Remedial Action Summary for Plant 2
FUSRAP St. Louis Downtown Site,
St. Louis, Missouri

Submitted to:

Department of the Army
U.S. Army Corps of Engineers
Kansas City District
700 Federal Building
601 East 12th Street
Kansas City, Missouri 64106

Department of the Army
U.S. Army Corps of Engineers
St. Louis District
FUSRAP Project Office
9170 Latty Avenue
Berkeley, Missouri 63134

Submitted by:

IT CORPORATION
A Member of The IT Group

IT Corporation
500 Northwest Plaza, Suite 820
St. Ann, Missouri 63074

September 27, 2000

Revision 0

Table of Contents

Table of Contents (Continued)

List of Tables

List of Figures

List of Acronyms and Abbreviations

AEC	U.S. Atomic Energy Commission
bgs	below ground surface
CEMVS	U.S. Army Corps of Engineers, St. Louis District
COC(s)	contaminant(s) of concern
CQCP	Contractor Quality Control Plan
DOE	U.S. Department of Energy
EE/CA	engineering evaluation/cost analysis
FUSRAP	Formerly Utilized Sites Remedial Action Program
ft	feet
ft^3	cubic feet
HAZWOPER	Hazardous Waste Operations and Emergency Response
in.	inch(es)
IT	IT Corporation
lb	pound
MARSSIM	*Multi-Agency Radiation Survey and Site Investigation Manual*
MED	Manhattan Engineering District
mg/kg	milligrams per kilogram
MI	Mallinckrodt Inc.
pCi/g	pico Curies per gram
PRAR	Post-Remedial Action Report
RAOs	remedial action objectives
RAS	Remedial Action Summary
RI	remedial investigation
RCRA	Resource Conservation and Recovery Act
ROD	Record of Decision
SAIC	Science Applications International Corporation
SLDS	Saint Louis Downtown Site
SOR	sum of ratios
SSHP	Site Safety and Health Plan
TERC	Total Environmental Restoration Contract
TLD	thermoluminesent dosimeters
USACE	U.S. Army Corps of Engineers
WASD	Work Area-Specific Description
yd^3	cubic yards

1.0 Introduction

This Remedial Action Summary (RAS) presents a description of remedial action activities conducted at Plant 2 at the St. Louis Downtown Site (SLDS) under the Formerly Utilized Sites Remedial Action Program (FUSRAP). This RAS has been prepared on behalf of the U.S. Army Corps of Engineers (USACE), St. Louis District, under the Total Environmental Restoration Contract No. DACW41-98-D9006, Task Order 0002. The scope of work for Task Order 0002 is the remediation of the FUSRAP SLDS according to the provisions and criteria set forth in the *Record of Decision for the St. Louis Downtown Site, St. Louis Missouri* (ROD) (CEMVS, 1998a). The selected remedy in the ROD calls for the excavation and offsite disposal of accessible, above-ROD-cleanup-criteria soils that are attributable to work performed in support of the Manhattan Engineer District (MED) and its successor the U.S. Atomic Energy Commission (AEC). The primary Contaminants of Concern (COC) at the SLDS Plant 2 are radium, thorium, and uranium.

Plant 2 is one of 13 separate work areas within the SLDS and was the second work area to be remediated under the ROD (CEMVS, 1998a). The scope of work for the remedial action at Plant 2 was the removal of all accessible soil containing radionuclides at concentrations above the ROD-specified remediation criteria. Remedial action activities (i.e., design through backfilling and site restoration) were conducted between October 1998 and August 2000.

This RAS has been organized into seven sections in conformance with the U.S. Environmental Protection Agency guidance contained in *9355.0-39FS, Remedial Action Report – Documentation for Operable Unit Completion* (EPA, 1992). The contents of each section are discussed below.

Section 1.0 – Introduction

– Presents an introduction to this RAS summarizing the objective and scope, description of Plant 2, and previous investigations.

Section 2.0 – Chronology of Plant 2 Remedial Action Events

– Summarizes the sequencing of remedial activities beginning with remedial design activities through backfilling and site restoration.

Section 3.0 – Performance Standards and Construction Quality Control

– Describes the performance standards and construction quality control measures implemented during the excavation and confirmation sampling activities. Deviations from performance standards are also discussed.

Section 4.0 – Construction Activities

– Presents a summary of the remedial action construction activities, including methods, equipment, contamination control measures, and lessons learned.

