Department of Transportation, 605 Suwannee Street, MS37, Tallahassee, Fla. 32399. L. Frantz, Westinghouse Remediation Services, Inc., 111 Kelsey Lane, Suite B, Tampa, Fla. 33619.

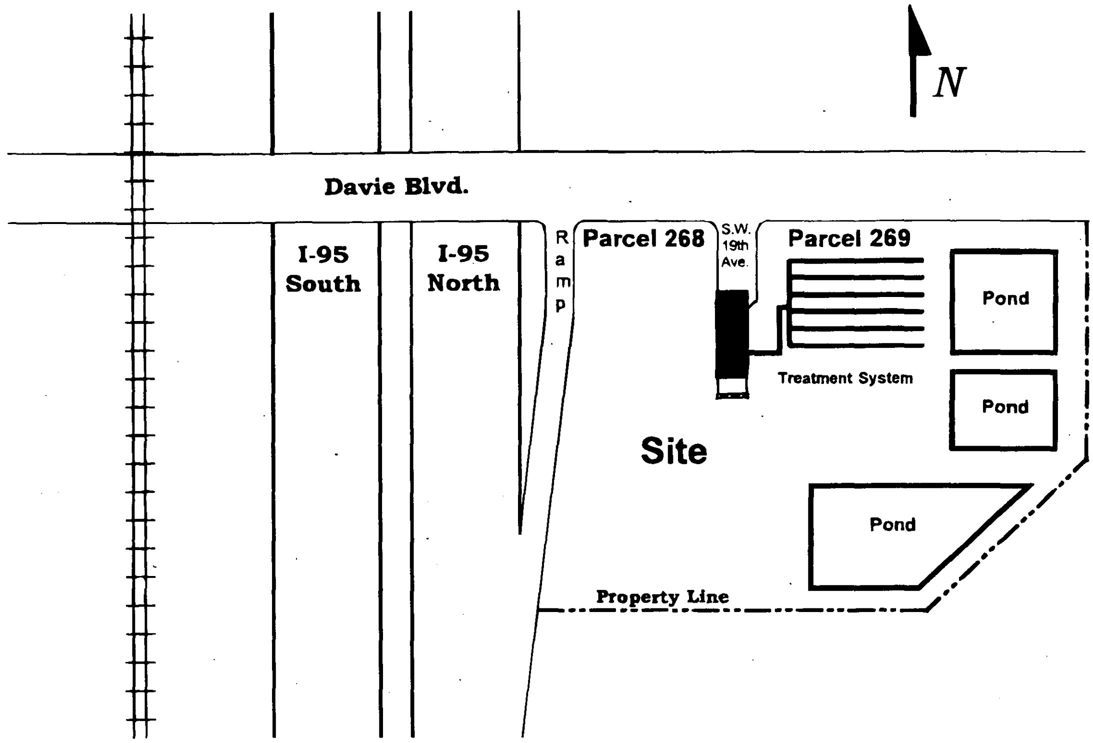

FIGURE 1 Site plan.

munities and small businesses. The tide-controlled South Fork of the New River is located to the east and south of the site.

Regulatory and Administrative Considerations

Petroleum-contaminated sites in Florida are administered by FDEP under the criteria of Chapter 17-770 Florida Administrative Code (FAC), *Petroleum Contamination Site Cleanup Criteria.* The criteria of Chapter 17-770, FAC require that petroleum-contaminated sites undergo a sequence of studies and submittals to FDEP designed to identify the extent of the contamination and the plans for remedial action. The principal documentation required to be submitted is

- Contamination assessment report (CAR): Identifies the findings of investigations and analyses performed to characterize the vertical and horizontal extent of soils and groundwater affected by releases of petroleum hydrocarbons from the underground storage tanks (USTs).
- Remedial action plan (RAP): Identifies the technology selected and engineered to remediate the site.
- Site rehabilitation completion report (SRCR): Identifies the work performed, level of cleanup attained, and actual performance of the system.

Early Detection Incentive

In recognition of the need to protect Florida's surface water and groundwater, the Florida legislature created the Inland Protection Trust Fund to provide funding for cleaning up petroleum-related contamination at eligible sites. These funds are administered by FDEP through the early detection incentive (EDI) program. Enacted in 1986 the EDI program provides state-funded cleanups or reimbursement of the cost of remediating UST-related petroleum contamination. Eligibility for reimbursement of remediation costs under the EDI program requires that the tanks be registered with the state and that all remediation-related activity is conducted in accordance with the provisions of Chapter 17-770, FAC, and records are submitted that document that the owner has paid "reasonable rates for allowable costs" in accordance with the rules.

South Florida Water Management District

The South Florida Water Management District (SFWMD) maintains jurisdiction throughout southeast Florida, where the site is located, for issues concerning water use and quality. Its oversight involvement with petroleum contamination is related to water use and quality and the potential for dewatering activities to exacerbate a contaminant plume. The usual requirements of SFWMD specify that the owner or remedial contractor establish the following:

- The engineering design must provide satisfaction that the entire plume will be captured and that the discharge will not cause previously uncontaminated areas to become contaminated through hydraulic plume movement,
- The owner/remedial contractor must obtain (at a minimum) a general use permit, and
- The owner/remedial contractor must provide monitoring data for the treatment system.

