SPARTON

SPARTON TECHNOLOGY

November 5, 1992

Environmental Protection Agency
Region VI
1445 Ross Ave.
Dallas, TX 75202

Attention: Mr. Keith Phillips

Dear Mr. Phillips:

Sparton Technology, Inc. is pleased to submit our "Draft Corrective Measures Study Report" for our Coors Road facility in Albuquerque, New Mexico.

We are available to review it with you at your convenience. Please call Mr. Jan Appel at (517) 787-8600 or myself at (505) 892-5300. Mr. Pierce Chandler at (214) 960-4000 is available to answer technical questions.

Sincerely,

SPARTON TECHNOLOGY, INC.

Richard D. Mico
Vice President and General Manager

Enc.

cc: Mr. J. Appel
Mr. P. Chandler

001012

Sparton Technology, Inc. □ 4901 Rockaway Blvd., SE □ Rio Rancho, NM 87124-4469 □ (505) 892-5300 □ FAX (505) 892-5515

DRAFT
CORRECTIVE MEASURE STUDY REPORT

SPARTON
TECHNOLOGY, INC.

COORS ROAD FACILITY
ALBUQUERQUE, NEW MEXICO

NOVEMBER 1992

HDR

001011

A Report Prepared for:

Sparton Technology, Inc.
4901 Rockaway Boulevard, SE
Rio Rancho, New Mexico

DRAFT
CORRECTIVE MEASURE STUDY
Sparton Technology, Inc.
Coors Road Facility
Albuquerque, New Mexico

Prepared by HDR Engineering, Inc.
12700 Hillcrest Avenue, Suite 125
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November 6, 1992

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I INTRODUCTION

This draft report presents the results of a Corrective Measures Study (CMS) conducted as the second part of a Corrective Action Plan (CAP) for the Sparton Technology, Inc. (Sparton) facility located at 9621 Coors Road, NW, in Albuquerque, New Mexico.

This CMS is based on the results of the RCRA Facility Investigation (RFI) submitted to the U.S. Environmental Protection Agency (U.S. EPA) May 14, 1992 and subsequently approved by U.S. EPA on July 1, 1992, in correspondence received by Sparton Technology, Inc., on July 8, 1992.

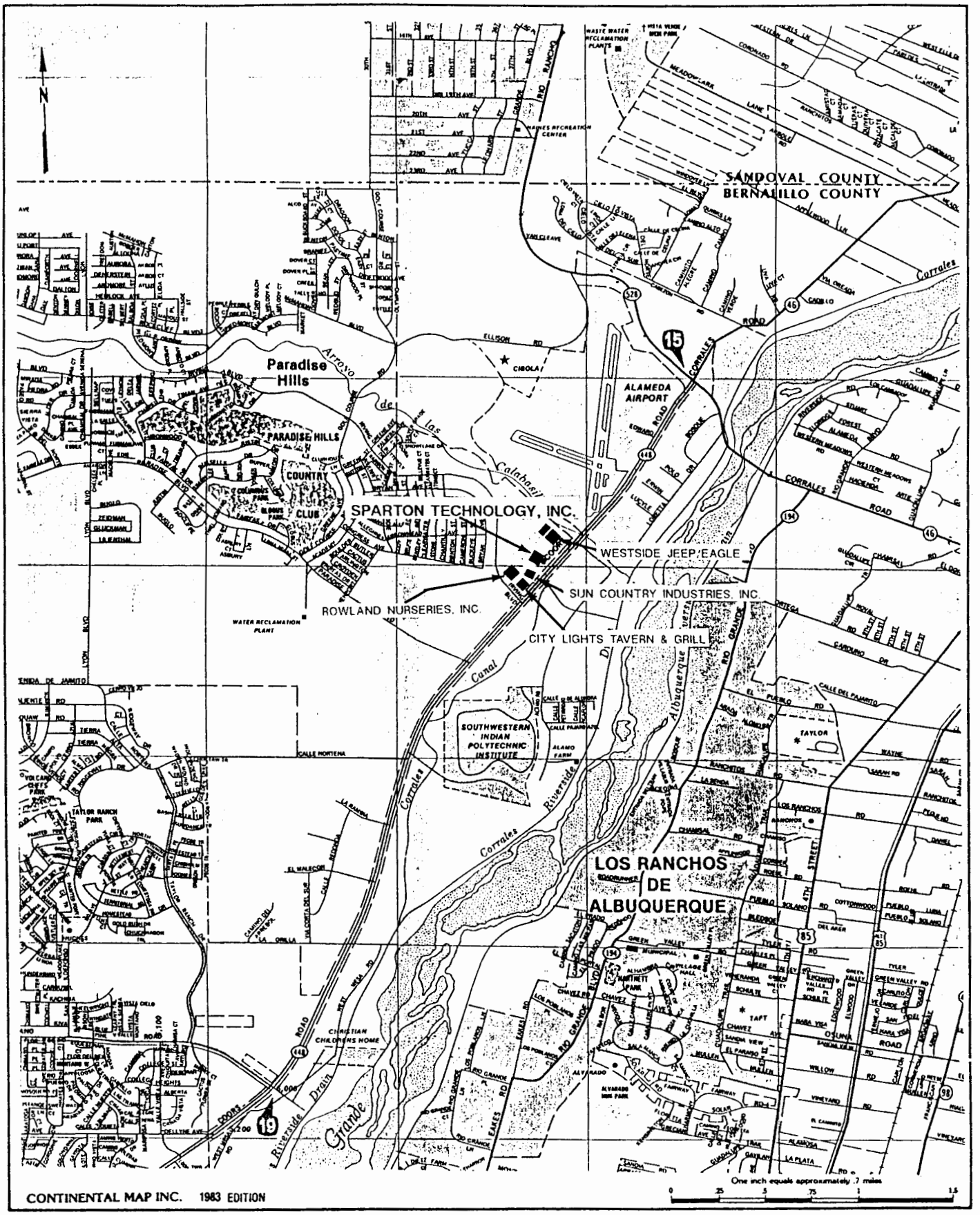
This CMS was conducted under the conditions of an Administrative Order on Consent entered into by Sparton and U.S. EPA which became effective October 1, 1988. This draft report is being submitted in accordance with the provisions of that Consent Order.

II BACKGROUND

The Sparton facility is sited on an approximate twelve-acre parcel of land located on the northwest side of Albuquerque, on State Highway 448, known locally as Coors Road, approximately 0.75 miles north of the intersection of Coors Road and Paseo del Norte (See Figure 1)(RFI Figure 1).

The Sparton facility began operation in 1961, and since that time has been engaged in the manufacture of electronic components, including printed circuit boards. The manufacturing process generates two waste streams which are managed as hazardous wastes: an aqueous metal plating waste stream and a solvent waste stream. The plating wastes were stored in an in-ground concrete basin until approximately 1975. This basin was replaced by a lined surface impoundment in 1975, termed the "West Pond". A second lined surface impoundment was installed circa 1977. This pond was termed the "East Pond". Accumulated wastewater was periodically removed from the ponds via vacuum truck for off-site disposal at a permitted facility. Figure 2 (RFI Figure 2) shows the facility layout.

After the installation of the East Pond, the West Pond was not used again until January 1981. At that time, the West Pond was refurbished by providing a new liner and by constructing concrete sidewalls for liner support. From 1981 through August 1983, use of the two ponds was alternated so that each pond could be regularly inspected. No significant liner damage was identified during any of these inspections. In August 1983,



Harding Lawson Associates
Engineering and
Environmental Services

LOCATION MAP

SPARTON TECHNOLOGY, INC.
9621 COORS ROAD NW
ALBUQUERQUE, NEW MEXICO

FIGURE **1**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
	06310,039.12	DJU	12-21-89		

001021

Sparton ceased discharging to either pond and removed the plating wastes which were in the ponds at that time. The ponds have not been used since that time. Plating wastes are currently stored in drums in an on-site "less than ninety day" storage facility prior to shipment to a permitted off-site disposal facility.

Waste solvents were accumulated in an on-site concrete sump and allowed to evaporate. Use of this sump was discontinued in 1980, at which time Sparton began to store the waste solvents in drums prior to off-site disposal at a permitted facility.

In 1983, several groundwater monitoring wells were installed around the pond and sump area to determine whether there had been a release of hazardous constituents from the ponds or the sump. Analytical results from groundwater samples taken from these wells indicated concentrations of several constituents above state standards.

Since this initial finding in 1983, investigation of the nature and extent of the contamination has continued through 1992. The wastes which were stored in the pond and sump area were typical of electronic manufacturing facilities. The waste stream stored in the ponds was an aqueous stream from the metal plating process which contained a variety of metal ions. The sump was used to store a mixture of waste solvents from process and degreasing operations. Historical analyses of the contents of either the ponds or sump are not available; however, the predominant constituents can be inferred from subsequent sampling and analysis of subsurface soils and groundwater. Based on groundwater analyses, the primary hazardous constituents appear to include trichloroethylene (TCE) and 1,1,1-trichloroethane (TCA), with lesser amounts of methylene

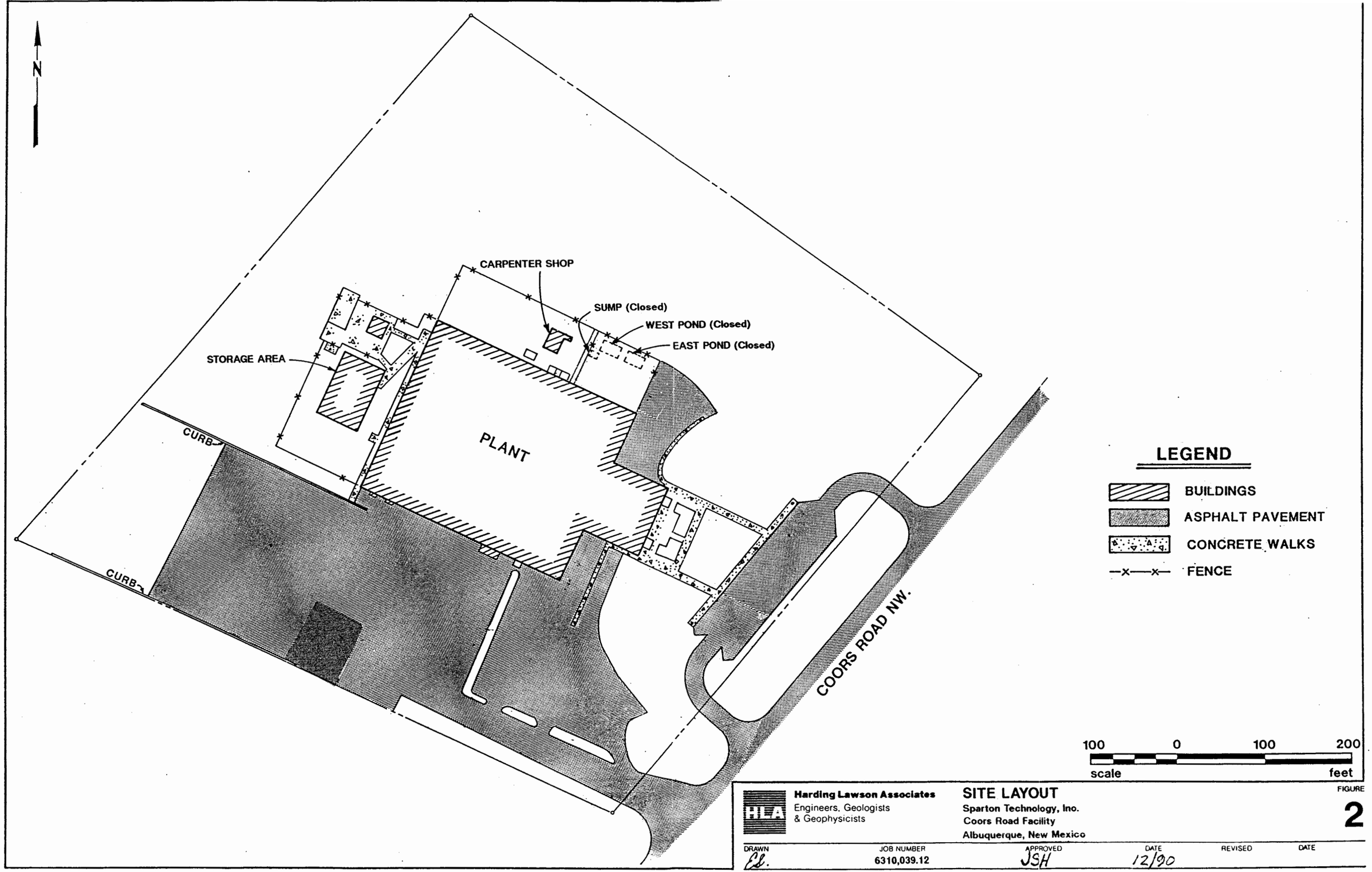
chloride (MeCl), acetone, and 1,1-dichloroethylene (DCE). Based on these analytical results from groundwater samples taken from on-site monitoring wells, it is apparent that the contaminant release originated primarily from the solvent storage sump.

Various metals have also been detected in both soil and groundwater samples. Historically, chromium has the highest frequency of occurrence at elevated concentration.

Aromatic petroleum hydrocarbon constituents including benzene, toluene, ethylbenzene, and xylene (BTEX) have been detected in a single well. The source of the BTEX constituents is unknown; however they are inconsistent with, and potentially anomalous to, the historical operation at this site and the constituent data base of all sampling and analysis conducted to date.

During the period 1983 to 1987, Sparton worked closely with the New Mexico Environmental Improvement Division (EID). Also during this period, the ponds were closed, and the entire pond and sump area was capped under a state-approved closure plan.

In 1987, when it became apparent that contaminants had migrated beyond facility boundaries, the EPA commenced negotiations with Sparton to develop an Administrative Order on Consent. This Order was signed and became effective on October 1, 1988. Under the provisions of this order, Sparton implemented an Interim Measure (IM) consisting of a groundwater recovery and treatment system in December, 1988. The purpose of the IM was to remove contaminants from the more concentrated areas of the contaminant plume in the uppermost flow zone.



Harding Lawson Associates
Engineers, Geologists & Geophysicists

SITE LAYOUT
Sparton Technology, Inc.
Coors Road Facility
Albuquerque, New Mexico

FIGURE **2**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
CL.	6310,039.12	JSH	12/90		

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Since 1983, the results of the ongoing investigation have been published in a number of reports, copies of which have been previously furnished to EPA and EID. A list of these reports is included in Figure 3. The most recent of these reports, the RFI and the Interim Measure Effectiveness, are the basis for the Corrective Measure Study (CMS).

As described earlier, the ponds were used from approximately 1961 until August 1983, at which time discharge to the ponds ceased, and the ponds were emptied. The sump was originally closed in October 1980 by removing the remaining wastes and filling the sump with sand. Final pond and sump area closure was conducted in December 1986 under a State-approved closure plan. This closure consisted of backfilling the ponds, and the construction of an asphaltic concrete cap over the entire area to divert rainfall and surface water run on, thus minimizing infiltration of surface water into the ground in this area (See Figure 4) (RFI Figure 4).

Sparton is committed to preserving environmental quality. Sparton has demonstrated its commitment at this facility by undertaking voluntary corrective actions and by working with U.S. EPA and the State of New Mexico to mitigate the effects of contaminant release. Sparton has further demonstrated its commitment by expending over $4.5 million at this facility for various corrective actions and investigative work from 1983 to the present time.

FIGURE 3

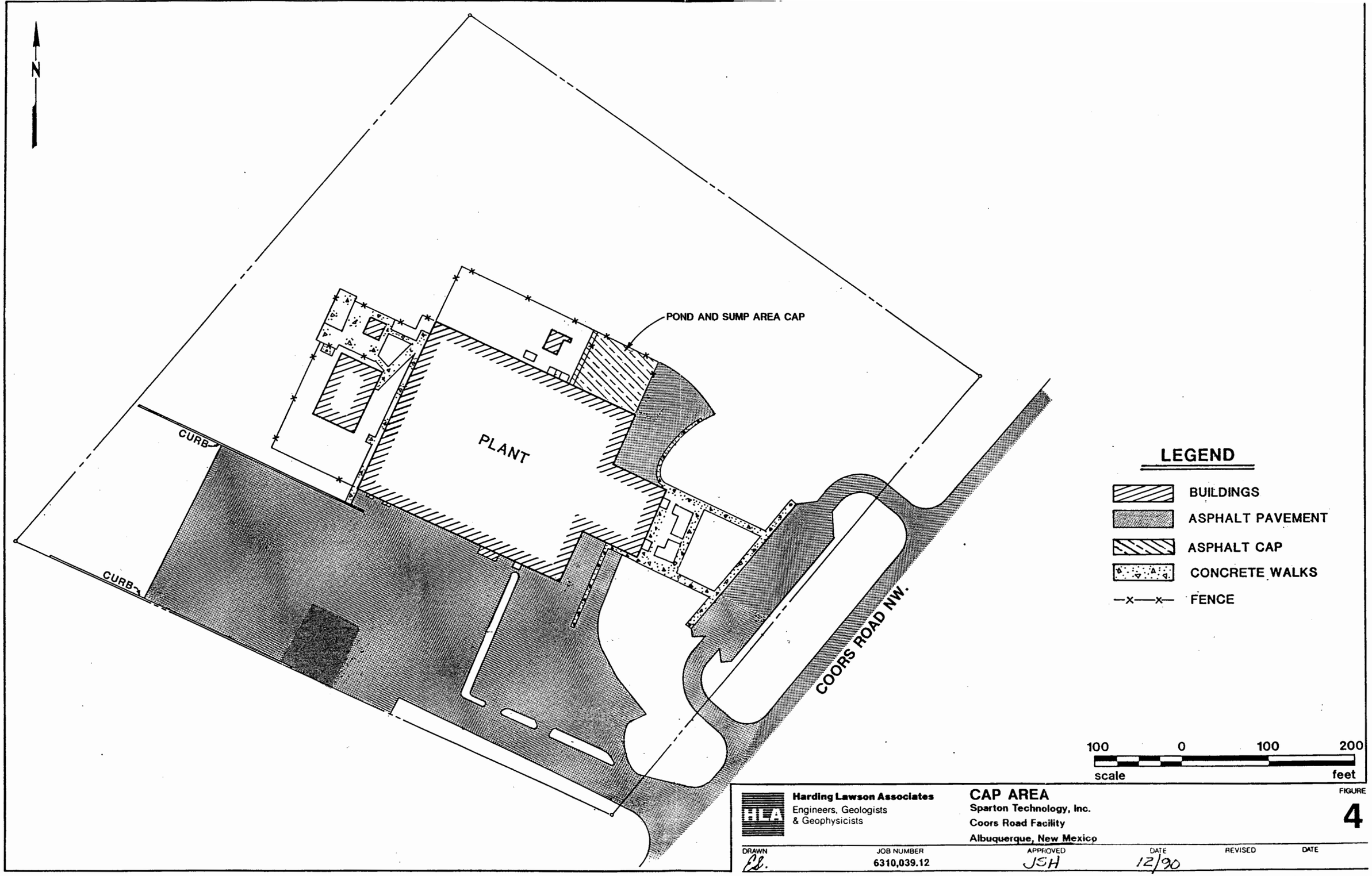
SUMMARY OF PREVIOUSLY PUBLISHED REPORTS

Date of Publication	Report Title
6/29/83	Groundwater Monitoring Program, Sparton Southwest, Inc., 9261 Coors Road, North-west, Albuquerque, New Mexico 87114; Harding Lawson Associates
3/19/84	Investigation of Soil and Groundwater Contamination, Sparton Technology, Inc., Coors Road Facility, Albuquerque, New Mexico; Harding Lawson Associates
3/13/85	Hydrogeologic Characterization and Remedial Investigation, Sparton Technology, Inc., 9621 Coors Road, Northwest, Albuquerque, New Mexico 87114; Harding Lawson Associates
6/30/86	Soil Investigation of the Unsaturated and Upper Saturated Zones, Sparton Technology, Inc., Coors Road Plant, Albuquerque, New Mexico; Harding Lawson Associates
7/15/86 (Rev. 9/22/86) (Rev. 10/3/86)	Vertical Profiling Program, Sparton Technology, Inc. Albuquerque, New Mexico; Harding Lawson Associates
4/87	Aquifer Testing, Sparton Technology, Inc., Coors Road Plant, Albuquerque, New Mexico; Metric Corporation
7/23/87	Corrective Measures Study Report, Sparton Technology, Inc., Coors Road Plant, Albuquerque, New Mexico; Harding Lawson Associates
10/19/87	Off-Site Investigation, Sparton Technology, Inc., Coors Road Plant, Albuquerque, New Mexico; Harding Lawson Associates
5/88	Aquifer Testing, Sparton Technology, Inc., Coors Road Plant, Albuquerque, New Mexico; Metric Corporation

FIGURE 3

SUMMARY OF PREVIOUSLY PUBLISHED REPORTS (Continued)

Date of Publication	Report Title
11/18/88	Aquifer Testing, Sparton Technology, Inc., Coors Road Plant, Albuquerque, New Mexico; Metric Corporation
10/26/89 (Revised 2/23/90)	Effectiveness of the Groundwater Recovery Well System, Coors Road Facility, Albuquerque, New Mexico; Harding Lawson Associates
12/27/89	Preliminary Environmental Assessment-Properties Surrounding Sparton Technology, Inc., 9621 Coors Road, N.W., Albuquerque, New Mexico; Harding Lawson Associates
7/6/90	Areal Extent of the Zones of Relatively Lower Permeability; Sparton Technology, Inc., 9621 Coors Road, N.W., Albuquerque, New Mexico; Harding Lawson Associates
12/1/91	Bench-Scale Report, Available Corrective Measures Technologies; Sparton Technology, Inc., Coors Road Facility, Albuquerque, New Mexico; HDR Engineering, Inc.
5/20/92	RCRA Facility Investigation; Sparton Technology, Inc. Coors Road Facility, Albuquerque, New Mexico; HDR Engineering Inc., in conjunction with Metric Corporation
8/1/92	Report on the Effectiveness of the Groundwater Recovery Well System in the Upper Flow Zone; Sparton Technology, Inc., Coors Road Facility, Albuquerque, New Mexico; HDR Engineering, Inc.