Section 5.0 – Final Inspection

– Identifies those final inspection activities that were performed.

Section 6.0 – Summary of Project Costs

– Describes the budgeted and actual costs and cost-variance factors.

Section 7.0 – References

– Provides a list of references used in this RAS.

The guidance (EPA, 1992) also recommends that two additional criteria be addressed in documenting completion of remedial activities. These criteria are (1) certification that the remedy is operational and functional and (2) a discussion of operation and maintenance requirements. These two criteria are intended for ongoing remedial actions, such as ground-water removal and treatment. The remedial action completed at Plant 2 involved restricted and unrestricted release; there were no remedial systems installed for ongoing, active remediation. Accessible soils above ROD remediation criteria have been removed, and COC concentrations in the remaining in-situ soil have been documented to be below ROD remediation criteria. Therefore, these two criteria have been omitted from further discussion in this RAS.

The following sections summarize the Plant 2 work area location, background (including previous studies), remedial action objectives, and COC criteria.

1.1 Location

The SLDS resides within a heavily industrialized area on the eastern border of St. Louis, 300 feet (ft) west of the Mississippi River (Figure 1-1). The SLDS is comprised of a large chemical-manufacturing complex owned and operated by Mallinckrodt Inc. plus adjacent commercial and city-owned properties. Manufacturing plants, support facilities, and administrative buildings cover a large portion of the SLDS, and several railroad tracks traverse north south through the SLDS. Plant 2 consists of approximately one city block bordered by Mallinckrodt Street and Destrehan Street to the north and south and , North Second Avenue and Norfolk and Western Railroad to the west, Hall Street and St. Louis Terminal Railroad Association to the east (Figure 1-2).

The Plant 2 area is one of 13 remedial work areas within the SLDS. Eight separate areas of contamination were identified within Plant 2. These areas include the following:

- The main excavation
- Area 1 at the Potassium Chloride Tank
- Area 2 near the east man door at building 501
- Area 3 at the southeast corner of Building 501
- Area 4 near the southeast corner of Building 506
- Area 5 between Building 509 and 507
- Area 6 north of the old Building 50 foundation.
- Area 7 east of building 508

The main excavation is addressed in the *Plant 2 Remedial Action Work-Area Specific Description and Design Package* (WASD) (IT, 1999a); Areas 1 through 5 are addressed in the *Remedial Action Work Description for Isolated Areas of Elevated Radiological Activity, Plants 1 and 2 St. Louis Downtown Site St. Louis, Missouri* (IT, 2000). Prior to beginning remedial action activities, the USACE extended the Plant 5 boundary to include Area 3. As a result, Area 3 was eliminated from the Plant 2 scope of work. Area 7 was remediated by Mallinckrodt during an earlier construction project. A final status survey sample collected from this area verified that the remaining soils were below ROD remediation criteria.

1.2 Background

Mallinckrodt Inc. (formerly Mallinckrodt Chemical Works) has operated a chemical/pharmaceutical facility at the SLDS continuously since 1867. From 1942 until 1957, Mallinckrodt was contracted by MED and its successor, the AEC, to process uranium ore for the production of uranium metal. Residuals of the process, including spent pitchblende ore, process chemicals and radium, thorium, and uranium, were inadvertently released from the Mallinckrodt facility into the environment through handling and disposal practices. From 1942 to 1945, Plants 1, 2, and 4 (now Plant 10) (Figure 1-2) were involved in the development of uranium-processing techniques, uranium compounds and metal production, and uranium metal recovery from residues and scrap. Mallinckrodt decontaminated Plants 1 and 2 between 1948 through 1950 to meet the AEC criteria then in effect. The AEC released the plants for use without radiological restrictions in 1951.