Memorandum of Understanding

FDOT regularly acquires property throughout the state for transportation improvements and often discovers unknown contaminated sites. Since the discovery of these sites furthers the mission of

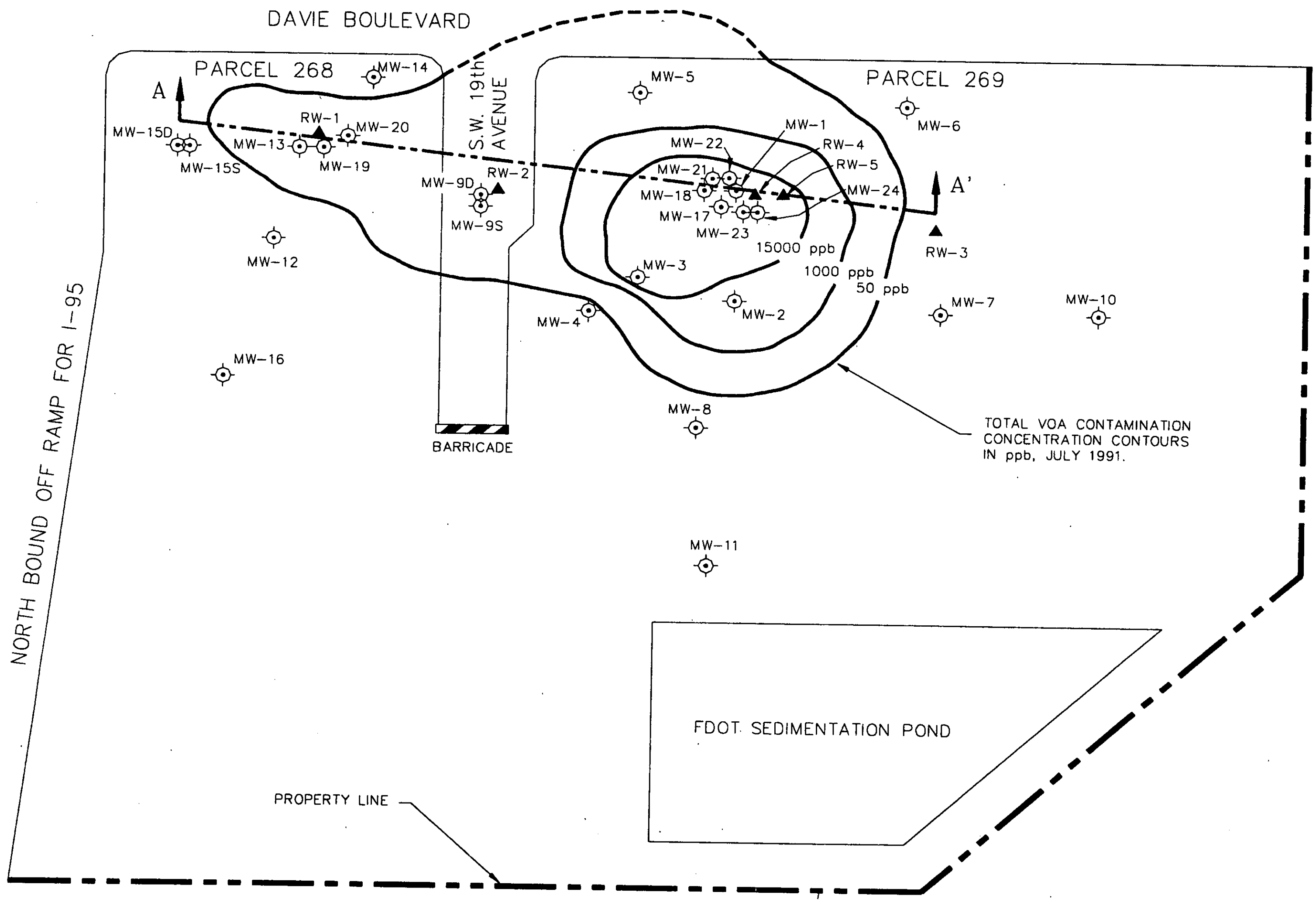

FIGURE 2 Site plan view of horizontal limits of contamination plume.