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CAP AREA
Sparton Technology, Inc.
Coors Road Facility
Albuquerque, New Mexico

FIGURE **4**

DRAWN	JOB NUMBER	APPROVED	DATE	REVISED	DATE
Ed.	6310,039.12	JSH	12/90		

III DESCRIPTION OF CURRENT SITUATION

A. Physiography, Geology, Hydrogeology, Climatology

1. Regional Setting

a. Physiography

The Sparton Technology facility is centrally located within the Albuquerque Basin of central New Mexico and is in the middle part of the Rio Grande Valley which extends through the length of New Mexico. The site is situated on the edge of a terrace next to the river flood plain at about elevation 5050 feet. The Rio Grande is located approximately 3000 feet east of the site at an elevation of approximately 4990 feet. Also, the Corrales Main Canal, a man-made hydraulic structure, is located approximately 300 feet east of the site and contains flowing water (Rio Grande source water) eight months out of the year. The canal is used primarily for irrigation. West of the facility, the elevation increases to about 5300 feet.

b. Geology

The Albuquerque Basin fill is estimated to be approximately 10,000 feet thick along the axis with sediment thickness varying throughout the basin boundaries. A generalized description of the sediments in the basin is presented in ascending order by age as follows:

- The Precambrian bedrock is overlain by Paleozoic and Mesozoic age sedimentary rocks which are comprised primarily of sandstones, shales, and

marine limestones. The upper section consists mainly of continental and marine shale, and of sandstone with some gypsum, coal, and conglomerate. Both Paleozoic and Mesozoic rocks outcrop east of Albuquerque in the Sandia and Manzano Mountains. Only Mesozoic age rocks outcrop to the west in the Rio Puerco Valley.

- Sedimentary rocks of the Tertiary and Quaternary age sequence unconformably overlie the rocks of pre-Tertiary age. They are generally composed of unconsolidated to loosely consolidated fluvial deposits of gravel, sand, and silt interbedded with some volcanic basalts and tuffs.

- The Galisteo Formation consists of Eocene and Oligocene(?) age beds of variegated sandstone, sand, clay, shale, minor amounts of conglomerate, tuff, and limestone.

- The Miocene-Pliocene basin fill consists of up to 10,000 feet of sandstone, mudstone, and gravel of the Santa Fe Formation or Group. Facies changes of the Santa Fe occur throughout the area and are, in some cases, divided into different units within the Santa Fe Formation. The Santa Fe Group is divided into two formations, both of which underlie the surficial deposits in the Rio Grande Valley. Before the Santa Fe was raised from formation to group status, Bryan and McCann (1937) had divided it into three members -- the Lower Gray, the Middle Red, and the Upper Buff. The units within the Santa Fe Formation were later reclassified as the Ceja Member (upper Pliocene), Middle Red Member (Pliocene), and the Zia Member (Miocene). All units are overlain by the Pleistocene age Ortiz gravel, (Kelly 1977).

c. Hydrogeology

Regional water table fluctuations occur as water is added to or withdrawn from the groundwater reservoir in the Albuquerque area. Long term water level declines may be attributed to heavy pumping from industrial and municipal wells in the Albuquerque area. Seasonal fluctuations are due to heavy precipitation and irrigation by surface water diverted from streams which tends to raise the water table. High water levels occur during the summer months in the inner valley when land is irrigated by water diverted from the Rio

Grande or where inundation by flood runoff is common. The lowest water levels in the area typically occur in the early spring before the first application of irrigation water.

d. Groundwater Flow Direction

The shape and slope of the water table throughout the valley fill, in most instances, is not uniformly planate. The irregularities in the surface occur as a result of lithologic facies changes which directly affect permeabilities and saturated thickness. This may cause mounding, coning, or troughing with the addition or withdrawal of water.

Because of groundwater extraction through municipal wells, it is estimated that the regional water table has declined forty feet in the last fifty years in this area. However, the influence that these wells have on the water table does not extend to the region around the Sparton facility. Groundwater pumping does not affect the water table in this area because large municipal and industrial wells are infrequent and widely spaced. The regional groundwater movement is generally to the southwest. The contour lines in Figure 5 (RFI Figure 9) show the configuration of the water table and the direction of movement of groundwater.

e. Groundwater Recharge

The groundwater reservoir in the Albuquerque area is recharged from many sources which include precipitation, underflow of groundwater from adjacent areas, applied irrigation water, seepage from streams, springs, seeps, drains, and canals.

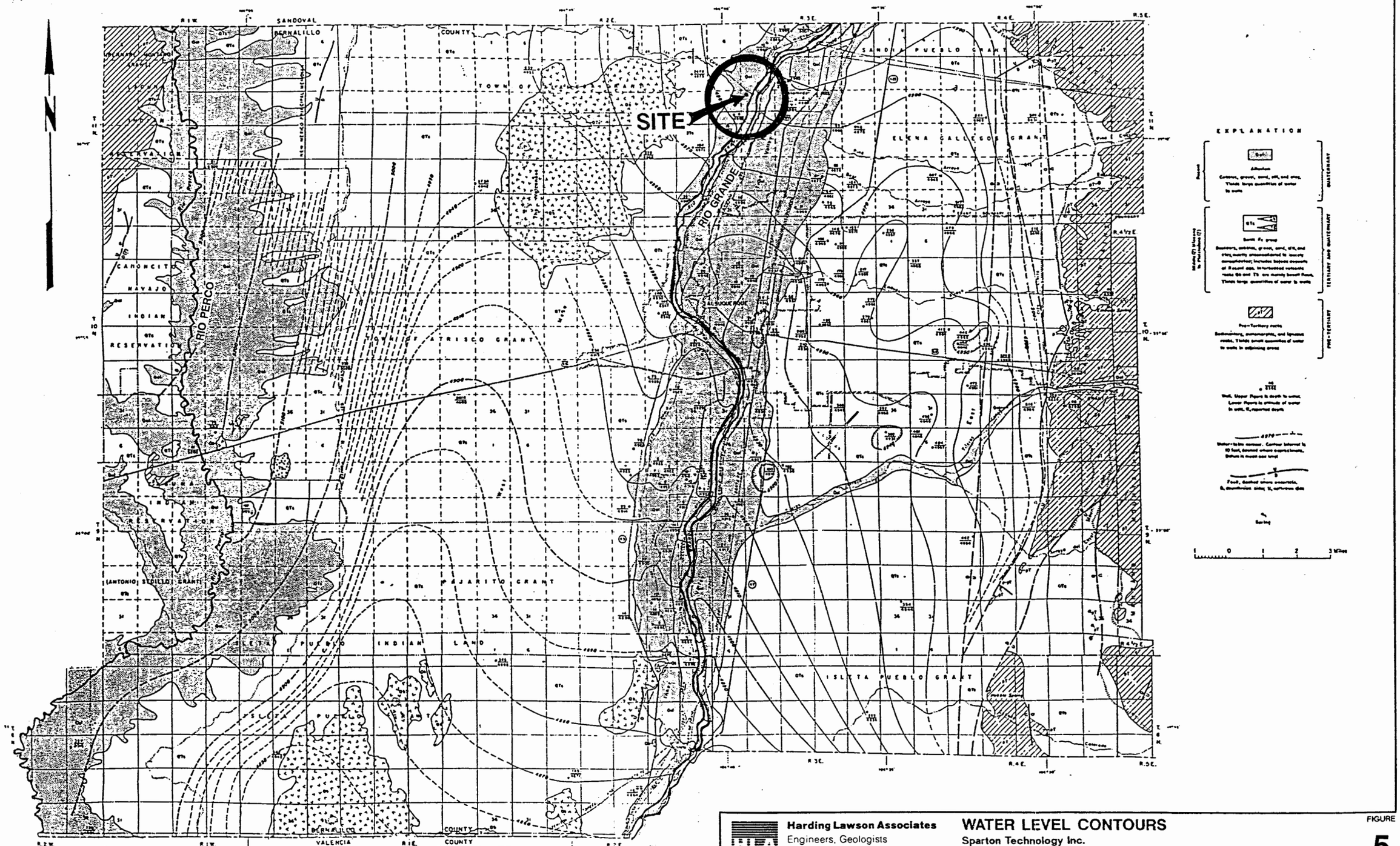

PLATE 1a

Map showing general geology and water-table contours in the southern half of the Albuquerque area, Bernalillo County, New Mexico.

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WATER LEVEL CONTOURS

Sparton Technology Inc.
Coors Road Facility
Albuquerque, New Mexico

FIGURE **5**

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	6310,039.12	JSH	7/90		

Discharge from the groundwater reservoir in the Albuquerque area occurs by means of evapotranspiration, springs and seeps, drains, water wells, and as base flow of the Rio Grande.

2. Site-Specific Conditions

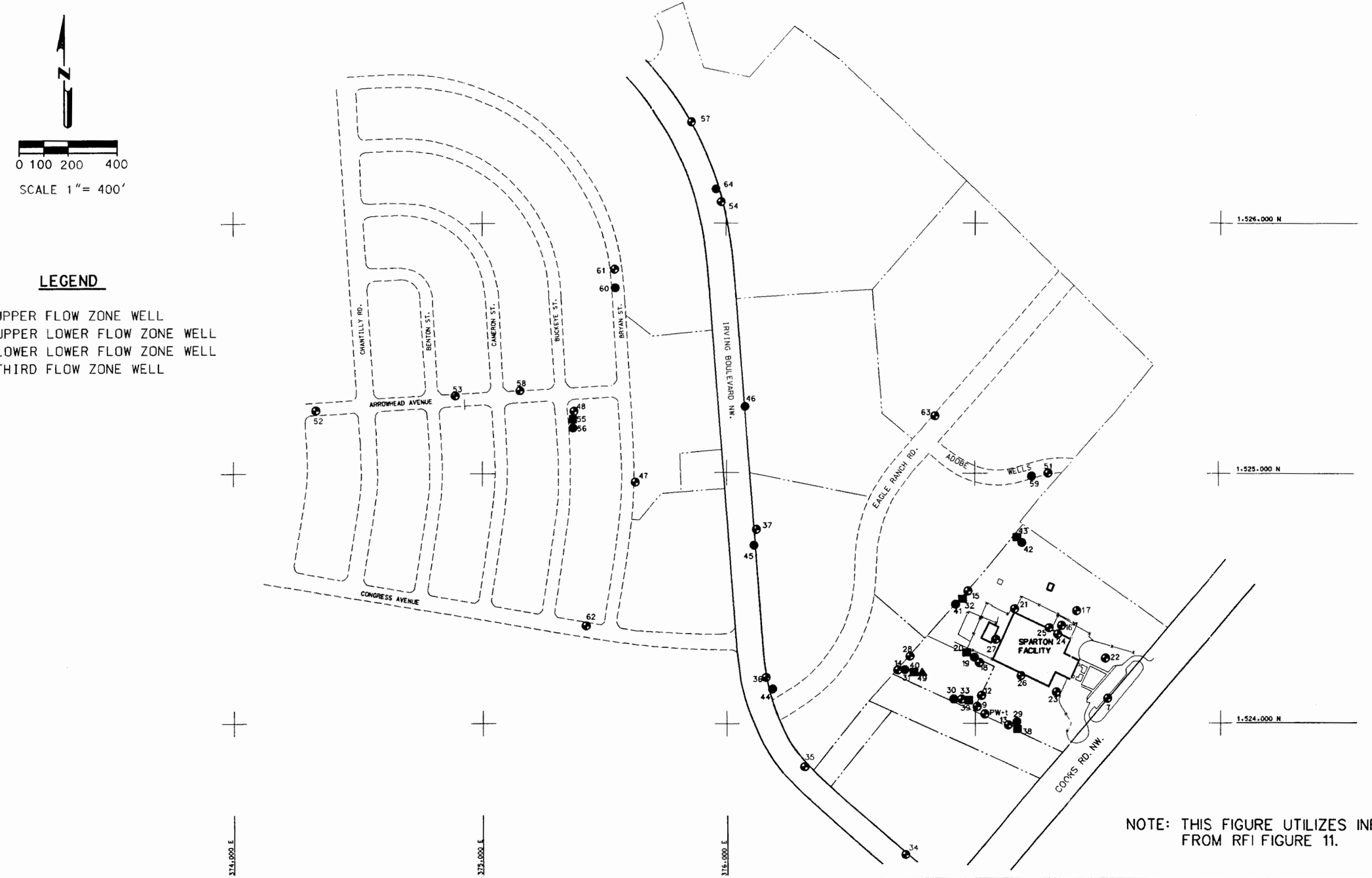
a. Geology/Hydrogeology

Several reports have been issued since 1983 describing various aspects of the site geologic and hydrogeologic regimes (See Figure 3). Copies of these reports have been previously furnished to EPA. Figure 6 (RFI Figure 11) shows the locations of all on- and off-site groundwater monitoring wells installed to date.

b. Site Stratigraphy

The Sparton RCRA facility investigation area is situated within the Albuquerque Basin, a fault trough defined by Bryan (1938) as a component of the Rio Grande depression. Several structural benches are delineated within the basin; fault scarps striking north-south face the trough.

Geologic materials of the Albuquerque Basin are Precambrian to Holocene (Recent age). The bulk of the basin fill, estimated to be as much as 10,000 feet in depth, is represented by the Santa Fe Group of Tertiary age overlain by Quaternary fill deposits. These deposits together comprise the local aquifer relevant to the Sparton facility.



NOTE: THIS FIGURE UTILIZES INFORMATION FROM RFI FIGURE 11.

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HDR Engineering, Inc.

MONITOR WELL LOCATION PLAN

SPARTON TECHNOLOGY, INC.
COORS ROAD FACILITY
ALBUQUERQUE, NEW MEXICO

Date
OCT '92

Page
FIGURE 6

Kelley (1977) characterized the Santa Fe Group as three stratigraphic members; the lower Zia Sandstone Member, the middle Red Member, and the Ceja Member (uppermost part). Monitoring wells of the RCRA facility investigation area are estimated to be completed above the top of the Ceja Member. Lambert (1968) described the upper part of the Ceja as being "dominantly yellowish to grayish sandy pebble gravel and pebbly sand with lesser amounts of interbedded clay, mud, and sand". Two major sediment types were encountered in borings at the Sparton facility. These sediment types include clays and sandy muds interbedded with gravelly sands. The gravelly sands predominate in the upper and lower flow zones. Both sediment types are found in every boring; however, correlation from boring to boring is not consistent because the depositional environment changes vertically as well as horizontally. Even at cluster well locations, where borings are in close proximity, significant lithologic variation has been observed.

Figure 7 (RFI Figure 13) provides a characterization of site specific stratigraphy by section through the project vicinity. For complete details on the description of Site Stratigraphy refer to the Final RCRA Facility Investigation Report, dated May 14, 1992.

c. Project Hydrogeology

Previous reports for this project have used three flow zones to describe site-specific hydrogeology. These flow zones were identified as the upper, lower, and third flow zones. The lower flow zone was divided into two members; the upper lower flow zone and

the lower lower flow zone. These flow zone divisions were based on stratigraphic and potentiometric differences observed on site.

Investigative work to date indicates that all of the referenced flow zones are hydraulically connected and constitute a single groundwater unit. However, due to the saturated thickness and the heterogeneous nature of this single groundwater unit, retention of the this flow zone identification is very useful for vertical location purposes and assisting in three-dimensional descriptions of the hydrogeology. For this reason and to maintain continuity with the previous reports and correspondence, the flow zone distinctions have been retained.

An evaluation of the extent of interconnection of the upper and lower flow zones was conducted in late 1989 and the results were issued in a report titled "Areal Extent of the Zones of Relatively Lower Permeability" (Figure 3). This report evaluated the presence of various fine-grained layers at the facility. These fine-grained layers, described as the "zones of relatively lower permeability" or ZORLP, generally range from clays to compacted silty sands that act somewhat like a barrier between the upper and lower flow zones. The ZORLP is thought to be the cause for the difference in potentiometric surfaces between the upper and lower flow zones observed on site. The ZORLP was not encountered off site.

The depth to groundwater varies from approximately 65 to 75 feet at the facility to approximately 200 feet in the hills to the west. On site, groundwater elevation varies as much as two to three feet as a result of recharge from irrigated fields and the

Corrales Main Canal which is located approximately 300 feet east of the facility. A potentiometric contour map illustrating the groundwater elevations and gradient for the upper flow zone during highest water levels is presented on Figure 8 (RFI Figure 25).

To the west of Irving Boulevard, hydraulic gradients are relatively flat and vary from 1:350 to 1:780 in a generally westward direction. Under the Sparton facility, gradients range from 1:50 to the southwest in the upper flow zone to 1:200 to 1:350 to the northwest in the lower flow zone.

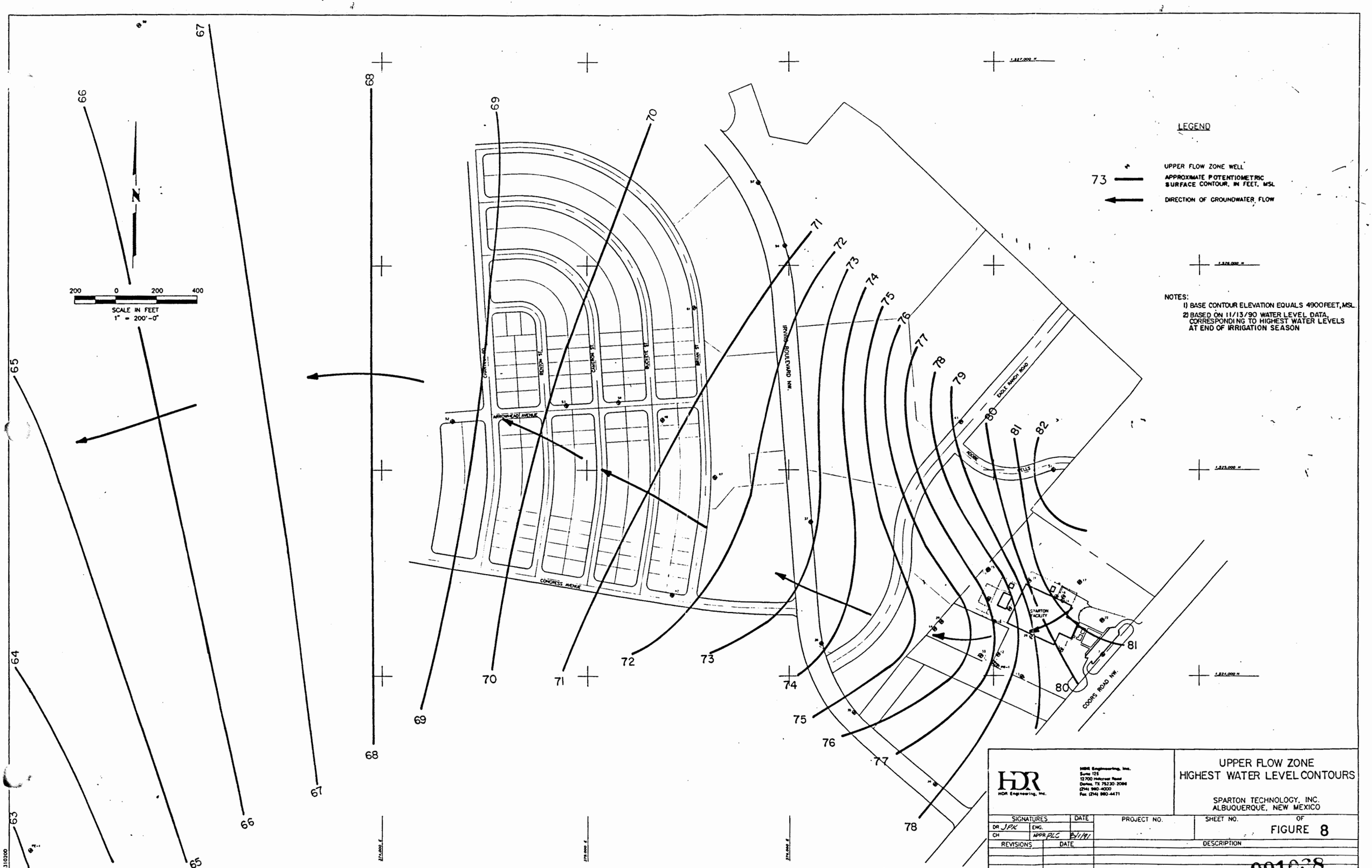
Based on the results of field work and interpretations of pumping tests and water level data, the following aquifer parameters have been calculated for the Sparton site:

Upper Flow Zone	Aquifer Parameters
T = 6-615 gpd/ft	T = 12,000-18,000 gpd/ft
K = 2.9×10^{-5}-2.9×10^{-3} cm/sec 0.6-61.5 gpd/ft^2	K = 0.0075-0.011 cm/sec 160-240 gpd/ft^2
S = 0.02	S = 0.002-0.003
N = 0.25-0.40	N = 0.25-0.40

T = Transmissivity
K = Hydraulic Conductivity
S = Storativity (dimensionless)
N = Porosity (dimensionless)

No pump test data exists for the third flow zone.

Only one well boring, MW-49, has been drilled into the third flow zone, consequently there is limited data for the third flow zone. Between the lower flow zone and the third flow zone, a stratum of clayey sand is present from a depth of 120 feet to 129


LEGEND
UPPER FLOW ZONE WELL
73
APPROXIMATE POTENTIOMETRIC SURFACE CONTOUR, IN FEET, MSL
DIRECTION OF GROUNDWATER FLOW
NOTES:
1) BASE CONTOUR ELEVATION EQUALS 4900 FEET, MSL.
2) BASED ON 11/13/90 WATER LEVEL DATA, CORRESPONDING TO HIGHEST WATER LEVELS AT END OF IRRIGATION SEASON
N
200 0 200 400
SCALE IN FEET
1" = 200'-0"
CONGRESS AVENUE
NORTHHEAD AVENUE
BOSTON ST.
CLIFTON ST.
BUCKEYE ST.
IRVING BOULEVARD NW.
EAGLE RANCH ROAD
COORS ROAD NW.
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UPPER FLOW ZONE
HIGHEST WATER LEVEL CONTOURS
SPARTON TECHNOLOGY, INC.
ALBUQUERQUE, NEW MEXICO
SIGNATURES
DATE
PROJECT NO.
SHEET NO.
OF
DR JPK
ENG.
CH
APPR PLC
8/1/91
FIGURE 8
REVISIONS
DATE
DESCRIPTION
001038

feet. Silty sands with clay lamination underlie this clayey sand layer to a depth of 138 feet. Below 138 feet are medium- to coarse-grained sands and sandy gravels to a depth of 148 feet. Monitoring well MW-49 is screened from 138 to 148 feet.

Monitoring wells MW-34, 35, 36, 37, 47, 48, 50, 51, 52, 53, 54, 57, 58, 61, 62, 63, and PZ-1 are screened in the upper flow zone. Monitoring wells MW-44, 45, 46, 56, 59, 60 and 64 are screened in the upper lower flow zone. Monitoring well MW-55 is the only off-site well screened in the lower lower flow zone (See Figure 6) (RFI Figure 11).

d. Summary of Recent Groundwater Levels and Flow Direction

Figure 8 (RFI Figure 25) is a water table contour map for the upper flow zone based upon November 13, 1990 data. This data is representative of highest groundwater conditions corresponding to the end of the irrigation (recharge) season. Maximum water levels occur to the north of the Sparton facility. Gradients are generally to the southwest across the Sparton property. Between the facility and Irving Boulevard, the gradients are generally to the west and northwest. Beyond Irving Boulevard the gradients begin a gradual arc back to the established southwestward regional gradient.