An initial radiological survey of the site was completed in 1977 by Oak Ridge National Laboratory (ORNL, 1981). The results of the survey showed that alpha and beta-gamma contamination levels exceeded guidelines for the release of the SLDS without radiological restrictions. Based on the results of the radiological survey, Bechtel National, Inc. completed a remedial investigation (RI) between 1986 and 1990. The site investigations were documented in *Radiological, Chemical, and Hydrogeological Characterization Report for the St. Louis Downtown Site in St. Louis, Missouri* (BNI, 1990) and the *Remedial Investigation Report for the St. Louis Downtown Site, St. Louis, Missouri* (BNI, 1994). These reports identified radiological contamination across the SLDS consisting primarily of radium-226, thorium-230, thorium-232, and uranium-238. During the RI, surface and subsurface soil samples were collected for analysis of radiological and chemical parameters. Soil sample characterization results indicated levels of radioactivity exceeding U.S. Department of Energy (DOE) guidelines for radium-226, thorium-230, thorium-232, and uranium-238 in 19 of 24 boreholes (BNI, 1994) within the SLDS. Chemical characterization results indicated that in general, hazardous characteristics as defined by the Resource Conservation and Recovery Act were not exhibited. An addendum to the RI was published in 1995 (SAIC, 1995) that presents additional characterization data collected after 1991.

An engineering evaluation/cost analysis (EE/CA) was completed by the DOE (1991) to determine appropriate interim remedial actions at four locations at the SLDS. Based on the results of the EE/CA, four interim actions were performed. Interim actions included the decontamination and demolition of the 50 Series buildings within Plant 2 during 1994 and 1995. The concrete rubble resulting from the demolition activities has been stored within the SLDS for possible use as excavation deep backfill material.

Within the Plant 2 area, Mallinckrodt has constructed a number of new buildings and facilities. In the early 1990's, Buildings 509 and 510 were constructed over areas that were identified during the RI as being radiologically affected. Mallinckrodt stated that much of the radiologically impacted soils were removed under the new building footprints during construction.

As a result of characterization of the soil, ground water, surface water, sediment, air, and structures associated with the SLDS, radiological contamination was determined to be present on buildings, in surface and subsurface soils and groundwater, including inaccessible soils under buildings, roads, and railroads. Science Applications International Corporation (SAIC) developed a three-dimensional model of the SLDS site in 1997/1998 to calculate volumes of radiological contaminated soils for various remedial action alternatives in the feasibility study (CEMVS, 1998b). The model interpolates concentrations of each radionuclide by location and depth. This model and the results of the Pre-Design Investigation Report (SAIC, 1998) served as the basis for Plant 2 remedial design activities.

Selective excavation and disposal was identified in the ROD (CEMVS, 1998a) as the preferred remedy at the SLDS. This remedy was implemented at Plant 2.

1.3 Remedial Action Objectives

Remedial action objectives (RAOs) specify media-specific COCs, potential exposure pathways, and remediation goals. The ROD (CEMVS, 1998a) established the RAOs for the remedial actions at the SLDS. These same RAOs are applicable for Plant 2. The RAOs are listed in Table 1-1.

1.4 Contaminants of Concern

Soil COCs for the SLDS were identified in the ROD (CEMVS, 1998a). The COCs at Plant 2 consist of both radionuclides and metals. Identified radionuclide COCs are: radium-226, radium-228, thorium-230, thorium-232, uranium-238, and decay products of uranium-235 and uranium-238 (including actinium-227 and protactinium-231). Metal COCs in soils are arsenic and cadmium. The ROD established radiological soil remediation criteria for COCs at three separate depth intervals. Remediation criteria are based on the sum of ratio (SOR) method, where the combined concentration ratios of the radioisotope COCs must be less than one. The SOR equations for the three depth intervals are (all concentrations are expressed as picoCuries per gram):

For the upper 6-inches (in.) the SOR equation is:

$$\frac{\text{greater of Ra - 226 or Th - 230}}{5} + \frac{\text{greater of Ra - 228 or Th - 232}}{5} + \frac{\text{U - 238}}{50}\left(\text{all isotopes above background}\right) < 1$$

For soils from 6 in. to 6 ft:

$$\frac{\text{greater of Ra - 226 or Th - 230}}{15} + \frac{\text{greater of Ra - 228 or Th - 232}}{15} + \frac{\text{U - 238}}{50}\left(\text{all isotopes above background}\right) < 1$$

For soils deeper than 6 ft

$$\frac{\text{Ra} - 226}{50} + \frac{\text{Th - 230}}{100} + \frac{\text{U - 238}}{150}\left(\text{all isotopes above background}\right) < 1$$

The ROD also established deep soil remediation criteria for arsenic and cadmium at 2,500 mg/kg and 400 mg/kg, respectively.