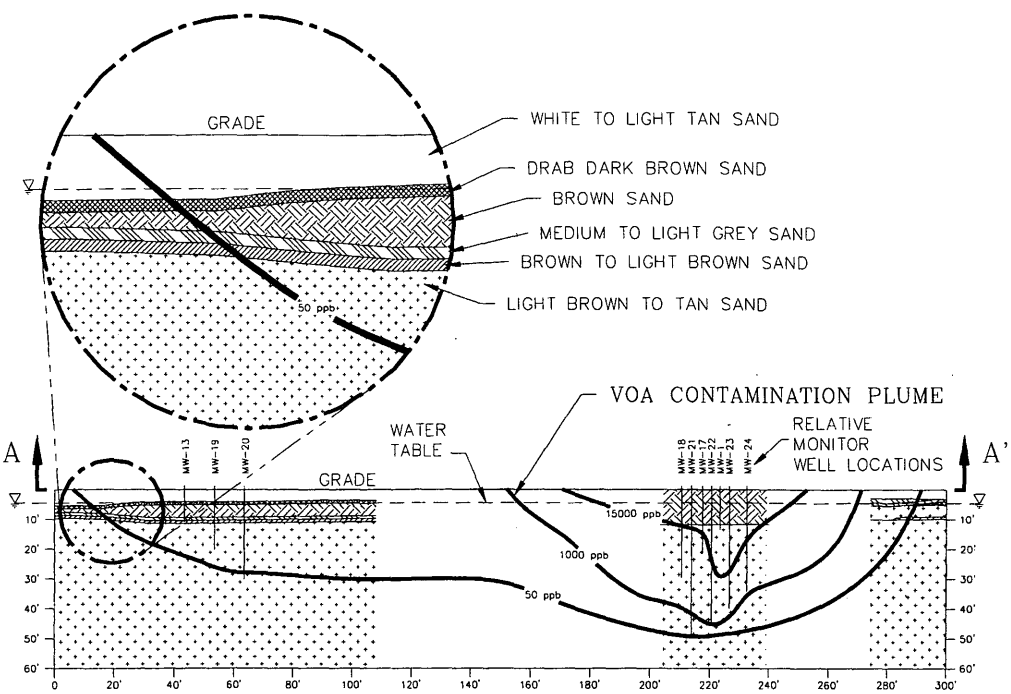

FIGURE 3 Site cross section showing vertical limits of contamination plume.

FDEP to protect the ground and surface waters, the two agencies entered an agreement in July 1989 that allows them to address and resolve contamination issues in a timely manner. That agreement, known as the memorandum of understanding (MOU), defines the role of FDOT in cleaning up contamination sites that accrue to FDOT through right-of-way acquisition. It also describes procedures for FDOT to seek reimbursement of the allowable cleanup costs from the Florida Inland Protection Trust Fund.

SITE ASSESSMENT AND REMEDIAL PLANNING

Previous Site Characterization

P269, occupied by a recently active service station of a major oil company, was an EDI site. P268, currently occupied by an insurance company, was previously the site of a gasoline station that had unregistered USTs that were leaking and, therefore, not eligible for EDI reimbursement. A CAR for P268 and P269, prepared by the FDOT general right of way consultant for this project, had been submitted to FDEP. That CAR concluded that the plume of contamination originally emanating from two separate sources had interacted and combined to create one plume. The CAR also indicated that tanks associated with the site had been removed and the associated petroleum-contaminated soils around the tank areas had been removed and incinerated, as part of initial remedial action activities.

Site Assessment

Upon reviewing the data provided in the CAR, it was determined that additional investigation was necessary to delineate the horizontal and vertical extents of the affected groundwater and soils. To fully delineate the plume, the following tasks were completed at the site:

- Additional monitoring wells were installed to determine the plume's horizontal and vertical extents.
- Groundwater samples were collected from newly installed wells and existing wells.
- The parcels were surveyed, depth to water was measured, and water table contour maps were constructed.
- Aquifers were tested in situ to determine the hydraulic conductivity.

Addendum documents to the original CAR, required by the regulatory agencies, were prepared and submitted to document that the extent of the contaminant plume was delineated horizontally and vertically.

Remedial Planning

Remedial planning and design took place almost contemporaneously, as new information became available. Planning required close interaction and coordination among FDOT, FDEP, Broward County Office of Natural Resource Protection, SFWMD, city of Fort Lauderdale, general contractor, and FDOT statewide environmental consultant performing all assessment and remediation activities. The following issues were considered:

- Timing of the construction operations,
- Coordination of highway construction efforts,
- Coordination with FDOT,
- Regulatory issues,
- Space constraints and site construction features,
- Traffic control,

- Ability to treat the plume effectively, and
- Discharge of the treated water on site.

A groundwater treatment system using conventional technologies to treat the contaminant levels found at the site would have taken 3 to 10 years to achieve "clean" conditions. Cooperation among FDOT, FDEP, and SFWMD was essential to accomplish a cleanup that satisfied each agency's rules and regulations. Because of the limited time frame available for remedial action to be implemented before construction, no time was available for normal regulatory review and approval, which routinely takes 12 to 18 months. Meetings were held frequently so that all agencies were informed about the selected remedial system. Key among the meetings were the brainstorming sessions held with all parties. These meetings were focused to address time constraints, parameters for technology implementation, consideration of specific technologies, and technology selection.

Technology selection considered the complex regulatory framework and FDOT's needs, addressing the following regulatory and technical issues:

- Regulatory:
  –Permitting,
  –Technology effectiveness,
  –EDI reimbursement eligibility, and
  –Monitoring requirements.
- Technical:
  –Performance,
  –Reliability,
  –Cost, and
  –Schedule.

The technologies considered at the brainstorming sessions included the following:

- Recovery:
  –Vertical wells, and
  –Horizontal drains.
- Treatment:
  –Carbon adsorption,
  –Air stripping,
  –Sparging,
  –Soil venting,
  –Soil washing,
  –Excavation/thermal treatment, and
  –Bioremediation.
- Discharge/disposal:
  –Sanitary sewer publicly owned treatment works,
  –Storm sewer,
  –On-site percolation, and
  –Deep well injection.

The remediation technologies selected for the different elements of work were as follows:

- Remedial element:
  –Groundwater recovery,
  –Groundwater treatment, and
  –Discharge.
- Selected technology:
  –Horizontal drains and deep vertical wells;
  –Clarification, filtration, and carbon adsorption; and
  –Surface infiltration.

A process layout is presented is presented in Figure 4.