The effect of irrigation results in a two- to three-foot change in potentiometric elevation to the south of the facility. However, west of Irving Boulevard the potentiometric elevation is relatively unaffected.

No gradient direction can be determined for the third flow zone as only one well has been set in that zone.

3. Surface Waters

Surface waters in the vicinity of the Sparton facility include the Rio Grande, Las Calabacillas Arroyo, and Corrales Main Canal. The Rio Grande is located approximately 3,000 feet east of the Sparton facility. Las Calabacillas Arroyo, located approximately 1,200 feet north of the site, is an ephemeral stream. The Corrales Main Canal, a man-made hydraulic structure, is located approximately 300 feet east of the site and contains flowing water (Rio Grande source water) eight months out of the year. The canal is used primarily for irrigation.

The level of the Rio Grande through most of the Albuquerque area is controlled by levees which maintain the river level above the level of the inner valley floor and the surrounding water table. The natural buildup of sediment which raises the river level allows recharge of the water table through a downward movement. As the water table rises under the riverbed, the water spreads out to the surrounding water table. This recharge by surface waters contribute to the irregularities of the gradient and flow direction of the shallowest water table (upper flow zone).

4. Climate

Albuquerque is located in Bernalillo County. The Rio Grande flows southward through the county, which is in the central part of New Mexico. The land rises on both sides of the river and forms mesas that have elevations of about 5,500 feet. The valley and mesa areas are arid, having average annual precipitation near eight inches. Summer is the

rainy season. An average of 44 storms occur each year, mostly during this period. The average number of days having 0.10 inch or more precipitation is 22.

The average annual temperature in Albuquerque is 57°F. The temperature reaches 90°F on an average of 75 days a year, and freezing temperatures occur on an average of 105 days a year. The average frost-free season at Albuquerque is 190 days, from mid-April to late October. Average annual relative humidity in Albuquerque is 43 percent, but ranges from near 60 percent early in the morning to nearly 30 percent in the afternoon.

The average annual windspeed is 9 miles per hour. Spring is the windy season. Winds blow most frequently from the north in winter, and from the south along the river valley in summer.

B. Contamination Characterization

1. Soil Contamination

a. Vadose Zone Investigation

The results of PID field screening during the drilling program, surface soil gas screening, and analytical testing of soil samples indicate that contaminants migrated downward from the ponds and sump. The vertical migration was influenced by the relative location of fine grained silt and/or clay lenses and the presence of more porous coarse-grained sand and gravel layers. Interpretation of the results indicates both sorption and some lateral spreading occurred due to silt/clay layers. Based on available results, the

bulk of the contaminant release has completed its migration to the water table, leaving behind only scattered residual levels primarily in the vadose zone underneath the pond and sump area.

Soil gas screening indicated a general increase in soil gas concentrations of volatile organic constituents (VOC) with depth with the highest concentrations observed under the sump/pond area. Isolated occurrences of higher soil gas concentrations were also observed at depths corresponding to clay/silt lenses. These localized soil gas concentrations are believed to be related to residual VOC sorbed onto the finer-grained soil materials.

Total metals analyses were conducted to assess concentrations of cadmium, chromium, lead, and nickel. Analytical results on several samples indicated that chromium exceeded nominal background levels (2-3 milligrams per kilogram (mg/kg)). Maximum chromium concentration exceeded 3000 mg/kg underneath the sump/pond area. Evaluation of the data indicates sorption onto silts and clays is probably the dominant process affecting chromium concentration.

b. Surface Soil Gas Investigations

Three soil gas investigations have been conducted at the Sparton facility. The first soil gas investigation was conducted in 1984, and involved primarily on-site locations. The second investigation was conducted in 1987, and involved both on-site and off-site locations for soil gas measurements. The third investigation was conducted in June 1990,

and covered both on-site and off-site locations (See Figure 3).

The purpose of these investigations was to obtain an estimate of the areal extent of the contaminant plume and to examine the impact of the Interim Measure (IM) on soil gas VOC concentration. All soil gas samples were taken in the shallow subsurface, approximately five to six feet below ground surface.

Based on these soil gas surveys, it appeared that the contaminant plume had moved a short distance beyond the facility boundaries. The shape of the soil gas plumes also seem to suggest dispersion and diffusion as the predominant plume transport mechanisms with a lesser advection influence.

Based on the results of the 1987 and 1991 soil gas surveys, TCA and TCE were detected in the soil gas over approximately the same area. However, within the facility boundary, the 1991 TCE concentration dropped approximately an order of magnitude with only a single sampling point south of the building above 10 micrograms per liter (μg/l). The 1991 TCA concentration also decreased approximately thirty to fifty percent within the property boundary to a single peak level above 10 μg/l. Comparison of 1991 data to 1984 on-site data indicate over a thirtyfold decrease in TCA and a fiftyfold decrease in TCE. The soil gas results indicate a significant change in soil gas concentration due to both source removal and initiation of the upper flow zone IM in 1988.

2. Surface Water and Sediment Contamination

There are three surface water bodies in the vicinity of the Sparton facility. The Rio

Grande is located approximately 3,000 feet east of the Sparton facility, the Las Calabacillas Arroyo is located approximately 1,200 feet north of the facility and the Corrales Main Canal, an irrigation channel, is located approximately 300 feet east of the facility.

Based on regional and site-specific groundwater gradients, each of these surface water bodies is either upgradient or cross-gradient from the source area at the Sparton facility. In addition, the elevations of the water bodies are well above groundwater elevations beneath the Sparton facility and hence would not be affected by the contaminant plume.

3. Air Contamination

Soil gas concentrations measured in 1991, approximately five to six feet below ground surface, indicated average TCE and TCA soil gas concentrations of less than 10 μg/l on-site at the Sparton facility, tapering off to 0.001 μg/l approximately 1/2 mile away. The mass flux rate of these constituents into the atmosphere, while not measured, is believed to be minimal due to the low concentrations of soil gas measured during the 1991 survey.

4. Groundwater Contamination

a. Definition of Plume

A total of fifty-six groundwater monitoring wells have been installed to assess groundwater elevations and to collect representative groundwater samples for chemical

analyses in an effort to evaluate the horizontal and vertical limits of the contaminant plume. Figure 9 (RFI Figure 53) presents pertinent well screen data for the wells. TCE and TCA concentration values have been used to define the plume configuration because they represent the major constituents of the groundwater contamination. Acetone, DCE and MeCl have also been detected, but are not as prevalent as TCE and TCA. Physical and chemical data for these constituents are given in Figure 10 (RFI Figure 70).

In addition to solvents, elevated concentrations of barium, chromium, lead, and manganese have been identified. Historically, chromium has the highest frequency of occurrence of elevated concentration. The elevated chromium detections are exclusively within the boundaries of the TCE plume and restricted to the upper and upper lower flow zones.

The groundwater protection Maximum Concentration Limit of 0.05 milligrams per liter (mg/l) has been used as the Level of Significance for chromium. A comparison of results from thirty-nine wells indicates that, out of thirteen chromium detections, eight samples exhibited concentrations above 0.05 mg/l. It should be noted that analytical results are for total metals analyses and were conducted on unfiltered, acid-preserved samples obtained from stainless steel well screens. Accordingly, comparison of these total metals results to groundwater protection standards based on dissolved metals concentrations may be misleading and/or inappropriate. However, the total metals analyses do provide a conservative estimate of chromium concentration.

FIGURE 9

WELL SUMMARY

WELL NUMBER	ZONE *	MEASURING POINT ELEVATION	DEPTH TO TOP OF SCREEN (FT.)	DEPTH TO BOTTOM OF SCREEN (FT.)	ELEVATION AT TOP OF SCREEN (FT.,MSL)	ELEVATION AT BOTTOM OF SCREEN (FT.,MSL)	LENGTH OF SCREEN (FT.)
PW-1	UFZ	5044.54	60.0	70.0	4984.54	4974.54	10.0
7	UFZ	5044.80	63.5	68.5	4981.30	4976.30	5.0
9	UFZ	5044.11	62.5	67.5	4981.61	4976.61	5.0
12	UFZ	5042.58	64.0	74.0	4978.58	4968.58	10.0
13	UFZ	5043.25	60.0	70.0	4983.25	4973.25	10.0
14	UFZ	5041.91	61.5	71.5	4980.41	4970.41	10.0
15	UFZ	5047.49	60.0	70.0	4987.49	4977.49	10.0
16	UFZ	5047.50	68.0	73.0	4979.50	4974.50	5.0
17	UFZ	5049.28	67.0	72.0	4982.28	4977.28	5.0
18	UFZ	5045.58	68.0	78.0	4977.58	4967.58	10.0
19	ULFZ	5046.25	97.0	107.0	4949.25	4939.25	10.0
20	LLFZ	5045.79	125.0	138.0	4920.79	4907.79	13.0
21	UFZ	5048.36	64.5	69.5	4983.86	4978.86	5.0
22	UFZ	5048.06	72.0	77.0	4976.06	4971.06	5.0
23	UFZ	5048.51	72.0	77.0	4976.51	4971.51	5.0
24	UFZ	5048.70	68.4	73.4	4980.30	4975.30	5.0
25	UFZ	5049.00	67.7	72.7	4981.30	4976.30	5.0
26	UFZ	5045.71	73.0	78.0	4972.71	4967.71	5.0
27	UFZ	5045.50	67.0	72.0	4978.50	4973.50	5.0
28	UFZ	5042.69	65.0	70.0	4977.69	4972.69	5.0
29	ULFZ	5044.51	103.0	113.0	4941.51	4931.51	10.0
30	ULFZ	5044.70	97.0	107.0	4947.70	4937.70	10.0
31	ULFZ	5043.53	96.0	106.0	4947.53	4937.53	10.0
32	LLFZ	5048.05	108.0	118.0	4940.05	4930.05	10.0
33	UFZ	5044.29	63.0	73.0	4981.29	4971.29	10.0
34	UFZ	5034.49	56.5	66.5	4977.99	4967.99	10.0
35	UFZ	5042.50	63.2	73.2	4979.30	4969.30	10.0
36	UFZ	5059.35	82.3	92.3	4977.05	4967.05	10.0
37	UFZ	5091.66	115.0	125.0	4976.66	4966.66	10.0
38	LLFZ	5044.32	126.5	136.5	4917.82	4907.82	10.0
39	LLFZ	5044.06	123.0	133.0	4921.06	4911.06	10.0
40	LLFZ	5043.35	117.0	127.0	4926.35	4916.35	10.0
41	ULFZ	5046.77	92.0	97.0	4954.77	4949.77	5.0
42	ULFZ	5057.33	105.0	115.0	4952.33	4942.33	10.0
43	LLFZ	5057.74	127.0	137.0	4930.74	4920.74	10.0
44	ULFZ	5058.71	106.0	116.0	4952.71	4942.71	10.0
45	ULFZ	5090.11	143.0	153.0	4947.11	4937.11	10.0
46	ULFZ	5118.98	170.0	180.0	4948.98	4938.98	10.0
47	UFZ	5155.83	180.0	195.0	4975.83	4960.83	15.0
48	UFZ	5168.31	192.0	207.0	4976.31	4961.31	15.0
49	3rdFZ	5043.67	137.7	147.7	4905.97	4895.97	10.0
50	UFZ	5211.51	235.0	250.0	4976.51	4961.51	15.0
51	UFZ	5058.86	75.0	85.0	4983.86	4973.86	10.0
52	UFZ	5165.81	190.8	206.0	4975.01	4959.81	15.2
53	UFZ	5164.24	189.8	204.0	4974.44	4960.24	14.2
(**) 54	UFZ	5097.64	117.0	132.0	4980.64	4965.64	15.0
55	LLFZ	5168.61	255.0	265.0	4913.61	4903.61	10.0
56	ULFZ	5168.61	220.0	230.0	4948.61	4938.61	10.0
57	UFZ	5103.54	126.0	141.0	4977.54	4962.54	15.0
58	UFZ	5168.89	194.0	209.0	4974.89	4959.89	15.0

FIGURE 9

WELL SUMMARY

WELL NUMBER	ZONE *	MEASURING POINT ELEVATION	DEPTH TO TOP OF SCREEN (FT.)	DEPTH TO BOTTOM OF SCREEN (FT.)	ELEVATION AT TOP OF SCREEN (FT.,MSL)	ELEVATION AT BOTTOM OF SCREEN (FT.,MSL)	LENGTH OF SCREEN (FT.)
59	ULFZ	5059.18	104.5	115.0	4954.68	4944.18	10.5
60	ULFZ	5133.62	185.0	195.0	4948.62	4938.62	10.0
61	UFZ	5133.98	158.0	173.0	4975.98	4960.98	15.0
62	UFZ	5075.00	95.0	110.0	4980.00	4965.00	15.0
63	UFZ	5065.74	83.0	98.0	4982.74	4967.74	15.0
64	ULFZ	5097.84	138.8	149.0	4959.04	4948.84	10.2
PZ-1	UFZ	5144.22	182.7	198.0	4961.52	4946.22	15.3

(*) UFZ = UPPER FLOW ZONE
ULFZ = UPPER LOWER FLOW ZONE
LLFZ = LOWER LOWER FLOW ZONE
3rdFZ = THIRD FLOW ZONE

(**) WELL # 54 IS NONFUNCTIONAL

THE FOLLOWING WELLS HAVE BEEN MODIFIED OR COMPLETELY PLUGGED:

Well Number	Status
PW-1	Plugged back to upper flow zone+ - Converted to recovery well
P-1	Plugged
1	Plugged
2	Plugged
3	Plugged
4	Plugged
5	Plugged
6	Plugged
8	Plugged
10	Plugged
11	Plugged
12	Plugged back to upper flow zone+
13	Plugged back to upper flow zone+
14	Plugged back to upper flow zone+
15	Plugged back to upper flow zone+
18	Converted to recovery well
23	Converted to recovery well
24	Converted to recovery well
25	Converted to recovery well
26	Converted to recovery well
27	Converted to recovery well
28	Converted to recovery well
54	Used only for water level measurements

+ ORIGINALLY OPEN TO UFZ, ULFZ, AND LLFZ

001047

FIGURE 10

CONSTITUENT PHYSICAL AND CHEMICAL DATA

NAME	CAS #	MOLECULAR WEIGHT (g/mole)	WATER SOLUBILITY (mg/l)	VAPOR PRESSURE (mm Hg)	HENRY'S LAW CONSTANT (atm-m^3/mole)	Koc (ml/g)	SPECIFIC GRAVITY @ 20°	VAPOR DENSITY (air=1.0)	BOILING POINT (^{o}C)
Acetone (2-Propanone)	67-64-1	58	1.00E+06	2.70E+02	2.06E-05	2.2	0.7880	2.00	56.5
Benzene	71-43-2	78	1.75E+03	9.52E+01	5.59E-03	83	0.8787	2.80	80.1
1,1-Dichloroethylene (Vinylidene Chloride)	75-35-4	97	2.25E+03	600E+02	3.40E-02	65	1.2129	3.40	31.70
Dichloromethane (Methylene Chloride)	75-09-2	85	2.00E+04	3.62E+02	2.03E-03	8.8	1.3255	2.90	39.75
Ethylbenzene	100-41-4	106	1.52E+02	7.00E+00	6.43E-03	1100	0.8660	3.90	136.25
1,1,2,2-Tetrachloroethane (Tetrachloroethane)	79-34-5	168	2.90E+03	5.00E+00	3.81E-04	118	1.5866	5.80	146.5
Tetrachloroethylene (Perchloroethylene)	127-18-4	166	1.50E+02	1.78E+01	2.59E-02	364	1.6230	5.80	121.0
Toluene	108-88-3	92	5.35E+02	2.81E+01	6.37E-03	300	0.8660	3.90	110.6
1,1,1-Trichloroethane (Methyl Chloroform)	71-55-6	133	1.50E+03	1.23E+02	1.44E-02	152	1.3376	4.60	113-114
Trichloroethylene	79-01-6	131	1.10E+03	5.79E+01	9.10E-03	126	1.4649	4.53	86.7
Vinyl Chloride (Chloroethylene)	75-01-4	63	2.67E+03	2.66E+03	8.19E-02	57	0.9106	2.20	-13.4
Xylene (mixed)	1330-20-7	106	1.98E+02	1.00E+01	7.04E-03	240	0.86-0.88	3.66	137-144

001048

b. Horizontal Extent of Contamination

As indicated under site-specific hydrogeology in previous Section III A.2.c. of this report, only a single groundwater unit has been investigated beneath the site. Previous reports and correspondence subdivided this groundwater unit into flow zones--the upper, the upper lower, the lower lower, and the third flow zones. Due to the saturated thickness of the groundwater unit, this subdivision has been retained to simplify three dimensional description and to maintain continuity in reporting. Use of these zone subdivisions is a convenient method to provide horizontal planes of reference at different depths within the groundwater unit.

(1) Upper Flow Zone

TCE concentration data collected from twenty-two upper flow zone wells were contoured to illustrate the general configuration of the contaminant plume (Figure 11)(RFI Figure 55). TCE concentrations were obtained from sampling and analysis conducted during June 1991. The less than 5 μg/l isopleth or contour represents the detection limit of the perimeter of the plume. Based on this boundary, the length along the longitudinal axis of the plume is approximately 2100 feet northwest from the facility's western property line. The longitudinal axis of the plume closely parallels the implied direction of groundwater flow given on Figure 8 (RFI Figure 25). Transverse width of the plume is approximately 1400 feet.

LEGEND

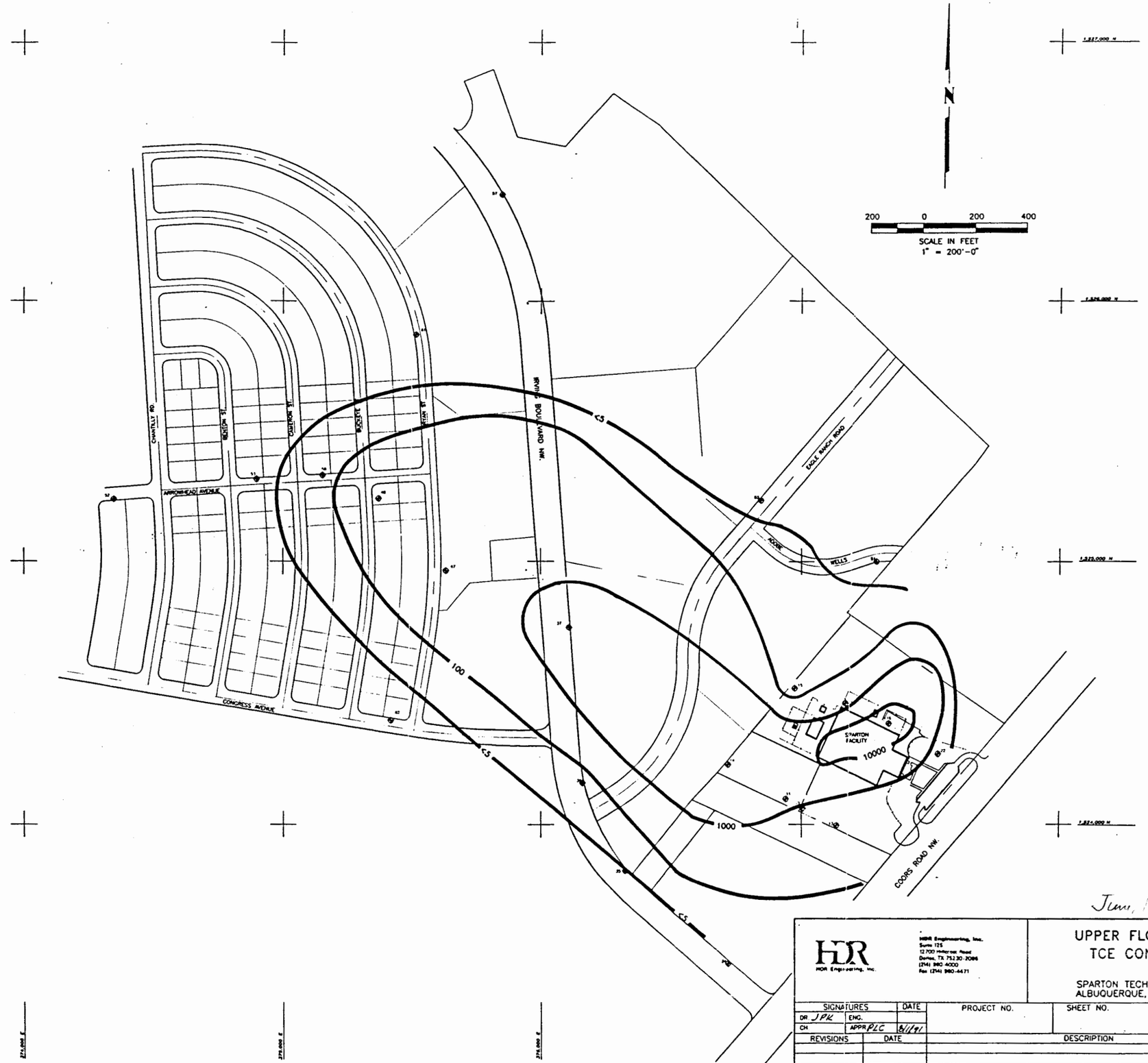
100 — TCE CONCENTRATION CONTOUR ( ) µg/l.