2.0 Chronology of Plant 2 Remedial Action Events

This chapter presents the chronology of remedial action activities for Plant 2. The principle remedial action activities conducted at Plant 2 included remedial design, site preparation (i.e., removal of cover material), excavation, verification sampling to evaluate levels of radionuclides remaining in situ following initial excavation efforts, additional excavation and additional verification sampling, Final Status Survey sampling to verify that remaining soils are below remediation criteria, backfill placement and testing, and site restoration activities (e.g., repaving). The chronology of these activities is presented in Table 2-1. Descriptions of remedial action construction activities are presented in Section 4.0, Construction Activities.

2.1 Remedial Design

IT Corporation (IT) conducted remedial design activities between October 1998 and August 2000. In February 1999, the initial design approach was documented in Revision 0 of the Plant 2 WASD. Before actual excavation work began, however, a method of precision excavation was identified that would allow for more cost-effective removal and segregation of above- and below-ROD-remediation criteria soils than the approach proposed in Revision 0. As a result, Revision 1 of the Plant 2 WASD was prepared and published in February 1999 to incorporate the precision excavation method. In October 1999, Revision 2 of the Plant 2 WASD was published to incorporate numerous design modifications necessitated by actual field conditions (Section 3.4).

During the remedial design effort, the Plant 2 work area was segregated into one main excavation and five smaller excavation areas (Figure 2-1). This was done based on the three-dimensional model interpretation of the occurrence of soils above ROD remediation criteria and results of the Pre-Design Investigation (SAIC, 1998). Area 3 was reclassified as inside the Plant 5 boundaries and will be addressed during the remediation of Plant 5.

2.2 Pre-Construction Activities

Pre-construction activities consisted of interacting with municipalities and utility companies, preparing the area, performing existing location and elevation surveys, and performing radiation field surveys. These activities were completed prior to commencing construction activities and are described in the following sections.

2.2.1 Utility Identification

Missouri One Call and MI were contacted to aid in determining the presence of utility lines in the excavation areas. Four MI- owned sewer lines were identified: one traversing north to south and three traversing east to west (one through the middle of the main excavation, one along the southern edge and one along the northern edge of the main excavation). Two MI-owned sprinkler lines, one running north to south and one running east to west in the main excavation were also identified (Figure 1-3).

2.2.2 Area Preparation

Area preparation activities were completed between December 1998 and January 1999. As part of these activities, the Plant 2 main excavation work area was fenced and cleared of cover material prior to performing radiological survey work (Section 2.2.4). Following the survey work, the foundations of Buildings 50, 51, and 52 were removed. Material above ROD remediation criteria (building foundation rubble, pavement, and cover material) was staged at the Material Handling Building and gradually added to the excavated soils for transportation to Envirocare of Utah, a permitted low-level radioactive waste disposal facility. Area preparation also included installation of sheet piling along Building 510 for foundation support.

2.2.3 Locational Surveys

An initial locational survey was completed by Zambrana Engineering in October 1998 to establish area excavation boundaries as presented in Appendix D of the Plant 2 WASD (IT, 1999a) and the *Remedial Action Work Description for Isolated Areas of Elevated Radiological Activity, Plants 1 and 2* (IT, 2000). Additional survey work then continued throughout remedial activities to map the actual excavation boundaries (vertical and horizontal) and existing conditions, support construction, perform subsidence surveys, and determine final status survey sampling locations.

2.2.4 *Radiological Field Surveys*

Prior to Buildings 50, 51, and 52 foundation demolition, radiological field surveys were conducted to determine the magnitude and extent of radiological contamination on the 50 Series building foundations. In order to eliminate the spread of contamination during foundation removal, fixed and loose contamination was detected and painted. Buildings 50, 51 and 52 foundations were then removed. Additional radiological field surveys were then conducted to determine which portions of the foundation material were potentially suitable for use as deep backfill in accordance with the ROD (CEMVS, 1998a) and which portions would require off-site disposal.

2.3 *Excavation Activities*

Excavation of soils began on February 18, 1999 and was completed in March 2000. An estimated 9,659 yd^3 of in-situ soil were excavated (Figure 2-1). An estimated 10,210 yd^3 of loose soil were transported by railcar to the Envirocare of Utah, a permitted low-level radioactive waste disposal facility. Descriptions of excavation activities are presented in Section 4.0 of this RAS. Following excavation activities within an individual excavation area, surface radiation surveys and verification sampling were conducted to determine whether the excavation area was ready for the Final Status Survey. The Data Quality Assessment Survey, included in Appendix B of this document, was completed by a USACE contractor to confirm that all in-situ radiological COC concentrations were below ROD remediation criteria.