Remedial Design

Groundwater Recovery

It was determined during remedial planning and subsequent groundwater modeling that a principal element of timely remediation would be to effect high rates of groundwater recovery. The desired groundwater recovery rate was determined to be about 3785 L/min (lpm) [1,000 gal/min (gpm)], with 2650 lpm (700 gpm) out of six horizontal drains and 1135 lpm (300 gpm) out of deep vertical recovery wells.

The six horizontal drains consisted of corrugated, perforated PVC pipes, 40 to 60 m (130 to 200 ft) long and 12.7 cm (5 in.) in diameter. The specific discharge capacity of these drains was estimated to be 3.4 lpm (0.90 gpm) per foot of pipe. The horizontal drains were installed typically at 4.88 to 5.49 m (16 to 18 ft) below land surface (BLS) using a pipe trencher. The trencher was configured to excavate the trench, place the pipe, and backfill the trench in a single operation. The corrugated pipe was fitted with continuous geotextile filter fabric cover to filter out fine sand particles.

Five vertical recovery wells were used (three operating at a time) to recover deeper elements of the plume of contaminated groundwater. These deep wells were 20.3 cm (8 in.) in diameter and screened from 1.53 to 10.68 m (5 to 35 ft) BLS and from 6.10 to 15.25 m (20 to 50 ft) BLS near the middle of the plume. The location of the screened interval was based on the depth of the plume being captured. The vertical wells were capable of producing 378.5 lpm (100 gpm) each.

Groundwater Treatment

A process flow diagram representative of the groundwater treatment system is shown in Figure 5. Because of the range of contaminant concentrations expected at the site and the presence of sands and fines accumulated through the horizontal drain recovery system, a system employing filtration and carbon adsorption treatment was selected and designed. The system features are described in the following sections.

Filtration The recovered groundwater was pumped from the drains or wells through a filtration system to remove suspended solids. The system consisted of a clarifier to remove the larger particles followed by bag filters to remove the fine particles (>50μm). The bag filters were numbered and sized to allow their replacement without interrupting system operation.

Carbon Adsorption The groundwater was then passed through a granular activated carbon (GAC) system. The system consisted of two parallel banks of dual 4540-kg (10,000-lb) carbon adsorbers 2.29 m (7.5 ft) in diameter operated in series. With this configuration, each parallel GAC train had a bed carbon adsorber and polishing filter. A third parallel carbon filtration system was installed that had a 6356-kg (14,000-lb) lead unit and a 4086-kg (9,000-lb) polishing cell. The empty bed contract times (EBCTs) for the two trains with 4540-kg (10,000-lb) units was 8.7-min at 1135.5 lpm (300 gpm) per cell, or a total of 17.4 min. The 6356-kg (14,000-lb) carbon column had an EBCT of 9.3 min with 1514.0 lpm (400 gpm). The 4086-kg (9,000-lb) column had an EBCT of 5.8 min. This train had a total EBCT of 15 min.

Infiltration A portion of the treated effluent was routed back over the site in designated areas to flush the vadose zone soils.