UPPER FLOW ZONE WELL

MONITOR WELL NUMBER	SCREEN INTERVAL (FT., MSL)	JUNE, 1991 TCE CONCENTRATION (ug/l)	PREVIOUS TCE CONCENTRATION AND SAMPLING DATE (ug/l)	DATE
9	4981.61–4976.61	1400	* 1900	3rd & 4th Quarter '90
13	4983.25–4973.25	330	* 630	FEB & MAR 1989
14	4980.41–4970.41	1100	* 2400	FEB & MAR 1989
15	4987.49–4977.49	91	* 210	FEB & MAR 1989
16	4979.5–4974.50	17000	* 17500	3rd & 4th Quarter '90
21	4983.86–4978.86	500	* 760	3rd & 4th Quarter '90
22	4976.06–4971.06	110	* 111.5	3rd & 4th Quarter '90
33	4981.29–4971.29	7300	* 7250	FEB & MAR 1989
34	4977.99–4967.99	ND < 5	* ND < 5	AUG 1989
35	4979.3–4969.30	ND < 5	* ND < 5	AUG 1989
36	4977.05–4967.05	22	* 9.45	AUG 1989
37	4976.66–4966.66	2000	* 1450	AUG 1989
47	4975.83–4960.83	120	* 275	JAN 1990
48	4976.31–4961.31	410	* 1016	AUG & SEPT 1990
51	4983.86–4973.86	ND < 5	* 6.45	APR & MAY 1990
52	4975.01–4959.81	ND < 5	* ND < 1	JUN 1990
53	4974.44–4960.24	ND < 5	ND < 1	JUN 1990
57	4977.54–4962.54	ND < 5	ND < 1	AUG 1990
58	4974.89–4959.89	29	* 22	OCT 1990
61	4975.98–4960.98	ND < 5	* ND < 5	OCT 1990
62	4980.00–4965.00	ND < 5	* 2.2	OCT 1990
63	4982.74–4967.74	ND < 5	* ND < 5	OCT 1990

* TWO-SAMPLE AVERAGE

Note: ND indicates non-detection of TCE at analytical limit indicated



June, 1991

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UPPER FLOW ZONE TCE CONTOURS

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ALBUQUERQUE, NEW MEXICO

SIGNATURES		DATE	PROJECT NO.	SHEET NO.	OF
DR JPK	ENG.			FIGURE 11	
CH	APPR PLC	6/1/91			

REVISIONS	DATE	DESCRIPTION

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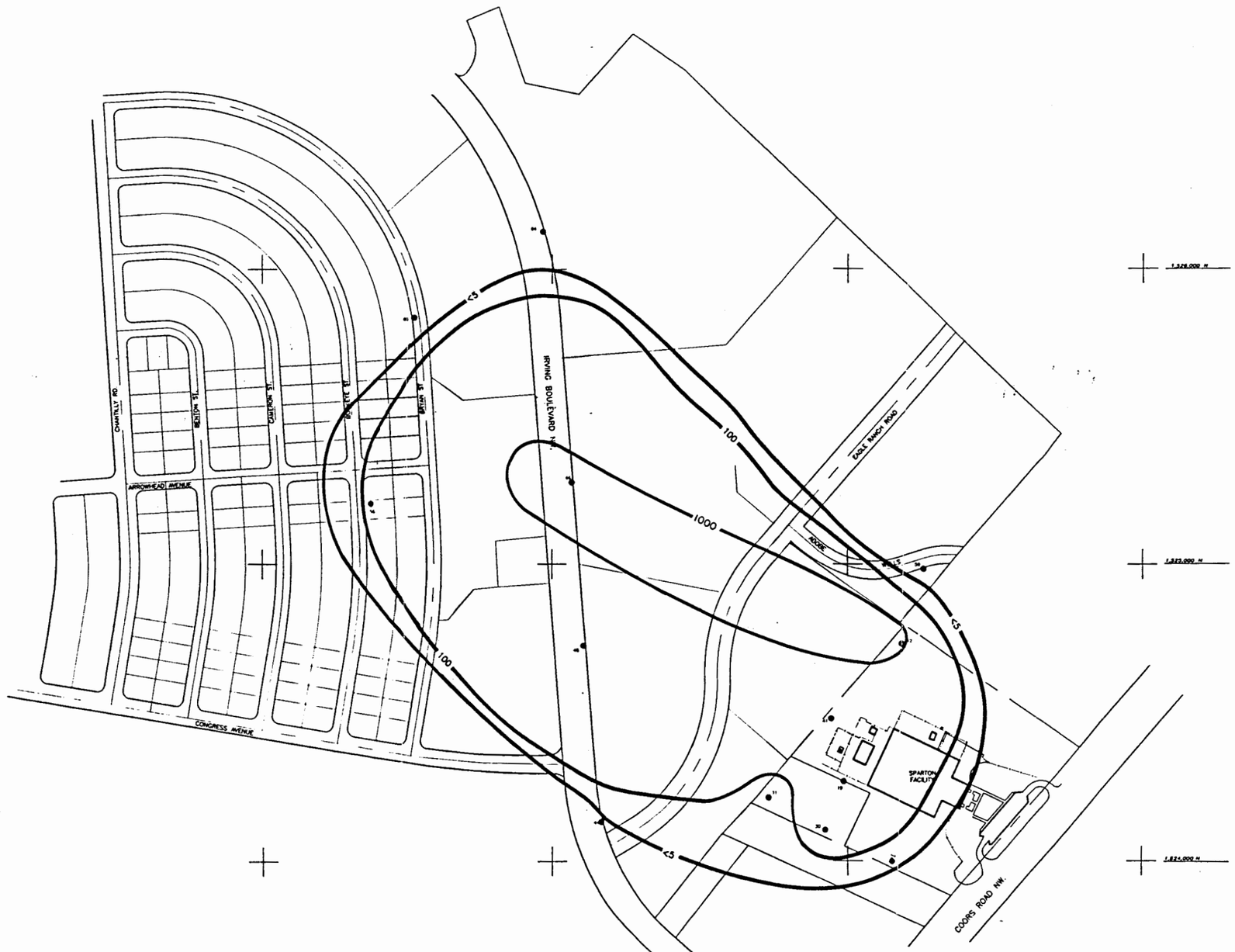
Comparison of the June 1991 data with data obtained in 1989 and 1990 indicates that the areal extent and concentrations of TCE are both decreasing. In addition, the plume migration has apparently stopped in response to source removal, on-site remediation, and various fate and transport processes.

The TCA plume has a similar alignment to the TCE plume with a slight increase in width. However, off site concentrations of TCA are generally over an order of magnitude less than the TCE plume. Comparison of the June 1991 data with previous analyses indicates little change in areal extent. However, the average concentration of TCA has dropped. The data comparison also indicates no migration of the TCA plume over the last several years.

(2) Upper Lower Flow Zone

Figure 12 (RFI Figure 57) presents the general configuration of the TCE plume based on analytical results from thirteen wells screened in the upper lower flow zone. The isopleth contours are based on June 1991 data. The length of the plume along the longitudinal axis is approximately 1900 feet northwest from the west side of the facility. The longitudinal axis of the plume parallels the implied direction of groundwater flow. Width of the plume is approximately 1400 feet. Overall, the areal coverage is similar to the upper flow zone plume.

The general configuration of the TCA plume is similar to the TCE plume; however, TCA concentrations are, on the average, over an order of magnitude less.



LEGEND

100 — TCE CONCENTRATION CONTOUR (ug/l)

•" — UPPER LOWER FLOW ZONE WELL

MONITOR WELL NUMBER	SCREEN INTERVAL (FT., MSL)	JUNE, 1991 TCE CONCENTRATION (ug/l)	PREVIOUS TCE CONCENTRATION AND SAMPLING DATE (ug/l)	DATE
19	4949.25–4939.25	570	* 720	3rd & 4th Quarter '90
29	4941.51–4931.51	ND < 5	* 5.55	FEB & MAR 1989
30	4947.7–4937.70	180	* 320	FEB & MAR 1989
31	4947.53–4937.53	60	* 120	FEB & MAR 1989
41	4954.77–4949.77	620	* 1030	NOV 1989
42	4952.33–4947.33	1000	* 1150	DEC 1989
44	4952.71–4942.71	ND < 5	* ND < 5	JAN 1990
45	4947.11–4937.11	770	* 1400	JAN 1990
46	4948.98–4938.98	1300	* 3250	JAN 1990
56	4948.61–4938.61	200	* 63.5	AUG & SEPT 1990
59	4954.68–4944.18	ND < 5	ND < 1	SEPT & OCT 1990
60	4948.62–4938.62	ND < 5	* ND < 5	OCT 1990
64	4959.04–4948.84	ND < 5	ND < 1	OCT 1990

* TWO-SAMPLE AVERAGE

Note: ND indicates non-detection of TCE at analytical limit indicated

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UPPER LOWER FLOW ZONE
TCE CONTOURS

SPARTON TECHNOLOGY, INC.
ALBUQUERQUE, NEW MEXICO

SIGNATURES		DATE	PROJECT NO.	SHEET NO. OF
DR. JPK	ENG.			FIGURE 12
CH.	APPR. PLC	8/1/91		

REVISIONS	DATE	DESCRIPTION

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Comparison with previous data indicates a reduction in TCA concentration with no detectable change in areal extent and/or location of the plume.

(3) Lower Lower Flow Zone

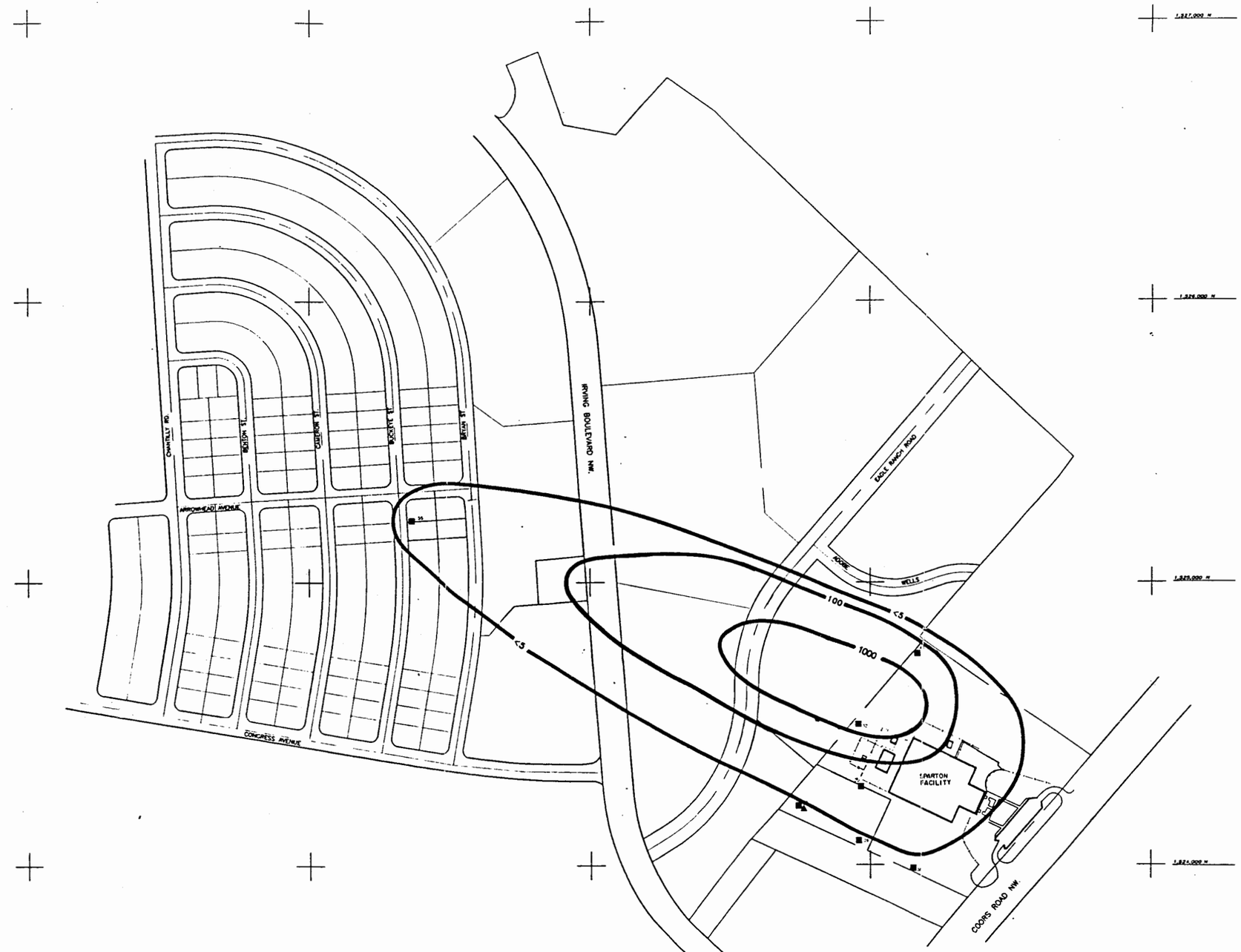
The TCE plume for the lower flow zone is shown on Figure 13 (RFI Figure 59). The TCE plume configuration is based on June 1991 concentration data obtained from 6 wells and November 1991 data for well MW-32 screened in the lower flow zone. The plume alignment parallels the implied groundwater flow direction for the lower flow zone. Off-site length is 1800 feet and width is approximately 700 feet.

Comparison of the June 1991 data with data from 1989 and 1990 indicate over an order of magnitude decrease in TCE concentration with no measurable change in areal extent or plume location.

The TCA plume has the same basic configuration and alignment as the TCE plume; however, it is much shorter and narrower than the TCE plume. The TCA concentrations are also lower. Comparison of June 1991 data with previous data indicates no significant change in either areal extent of the plume or TCA concentration.

(4) Third Flow Zone

Only a single well has been constructed in the third flow zone (Well No. 49). June 1991 analyses from this well did not detect volatile organic constituents. Previous analyses in January 1990 detected trichlorofluoromethane at



LEGEND

100 — TCE CONCENTRATION CONTOUR (ug/l)

■* LOWER LOWER FLOW ZONE

▲** THIRD FLOW ZONE

MONITOR WELL NUMBER	SCREEN INTERVAL (FT., MSL)	JUNE, 1991 TCE CONCENTRATION (ug/l)	PREVIOUS TCE CONCENTRATION AND SAMPLING DATE (ug/l)	DATE
20	4920.79–4907.79	12	* 12.5	3rd & 4th Quarter '90
** 32	4940.05–4930.05	** 57	4100	FEB & MAR 1989
38	4917.82–4907.82	ND < 5	* ND < 5	NOV 1989
39	4921.06–4911.06	ND < 5	* ND < 5	NOV 1989
40	4926.35–4916.35	ND < 5	* ND < 5	NOV 1989
43	4930.74–4920.74	280	* 215	DEC 1989
55	4913.61–4903.61	45	* 10.6	AUG 1990
49	4905.97–4995.97	ND < 5	* ND < 5	JAN 1990

* TWO-SAMPLE AVERAGE

Note: ND indicates non-detection of TCE at analytical limit indicated

** November 1991 resampling of MW-32 indicates TCE concentration is 2400 ug/l.

HDR Engineering, Inc.

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(214) 980 4000
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LOWER LOWER FLOW ZONE TCE CONTOURS

SPARTON TECHNOLOGY, INC.
ALBUQUERQUE, NEW MEXICO

SIGNATURES		DATE
DR JPK	ENG.	
CH	APPR PLC	8/1/91

PROJECT NO.

SHEET NO. OF

FIGURE 13

REVISIONS	DATE	DESCRIPTION
PLC	5/1/92	Added November 1991 data.

001054

06310100

concentrations slightly above detection limits of 5 μg/l.

c. Vertical Extent of Contamination

Vertical extent of contamination has been demonstrated using groundwater analytical results from ten well clusters. The location of the ten well clusters (five on-site and five off-site) is shown on Figure 6 (RFI Figure 11). Analytical data used to evaluate the vertical extent of contamination was obtained from the June 1991 sampling. Figure 14 (RFI Figure 63) is a key for identifying the wells, screen elevations, and flow zones monitored at each of the ten well clusters.

Of the ten well clusters, eight clusters (1, 2, 3, 4, 5, 6, 7 and 9) have detectable concentrations of TCE. Seven of these clusters show significant decreases in TCE concentration with depth. Only well cluster 4 on the west side of the Sparton property shows an increase in TCE concentration with depth. In the four cluster wells south and southwest of the facility (Clusters 1, 2, 3 and 6), TCE concentration was below detection limit (5 μg/l) in the bottom well of the cluster.

Analytical data suggests that possible horizontal channeling of TCE in the upper lower flow zone in the central area of the plume has occurred. This channeling is probably related to differential fate and transport processes associated with the gravelly lower flow zone, i.e. minimal sorption, ease of movement.

TCA concentrations in three clusters (6, 8, and 10) are below 5 μg/l detection limits. In three other clusters (3, 7 and 9), TCA is below increased detection limits resultant

FIGURE 14

WELL CLUSTER SUMMARY

Well Cluster No.	Well No.	Screened Interval Elevation, Ft (MSL)	Flow Zone
1	13	4983.35 - 4978.35	UFZ
	29	4941.57 - 4931.57	ULFZ
	38	4917.85 - 4907.85	LLFZ
2	33	4981.36 - 4971.36	UFZ
	30	4947.70 - 4937.70	ULFZ
	39	4921.07 - 4911.07	LLFZ
3	14	4980.94 - 4970.94	UFZ
	31	4947.57 - 4937.57	ULFZ
	40	4926.46 - 4916.26	LLFZ
	49	4905.88 - 4895.88	TFZ
4	15	4987.51 - 4977.51	UFZ
	41	4954.79 - 4949.79	ULFZ
	32	4940.08 - 4930.08	LLFZ
5	42	4952.28 - 4942.28	ULFZ
	43	4930.69 - 4920.69	LLFZ
6	36	4977.0 - 4967.0	UFZ
	44	4954.68 - 4944.68	ULFZ
7	37	4976.66 - 4966.66	UFZ
	45	4949.35 - 4939.35	ULFZ
8	51	4983.86 - 4973.86	UFZ
	59	4954.68 - 4944.18	ULFZ
9	48	4976.31 - 4961.31	UFZ
	56	4948.61 - 4938.61	ULFZ
	55	4913.61 - 4903.61	LLFZ
10	61	4975.98 - 4960.98	UFZ
	60	4948.62 - 4938.62	ULFZ

Note:

UFZ = UPPER FLOW ZONE
ULFZ = UPPER LOWER FLOW ZONE
LLFZ = LOWER LOWER FLOW ZONE
TFZ = THIRD FLOW ZONE

from sample dilution requirements for other constituents; however, detection limits decreased to 5 μg/l with depth. Clusters 2 and 5 show decreasing TCA concentrations with depth. Cluster 4 shows higher TCA concentration in the upper lower and lower lower flow zones.

d. Plume Movement

Based on the groundwater data collected to date, the TCE and TCA plumes appeared to have migrated at least fifty to sixty feet per year over the last twenty-five years. The plume movement is within the range of groundwater velocities reported in the HLA report titled "Off-site Investigation" (See Figure 3). However, groundwater analytical results indicate no discernible movement of the perimeter of the plume since 1989. This reduction or loss of an advective component is believed to be the result of the significant decrease in hydraulic gradient to the west of the facility, Interim Measure pump and treatment program and retardation effects including sorption, dissolution, hydrolysis, and/or biodegradation.

e. Presence of Appendix IX Constituents

The predominant Appendix IX constituents found consistently throughout the study area are TCE and TCA. DCE and MeCl were detected on a less frequent or consistent basis, but still with some regularity. Chromium was detected with some regularity within the boundaries of the TCE plume in the upper and upper lower flow zones.

Previous analysis in March 1989 and re-analysis of MW-32 (lower lower flow zone) in November 1991 indicted low levels of benzene, toluene, ethylbenzene, and xylene (BTEX). The presence of BTEX seems anomalous and isolated to this well; however, in early sampling (1983-1984) of upper flow zone wells MW-9, MW-14, and MW-16, BTEX constituents were also encountered. Occurrences of other Appendix IX constituents were random and inconsistent. A complete listing of all analytical results is provided in Attachments 3, 9, and 11 of the RFI Report dated May 14, 1992.

Due to elevated levels of TCE in many of the samples, dilution of the samples prior to analysis was necessary to lower the TCE concentration to within the limits of the analytical instrument. Because of this dilution, the detection limits for other VOC compounds included in the analytical suite were raised to levels which in most cases, exceeded either federal or state standards. All such instances occurred in wells which are inside the plume boundaries and which are therefore considered to be contaminated.

C. Previous and Continuing Corrective Action

1. Closure of Solid Waste Management Units

The facility operation produced two waste streams--an aqueous metal plating waste stream and a spent solvent waste stream. The aqueous plating wastes were stored on site in one of two adjacent lined ponds approximately nineteen feet by twenty-eight feet in surface dimension and approximately five to six feet deep. The spent solvent waste was stored in a sump approximately five feet by five feet and two feet deep. The ponds and

sump were periodically emptied by vacuum truck for off-site disposal at a permitted facility.

The solvent sump was removed from service in October 1980 and the solvent waste stream diverted to drums stored in a "less-than-ninety-day" on-site storage area. All residues in the sump were removed and the sump was then backfilled to prevent water accumulation and/or continued use.

The metal plating waste ponds were removed from service in 1983 and all waste residues were removed. The metal plating waste stream was diverted to a "less-than-ninety-day" on-site drum storage area.

2. Final Closure of Solid Waste Management Units

Final pond and sump closure was completed in December 1986 under a state-approved closure plan. Sparton had worked closely with the New Mexico Environmental Improvement Division (NMEID) since 1983 to investigate possible releases from the Solid Waste Management Units (SWMU's) and to develop a final closure plan for the SWMU's. The State-approved closure plan included removing the ponds and sump and capping the entire pond/sump area with an asphaltic concrete cap approximately seventy feet by ninety feet in areal extent to eliminate surface infiltration.

3. Interim Measure

In 1987, Sparton determined that contaminants had migrated beyond the facility boundary and commenced negotiations with U.S. EPA Region VI to develop an

Administrative Order on Consent. This Consent Order was signed and became effective on October 1, 1988. Less than three months later, in December 1988, a groundwater recovery well network was installed in the upper flow zone as an Interim Measure (IM). The purpose of the IM was to mitigate the spread of the shallow contaminant plume off-site. In order to maximize contaminant removal, the recovery well network utilized eight on-site wells located in the higher constituent concentration portions of the contaminant plume. The recovery network was designed and constructed according to the provisions of the Interim Measure Work plan approved by EPA on March 1, 1989.

The pumping network consists of eight wells installed in the upper flow zone at the site. Compressed-air-operated pumps remove groundwater from the wells. Groundwater extracted simultaneously at each well location is piped to an air stripper system for treatment and ultimate use in the Sparton facility.

Operation of the IM continues through the present date. Operation of the IM continues to reduce the source of contamination to the groundwater. Specific details and documentation of performance are contained in the draft IM Effectiveness Report (HDR, 1992). Over 2.2 million gallons of groundwater have been recovered, treated and used beneficially in the Sparton Facility. The IM treatment has reduced effluent constituent concentrations to less than one microgram per liter (μg/l) from an incoming influent concentration exceeding 1000 μg/l.

D. Potential Receptors/Exposure Pathways

1. General

Due to the absence of significant development downgradient of the Sparton Facility, the general location of the plume relative to surface features, and the static condition of the plume areal extent, there are few receptors to the contamination characterized in the RFI. Specific receptors and/or exposure pathways are described in the following paragraphs.

2. Groundwater

The nearest downgradient municipal well is approximately 2.1 miles from the leading edge of the plume. There are no plans for any additional municipal wells in the general plume area until at least the year 2000. The area is currently served by a municipal water supply. There are no identified private wells in the plume area and the absence of any significant development over the plume area probably precludes their existence. Considering the current level of development, the improbability of near-term future development, and the availability of municipal water, installation of private wells in the plume area is not anticipated in the foreseeable future. Because of the absence of wells within the immediate plume area and the static nature of the plume, groundwater is not currently an exposure pathway.

3. Surface Water

Surface water in the area includes the Rio Grande and its associated canals and drains to the east of Sparton and the ephemeral Las Calabacillas Arroyo to the northwest of Sparton. These surface water bodies are a source of recharge to the groundwater. The observed contamination is horizontally distant, and well below (downgradient of) surface water. Based on the RFI characterization, surface water does not represent an exposure pathway.