2.4 *Utility Modifications*

Numerous utility modifications were required before, during, and after excavation activities. These modifications included temporary plugging, temporary work-arounds, and/or reinstallation of the following:

- East-west sewer line through the middle of the main excavation
- East-west sewer line along the southern edge of the main excavation
- North-south sewer line
- Sprinkler piping water lines

The east-west sewer located in the middle of the main excavation was anticipated to only require a simple plug on the east-west line (see Figure 1-3). The east-west sewer line along the northern edge of the main excavation was deemed critical to Mallinckrodt operations and rerouting was not feasible. The north-south sewer line required work-around rerouting to maintain operation during excavation. Well-point dewatering was implemented near the north end of the north-south sewer line to minimize effluent seepage into the excavation. Excavation activities were sequenced to minimize exposure of the sewer lines during remediation. The sprinkler piping water lines were temporarily plugged and a work-around installed with minimal disruption to the fire protection system.

2.5 Backfilling Activities

Backfilling activities began on November 29, 1999, following backfill approval from the USACE. As discussed in more detail in Section 3.1.2, portions of stockpiled crushed concrete, brick, and/or cinder block from previously demolished Mallinckrodt buildings (i.e., crushate) were determined to meet all ROD criteria. Approximately 5,700 yd^3 of crushate was placed as deep backfill in the Plant 2 main excavation from total depth to 6 ft bgs. The crushate was radiologically surveyed prior to placement to assure no pockets of crushate with elevated radiological contamination were used as backfill. Clean off site borrow material or commercially available crushed aggregate was placed from 6 feet below ground surface to the level of the crushed aggregate base course for the new pavement. Commercially available crushed aggregate was also used as deep backfill material when the crushate supply was exhausted.

2.6 Site Restoration

Site restoration activities at the Plant 2 work areas were completed on August 2000. Site restoration activities included removal of fencing, removal of sheet pile, reconnection of utilities, paving, and grading.

2.7 Significant Events During Remedial Action

During remedial actions at the Plant 2 areas, such unexpected events occurred as the breaching of unidentified underground utility lines, collection of greater-than-anticipated quantities of ground water, and the discovery of ordnance. During remediation of the main excavation area in Plant 2, multiple utility lines were encountered that were not previously identified by any Missouri utility company or Mallinckrodt. Leaking sewer lines also became a concern during the Plant 2 main excavation, at times causing remediation delays due to excessive water accumulation in the excavation. In addition, the sewer lines proved to be more difficult to plug than anticipated, which added to the delays. During soil removal at the main excavation, ordnance was unexpectedly discovered within the excavation boundaries. Work was halted and safety specialists from the USACE St. Louis and Huntsville Districts, the St. Louis Police Department's Bomb Squad and Arson Squad, and MI were called in to safely extract the nearly 150-year-old ordnance. Over a five-month period, 58 pieces of ordnance were eventually removed and disposed of by the Bomb and Arson Squad. A permanent brass marker was placed on the pavement surface to identify the location of ordinances left in place beyond the excavation limits. These and additional events that occurred during remedial action are discussed in Section 4.3, Lessons Learned.

3.0 Performance Standards and Construction Quality Control

This section of the RAS presents the remedial action performance standards used during the remedial activities and provides documentation that the remedial action activities completed at Plant 2 met the requirements of the ROD (CEMVS, 1998a) and the remedial design. In addition, construction quality control implementation and deviations from planning documents are discussed.

3.1 Record of Decision Performance Standards

The ROD (CEMVS, 1998a) specifies a number of requirements for the successful completion of remedial actions at the SLDS. The requirements include meeting COC-specific cleanup levels, meeting backfill material requirements, and conducting a post-remediation risk assessment. Constituent of concern-specific cleanup levels and backfilling requirements are presented below. The post-remediation risk assessment is addressed in Appendix B of this Post-Remedial Action Report (PRAR).

3.1.1 Contaminant of Concern Concentration Compliance

As discussed in Section 1.4, SLDS Plant 2 COCs include radionuclides and metals. Identified COCs are: radium-226, radium-228, thorium-230, thorium-232, and uranium-238, their decay products (including actinium-227 and protactinium-231), and arsenic and cadmium. The ROD (CEMVS, 1998a) established radiological soil remediation criteria for COCs and established that the combined concentration ratios of the radioisotope COCs must be less than one (SOR method, see Section 1.4). In addition, individual metals COC cleanup levels were established. Plant 2 remediation criteria are listed on Table 1-2.