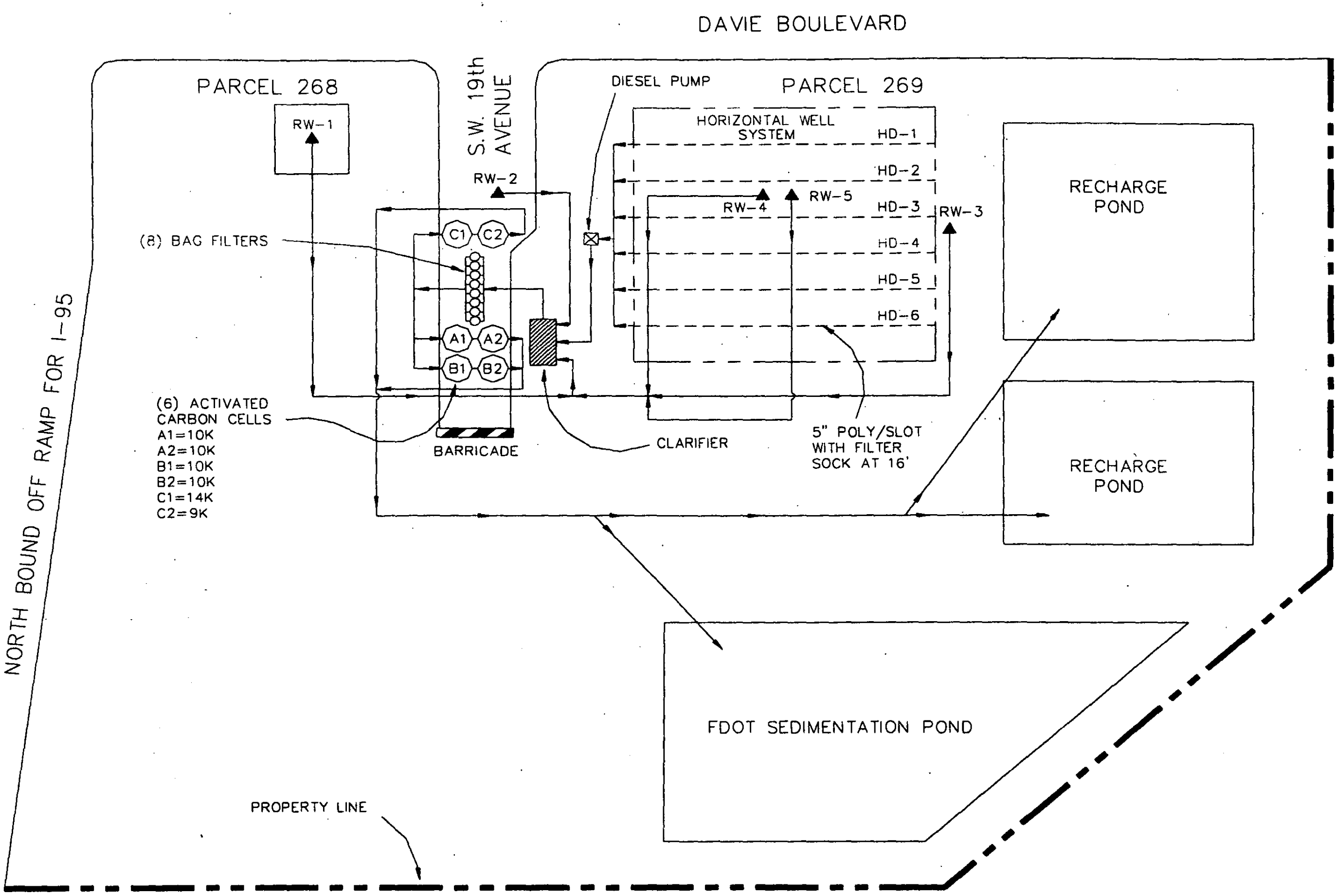

FIGURE 4 Process layout.

Treated Water Discharge

The effluent from the groundwater treatment system was discharged into three recharge ponds having a total area of 3380.55 m^2 (0.336 ha) [36,350 ft^2 (0.83 acre)]. Additionally, five horizontal perforated PVC pipes, paralleling the drain pipes, were installed above the horizontal underdrains at a depth of approximately 5 ft to discharge treated effluent.

Design provided that the ponds would be rotated in operation—that is, one pond would receive treatment system effluent while the other two rested. The discharge of treatment system effluent was theorized to aid in the remediation of overlying soils through flushing with clean water and also in groundwater capture by providing a hydraulic mounding effect to the groundwater plume. The mounding effect would exert a hydraulic pressure on the plume to move it to the horizontal drains and vertical wells to enhance capture.

REMEDIAL ACTION DESCRIPTION

Overview

Remedial action began before the RAP was approved: remediation began in December 1991, and the RAP for the site was not submitted for regulatory review until March 1992. The authority for this action was granted by FDOT, which did this at some risk to reimbursement eligibility. However, the risk was minimal because of the frequent communication and coordination with FDEP, where each step was discussed before implementation and after receiving oral agreements as the project developed.

The remediation system was operated from mid-December 1991 until mid-February 1992. With the exception of brief periods of downtime for holidays or maintenance, the system was in operation 24 hr/day, 7 days a week. Pulse or cyclic pumping was employed to enhance removal rates. Periodically, the system was shut down to reestablish the static groundwater level. This action served to flush contamination from the soil in the zone between the static and drawn-down water levels. Most maintenance activities were conducted during these shutdowns.

Site Preparation

The site required clearing, grubbing, and grading to accommodate the installation of the horizontal drains as well as other facets of the treatment system. Site preparation activities were coordinated to maintain traffic control around the site. An added benefit of this site preparation was that it could be removed from the construction contract since the site would be turned over to construction in a ready-to-build state.