4. Residential

A residential subdivision is located downgradient of the groundwater plume as shown in Figure 15. The closest residences are approximately 800 feet horizontally from the edge of the plume. Due to the topographic rise west of the facility, residences are also at least 200 feet above the groundwater surface. Because of the relatively static condition of the plume, there is no immediate threat posed to these residences. All of these residences are served by municipal water supplies. Soil gas surveys did not detect any VOC in or near the residential area at a method detection limit (MDL) of 0.005 μg/l. The land east of this subdivision is also zoned residential; however, the lack of streets, drainage and all utilities in this area precludes immediate development in the current economic market. Residential development is therefore not considered a potential receptor.

5. Commercial/Industrial

The Sparton Facility is located within an area zoned for manufacturing. Adjacent land to the north along Coors Road is also zoned for manufacturing. To the west and south of the facility, zoning is for commercial development. Land to the east is zoned for agriculture. Continuation of current zoning is expected under future land planning. As shown in Figure 15, little development has occurred over the plume area. Existing facilities are on public water supply. In addition, surface soil gas studies indicate VOC concentrations well below permissible exposure limits in off-site areas. Current conditions indicate little potential for exposure.

E. Groundwater Protection Standards

1. Maximum Concentration Limits

Maximum concentration limits for groundwater protection have been established by EPA in 40 CRF 264.94 relative to releases from solid waste management units. These limits are shown in Figure 16 (RFI Figure 82).

2. Maximum Contaminant Levels (MCL's)

Maximum contaminant levels (MCL's) for drinking water are promulgated under the Safe Drinking Water Act and can be found in 40 CFR 141.61 and 141.62. MCL's may be considered as appropriate standards for groundwater protection if the groundwater is, or could be potentially, used for drinking consumption. Current MCL's (September 1992)

FIGURE 16

MAXIMUM CONCENTRATION OF CONSTITUENTS FOR GROUNDWATER PROTECTION	
Constituent	**Maximum Concentration mg/l**
Arsenic	0.05
Barium	1.0
Cadmium	0.01
Chromium	0.05
Lead	0.05
Mercury	0.002
Selenium	0.01
Silver	0.05
Endrin	0.0002
Lindane	0.004
Methoxychlor	0.1
Toxaphene	0.005
2,4-D	0.1
2,4,5- P Silvex	0.01

Source: 40 CFR 264.94

are given in Figure 17.

3. New Mexico Groundwater Standards

The New Mexico Water Quality Control Commission (WQCC) Human Health Standards for groundwater quality, as defined in Part 3-103 of the WQCC regulations, are shown in Figure 18 (RFI Figure 84).

4. Other Standards

For constituents not covered by regulatory protection standards, alternate concentration limits (ACL's) or action levels can be developed using constituent data obtained from the Integrated Risk Information System (IRIS) updated on a continuous basis by U. S. EPA's Office of Health and Environmental Assessment. Using the constituent data and standardized human intake assumptions, ACL's can be calculated. Constituent data is given as carcinogen slope factors (CSF's) for carcinogenic effects and as reference doses (RfD's) for systemic toxicants. For those constituents identified at this site, CSF and RfD data is included in Figure 19 (RFI Figure 85).

5. Background Concentrations

Monitor well MW-6 was located upgradient of the source area in the northern corner of the facility property. Historical analyses of groundwater samples from this well showed elevated concentrations of the principal parameters found in the Sparton plume.

FIGURE 17

SAFE DRINKING WATER ACT

MAXIMUM CONTAMINANT LEVELS

Type of Contaminant	Name of Contaminant	Maximum Contaminant Level (MCL) (mg/l, unless noted otherwise)
Inorganic Chemicals	Antimony	0.006
	Asbestos	7 MFL (million fibers per liter longer than 10 microns)
	Arsenic	0.05
	Barium	2
	Beryllium	0.004
	Cadmium	0.005
	Chromium	0.1
	Cyanide	0.2
	Fluoride	4 (secondary MCL of 2 triggers public notice)
	Mercury	0.002
	Nickel	0.1
	Nitrate (as N)	10
	Nitrite (as N)	1
	Total Nitrate/Nitrite	10
	Selenium	0.05
	Sulfate	Deferred - see comments
	Thallium	0.002
	Lead, Copper	See comments
Organic Chemicals	**Pesticides**	
	Alachlor	0.002
	Aldicarb	Deferred
	Aldicarb sulfoxide	Deferred
	Aldicarb sulfone	Deferred
	Atrazine	0.003
	Carbofuran	0.04
	Chlorodane	0.002
	Dalapon	0.2
	Dibromochloropropane (DBCP)	0.0002
	Dinoseb	0.007
	Diquat	0.02
	Endothall	0.1
	Endrin	0.002
	Ethylene dibromide (EDB)	0.00005
	Glyphosate	0.7
	Heptachlor	0.0004
	Heptachlor epoxide	0.0002
	Lindane	0.0002
	Methoxychlor	0.04
	Oxamyl (Vydate)	0.2
	Pentachlorophenol	0.001
	Picloram	0.5
	Simazine	0.004
	Toxaphene	0.003
	2, 4, 5 - TP (Silvex)	0.05
	2, 4 - D	0.07

FIGURE 17

SAFE DRINKING WATER ACT

MAXIMUM CONTAMINANT LEVELS

Continued

Type of Contaminant	Name of Contaminant	Maximum Contaminant Level (MCL) (mg/l, unless noted otherwise)
Organic Chemicals	**Volatile Organic Chemicals**	
	Benzene	0.005
	Carbon tetrachloride	0.005
	para-Dichlorobenzene	0.075
	ortho-Dichlorobenzene	0.6
	1, 2 - Dichloroethane	0.005
	1, 1 - Dichloroethylene	0.007
	cis - 1, 2 - Dichloroethylene	0.07
	trans - 1, 2 - Dichloroethylene	0.1
	Dichloromethane	0.005
	1, 2 - Dichloropropane	0.005
	Ethylbenzene	0.7
	Monochlorobenzene	0.1
	Styrene	0.1
	Tetrachloroethylene (PCE)	0.005
	Toluene	1
	1, 2, 4 - Trichlorobenzene	0.07
	1, 1, 1 - Trichloroethane (TCA)	0.20 → NM = 0.06
	1, 1, 2 - Trichloroethane	0.005
	Trichloroethylene (TCE)	0.005
	Vinyl chloride	0.002
	Xylenes	10
	Synthetic Organic Chemicals	
	Benzo (a) pyrene	0.0002
	Di (2 - ethylhexyl) adipate	0.4
	Di (2 - ethylhexyl) phthalate	0.006
	Hexachlorobenzene	0.001
	Hexachlorocyclopentadiene (HEX)	0.05
	PCBs	0.0005
	2, 3, 7, 8 Tetrachlorodibenzo - p - dioxin	3×10^{-8}

Proposed Regulations/Expected Date/Comments

Regulation of sulfate has been deferred because of its relatively low health risks, high cost of removal, and impacts mainly to transient population, according to EPA.

EPA promulgated the Lead and Copper Rule on June 7, 1991. Major points in the regulation are:

1. Action levels (ALs) measured at the tap have been set instead of MCLs. Action levels are: lead ≤ 0.015 mg/L and copper ≤ 1.3 mg/L. Both must be met in at least 90% of samples taken during either sampling period.
2. Two initial sampling periods, each six months long and to be consecutive. Sampling periods must begin by: January 1, 1992 for systems > 50,000; July 1, 1992 for systems 3,301 to 50,000; and July 1, 1993 for systems ≤ 3,300.
3. Systems > 50,000 must optimize corrosion control.
4. Systems < 50,000 not meeting action levels must provide corrosion control treatment and public education.
5. Systems not meeting action levels that are providing corrosion control treatment must initiate lead service line replacement.
6. Systems consistently meeting action levels can reduce monitoring to annually, and then to every 3 years.

FIGURE 18

NEW MEXICO GROUNDWATER STANDARDS	
Parameter	**Maximum Allowable Concentration**
Arsenic	100 μg/l
Barium	1000 μg/l
Cadmium	10 μg/l
Chromium	50 μg/l
Cyanide	200 μg/l
Fluoride	1600 μg/l
Lead	50 μg/l
Total Mercury	2 μg/l
Nitrate as N	10000 μg/l
Selenium	50 μg/l
Silver	50 μg/l
Uranium	5000 μg/l
Radioactivity: Combined Radium-226 and Radium-228	30.0 pCi/l
Benzene	10 μg/l
Polychlorinated Biphenyls	1 μg/l
Toluene	750 μg/l
Carbon Tetrachloride	10 μg/l
1,2-Dichloroethane	10 μg/l
1,1-Dichloroethylene	5 μg/l
1,1,2,2-Tetrachloroethylene	20 μg/l
1,1,2-Trichloroethylene	100 μg/l
Ethylbenzene	750 μg/l

FIGURE 18 (Continued)

NEW MEXICO GROUNDWATER STANDARDS	
Parameter	**Maximum Allowable Concentration**
Total Xylenes	620 μg/l
Methylene Chloride	100 μg/l
Chloroform	100 μg/l
1,1-Dichloroethane	25 μg/l
Ethylene Dibromide	0.1 μg/l
1,1,1-Trichloroethane (TCA)	60 μg/l
1,1,2-Trichloroethane	10 μg/l
1,1,2,2-Tetrachloroethane	10 μg/l
Vinyl Chloride	1 μg/l
PAHS: total naphthalene plus monomethylnaphthalenes	30 μg/l
Benzo-a-pyrene	0.7 μg/l
Secondary Standards	
Chloride (Cl)	250 mg/l
Copper (Cu)	1000 μg/l
Iron (Fe)	1000 μg/l
Manganese (Mn)	200 μg/l
Phenols	5 μg/l
Sulfate (SO_4)	600 mg/l
Total Dissolved Solids (TDS)	1000 mg/l
Zinc (Zn)	10 mg/l
Ph	between 6 and 9

FIGURE 18 (Continued)

NEW MEXICO GROUNDWATER STANDARDS	
Parameter	**Maximum Allowable Concentration**
Irrigation Standards	
Aluminum (Al)	5000 μg/l
Boron (B)	750 μg/l
Cobalt (Co)	50 μg/l
Molybdenum (Mo)	1000 μg/l
Nickel (Ni)	200 μg/l

Source: New Mexico Water Quality Control Commission Regulations, Part 3-103.

FIGURE 19

CONSTITUENT DATA FOR HEALTH RISK ASSESSMENT			
CONSTITUENT NAME	CLASS	ORAL REFERENCE DOSE (mg/kg/day)	ORAL CARCINOGEN SLOPE FACTOR $(mg/kg/day)^{-1}$
Acetone	D	1.0E-01	NA
1,1-Dichloroethylene DCE	C	9.0E-03	6.0E-01
Methylene Chloride Me Cl	B	6.0E-02	7.5E-03
1,1,2,2-Tetrachloroethane	C	NA	2.0E-01
Tetrachloroethylene PCE	B2	1.0E-02	5.1E-02
1,1,1-Trichloroethane TCA	D	9.0E-02	NA
Trichloroethylene TCE	B2	NA	1.1E-02
Chromium (VI)	A	5.0E-03	4.1E+01*
Benzene	A	NA	2.9E-02
Ethylbenzene	D	1.0E-01	NA
Toluene	D	3.0E-01	NA
Xylenes	D	2.0E+00	NA

BTE

* Inhalation slope factor

MW-6 (upgradient well)

The well was plugged and abandoned in early 1989 under the provisions of the Consent Order. Monitor well MW-51 was installed in April 1990. This well is located north of the Sparton facility, west of the car dealership which is adjacent to Sparton's northeastern boundary. Analyses of groundwater samples from this well show slightly elevated concentrations of TCE.

F. Purpose for Response

The contamination characterized in the RFI poses minimal threat or risk to human health and the environment. There are no significant exposure pathways or potential receptors under existing conditions. Previous corrective actions including the Interim Measures implemented on site have significantly impacted constituent concentrations and accomplished contaminant source removal. However, since groundwater contamination exceeds both New Mexico and Federal Groundwater Protection Standards, further corrective action must be evaluated.

IV ESTABLISHMENT OF CORRECTIVE ACTION OBJECTIVES

The objectives of a Corrective Action Program (CAP) are: to evaluate the nature and extent of a release of hazardous constituents to the environment; to evaluate the site characteristics of the facility and surrounding area; and to identify, develop, and implement the appropriate corrective measure(s) necessary to protect human health and the environment.

The RCRA Facility Investigation (RFI) identified the sources of the releases and characterized the nature and extent of contamination resulting from the releases. Further, the RFI identified potential receptors and assessed short- and long-term threat to these receptors. An updated review of potential receptors and exposure pathways was given in previous Section III.D. As part of the CAP, various corrective measures have already been undertaken at this facility since 1983. These measures included closure of the Solid Waste Management Units (SWMU's) responsible for the releases; capping of the closure area; and source removal through operation of an Interim Measure (IM) consisting of groundwater recovery and treatment implemented in 1988. Details of these corrective measures are given in previous Section III.C. Continuing analyses of soil gas and groundwater samples since implementation of these corrective measures indicate the contaminant plume is shrinking in areal and vertical extent.

The objective of this Corrective Measure Study (CMS) is to provide corrective action alternative(s) addressing both source control measures and restoration of groundwater

quality. The CMS objective will be achieved by identifying and developing corrective action alternatives that are protective of human health and the environment and designed within the capability of available technology to attain a significant reduction in subsurface contamination. These corrective action alternatives will be conditioned to the risk assessment, site characterization and protection standards identified in the RFI.

The corrective action alternatives will be screened and developed in a dynamic context focusing on technology(ies) capable of both source removal and reduction in groundwater contamination levels in a timely and efficient manner. This dynamic approach acknowledges the limitations of available technology in obtaining compliance with identified groundwater protection standards. However, this approach recognizes that source removal and a reduction in groundwater contamination may enable either natural degradation processes and/or future application of emerging technologies such as biorestoration and bioenhancement an opportunity to achieve groundwater protection standards.

V SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES

Corrective measure technologies (CMTs) are defined as specific processes, systems or actions that may be utilized to remediate or mitigate chemical problems. CMTs may be used singly or combined to form Corrective Measure Alternatives.

A screening of known corrective measure technologies applicable to groundwater, soil and soil gas remediation is summarized in Figure 20. General categories of corrective measure technologies include no further action, containment, disposal, in situ treatment and ex situ treatment.

The CMTs in this figure were screened according to three general criteria. The first criterion is the ability of the process option to be effective for the affected medium (site characteristics). Technologies inappropriate for groundwater have been eliminated. The second criterion is the ability of the CMT to be effective for the waste type. The third criterion is the stage of development of the CMT (i.e, whether the CMT is past bench-scale, pilot-scale, or full-scale development for the particular medium and type of chemical). CMTs can be eliminated if they are not past bench-scale development, if they have failed at pilot- or full-scale development, or if they cannot be implemented without extensive technology transfer or development.

FIGURE 20

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES							
ENVIRONMENTAL MEDIA	GENERAL RESPONSE ACTION	PROCESS OPTION	APPLICATIONS	EFFECTIVENESS/ LIMITATIONS	IMPLEMENTATION/ WASTE MANAGEMENT ISSUES	STATE OF DEVELOPMENT	RESULT OF SCREENING
GROUNDWATER	NO FURTHER ACTION	Not Applicable	Sites without and/or limited potential receptors. Exposure is limited	Effective where receptors and exposure pathways are limited. Applicable to slow-moving plumes where groundwater can be monitored. Can be impacted by change in demographics/land use.	Implementable due to moderate size of plume. No waste management issues	Not Applicable	Retained. The plume size is shrinking and concentrations are decreasing. No significant potential threat or risk.
	CONTAINMENT	Slurry Walls	Sites with relatively level grade, and shallow impermeable zones (i.e. bedrock)	Varies with chemicals and concentrations. The limitation is the deep bedrock and areal extent of plume.	Difficult to implement in areas of deep bedrock and access constraints. Contaminated slurry must be removed or treated on-site.	Conventional: readily available	Eliminated: due to deep bedrock and areal extent of plume.
		Subsurface Drains	Intercept shallow contamination in areas with low hydraulic conductivity.	Varies/applicable to depths less than 40 feet.	Easy to implement contaminated soil and water must be removed or treated on-site.	Conventional: widely accepted.	Eliminated due to depth limitations and areal extent of plume.
		Extraction Wells	Flat hydraulic gradient, moderate conductivities, immiscible contamination.	Varies, depending on the intergranular hydraulic conductivity of the aquifer/steep gradients, high conductivity, miscible contamination, limited to high concentration areas.	Easy to implement contaminated water must be removed or treated on-site.	Conventional: widely accepted. However, will not get contamination levels to MCL.	Retained for potential use with treatment option. Site hydraulic gradients and conductivities are within those required to achieve adequate effectiveness.
		Infiltration gallery	Applicable to organic and inorganic wastes after treatment	Effective in areas of highly permeable surface soils and moderately high groundwater table/infiltration depends on homogeneity of subsurface soil impermeable zones impede flow.	Implementation requires sufficient access. Permit from the State of New Mexico is required. Additional treatment needed to meet no-degradation requirement. Permit difficult to obtain.	Conventional: not widely used.	Retained per consent order.

FIGURE 20

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES							
ENVIRONMENTAL MEDIA	GENERAL RESPONSE ACTION	PROCESS OPTION	APPLICATIONS	EFFECTIVENESS/ LIMITATIONS	IMPLEMENTATION/ WASTE MANAGEMENT ISSUES	STATE OF DEVELOPMENT	RESULT OF SCREENING
GROUNDWATER cont'd	CONTAINMENT cont'd	Injection wells	Applicable to organic and inorganic wastes after treatment	Effective in high hydraulic conductivity aquifers/groundwater cannot be pumped back into the aquifer at the same rate it was extracted.	Implementation requires sufficient access. Permit from the State of New Mexico is required. Additional treatment needed to meet no-degradation requirement. Permit difficult to obtain.	Rarely used due to regional prohibitions	Retained per consent order.
	DISPOSAL	Discharge to publicly owned treatment works (POTW).	Applicable to organic and inorganic wastes after treatment and in areas where extraction wells or other methods of removing GW can be used.	Effective for low concentrations in conventional WWT process. Limitations are distance to POTW and concentrations of chemicals POTW can accept. Capacity of POTW.	Normally easy to implement; however, must meet EPA effluent criteria POTWs may restrict the amount that can be accepted.	Conventional: widely accepted	Eliminated: POTW unavailable because of capacity overloads.
		Discharge to surface water.	Applicable to organic and inorganic wastes after treatment.	Effective if NPDES discharge standards are met/requires constant monitoring.	Implementable due to close proximity of the Rio Grande. Must obtain NPDES permit and meet New Mexico Water Quality Standards.	Conventional: widely accepted	Retained for potential use with treatment options.
		Infiltration gallery	Applicable to organic and inorganic wastes after treatment	Effective in areas of highly permeable surface soils and moderately high groundwater table/infiltration depends on homogeneity of subsurface soil impermeable zones impede flow.	Implementation requires sufficient access. Permit from State of New Mexico is required. Additional treatment needed to meet no-degradation requirement. Permit difficult to obtain.	Conventional: yet not widely used.	Retained per consent order.
		Injection wells	Applicable to organic and inorganic wastes after treatment	Effective in high hydraulic conductivity aquifers/groundwater cannot be pumped back into the aquifer at the same rate it was extracted.	Implementation requires sufficient access. Permit from State of New Mexico is required. Additional treatment needed to meet no-degradation requirement. Permit difficult to obtain.	Rarely used due to regional prohibitions	Retained per consent order.

FIGURE 20

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES							
ENVIRONMENTAL MEDIA	GENERAL RESPONSE ACTION	PROCESS OPTION	APPLICATIONS	EFFECTIVENESS/ LIMITATIONS	IMPLEMENTATION/ WASTE MANAGEMENT ISSUES	STATE OF DEVELOPMENT	RESULT OF SCREENING
GROUNDWATER cont'd	DISPOSAL cont'd	Evaporation Ponds	Applicable to organic and inorganic wastes after treatment	Effective if area is large and climate suitable. Limited during certain times of the year.	Implementable. Must obtain NPDES permit and possibly air emissions permit.	Conventional, proven technology.	Eliminated: insufficient area for use, excessive water quantity for application.
	IN SITU TREATMENT	Vapor Extraction	VOC contaminated groundwater	Effective on shallow water in permeable soils.	Implemented by conventional means, off gas air emissions must be collected and treated.	Commercially available	Retained for potential use with other treatment options.
		In situ air stripping (air sparging)	Applicable to volatile organic compounds (VOCs)	95-97% removal in sandy soil less effective in clay soil/maximum depth of groundwater 140 feet.	Implementable, requires VES	Innovative technology	Retained for potential use with other treatment options.
		Bioremediation	VOC contaminants	97% reduction in contaminant concentration/will not treat metals, pesticides, and chlorinated hydrocarbons.	Difficult to implement in low permeability soils or deep aquifers/biological clogging of aquifers and/or wells may occur.	Technology is commercially available	Retained for potential use with other treatment options.
	EX SITU TREATMENT	Aerobic biological treatment	Applicable to non-halogenated organics and certain halogenated organics	98% removal/cannot be used with high concentrations of metals.	Easy to implement/remaining biosludge requires disposal.	Conventional, broadly used technology	Retained for potential use with other treatment options
		Activated sludge	Applicable to dilute non-halogenated organics	99% removal/subject to breakdowns from varying influent.	Requires major design and construction/output sludge requires further treatment.	Conventional, proven technology	Eliminated: lacks flexibility to treat varying influent. Extensive design and construction time.
		Anaerobic digestion	Aqueous wastes with low to moderate level of VOCS	Effective widely used at POTWS/will not treat inorganics and subject to breakdowns from varying influent.	Requires major design and construction/no mobile units available/sludges require further treatment.	Conventional, proven technology	Eliminated: lacks flexibility to treat varying influent. Extensive design and construction time.
		White rot fungus	Aqueous organic wastes	97% reduction on laboratory scale/will not treat inorganics	Laboratory scale only	Bench scale	Eliminated: technology is not commercially available and not proven in field applications

FIGURE 20

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES							
ENVIRONMENTAL MEDIA	GENERAL RESPONSE ACTION	PROCESS OPTION	APPLICATIONS	EFFECTIVENESS/ LIMITATIONS	IMPLEMENTATION/ WASTE MANAGEMENT ISSUES	STATE OF DEVELOPMENT	RESULT OF SCREENING
GROUNDWATER cont'd	EX SITU TREATMENT cont'd	Chemical oxidation/reduction	Aqueous wastes containing Cr, Hg, Pb	Effective for inorganics/cannot be used for organics	Conventional process/waste composition and reactions must be well known to prevent inadvertent production of a more hazardous end product	Commercially available, full scale	Eliminated: influent stream contains organics.
		Ultraviolet oxidation	Low level aqueous organics	79% reduction in contaminant concentration/will not treat inorganics	Requires clear aqueous solutions/no further treatment of residues is required	Commercially available	Retained for potential use with other treatment options.
		Chemical precipitation	Aqueous wastes containing metals	79% reduction in contaminant concentration/will not treat organics	Difficult to implement for more than one metal if pH's required to precipitate are different/sludges may be hazardous	Commercially available	Eliminated: influent stream contains organics.
		Advanced oxidation (Ozonation)	Aqueous organics	Effective on waste streams which contain less than 1.0% oxidizable compounds/will not be effective on sludges and solids	Easy to implement mobile units are available/no residues or sludges are generated	Commercially available	Retained for potential use with other treatment options.
		Carbon adsorption (GAC)	Low concentration aqueous organics	99% reduction in contaminant concentration/cannot be used if concentrations are greater than 10,000 ppm suspended solids, >50 ppm alcohols, ketones.	Easy to implement mobile units are available/carbon must be replaced or regenerated periodically	Commercially available	Retained for potential use with other treatment options. Best Demonstrated Available Technology (BDAT)
		Filtration	Suspended solids	Can reduce suspended solids to between 1 and 10 mg/l will not affect dissolved contaminants	Easy to implement/residues may be hazardous - no reduction of toxicity disposal required	Commercially available	Eliminated: suspended solids not a concern
		Steam stripping	Aqueous wastes contaminated with VOC's boiling point at 150°C	Effective for VOCs/cannot be used on VOC with BP >150°C	May be difficult to implement depending on availability of steam/air emissions	Commercially available	Eliminated: insufficient steam available. Not appropriate for current conditions.