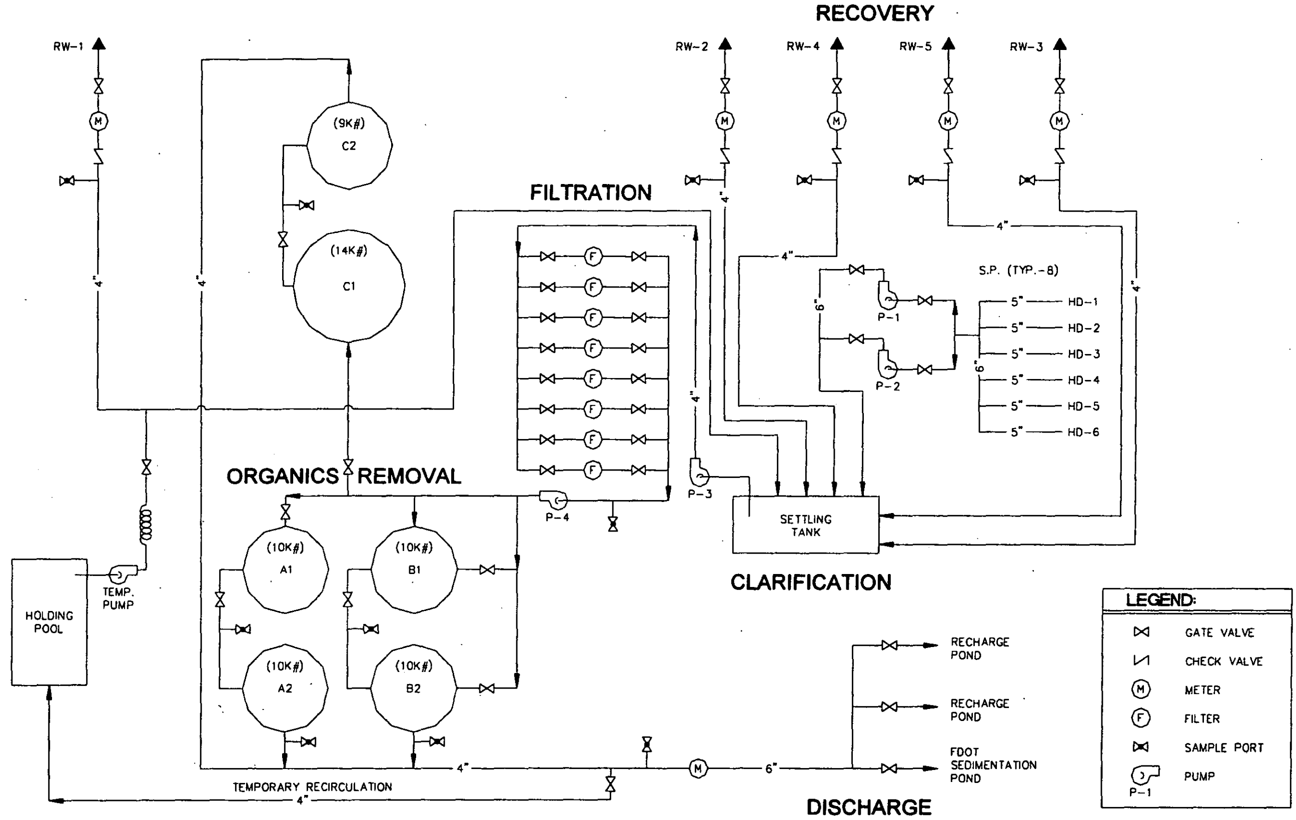

FIGURE 5 **Process flow.**

Groundwater Extraction

The groundwater extraction system consisted of deep vertical extraction wells and shallow horizontal drains. The application of horizontal drains in such a remedial action is unique in Florida and other locations with similar hydrogeologic parameters. Using horizontal drains as the primary technology for groundwater extraction at this scale is also unique.

The system generally performed as expected, recovering approximately 132 475 000 L (35,000,000 gal) from the site over 90 days. The average recovery rate at the site was approximately 3785 lpm (1,000 gpm), and the area of influence and rates of recovery were consistent with the remedial design.

Groundwater Treatment

In the early stages of treatment system operation, the bag filters repeatedly clogged with fine sand and silt particles. The filter fabric covering on the horizontal drains allowed passage of some fine particles. To limit this problem, a primary settling tank/clarifier was added to the system. Settling out the fine sands and silt resulted in a dramatic decrease in solids loading on the bag filters. This solution enabled the system to operate for longer periods without maintenance.

The treatment system, set up as designed and modified, operated efficiently. Throughout the treatment period, analytical monitoring (both on-and off-site) showed no treated effluent discharge above required regulatory discharge levels [1 part per billion (ppb) benzene and 50 ppb total volatile organic aromatics (VOAs)].

Monitoring Program

A field laboratory was established to expedite sample analysis. The laboratory included a bench-top gas chromatograph (GC) to meet the parameters established in Environmental Protection Agency Method 602 analysis inclusive of quality assurance/quality control. This unit was used at the site to analyze samples of influent and effluent and run spot checks on system performance. The sampling and analysis program was designed and implemented in compliance with quality assurance and system requirements and the brainstorming meetings with the regulatory agencies, as follows:

- One sample was collected from influent, intermediate (between the primary unit and polishing cell), and effluent every hour for the first 8 hr;
- One sample was collected from influent, intermediate, and effluent every 4 hr for the next 16 hr; and
- One sample was collected from influent, intermediate, and effluent every 8 hr thereafter.

Samples from monitoring wells and other points of interest were collected and analyzed daily to assess the conditions of the plume distribution. After periods of rainfall, elevated contaminant levels were noted in the influent and most of the monitoring wells around the center of the plume at the site. These anomalous readings were attributed to desorption of contaminants from the vadose zone soil matrix by infiltration of rainfall. When this phenomenon was discovered, it was decided that the treated effluent would be reapplied to the site by horizontal drains to flush the soil. Extreme care was taken to monitor the loading rate to ensure that the plume was not

pushed to uncontaminated areas. The GC was used to analyze real-time samples, providing the flexibility to make real-time adjustments to maximize the efficiency of the system in recovering and treating groundwater.

Treated Water Discharge

Multiple retention ponds were built to accommodate effluent from the treatment system. The surface area of these ponds was 3380.55 m^2 (36,350 ft^2). It was determined that one of the retention ponds planned as part of the roadway construction project (to be constructed after remediation by the general contractor) could be used in the remediation process. Therefore, the remedial contractor built the pond early for use during remediation and left it as a permanent feature, expediting the construction schedule.

The ponds were used to control the plume and facilitate mounding to expedite remediation. Mounding caused by infiltration through the retention ponds was established by design and served to intensify the gradient pushing the plume of petroleum-affected groundwater toward the recovery system.

The mounding effect, demonstrated through the rotating use of the three pond areas, was evaluated through the monitoring program to have the desired effect of pushing the contaminant plume to the recovery system, thus shortening the time to capture the plume using normal infiltration techniques.

Further, the monitoring program demonstrated that the soil flushing achieved through use of the horizontal drains for discharging treated groundwater within the plume of contamination was effective by eliminating the "rebound effect" experienced in most pump and treat sites.

The infiltration rates ranged from 50 to 75 percent of the removal rate—that is, when 1,000 gpm was removed, 500 to 750 gpm was discharged to the horizontal drains for soil flushing with the remaining 500 to 250 gpm discharged to the ponds for mounding effects. Treated water was never discharged off-site.

Site Restoration

Because the site would ultimately support highway-related structures [a reinforced earth embankment, 7.63 to 9.15 m (25 to 30 ft) high], the principal element of site restoration activities was the compaction of soils affected by the remedial action to state construction compaction standards. After the remedial activities, the remedial contractor backfilled the site in accordance with FDOT compaction requirements for structural fill. Compacted fill was placed atop the lateral drains, which were to remain in place following construction, and compacted backfill was placed above the rest of the collection and distribution piping associated with the treatment system.

When remedial activities were finished, all equipment was removed from the site, which was then graded to a generally level surface.

Community Relations

Because the site is so close to residential communities, several steps were taken to ensure minimal intrusion and safety for the residents; they included

- Procurement and use of ultra-quiet generators,
- Erection of protective fencing,
- Construction of sound barriers,
- Use of the city of Fort Lauderdale police force for security, and
- Observation of holidays to avoid disrupting the residents.

RESULTS

Site Rehabilitation Completion Levels

Groundwater remediation was effective at the site, removing more than 99 percent of the benzene and 95 percent of the total volatile organic aromatics (VOAs). The graphs in Figures 6 and 7 are examples of the reduction of contaminant levels over the 3-month course of the remediation.

The contaminant reduction is also demonstrated by the groundwater data presented in Table 1. Total VOA levels in all wells at the site decreased dramatically during the period of active remediation. Total VOA levels remained slightly elevated in MW-1, MW-2, and MW-13 (MW-13 was located in the center of highest original con-

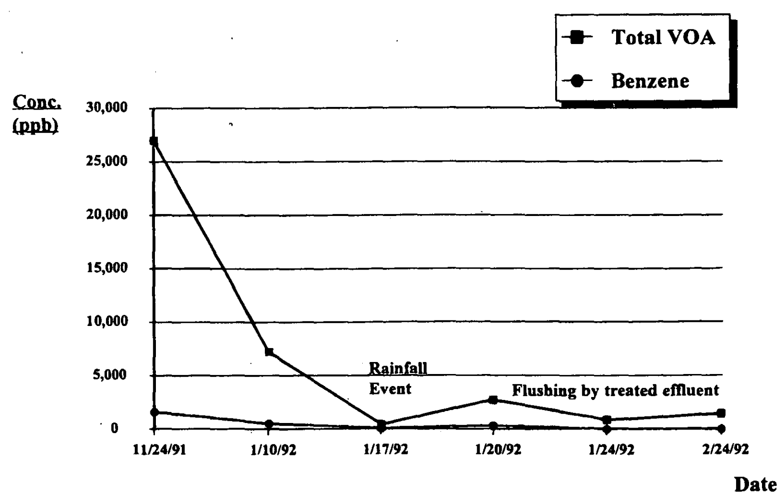

FIGURE 6 Contaminant concentrations in MW-1.

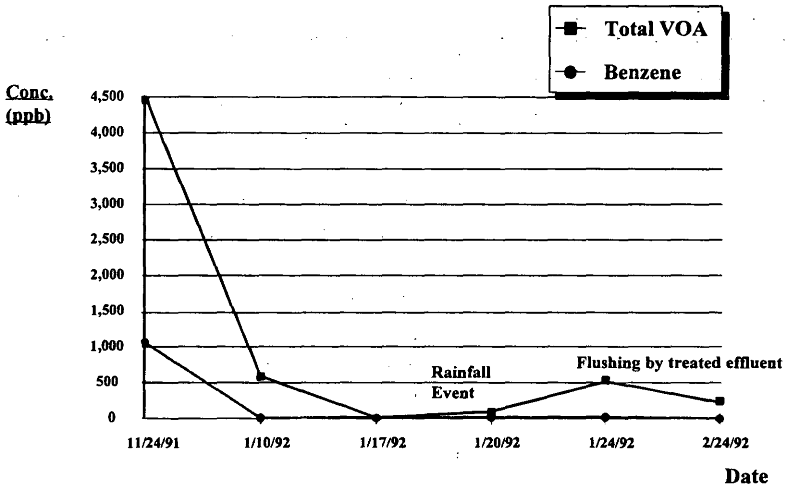

FIGURE 7 Contaminant concentrations in MW-2.

taminant concentrations). The treatment system reduced benzene concentrations from a preremediation maximum of 1,600 ppb to a postremediation maximum of 10 ppb, a reduction of 99.6 percent. Total VOAs were reduced from a preremediation maximum of 27,000 ppb to a post/remediation maximum of 1,429 ppb, a reduction of 95 percent.

In many conventional pump and treat operations, there is a rebound effect due to the interaction of the recovered water table and vadose zone soil contamination. This effect is believed to have been limited at this site by the thorough flushing of vadose zone soils during remediation with treated groundwater in areas of higher concentrations.