FIGURE 20

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES							
ENVIRONMENTAL MEDIA	GENERAL RESPONSE ACTION	PROCESS OPTION	APPLICATIONS	EFFECTIVENESS/ LIMITATIONS	IMPLEMENTATION/ WASTE MANAGEMENT ISSUES	STATE OF DEVELOPMENT	RESULT OF SCREENING
GROUNDWATER cont'd	EX SITU TREATMENT cont'd	Air stripping (Packed Tower Aeration)	Aqueous VOC contaminated wastes	99.99% reduction in contaminant concentration/cannot treat metals or semi-volatiles	Conventional equipment and mobile units air emissions must be monitored	Commercially available	Retained for potential use with other treatment options BDAT
		Catalytic oxidation	Aqueous organic wastes	99.99% reduction in contaminant concentration/inorganics	May be difficult to implement due to permitting/no residues	Commercially available	Eliminated. Other BDAT's available. High costs.
		Wet air oxidation	Aqueous organic wastes	93% to 99% reduction in contaminant concentration/inorganics	Implementation is not difficult but may be costly/no residues	Commercially available	Eliminated. Other BDAT's available. High costs.
		Thermal destruction	VOC contaminated groundwater	99.99% reduction in contaminant dependent on VOC concentrations and volumes of water to be treated.	Conventional equipment and mobile units, air emissions must be monitored.	Commercially available. May be difficult to implement due to permitting/no residues.	Eliminated. High costs. Other BDAT's suitable for site.
SOIL	NO FURTHER ACTION	Not applicable	Sites without and/or limited potential receptors. Exposure is limited.	Effective where receptors and exposure pathways are limited.	Implementable. No waste management issues.	Not applicable	Retained. Soil concentrations confined to site. No immediate threat to any potential receptors.
	IN SITU TREATMENT	Bioremediation	Organics	Effectiveness waries with chemical contaminant, concentration, and soil type. Will not treat metals.	Implemented by conventional means/biological clogging may occur	Commercially available	Retained for potential use with other treatment options.
		Vapor extraction	VOC contaminated soils	99.9% reduction in contaminant concentration/cannot be used on sludges, liquids, and in dense clays.	Implemented by conventional means/off gas air emissions must be collected	Commercially available	Retained for potential use with other treatment options BDAT
		Air injection	VOC contaminated soils	99.9% reduction in contaminant concentration/not effective in soils containing clay layers. Must be used with VES.	Implemented by conventional means/off gas air emissions must be collected	Commercially available	Retained for potential use with other treatment options
		Soil flusing	Organic and inorganic contaminated soils	79% to 99% reduction in contaminant concentration/will not be effective in heavy clays.	Implemented by conventional means/effluent must be treated	Pilot scale/emerging field scale	Retained for potential use.

FIGURE 20

SCREENING OF CORRECTIVE MEASURE TECHNOLOGIES							
ENVIRONMENTAL MEDIA	GENERAL RESPONSE ACTION	PROCESS OPTION	APPLICATIONS	EFFECTIVENESS/ LIMITATIONS	IMPLEMENTATION/ WASTE MANAGEMENT ISSUES	STATE OF DEVELOPMENT	RESULT OF SCREENING
SOIL GAS	NO FURTHER ACTION	Not applicable	Sites without and/or limited potential receptors. Exposure is limited.	Effective where receptors and exposure pathways are limited.	Implementable. No waste management issues.	Not applicable	Retained. Soil gas concentrations low and areal extent limited to on site.
	IN SITU TREATMENT	Soil flushing	Organic and inorganic contaminated soils	79% to 99% reduction in contaminant concentration/will not be effective in heavy clays	Implemented by conventional means/effluent must be treated	Pilot scale/emerging field scale	Retained for potential use.
		Vapor Extraction	VOC contaminated soil gas	99.99% reduction in contaminant. Concentration will not be as effective in heavy clay	Implemented by conventional means/effluent must be treated.	Commerically available	Retained for potential use

VI IDENTIFICATION OF THE CORRECTIVE MEASURE ALTERNATIVE OR ALTERNATIVES

A. General

Each corrective measure technology is identified by its applicability to the containment or remediation of three phases of the contaminants, which include the (i) dissolved groundwater phase (saturated zone), (ii) soil sorbed phase (unsaturated zone), and (iii) soil gas vapor phase (unsaturated zone). TCE and TCA in the free product or non-aqueous phase in the saturated zone (if any) or the soil pore water dissolved phase (unsaturated zone) can be remediated as part of the three phases described above. A combination of several methods, or treatment train, should be evaluated to address the successful remediation of the specified contaminants.

B. Retained Alternatives

Based upon the results of the screening, the alternatives that should attain the corrective action objectives for this site are summarized below. Each of these retained alternatives is discussed in greater detail in Section VII.

Groundwater Phase (Saturated Zone)

- No Further Action.
- Continuation of Interim Measure Corrective Action
- Expansion of Interim Measure

- Infiltration gallery or injection wells to contain plume (per consent order).
- Large-scale groundwater extraction combined with either air stripping, granular activated carbon, advanced oxidation, or aerobic bioreactors to treat the groundwater (pump and treat system).
- Vapor extraction to remove soil gas and eventually VOC from groundwater through phase equilibrium.
- In situ bioremediation to treat the groundwater in place.

Soil Sorbed Phase (Unsaturated Zone)

- No Further Action.
- Soil flushing to remove contaminants adhered to soil particles.
- In situ bioremediation to treat the soil in place.
- Vapor extraction to remove soil gas and eventually VOC from soil through phase equilibrium.

Soil Gas Vapor Phase (Unsaturated Zone)

- No Further Action.
- Vapor extraction to remove soil gas for treatment.

C. Non-Retained Alternatives

The alternatives that were judged as not being suitable for the Sparton facility are described in the following paragraphs:

1. Slurry Wall

This alternative was not retained because it is a containment technology. The objective of the corrective measure study is to provide groundwater remediation. Since the contaminant plume is shrinking in areal extent, containment would not be appropriate. Furthermore, the lack of an impervious strata to tie a slurry wall into, the overall extent of the contaminant plume off the Sparton site, and the possible creation of contaminated slurry wall material render this option non-feasible.

2. Subsurface Drains

This alternative was not retained because it is a containment technology. Groundwater and bedrock are too deep for economic installation and the areal extent of the plume is too large. Furthermore, this technology is not appropriate for groundwater restoration at the Sparton facility.

3. Discharge to POTW

This alternative is not appropriate because the quantity and rate at which groundwater would be removed is too large for the capacity of the publicly owned

treatment works (POTWs) in the vicinity. Adding POTW capacity is very expensive and time consuming relative to the remediation of groundwater from the Sparton site.

4. Activated Sludge

This technology is used to dilute non-halogenated organics and make them inert. This technology requires extensive design and construction time that will increase costs substantially, making it less cost effective than other best demonstrated available technologies (BDAT). Furthermore, this process creates another medium to have to treat or dispose which further increases costs. This alternative was not retained because it is not appropriate methodology for treatment of halogenated VOC, such as TCE and TCA, present at this site.

5. Anaerobic Digestion

This technology utilizes anaerobic microorganisms to reduce halogenated compounds into compounds that are generally less toxic and less likely to bioaccumulate. The reducing process consists of removing halogen from the halogenated compound through electron exchanges between the halogenated compound and the microorganisms. Once the reduction process is completed, the compound can undergo further reductions and transformations by aerobic microorganisms.

This alternative was not retained because it involves extensive design and portable units are not available to make this a feasible methodology. In addition, this process may

break down the constituents and form vinyl chloride (VC) which is a toxic compound. Additional treatment of VC will be required which would increase costs.

6. White Rot Fungus

This alternative was not retained because it has only been used in laboratory testing and has not been proven in field applications. There is uncertainty in the reliability of this technology on a large scale.

7. Chemical Oxidation/Reduction

This technology involves changing the chemical form of a hazardous material in order to create a less toxic compound for handling or disposal purposes. The oxidation process involves the transformation of organics to various compounds such as carbon dioxide and water. The function of chemical oxidation is to change the chemical form of the molecular structure for the purposes of detoxification. Chemical reduction essentially converts inorganics to less toxic forms so additional treatment processes can be applied.

This alternative was not retained because this technology will not work on organic waste streams that contain VOC such as TCE and TCA. In addition, chemical reactions may be explosive and must be monitored carefully to avoid creating a more hazardous by-product.

8. Chemical Precipitation

This technology involves chemically precipitating metals from the soluble state by adjusting the pH of the waste stream. Metals are typically precipitated from the aqueous stream in the form of hydroxides, sulfides, carbonates, or other soluble salts.

This technology was not retained because metals are not the focus of the corrective action and there would be no effect on the organics in the groundwater.

9. Filtration

This technology removes suspended solids by passing an aqueous waste stream through a particulate filter. This technology was not selected because suspended solids are not a concern at the Sparton facility.

10. Steam Stripping

This technology involves the injection of steam into the selected medium for the purpose of volatilizing VOC and various non-soluble constituents. For soil, the steam is injected directly into the subsurface soils through selective well locations and then the volatilized constituents are removed from the subsurface by vacuum extraction wells. For aqueous waste streams the process is similar; however, the application of the steam is conducted in a controlled environment (i.e., pressure chamber). The volatilized constituents are then thermally destroyed or vaporized.

This alternative was not retained because a steam source is not readily available

at the site and there are better BDATs for the Sparton Facility. This technology is also not effective on VOC with boiling points greater than 150°C. TCA and TCE both have boiling points greater than 150°C.

11. Catalytic Oxidation

This technology involves destruction of contaminants by oxidizing the constituents in the presence of a catalyst in order to detoxify the compound. The process involves removing electrons from the constituent (oxidizing) to alter the molecular structure of the constituent.

This alternative was not retained because permitting is difficult and costs can be excessive pending energy requirements.

12. Wet Air Oxidation

This technology involves generally the same principals as catalytic oxidation except the process uses air with high moisture content to effectively oxidize the contaminants into less toxic compounds.

This alternative was not retained because costs can be excessive and this technology has not been used widely enough to evaluate its effectiveness.

13. Thermal Destruction

This technology essentially destroys contaminants by direct application of intense heat. Thermal destruction is an oxidative process which is used for detoxification and sterilization, volume reduction, energy recovery, and by-product chemical recovery. The thermal destruction process can be used to destroy organics in liquids, solids/sludges, soils and gases. For liquids, several types of thermal destruction methods such as liquid injection furnaces, plasma arc units, and rotary kilns can be used to effectively treat liquids containing organic compounds. For solids, methods such as rotary kiln, fluidized bed, circulating bed, and infrared are typically used for treatment.

This alternative was not retained because residuals are produced such as ash and solids that will require additional treatment before disposal. Furthermore, this process generates off-gas emissions which would require treatment before releasing them to the atmosphere. This technology can be very costly pending energy requirements.

VII EVALUATION OF THE CORRECTIVE MEASURE ALTERNATIVE OR ALTERNATIVES

A. General

As specified under Task VIII of Exhibit I, Corrective Action Plan (CAP), of the Order, each corrective measure alternative passing through the Initial Screening identified under Task VII has been evaluated using specific criteria. The evaluation of each alternative considered for potential implementation has been evaluated based on 1) technical, 2) environmental, 3) human health, and 4) institutional concerns. In addition, cost estimates for each corrective measure alternative have been prepared. Specific evaluation procedures are discussed in the following paragraphs.

1. Technical Evaluation Criteria

Each retained technology or corrective measure technology has been evaluated relative to a set of technical criteria. Technical evaluation criteria included: effectiveness, useful life, reliability and implementability. Application of these criteria to the evaluation process is outlined in this section.

- Effectiveness has been evaluated with respect to accomplishing source control and/or restoration of groundwater quality and with respect to specific application to conditions characterized at the Sparton facility. Any specific waste or site characteristics which could reduce effectiveness of a given technology have also been considered.

- Useful life has been evaluated with respect to the ability of a given technology to be successfully operated for a sufficient length of time necessary to achieve the CMS objectives.
- Evaluation of reliability has been based on previous demonstrated performance under similar conditions to those found at the Sparton facility. Particular emphasis has been placed on operation and maintenance costs as evidence of reliability. Evaluation of the retained alternatives and appropriate treatment trains has determined if failure of any one technology has an immediate effect on potential receptors and whether the technology has the flexibility to deal with uncontrollable changes at the site.
- Implementability has been evaluated relative to the ease with which a given technology can be installed and operated. This evaluation included how well a given alternative matches site characteristics, existing facility operation, institutional requirements, and time requirements. Time requirements included both time for implementation and time required to achieve beneficial results.

In addition to evaluating individual technologies or alternatives under these criteria, combinations of technologies or treatment trains have also been evaluated. The synergism resulting from combining technologies into a treatment train may result in higher evaluation relative to these technical criteria.

2. Environmental Evaluation Criteria

Each retained technology or alternative has been evaluated in terms of environmental risk and/or threat resulting from construction and operation. This includes short- and long-term beneficial and adverse effects on the environment from application of the technology. The ability to reduce existing risk in a timely, efficient manner has also been evaluated. The potential of a given technology to transfer or create additional problems, such as creating a residual waste, have also been examined. The evaluation has also considered whether any adverse effects created by the technology can be successfully mitigated.

3. Human Health Criteria

Each retained corrective measure alternative has been evaluated relative to minimizing potential adverse effects on human health, both short- and long-term, and to mitigating potential exposure. Potential exposure pathways and level of exposure resulting from construction and operation of a given technology have also been evaluated.

4. Institutional Criteria

Each retained technology has been evaluated with respect to institutional concerns including: esthetics; community acceptance; and compliance with city, county, state, and federal requirements. Included in this evaluation criteria is the number and types of permits required for implementation of a given technology and the time and difficulty associated

with obtaining the necessary permits.

B. Containment of the Dissolved Groundwater Phase (Saturated Zone)

1. No Further Action

Under the No Further Action (NFA) alternative, the current correction action (IM) would be discontinued and no additional treatment technology would be implemented at the site. The NFA alternative has been retained because the RFI identified no significant risk or threat to human health or the environment. Existing land use and probable future development of this area minimize both potential receptors and exposure pathways with respect to the contamination characterization for the Sparton Facility. In addition, the RFI indicated the groundwater contaminant plume is shrinking in areal and vertical extent and is experiencing a significant reduction in concentration at almost all sampling locations.

Under the NFA alternative, quarterly monitoring of selected wells would continue. The results of the continued monitoring and changes in land use/development would be annually evaluated to determine the need, if any, for other corrective measures.

Costs on an annual basis for quarterly monitoring of approximately twenty wells and providing an annual report is as follows:

Sampling	$22,500
VOC Analyses	40,000
Evaluation, Annual Report	15,000
	$77,500 annually

2. Infiltration Gallery/Injection Wells

This alternative has been retained for consideration as required under provisions of the Consent Order (Exhibit I, CAP Scope of Work, Task VII.D.).

In many instances, the function of injection wells and infiltration galleries during a groundwater remedial program are as follows:

- Dispose groundwater after treatment.
- Utilize them as injection devices for nutrients to operate a bioremediation system.
- Force a contaminant plume toward a recovery point to facilitate groundwater restoration.

However, in most cases the primary function or purpose of injection wells and infiltration galleries is to provide containment for a contaminant groundwater plume while other processes are used to provide groundwater restoration. The proper use of injection wells and infiltration galleries is to install them just beyond the downgradient edge of a plume.

Under the current set of geologic/hydrogeologic conditions at the Sparton facility, infiltration galleries and injection wells are not considered appropriate corrective measure alternatives to accomplish the corrective action objectives. However, in order to comply with the Consent Order, infiltration galleries and injection wells have been retained from the screening process to select the appropriate corrective measure alternatives. Under an objective screening process, neither infiltration galleries and/or injection wells would have

been retained due to site-specific application, technology constraints, and institutional issues. Specific reasons why these technologies would not have been retained are as follows:

- Infiltration galleries are usually constructed under shallow groundwater conditions (generally less than forty feet in depth). Infiltration galleries are generally constructed to just above the receiving body of water. Groundwater at the Sparton facility ranges from sixty-five to seventy-five feet below ground surface to over 200 feet off site toward the northwest and downgradient edge of the contaminant plume. Under these sets of hydrogeologic conditions, an infiltration gallery could not be constructed using conventional equipment/technology because of the depth to groundwater and the instability of the soil during construction.
- Because of the areal extent of the downgradient edge of the contaminant plume, numerous injection wells or a significant length of infiltration gallery would need to be installed to provide a reasonable possibility of dealing with the plume. Because of the areal extent of the plume and the depth to groundwater along the downgradient edge of the plume, capital costs for injection well installation could easily exceed several million dollars. Infiltration galleries, assuming that equipment/technology could be developed to meet site requirements, would be prohibitively expensive. Note that these costs do not take into account the operation and maintenance costs to service such

a system. Given the magnitude of such a program and the objective of the corrective measure, this type of corrective measure alternative would not be cost effective and would not adequately deal with the problem.

- Injection wells and infiltration galleries may create a mounding of the water table and cause the groundwater contaminant plume to disperse and spread over a larger area.
- Because the contaminant plume extends off site, most of the construction for injection wells and infiltration galleries would have to take place on private property. Gaining access to private property for construction could be difficult. In addition, numerous political and technical issues would need to be addressed.
- Installation of infiltration galleries and injection wells requires a permit from the State of New Mexico. Obtaining required permits is a long process. In addition, the State of New Mexico has a no degradation policy for groundwater protection. Consequently, the issuance of a permit may require a change in the level of treatment above that required for remediation.
- As discussed earlier, infiltration galleries and injection wells are viewed primarily as a containment technology to inhibit or slow the advancement of a groundwater contaminant plume. Based on the data from the RFI report, the groundwater contaminant plume has not migrated beyond its present position since 1989. In fact the plume has decreased in size since 1989.

Furthermore, the groundwater gradient off site near the leading edge of the plume is nearly flat so there is no significant mechanism causing the plume to continue to migrate toward the northwest. Any attempt to alter the groundwater gradient in the vicinity of the downgradient edge may cause the plume to disperse over a larger area and spread the contamination.

- Infiltration galleries and injection wells are used primarily for small groundwater plumes. The areal extent of the plume makes the use of these alternatives infeasible. Furthermore, these alternatives require a steady flow of water to be effective. Under typical groundwater extraction plans, wells are pumped in a pulse format, i.e., a several week pumping period followed by a similar recovery period. This type of pumping scheme will not supply either sufficient quantities, or a continuous supply, of water to the injection wells or infiltration galleries for them to be effective.

C. Remediation of the Dissolved Groundwater Phase (Saturated Zone)

Groundwater remediation alternatives for this project would include no further action, groundwater extraction and treatment system, vapor extraction system, in situ air stripping, and in situ bioremediation. Treatment of the water effluent pumped from the ground may utilize air stripping, granular activated carbon (GAC), advanced oxidation, aerobic bioreactors, or a combination of all the above. Vapor obtained from vapor extraction and/or in situ air stripping may be treated with granular activated carbon (GAC) or

thermally destructed. Bioremediation provides total treatment in place.

1. No Further Action

Under the No Further Action alternative, the current corrective action (IM) would be discontinued and no additional treatment technology would be implemented at the site. The NFA alternative has been retained because the RFI identified no significant risk or threat to human health or the environment. Existing land use and probable future development of this area minimize both potential receptors and exposure pathways with respect to the contamination characterization for the Sparton Facility. In addition, the RFI indicated the groundwater contaminant plume is shrinking in areal and vertical extent and is experiencing a significant reduction in concentration at almost all sampling locations.

Under the NFA alternative, quarterly monitoring of selected wells would continue. The results of the continued monitoring and changes in land use/development would be annually evaluated to determine the need, if any, for other corrective measures.

Costs on an annual basis for quarterly monitoring of approximately twenty wells and providing an annual report is as follows:

Sampling	$22,500
VOC Analyses	40,000
Evaluation, Annual Report	15,000
	$77,500 annually

2. Continuation of Interim Measure Corrective Action

Continuation of the Interim Measure (IM) groundwater recovery and treatment system has been retained as a corrective measure alternative at the Sparton Facility. The IM consists of eight groundwater extraction wells located on-site. The recovery wells were installed in the upper flow zone. Compressed-air-operated pumps are installed in each well. Produced water is routed through double-walled piping to the treatment building. The water is treated in a packed tower aeration (PTA) unit to remove VOC. After treatment the produced water is used in the Sparton plant as cooling and flushing water and then discharged into the sanitary sewer system. The total system capacity is twenty gallons per minute (gpm). Since start-up in December 1988, the IM system has successfully treated over two million gallons of recovered groundwater with a treatment efficiency of over ninety-nine percent. Operation of this system has achieved significant source removal and reduction in VOC concentration in groundwater.

Under this alternative, the IM would continue to be operated to obtain the maximum practical source removal and reduction in groundwater contamination. Reliability has been demonstrated by almost four years of successful operation.

Use of this alternative poses little risk to human population or the environment. All operating equipment is located on-site and treatment facilities are located in a secure, fenced area. Performance will be monitored by quarterly sampling and analysis of selected wells.