TABLE 1 Summary of Remedial System Performance

Well No.	Benzene (ppb)		Total VOA (ppb)	
	11/91	2/24/92	11/91	2/24/92
MW-1	1,600	<5	27,000	1,429
MW-2	1,040	<1	4,450	240
MW-3	2,700	9.3	17,500	84.2
MW-4	---*	---	---	7.1
MW-5	233	<1	484.2	7.2
MW-7	<1	<1	---	---
MW-8	---	---	---	3.2
MW-9S	72.3	10	79.1	22.5
MW-9D	5.1	<1	5.1	<50
MW-13	5	<1	510	136
MW-14	<1	<1	<50	<50
MW-17	1,800	<1	2,522	46.2
MW-18	1,700	<1	4,781	<50
MW-19	13	<1	92.8	<50
MW-20	58	<1	17.1	<50
MW-21	84	<1	35.5	<50
MW-22	330	<1	1,362	<50
MW-23	1,800	<1	6,102	<50
MW-24	430	<1	1,081	<50
Regulatory Clean-up Standards	1 ppb	1 ppb	50 ppb	50 ppb
Note: --- indicates no sample collected				

TABLE 2 Cost Comparison and Alternative Evaluation

As Performed		Alternative	
Actual Cost (1)	$750,107.52	Acquire new right-of-way (2,3) 30,000 SF @ $5/SF	$150,000.00
		Administrative Costs for Acquisition (4)	$150,000.00
		Delay to Project to accomplish acquisition 4 months (120 days) @ $25,000/day (5)	$3,000,000.00 (Maximum)
		Requirement to remediate previously purchased parcels (6)	$741,702.00
Reimbursable amount through MOU	$(750,107.52) (7)	Reimbursable amount through MOU	$(741,702.00) (7)
Total actual cost to the Department	$0.00	Total actual cost to the Department	$3,300,000.00

Footnotes:

1) From FDOT's reimbursement request submitted to FDEP.
2) Area defined as needed to accommodate retention pond.
3) Real estate pricing for nearby properties acquired by the Department.
4) Administrative costs for acquisition and re-design costs.
5) Time and delay charges due to the time required to acquire the alternative location.
6) With the alternative location, the Department would still be required to remediate the project. Average cost for petroleum contaminated sites has been $250,000 according to FDEP sources. Assumed $500,000 average cost for two sites with co-mingled plumes and then converted this cost to present worth value to allow proper comparison. Assumptions made include 12% time value of money and seven year clean-up program (estimated routine clean-up would require 3 to 10 years).
7) Actual remediation costs for both the actual performance and the alternative would be reimbursable thorough the MOU between FDOT and FDEP.

Costs and Evaluation of Alternative Solutions

Alternative solutions were limited because the project had been awarded and the general contractor had begun his purchasing, planning, fabrication, and other mobilization activities. Damages due to delays to the $83 million project were established at $25,000/day, and the use of the proposed storm water retention pond was a critical path task on the project schedule.

The two best options available to the department were to relocate the retention pond to a separate, uncontaminated area of the project and to remediate the known contaminated site in a manner so as to minimize any delay to the project. The department chose the latter as the most viable.

Table 2 includes a cost analysis that provides an evaluation of the two alternatives. The actual costs to perform the project were $750,107.52, which is expected to be reimbursed to FDOT through the Inland Protection Trust Fund as allowed under the MOU between FDOT and FDEP.

The alternative solution to relocate the pond would have required the department to acquire new right of way and provide the necessary administrative services in order to accommodate the proposed retention pond and redesign drawings to accommodate the relocated pond. Because FDOT had already acquired the original site of the retention pond, it would still be required to remediate the site; however, this cost would be reimbursable through the MOU. Table 2 provides the estimated costs for the alternative, including the estimated delay that the project would have incurred.

After comparing the two alternatives, it is evident that FDOT's expedition of the remedial action saved the taxpayers approximately $3,300,000. In addition, recognizing the time value of money and comparing the cleanup costs on present-worth value, the cost alone to expedite the cleanup is virtually equal to what the de-

partment would have spent on a routine cleanup over the assumed 7-year period. These factors show that the alternative chosen was the most cost-effective option available to the department.

Related Construction Activities

The construction of the Davie Boulevard overpass over I-95 has progressed. The former remediation site is covered with an embankment 7.63 to 9.15 m (25 to 30 ft) high, and the storm water retention pond is in use. Following completion of the remedial activities, an SRCR was presented to FDEP. The SRCR included the following key points:

- No potable supply wells were present within 0.40 km (0.25 mi) of the site.
- Biological agents and dilution factors are expected to effectively mitigate the localized areas of VOA and benzene concentrations remaining above target levels of 1 ppb for benzene and 50 ppb for VOAs.
- The proposed construction of the 7.63- to 9.15-m (25- to 30-ft) embankment and the addition of impervious surface area (travel lanes) would make the site inaccessible for further remediation.
- Linear regression analyses results were within the range of acceptable correlation, indicating that the concentrations were decreasing asymptotically.

FDOT and FDEP have agreed to implement a 1-year postremediation monitoring plan at the site. Because of current construction activities within this area, the monitoring plan has not yet been implemented.

LESSONS LEARNED

To expedite a remedial action such as that described in this case history, the following elements must be addressed:

- A method of soil flushing within the vadose zone must be implemented to minimize the rebound effect typical of most pump and treat remedial operations.
- Given an expedited construction schedule and defined budget, it is imperative that there be frequent and thorough coordination among the regulatory agencies, contracting agency or client, remedial contractor or consultants, and other participating entities. This project demonstrates that up-front planning meetings are essential to developing mutually agreeable remedial objectives and strategies.
- Because of the close and intense coordination required, each participant should have one point of contact.

Publication of this paper sponsored by Task Force on Waste Management in Transportation.