There are no additional capital costs for continuing operation of the IM system.

However, design and capital costs of approximately $200,000 were incurred in 1988. Current annual operation and maintenance (O&M) costs for the system are approximately $25,000. Quarterly sampling and analysis would bring the total O&M costs for this alternative to $100,000 annually.

3. Expansion of Interim Measure

This alternative is similar to the previous discussion in Item 2 with the exception of adding a single groundwater recovery well to the existing IM system. On-site lower lower flow zone well 32 would be added to the IM to address the anomalously high concentrations of VOC in this well. The current IM system has sufficient remaining capacity to accommodate the inclusion of well 32. Capital costs would be approximately $10,000. Operation and maintenance costs would be unchanged from Item 2.

4. Large-Scale Groundwater Extraction and Treatment System

Extracting groundwater with pumped wells on a large scale and treating it at the surface has been retained as a corrective measure alternative at the Sparton site. This technology is suitable for high permeability materials such as the subsurface sands and gravels at the Sparton site. It should be noted that groundwater extraction and treatment is limited in its ability to reduce groundwater contamination to low levels approaching groundwater protection standards. This technology is most appropriate for reducing high concentrations of contaminants in an expedient manner. Achievement of low contaminant

concentration in groundwater may be inordinately difficult, if not impossible. The application of "pump and treat" technology in high contaminant concentration areas at this site has been demonstrated by the successful performance of the Interim Measure (IM) pump and treat system over the past 3-1/2 years.

For maximum efficiency in contaminant removal from the groundwater, intermittent or pulse pumping would be required. Continuous pumping removes a constant volume of water which can result in an initial rapid decrease in contaminant concentration. Continuous pumping, however, often cannot decrease the contamination level below a certain minimum concentration level, also called "tailing phenomenon", because the rapid pore velocities do not provide sufficient time for contaminant levels to build back up to equilibrium levels. Pulse or intermittent pumping provides greater efficiency in contaminant removal by allowing sufficient time for dissolved contaminants to diffuse out of less permeable zones and sorbed contaminants to reach equilibrium concentrations with groundwater prior to removal for surface treatment. Using pulse pumping, several years of operation would be required to obtain a maximum reduction in contaminant concentration.

On-site pump testing has established aquifer parameters. These parameters include a 600-foot radius of influence and a specific capacity of 7.5 to 9 gallons per minute per foot of drawdown. Based on the present groundwater plume characterization, this alternative could involve anywhere from one to three groundwater extraction wells. A single on-site well would effectively cover the high contaminant concentration area of the plume.

A total of three wells would be required to cover the entire area of the plume. Off-site wells, if any, would be located in public rights-of-way to minimize off-site access problems. It should be noted that off-site wells pose some risk to the general public and off-site landowners. This risk is the result of bringing contaminated water to the surface and then conveying it through a buried pipeline to the Sparton facility for treatment. Both the well head and buried pipeline are subject to possible malfunction, inadvertent destruction and possible vandalism.

Wells should not be screened more than thirty to thirty-five feet into the aquifer to prevent the migration of higher concentrations of constituents into lower portions of the aquifer. Based on drawdown limitations posed by this screen depth, pumping rates in the order of 180 to 200 gallons per minute (gpm) would be utilized. This pumping rate would require eight- to ten-inch wells with pump size ranging from ten to twenty horsepower depending on depth to groundwater. Costs for extraction wells have been estimated in Figure 21. Costs for both a single on-site groundwater extraction well and a three well system (one on-site well and two off-site wells) are given for comparison purposes.

After treatment, effluent would be routed along public right-of-way to Las Calabacillas Arroyo and then along the Arroyo to the Rio Grande. Discharge to the Rio Grande would require a National Pollutant Discharge Elimination System (NPDES) permit. Discharge to the Rio Grande would be considered the most appropriate disposal method since reinjection of the water may be difficult, if not impossible, to permit under current state regulations and also since area sewer capacity is inadequate to handle the produced

FIGURE 21

GROUNDWATER EXTRACTION WELL COSTS		
CAPITAL COSTS		
Item	**One On-Site Well (200 gpm)**	**Three Wells Total (600 gpm)**
Well Installation	$10,000	$35,000
Submersible Pump	4,500	18,000
Controls	4,500	13,500
Electric Service	1,000	15,000
Wellhead Protection	N/A	10,000
Double Contained Piping To Sparton Facility	N/A	60,000
Contingency (25%)	5,000	38,000
Total Capital Cost	$25,000	$189,500
ANNUAL OPERATION AND MAINTENANCE COSTS		
Item	**One On-Site Well (200 gpm)**	**Three Wells Total (600 gpm)**
Electricity (4380 hr)	$3,285	$14,785
Maintenance, Depreciation	2,500	18,950
Effluent Monitoring	3,000	9,000
Annual O & M	$8,785	$42,735

water volume. The State of New Mexico has a no degradation requirement for injection or land application which typically requires significant additional treatment beyond that required for groundwater remediation.

Treatment options for extracted groundwater pumped to the surface at the Sparton site would include a number of technologies which may be used individually or in combination with one another. These options are discussed in detail in subsequent sections. After treatment, water would be routed through approximately 4500 feet of buried pipeline to reach the Rio Grande. Estimated costs for disposal of extracted groundwater are given in Figure 22. Costs for handling discharge from both a single well system and a three well system have been estimated to show the effect of disposal quantity.

The groundwater extraction and treatment alternative is conventional in concept. Operation will be similar to the current Interim Measure pump and treat system. Because this alternative is self-explanatory, preliminary process flow diagrams have not been included in this report.

Time required for implementation of this alternative will be a function of season, chosen treatment option, required permits, and whether groundwater wells are located on-site or off-site. Assuming a single on-site well, this alternative could be fully operational in approximately one year. Once operation in a pulsed mode is begun, it is estimated that two to three years of operation will be required to produce a significant reduction in VOC concentration in groundwater. The useful life of the equipment is much longer (in excess of ten years).

FIGURE 22

GROUNDWATER EXTRACTION DISPOSAL COSTS		
CAPITAL COSTS		
Item	**One On-Site Well (200 gpm)**	**Three Wells Total (600 gpm)**
Transfer Pump and Surge Tank	$5,000	$10,000
Controls	4,500	4,500
Pipeline	50,000	50,000
Coors Road Crossing	10,000	10,000
Discharge Structure	5,000	5,000
Contingency (25%)	18,600	20,000
Total Capital Cost	93,000	99,500
ANNUAL OPERATION AND MAINTENANCE COSTS		
Item	**One On-Site Well (200 gpm)**	**Three Wells Total (600 gpm)**
Electricity (4380 hr)	$3,285	$8,212
Maintenance, Depreciation	9,300	9,950
Effluent Monitoring	3,000	3,000
Annual O & M	$15,585	$21,162

a. Air Stripping

Air stripping is a mass transfer process in which volatile contaminants in water or soil are transferred to gas. Generally, organic chemicals such as TCE and TCA with Henry's law constants greater than 0.003 (3×10^{-3}) can be effectively removed by air stripping. Air stripping is considered one of several best demonstrated available technologies (BDATS) for removal of volatile contaminants such as those present at the Sparton site. Air stripping is frequently accomplished in a packed tower aerator (PTA) equipped with an air blower.

In packed tower aeration, loosely packed material is placed within a vertical cylindrical tower. Water cascading through the packing breaks into small droplets providing a large surface area to enhance mass transfer. Air forced upward through the packing from the tower base promotes the transfer of VOC from the water to the air.

Air stripping is suitable for this site because of its high effectiveness in removing VOC and its moderate cost. Capital cost for a packed tower aeration treatment unit is a function of treatment capacity. Estimated costs corresponding to the range of flows anticipated from the groundwater extraction system are given in Figure 23. For the 200-gpm capacity, a 36- to 42-inch diameter packed column will be required. For 600 gpm, a 72-inch packed column will be used. Operation and maintenance (O & M) costs will be in the range of $0.15 to $0.22 per 1000 gallons.

Air stripping technology has been used on site at the Sparton Facility for approximately three years as an Interim Measure (IM). The effectiveness of this method has been demonstrated by pumping and treating over 2.1 million gallons of water to date

FIGURE 23

PACKED TOWER AERATION COSTS		
CAPITAL COSTS		
Item	**200-gpm Capacity**	**600-gpm Capacity**
Packed Tower	$30,000	$70,000
Control Building	5,000	5,000
Miscellaneous Electric and Plumbing	2,500	2,500
Controls	5,000	5,000
Tower Foundation	2,500	2,500
Contingency (25%)	11,250	21,250
Total Capital Cost	$56,250	$106,250
ANNUAL OPERATION AND MAINTENANCE COSTS		
Item	**200-gpm Capacity**	**600-gpm Capacity**
Electricity (4380 hr)	$3,450	$9,850
Maintenance, Depreciation	5,000	10,000
Monitoring	3,000	3,000
Annual O & M	$11,450	$22,850

with a contaminant removal efficiency of ninety-nine per cent. Assuming an average influent concentration of 2 mg/l VOC (1.5 mg/l TCE and 0.5 mg/l TCA), the air stripping will produce five to fifteen pounds of VOC in the air effluent. It is understood that city of Albuquerque air quality regulations may require treatment or "polishing" of the air effluent to remove VOC. Polishing of the air effluent can be most efficiently achieved by the use of granular activated carbon (GAC) treatment. GAC treatment costs are estimated in Figure 24. Operation and maintenance costs would be in the range of $0.34 to $0.43 per 1000 gallons.

Thermal destruction of the contaminants in off gas is also feasible using mobile incineration units. A catalytic operation, which costs less than thermal destruction, may be considered using lower temperatures. Thermal destruction has been successfully used in the Albuquerque area at petroleum hydrocarbon remediation sites.

b. Granular Activated Carbon (GAC) Treatment

This process consists of passing the water through packed beds of granular activated carbon. Contaminants are absorbed in the internal pores of the carbon granules. The activated carbon is an effective method for removing volatile organic constituents (VOC) and it is not sensitive to flow rate changes, concentration changes, or toxic materials. It is sensitive to suspended solids and oil and grease concentrations. This method is also considered a best demonstrated available technology (BDAT) for treatment of VOC and is widely used in the treatment of hazardous waste streams.

FIGURE 24

GAC AIR POLISHING COSTS		
CAPITAL COSTS		
Item	**200-gpm Air Stripper**	**600-gpm Air Stripper**
GAC Unit With Heater	$30,000	$50,000
Miscellaneous Electric and Plumbing	5,000	5,000
Shelter Unit	5,000	5,000
Contingency (25%)	10,000	15,000
Total Capital Cost	$50,000	$75,000
ANNUAL OPERATION AND MAINTENANCE COSTS		
Item	**200-gpm Air Stripper**	**600-gpm Air Stripper**
Electricity (4380 hr)	$4,380	$13,140
Maintenance, Depreciation	5,000	7,500
Carbon Replacement	10,000	30,000
Effluent Monitoring	3,000	3,000
Annual O & M	$22,380	$53,640

The primary limitation of GAC treatment is the high cost of carbon disposal and/or regeneration. Because of the relatively low concentrations of VOC in extracted groundwater produced at the site, carbon exhaustion is estimated at 250 to 750 pounds of carbon per day. This rate of exhaustion can be economically handled by either off-site disposal or off-site regeneration. On-site regeneration is not cost effective until carbon exhaustion exceeds 1500 to 2000 pounds of carbon per day. Estimated costs for GAC treatment of the produced groundwater are given in Figure 25.

c. Advanced Oxidation

This technology involves the complete destruction of organic compounds such as TCE and TCA by using ozone and the generation of hydroxyl radicals (OH). By combining hydrogen peroxide (H_2O_2) and O_3 to the ozone stream, decomposition of O_3 occurs, which in turn helps the formation of OH radicals. The process involves the exchange of electrons. Advanced oxidation essentially destroys the organic compound by oxidation and the compounds become mineralized. The advanced oxidation process can be accelerated by combining ultraviolet (UV) light with H_2O_2 and O_3. The absorption of UV energy results in a molecule's cleavage, which increases the ease of subsequent oxidation of the molecule. Varying doses of H_2O_2 and O_3 with UV in the reaction process controls the effectiveness of the treatment. The dosage ratios of H_2O_2 and O_3 is dependant upon the contaminant concentrations. In addition, contact time of the waste stream in the reactor is critical to assure complete mineralization of the compound.

FIGURE 25

GAC TREATMENT COSTS		
CAPITAL COSTS		
Item	**200-gpm Capacity**	**600-gpm Capacity**
Parallel Treatment Unit	$125,000	$250,000
Carbon	25,000	50,000
Shelter Unit	10,000	15,000
Miscellaneous Plumbing	5,000	5,000
Contingency (25%)	41,000	80,000
Total Capital Cost	$206,000	$400,000
ANNUAL OPERATION AND MAINTENANCE COSTS		
Item	**200-gpm Capacity**	**600-gpm Capacity**
Electricity/Water	$3,000	$6,000
Maintenance, Depreciation	20,600	40,000
Carbon Replacement	100,000	200,000
Effluent Monitoring	3,000	3,000
Annual O & M	$126,600	$303,000

Advanced oxidation has been demonstrated to be an effective treatment process for groundwater contaminated with VOC such as TCE and TCA. The process has been found to be more effective in low alkalinity waters that are softened before treatment and by applying UV light to the waste stream.

Costs for advanced oxidation vary depending on factors such as contaminant concentrations, treatment volume, dosage ratios, treatment levels, contact or residence time in the reactor, and energy consumption. Estimated costs for advanced oxidation are presented in Figure 26. The costs include generating ozone on-site.

d. Aerobic Bioreactors

This technology also destroys volatile organics instead of mass transfer to other mediums. This process uses aerobic biodegradation to convert VOC into non-toxic constituents. Pilot scale studies have achieved effective removal of TCE in groundwater. Similar technology has also been used on industrial wastewater streams.

At this site, fixed-film bioreactors would be appropriate. The bioreactor vessel would be covered to prevent any VOC emission to the atmosphere. Bioreaction units would be vented through a GAC polishing unit similar to that used for treatment of air stripper emissions.

Although the low concentration of VOC in the extracted groundwater would result in a minimal biosolids production rate, a sedimentation tank would be included to capture biosolids during sloughing events. Costs for aerobic bioreaction treatment are

FIGURE 26

ADVANCED OXIDATION TREATMENT COSTS		
CAPITAL COSTS		
Item	**200-gpm Capacity**	**600-gpm Capacity**
Treatment Unit	$800,000	$2,000,000
Miscellaneous Plumbing and Electric	5,000	5,000
Shelter Unit	10,000	15,000
Installation/Start-up	16,000	20,000
Contingency	207,750	510,000
Total Capital Cost	$1,038,750	$2,550,000
ANNUAL OPERATION AND MAINTENANCE COSTS		
Item	**200-gpm Capacity**	**600-gpm Capacity**
Electricity (4380 hr)	$350,000	$900,000
Maintenance, Depreciation	103,875	255,000
Hydrogen Peroxide	21,000	63,000
Effluent Monitoring	3,000	3,000
Annual O & M	$477,875	$1,221,000

given on Figure 27. Note that costs for disposal of biosolids has not been included.

5. Vapor Extraction System

Vapor extraction systems (VES), also known as vapor recovery systems (VRS), soil vapor extraction (SVE) systems or forced air venting, remove existing soil gas by placing a partial vacuum on the unsaturated or vadose zone. The partial vacuum is obtained through a series of vapor extraction wells connected to a suction fan. Soil, gas and vapor-phase VOC are removed from the subsurface. The resulting decrease in VOC concentration in the soil gas often results in the desorption or off-gassing from VOC adsorbed into fine-grained soils or dissolved in shallow groundwater. This off-gassing results from phase-equilibrium requirements.

For highly porous subsurface conditions with high VOC concentrations observed in the uppermost portion of the aquifer, operation of vapor recovery systems installed immediately above the water table can significantly impact the groundwater dissolved-phase VOC concentrations. Removal of soil gas from above the water table reduces the vapor phase VOC concentrations resulting in off-gassing (dissolution) from the groundwater in accordance with Henry's Law. To be most effective, vapor recovery systems should be operated in a pulsed mode similar to groundwater extraction systems. Vapor extraction is also useful in removing adsorbed phase VOC from soil materials dewatered during groundwater extraction.

Soil gas surveys and groundwater sample analyses indicate highest soil gas (and

FIGURE 27

AEROBIC BIOREACTOR TREATMENT COSTS		
CAPITAL COSTS		
Item	**200-gpm Capacity**	**600-gpm Capacity**
Fixed-Film Treatment Units	$335,000	$890,000
Covers	24,000	72,000
Sedimentation	45,000	275,000
Sitework, Piping, Building	191,000	583,000
Nutrient Feed Systems	12,000	15,000
Air Polishing System	50,000	75,000
Contingency (25%)	164,250	477,500
Total Capital Cost	$821,250	$2,387,500
ANNUAL OPERATION AND MAINTENANCE COSTS		
Item	**200-gpm Capacity**	**600-gpm Capacity**
Electricity (4380 hr)	$7,400	$22,200
Maintenance, Depreciation	82,125	238,750
Effluent Monitoring	3,000	3,000
Annual O & M	$92,525	$263,950

groundwater) VOC concentrations occur under the facility. Based on the characterization discussed in the RFI, an average radius of influence of approximately 150 feet is also anticipated.

Depending on the overlap between vapor extraction wells, between ten and twenty wells will be required. Combined extraction rate would thus range from 200 standard cubic feet per minute (scfm) to 500 scfm (or 20 to 25 scfm per well). Extracted vapor would be routed to a central vacuum unit. The effluent from the vacuum unit would then be treated using GAC air polishing or thermal destruction to remove VOC. Estimated costs for VES installation and operation are given in Figure 28.

The benefits of using vacuum extraction include:

- Implementation can be conducted in situ and requires relatively little disturbance to existing facilities or operations.
- The process reduces contaminant concentration and mobility at the treated area.
- Implementation can be flexible, allowing for adaptation to changing site conditions or as additional analytical and subsurface data is developed.
- In situ installation and operation requires little handling of contaminated materials, limiting the risk of exposure to workers and the public.
- Vacuum extraction has few secondary impacts.

Vacuum extraction is only applicable to VOC. Vacuum extraction will be costly and may require prohibitive operation times to achieve cleanup at sites where soil is

FIGURE 28

VAPOR EXTRACTION SYSTEM COSTS		
CAPITAL COSTS		
Item	**Ten-Well System**	**Twenty-Well System**
Well Installation	$17,500	$35,000
Buried Piping	13,000	25,000
Blower Unit	10,000	20,000
Miscellaneous Electric and Plumbing	5,000	5,000
Controls	5,000	5,000
GAC Air Treatment Unit	7,500	15,000
Shelter Unit	10,000	15,000
Contingency (25%)	17,000	30,000
Total Capital Cost	$85,000	$150,000
ANNUAL OPERATION AND MAINTENANCE COSTS		
Item	**Ten-Well System**	**Twenty-Well System**
Electricity (4380 hr)	$2,465	$4,928
Maintenance, Depreciation	8,500	15,000
Carbon Replacement	2,500	5,000
Effluent Monitoring	3,000	3,000
Annual O & M	$16,465	$27,928

heterogeneous with significant clay/silt content and has very low air permeability. In addition, off-gas treatment may produce RCRA-regulated wastes, which may require special handling and disposal practices.

The process description given above is sufficiently detailed that process flow diagrams are not needed to explain operation. It is estimated that approximately one year will be required to place a VES into full operation. Approximately one to three years of pulsed extraction will be required to improve groundwater quality. VES equipment has a useful life of approximately ten years.

6. In Situ Air Stripping (Air Sparging)

An innovative technology for treatment of volatile organic compounds in groundwater is in situ air stripping or sparging. This technology is an enhanced version of vapor recovery and utilizes air injection wells installed in the aquifer in addition to the vapor extraction system (VES). Dissolved-phase VOC are stripped from the groundwater by the mechanics of the rising air bubbles around the air injection wells. The vapor-phase VOC are then removed by the VES. Typical operation utilizes standard VES operation until a tailing phenomenon is observed in soil-gas VOC concentrations. Air injection is then begun to increase efficiency of removal. Air injection quantities are on the order of ten percent (10%) of the VES recovery rate. Injection wells should be located in the vicinity of the recovery wells to obtain maximum removal efficiency and to avoid spreading of the soil-gas plume.

Air sparging also increases the dissolved oxygen content which greatly enhances natural biodegradation. Injection of air also causes a "mounding" of the groundwater near the injection well; however, this mound is the result of reduced water density from entrained air bubbles and does not represent a dispersing factor. It should be noted that air sparging wells are often subject to biofouling and periodic treatment with hydrogen peroxide may be required to maintain performance.

Recent studies have indicated that air sparging enhancement may increase VES performance to a significant degree. Estimated costs for air sparging enhancement are given in Figure 29.

7. In Situ Bioremediation

This technology uses existing or transplanted microbes to biologically transform VOC under aerobic and anaerobic conditions. Both aerobic and anaerobic biologic processes are applicable to the degradation of VOC identified at this site. Chlorinated VOC such as TCE and TCA were originally thought to be resistant to aerobic biodegradation; however, recent studies reported in the literature indicate that TCE and TCA can be aerobically degraded or mineralized under several different mechanisms. Anaerobic degradation of TCE and TCA is also well documented in the literature.

Before implementation of an in situ bioremediation system, the concentration of VOC in the groundwater should be reduced as much as possible using other technologies. Bioremediation can be utilized as the final part of a treatment train or used as a separate,

FIGURE 29

AIR SPARGING COSTS *		
CAPITAL COSTS *		
Item	**Ten-Well System**	**Twenty-Well System**
Well Installation	$25,000	$50,000
Buried Piping	9,000	18,000
Blower Unit	4,500	7,000
Miscellaneous Electric and Plumbing, Controls	5,000	5,000
Contingency (25%)	11,000	20,000
Total Capital Cost	$54,500	$100,000
ANNUAL OPERATION AND MAINTENANCE COSTS *		
Item	**Ten-Well System**	**Twenty-Well System**
Electricity (4380 hr)	$ 500	$1,000
Maintenance, Depreciation	5,500	10,000
Biofouling Treatment	10,000	20,000
Annual O & M	$16,000	$40,000

* In addition to VES Capital and O & M Costs

later technology application.

The benefits of in situ bioremediation include:

- Excavation of contaminated materials is not required.
- It may result in complete degradation of organic contaminants to non-toxic byproducts (carbon dioxide, methane, water, etc.).
- There are minimal mechanical equipment requirements.

The limitations of in situ bioremediation include:

- There is a potential for partial degradation to equally toxic, more highly mobile byproducts - particularly under anaerobic conditions.
- It may be difficult to contain volatile organic compounds emitted during remediation.
- The process is highly sensitive to toxins and environmental conditions.

The advantage of this method is that contaminated materials can remain in place, even outside the Sparton site. The limitations are the ability to achieve adequate contact between microbes and the VOC and the degree of degradation that can be obtained.

Aerobic biodegradation would be the preferred technology due to the complete degradation of the target VOC to non-toxic products. Aerobic bioremediation of groundwater (using either indigenous or introduced microorganisms) will require injection wells to introduce oxygen (usually air) and nutrients. Permitting of these injection wells may be difficult under New Mexico groundwater regulations. In addition, a vapor extraction system (VES) may be needed to remove carbon dioxide produced by the aerobic

degradation.

Assuming that this alternative is permittable, estimated costs for in situ treatment of groundwater using aerobic biodegradation would be on the order of $2 million capital cost and $500,000 annual operation and maintenance costs. These costs are based on treatment of the entire eighty-acre plume.

Implementation of in situ bioremediation may require up to one year to install equipment and obtain the necessary permits. Because of the somewhat experimental nature of the alternative, it is believed that up to three years of operation may be required to produce beneficial results.

D. Remediation of the Soil-Sorbed Phase (Unsaturated Zone)

Potential technologies for removing the soil-sorbed phase of contamination includes no further action, soil flushing, in situ bioremediation, and vapor extraction systems.

1. No Further Action

Under the No Further Action (NFA) alternative, no additional treatment technology for soil would be implemented at this site. This alternative has been retained because characterization in the RFI identified only scattered residual levels of VOC and heavy metals under the sump/pond area. The entire sump/pond area has been capped, thus minimum potential exists for further migration of soil contamination down to groundwater. Soil concentrations under the facility pose no significant risk or threat to human health since no

potential receptors or exposure pathways exist.

2. Soil Flushing

Soil flushing is used for removal of a number of organic and inorganic materials from vadose zone soils. A variation of soil flushing, referred to as chemical extraction, may be used to remove non-water soluble organics from the saturated zone.

Soil flushing involves the addition of a solvent or surfactant to contaminated soil to enhance contaminant mobility. The contaminants are then recovered in the ground water by strategically placed extraction wells and pumped to the surface for treatment. Soil flushing is most applicable when soils must be remediated but other technologies such as vacuum extraction, bioremediation, or physical removal (i.e. excavation) are not feasible. The addition of chemicals to the flushing solution that will increase contaminant mobility are necessary if strongly adsorbed, hydrophobic contaminants are present in the soil. The extraction of strong adsorbed contaminants may not be desirable for a corrective action unless there is an imminent threat to human health and the environment. The more permeable the soil and the more water that can be flushed through the soil, the more practicable is this technology. Soil flushing strategies can be incorporated into pump and treat or containment systems to accelerate the contaminant removal processes. Soil flushing can be accomplished using sprinkling systems or, more aggressively, by flooding the contaminated area. Chemical extraction involves extracting ground water, amending it with solvents and/or other chemicals, and reinjecting it at strategic locations into the

aquifer. With any soil flushing system, proper controls must be incorporated to prevent migration of extractant-contaminant mixtures.

The flushing solution to be used at a site depends on the type of contamination present. Flushing solutions may include water, acidic aqueous solutions (i.e., sulfuric, hydrochloric, nitric, phosphoric, and carbonic acids), basic solutions (i.e., sodium hydroxide), surfactants (i.e., alkylbenzene sulfonate), chelating agents, oxidizing agents, or reducing agents. Water can be used to extract water-soluble or water-mobile constituents. Acidic solutions are used for metals and certain organic constituents (including amines, ethers, and anilines) that are soluble in an acidic environment.

The level of treatment that can be achieved will vary depending on the contact of the flushing solution with waste constituents, the appropriateness of the solutions for the wastes, the soil adsorption coefficients of the waste, waste partitioning coefficients, and the unsaturated hydraulic conductivity of the soil. This technology should produce the best treatment results in highly permeable soils with low organic content.

Soil flushing may be used as a pretreatment for, or in combination with, bioremediation. As a pretreatment step, soil flushing may be used to remove inhibitory compounds or reduce contaminant levels, making the soil media more amenable to biological activity. In combination with bioremediation, the flushing solution can be amended with nutrients to enhance biological activity.

The benefits of using soil flushing include:

- Removal of contaminants is permanent.

- Removal of soils is not necessary.
- The technology is easily applied to permeable soils.

The limitations of soil flushing technologies include:

- The State of New Mexico may not permit soil flushing under its no degradation policy.
- The technology introduces potential toxins (the flushing solution) into the soil system. Therefore, containment may be needed.
- Physical/chemical properties of the soil system may be altered because of the introduction of the flushing solution.
- A potential exists for solvents to transport contaminants away from the site into uncontaminated areas. Therefore, containment may be needed.
- A potential exists for incomplete removal of contaminants due to heterogeneity of soil permeability.
- Contaminants are not destroyed. On-site treatment is required to remove contaminants from extracted flushing solvents.
- Flushing agents usually cannot be recycled.
- It may take a long period of time for remediation below cleanup standards to be achieved.

Assuming that the State of New Mexico would permit a soil flushing alternative, the costs will be impacted by the area treated and by the type of flushing agent used. Considering that soil contamination occurs primarily on site, estimated costs for this

technology are approximately $0.5 million for capital equipment and $160,000 in annual O & M costs. Cost could be reduced by including soil flushing as an enhancement to a groundwater pump and treat remediation system.

Implementation time for this alternative will be approximately one year assuming that permits can be obtained. Beneficial results will require multiple treatments over several years.

3. In Situ Bioremediation

In situ bioremediation is the process of using bacteria to biodegrade organic compounds in soils. Under favorable conditions, microorganisms may be capable of completely degrading many organic compounds into carbon dioxide, methane, water and/or organic acids. Both aerobic and anaerobic processes can be used to degrade TCE and TCA and other volatile chlorinated organics.

In situ bioremediation of soils generally involves the stimulation of naturally occurring, or indigenous, microorganisms to degrade organic contaminants. Transplanted and/or genetically engineered microorganisms can be utilized as well. Aerobic processes will dominate in the shallow, unsaturated zone where oxygen is available and in deeper zones if oxygen can be successfully introduced. Microorganisms are stimulated by the addition of nutrients such as ammonia, methane, nitrate, and/or orthophosphate.

Very often bioremediation is used as part of a treatment train, such as post treatment following soil flushing or vacuum extraction.

The benefits of in situ bioremediation include:

- Excavation of contaminated materials is not required.
- It may result in complete degradation of organic contaminants to non-toxic byproducts (carbon dioxide, methane, water, etc.).
- There are minimal mechanical equipment requirements.

The limitations of in situ bioremediation include:

- There is a slight potential for partial degradation to equally toxic, more highly mobile byproducts--particularly under anaerobic conditions.
- It may be difficult to contain volatile organic compounds emitted during remediation.
- The process is highly sensitive to toxins and environmental conditions.

In situ bioremediation would be appropriate to treat VOC contaminated soils occurring within the general boundaries of the facility. Assuming that the State of New Mexico will allow the injection of nutrients into the subsurface, the estimated costs for bioremediation of soil on site will be $500,000 capital and $150,000 annual operation and maintenance.

The advantage of this method is that contaminated materials can remain in place, even outside the Sparton site. The limitations are the ability to achieve adequate contact between microbes and the sorbed VOC and the degree of degradation that can be obtained.

4. Vapor Extraction System

Vapor extraction systems (VES), also known as vapor recovery systems (VRS), soil vapor extraction (SVE) systems and forced air venting, consists of the removal of existing soil gas by placing a partial vacuum on extraction wells installed in the unsaturated zone. Contaminants desorb from the soil and are carried away with the exhausted air. Continued flushing with clean air brought in from outside the contaminated area can result in a significant decrease in the concentration of volatile compounds in soil.

The basic components of a vacuum extraction system are extraction wells and a blower. In most cases, moisture separation and off-gas treatment will also be required in order to meet air discharge requirements. Recharge wells, an impermeable cover, conditioning of recharge air, flow control and measurement instrumentation, vapor concentration monitoring, and other enhancements are also frequently added in order to improve system performance and flexibility.

The physical basis of the technique rests on the tendency of many volatile organic compounds to diffuse from the soil matrix to the air in pore spaces as result of the concentration difference between the soil and the clean air that is introduced. Once the contaminants have become entrained in the soil gas, they are carried out of the soil through the circulation of fresh air. The effectiveness of vacuum extraction is therefore related to those properties that determine the extent to which contaminants diffuse into the soil atmosphere and the effort required to remove the contaminant-laden air from the soil.

Vacuum extraction is most likely to be successful at sites where highly volatile contaminants are present in homogeneous soils of high permeability and porosity. The

benefits of using vacuum extraction include:

- Implementation can be conducted in situ and requires relatively little disturbance to existing facilities or operations.
- Contaminant concentration and mobility is reduced in the treated area.
- Implementation can be flexible, allowing for adaptation to changing site conditions or as additional analytical and subsurface data is developed.
- In situ installation and operation requires little handling of contaminated materials, limiting the risk of exposure to workers and the public.
- Vacuum extraction has few secondary impacts.

Vacuum extraction is only applicable to VOC. Vacuum extraction will be costly and may require prohibitive operation times to achieve cleanup at sites where soil is heterogeneous with significant clay/silt content and has very low air permeability. In addition, off-gas treatment may produce RCRA-regulated wastes, which will require special handling and disposal practices.

- Soils must be permeable and fairly homogeneous for the technique to be efficient; impermeable lenses may adversely affect the results of the process.
- Cleanup to low levels can be difficult and require lengthy remediation time with the potential for greater than anticipated operation and maintenance costs, particularly in heterogeneous soils.
- Verification of complete cleanup effectiveness can be difficult, particularly in heterogeneous soils.

Estimated costs for vapor extraction have been given previously in Figure 28.

E. Remediation of Soil Gas Vapor Phase (Unsaturated Zone)

1. No Further Action

Under the No Further Action (NFA) alternative, no additional treatment technology for soil gas would be implemented at this site. Soil-gas concentrations under the facility pose no significant risk or threat to human health since no potential receptors or exposure pathways exist. This alternative has been retained since multiple soil gas surveys and bore-hole screening have indicated that elevated soil-gas VOC concentrations occur only on site with highest concentrations in the sump/pond area.

2. Vapor Extraction System

Vapor extraction systems (VES) as previously discussed in Sections VII.C.3. and VII.D.4. are also directly applicable to remediation of soil-gas contamination. VOC existing in the vapor phase in interstitial pore space in the unsaturated zone can be removed by VES. As vapor phase VOC is removed, phase equilibrium mechanisms result in off-gassing from the soil-sorbed phase and the dissolved groundwater phase. Continued operation of the VES results in remediation of all three phases.

VIII JUSTIFICATION AND RECOMMENDATION OF THE CORRECTIVE MEASURE

A. General

Continued operation of the Interim Measure (IM) groundwater recovery and treatment system has been selected as the recommended corrective action alternative. This recommendation was based on the following:

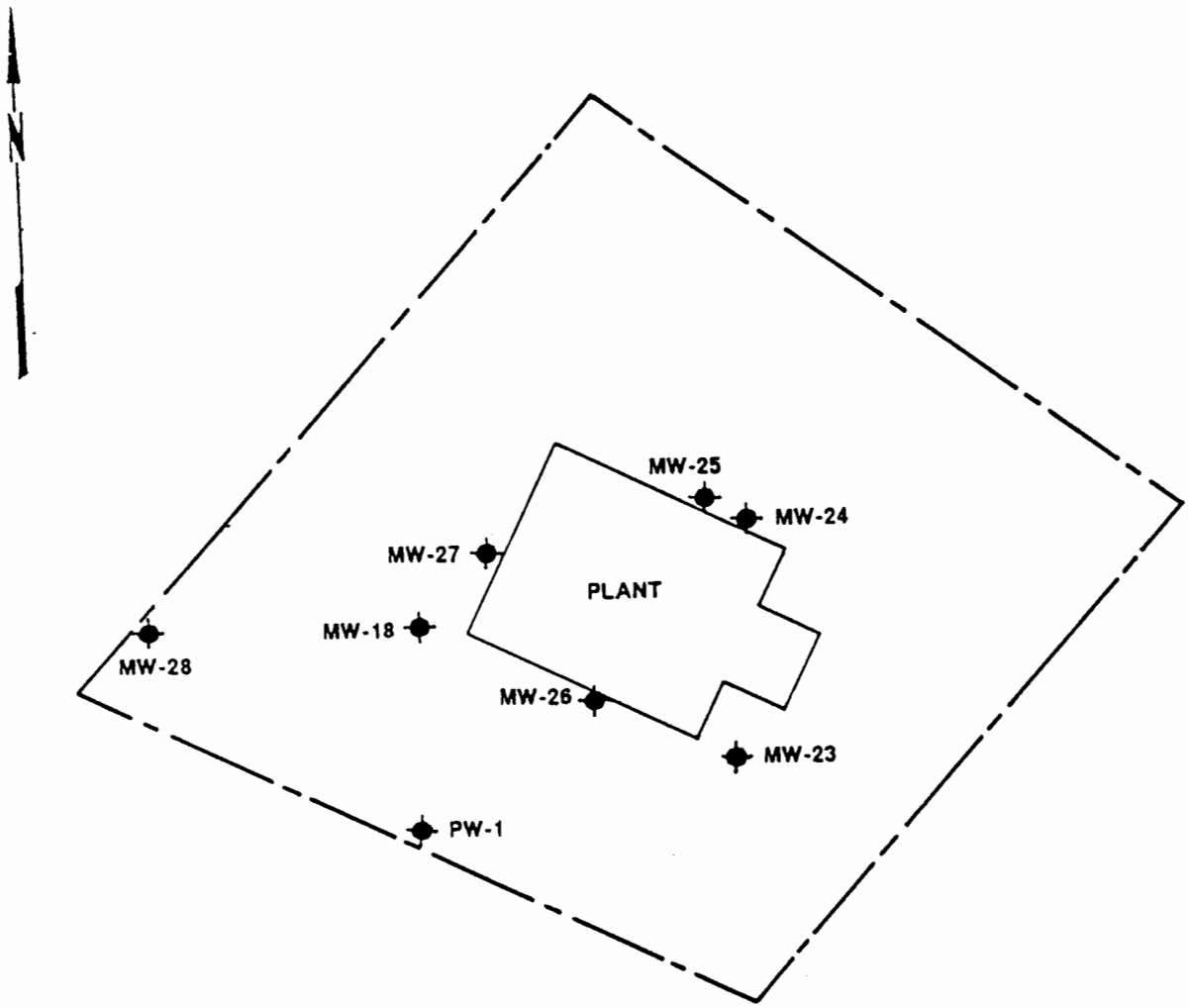
- Risk assessment considering both current and potential receptors and exposure pathways identified at the site.
- Reduction in areal and vertical extent (and concentration) observed in both groundwater and soil gas plumes since the late 1980s.
- Lack of significant forward movement in the groundwater plume.
- Elevated constituent concentrations are retreating to the facility boundaries.
- Inability of available technologies to restore groundwater quality to Maximum Contaminant Levels (MCLs).
- Off-site constituent concentrations in much of the plume area have already dropped below technology application levels.
- Specific requirements of 40 CFR 264.100 with respect to "where necessary to protect human health and the environment."
- Effectiveness of previous corrective actions (i.e., closure and capping of the ponds/sump).
- Effectiveness of the currently operating IM system.
- Cost effectiveness of the IM system relative to other alternatives retained from the Initial Screening.

B. Description of the Recommended Alternative

Based on the characterization presented in the RFI, corrective action in the form of continuation of the existing IM groundwater recovery and treatment system is recommended. As part of this recommendation, groundwater monitoring wells at selected locations would be sampled and analyzed on a quarterly basis to verify degradation of the plume. The results of monitoring and evaluations of any changes in land use/development would be analyzed annually to determine the need, if any, for further corrective measures studies.

The IM consists of groundwater extraction wells and treatment in a packed tower aeration unit. The IM groundwater recovery network is comprised of eight wells (PW-1, MW-18, MW-23, MW-24, MW-25, MW-26, MW-27, and MW-28) installed in the upper flow zone at the on-site locations shown on Figure 30 (Figure 5, Effectiveness Report). The wells are set in the upper flow zone (UFZ) with screened interval depths ranging from 60 to 78 feet below the existing ground surface. Figure 31 (Table 1, Effectiveness Report) lists the pertinent construction details for each of the eight wells.

Compressed-air-operated, positive-displacement pumps were installed at or near the bottom of each well. The compressed air is supplied by an air compressor located in the central control building. Air is pumped through piping to the well pumps and pump controllers. Four controllers are provided to control pump operations. Two pumps are controlled by each controller. Each well pump is equipped with a remote well operator to allow independent adjustment of pumping rates for each well. Each well pump discharges



LEGEND

MW-23
RECOVERY WELL LOCATION AND NUMBER

0 200 400
SCALE FEET

HDR
HDR ENGINEERING, INC.
DALLAS, TEXAS

Recovery Well Location Plan
Sparton Technology, Inc.
Coors Road Facility
Albuquerque, New Mexico

Date 8/92

001132

FIGURE 30

FIGURE 31

IM GROUNDWATER RECOVERY NETWORK WELL CONSTRUCTION DETAILS						
Well No.	Well Diameter (inches)	Well Screen Material	Riser Material	Depth of Screened Interval (feet)	Elevation at top of Screen (ft., MSL)	Construction Date
PW-1	10	PVC (1)	PVC	60-70	4984.54	9/84
MW-18	4	PVC	PVC	68-78	4977.58	5/86
MW-23	2	SS(2)	PVC	72-77	4976.51	8/86
MW-24	2	SS	PVC	68.4-73.4	4980.30	12/86
MW-25	2	SS	PVC	67.7-72.7	4981.30	12/86
MW-26	2	SS	PVC	73-78	4972.71	5/88
MW-27	2	SS	PVC	67-72	4978.50	5/88
MW-28	2	SS	PVC	65-70	4977.69	5/88

(1) Polyvinyl chloride
(2) Stainless Steel

through flexible tubing into a common gravity drain or header. Each discharge line is equipped with a two-way sampling valve for sample collection and flow measurement.

Groundwater extracted simultaneously at each well location is piped to an air stripper system for treatment and ultimate beneficial use in the Sparton Facility. The collection piping system consists of discharge lines encased in secondary piping to provide leak detection and containment. Figure 32 (Table 2, Effectiveness Report) describes the pumping flow rate for each recovery well as of late February 1992.

The produced groundwater is collected in a 550-gallon fiberglass-coated steel tank. The double wall tank has a leak detection system with a visual and audible alarm in the control building. A centrifugal transfer pump, which is controlled by the water level in the collection tank, transports water from the collection tank to the top of the packed tower (air stripper).

The twenty-gallon-per-minute packed tower aeration unit receives untreated water from the transfer pump and discharges to the storage tank. A 400-cfm blower provides a counter-current flow of air through the packed tower to remove volatile organic constituents (VOC) from the water. A recirculation line is provided on the packed tower discharge to allow a portion of the flow to be recirculated to the collection tank. The recirculation shortens the time between pumping cycles of the transfer pump. This procedure maintains the tower packing in a wet condition, thus improving treatment efficiency. The rate of recirculation may be adjusted by setting the butterfly valve on the recirculation line.

Effluent from the packed tower is discharged to a 15,000-gallon fiberglass-coated steel

FIGURE 32

CURRENT RECOVERY WELL NETWORK FLOW RATES	
Well No.	Flow Rate (gal/hr)
PW-1	3.7
MW-18	10.0
MW-23	21.3
MW-24	1.0
MW-25	1.8
MW-26	2.0
MW-27	13.4
MW-28	2.9
TOTAL	56.1

tank for storage. The double-walled tank has a leak detection system with a visual and audible alarm in the control building. Water from the storage tank is used in the main plant building as cooling and flushing water and eventually discharged into the sewer system.

To date, approximately 2.2 million gallons of water have been treated in the packed tower. The air stripping system has demonstrated an average VOC removal efficiency of 99 percent for the measured indicators, which include 1,1-dichloroethylene (DCE), methylene chloride (MeCl), 1,1,1-trichloroethane (TCA), and trichloroethylene (TCE). Total influent concentrations have exceeded 1000 micrograms per liter (μg/l). Air stripper treatment is producing effluent concentrations in the range of one μg/l for each constituent being monitored. Demonstrated reliability and performance to date indicate a remaining useful life of at least ten years.

C. Justification of Recommended Corrective Measure

1. Human Health/Environmental

The recommended alternative of corrective action through continuation of the existing IM is consistent with the requirements of 40 CFR 264.100. The RFI indicates that the groundwater plume is shrinking in areal and vertical extent and constituent concentrations are decreasing. Highest concentrations of TCE and TCA are still present in the immediate vicinity of the Sparton Facility.

The RFI and a recent confirmation of nearby land use did not identify any current threat or risk to any potential receptors or any recognized pathways for exposure as

detailed in previous Section III.D. Further, it is believed that a low probability exists for significant change in the immediate future with respect to both receptors and exposure pathways. Because of the observed plume behavior and the absence of risk to potential receptors, the recommended alternative is justifiable from a human health/environmental perspective. In addition, quarterly monitoring and annual evaluation reports should provide ample opportunity to address any unforeseen or uncontrollable changes. The on-site location of the IM shields the general public and the environment from any problems associated with equipment malfunction or unexpected discharge. The operating equipment can also be maintained in a secure, protected area to avoid tampering or vandalism.

2. Performance

Groundwater extraction combined with PTA treatment is considered a best demonstrated available technology (BDAT) for volatile organic constituents (VOC) such as TCE and TCA. Further, over 3-1/2 years successful experience with the current IM consisting of groundwater extraction and PTA treatment confirms the applicability of this technology to the Sparton site.

The ability of this system to achieve significant reduction in contaminant concentration coupled with the location in the area of maximum constituent concentration should provide an effective source removal/groundwater remediation tool. As previously demonstrated, the IM system performance can also be easily monitored through the numerous available sampling points existing at the Sparton site.

3. Reliability

The recommended alternative consists of proven, state-of-the-art technologies that have been designated BDATS. It should be noted that the IM has been operated for over 3-1/2 years without any difficulty or breakdown of any kind. There has been no evidence of any decrease in system performance.

4. Implementability

Since the IM system is already in operation, there are no implementability concerns or restrictions.

5. Summary

The recommended corrective measure alternative is a synergistic combination of proven technologies capable of achieving significant reductions in contaminant levels in an efficient, cost-effective manner. Continued operation of the IM will meet the requirements for source control and restoration of groundwater quality at this site. Continued monitoring over the operation period of this alternative will provide ample opportunity to assess the need, if any, for additional measures beyond the recommended system. Any new development in off-site areas will also be periodically evaluated during the operational period relative to potential receptor/exposure pathways. Any significant increase in risk or threat resultant from unexpected off-site development may require additional corrective measure studies.

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