The ROD (CEMVS, 1998a) also required that compliance with the soil remediation criteria be demonstrated using methods that are compatible with the *Multi-Agency Radiation Survey and Site Investigation Manual* (MARSSIM) (DOD et al., 1997). The MARSSIM protocols were implemented through the *Radiological Final Status Survey Plan for Accessible Soils within Plant 1, Plant 2 and the City Property at the St. Louis Downtown Site* (CEMVS, 1999a). Documentation of compliance with the MARSSIM protocol and Final Status Survey results and field activities at Plant 2 is provided in Appendix B of this PRAR.

3.1.2 Backfill Requirements

The ROD (CEMVS, 1998a) specifies that deep (greater than 6 ft bgs) backfill consist of material that does not exceed the deep-soil criteria (risk-based) or exhibit a hazardous characteristic. The ROD also specifies that only approved off-site borrow material be used for shallow backfill in Plant 2. In order to meet these ROD-specified criteria, the Plant 2 deep backfill consisted of a combination of previously excavated below-ROD-cleanup-criteria soil and crushed concrete, brick, and/or cinder block from previously demolished 700 Series and/or 50 Series buildings (i.e., crushate) determined to meet ROD deep backfill criteria. Prior to use, both the crushate and the off-site borrow backfill materials were tested for hazardous characteristics and radionuclide concentrations and met all applicable parameters. The specific tests conducted on the backfill materials are listed in Table 3-1. Testing results demonstrated that crushate met Environmental Protection Agency promulgated 5/15 remediation criteria for unrestricted release of the areas involved, and off-site borrow backfill material met all relevant requirements for unrestricted site release.

3.2 Design Requirements

Design requirements were identified in Appendix B of the Plant 2 WASD (IT, 1999a). Specific design requirements, in addition to requirements discussed in Section 3.1 above, are listed in Table 3-2. As shown in Table 3-2, the design requirements were satisfied.

During the Plant 2 remedial action activities, several design changes were implemented as a result of the actual field conditions encountered. Various difficulties were experienced during the remedial action activities, such as utility breaks, lack of availability of plumbers and pipefitters with 40-hour Hazardous Waste Operations and Emergency Response (HAZWOPER) and Radworker training, contamination extending deeper and further laterally than planned, all of which required design changes. The design requirements such as the maintenance of safe excavation slopes and the integrity of structural foundations, water management, and other topics addressed in the original WASD remained unchanged. An engineering-during construction effort was maintained to ensure that the original design requirements stated in the WASD were maintained as the details of implementation were changed. These changes were documented in Field Work Variances as discussed in Section 3.4.

3.3 Quality Control

The *Contractor Quality Control Plan, FUSRAP St. Louis Downtown Site, St. Louis Missouri* (CQCP) (IT, 1999b) was the quality controlling document for remedial actions at Plant 2. The

CQCP was implemented through a three-phase inspection system and associated checklists. The three-phase inspection system consisted of Preparatory, Initial, and Follow-up Inspections of each definable feature of work. The objective of the Preparatory Inspection was to establish and document that required preliminary activities necessary to start an activity had been completed. Preparatory Inspections were documented on a Preparatory Inspection form, were filed, and are retained in the Total Environmental Restoration Contract (TERC) Central Files maintained by IT, Kansas City.

Initial Inspections were conducted at the start of key work items to document that the work was initiated in accordance with the specified requirements. Initial Inspections were documented on an Initial Inspection form, were filed, and are retained in the TERC Central Files maintained by IT, Kansas City.

Follow-up Inspections on work activities were completed to document that work activities continued to be performed in accordance with specified requirements. Follow-up Inspections were documented in the Daily Quality Control Report. Documentation of all inspections and are retained in the TERC Central Files maintained by IT, Kansas City.

Field Work Variances were utilized as the official mechanism to implement and document changes to the WASD (IT, 1999a) design document and were approved by the USACE before the change was implemented in the field. Field Work Variances were documented on the Field Work Variance Log and are retained in the TERC Central Files maintained by IT, Kansas City.
The definable features of work for the Plant 2 remedial action fall under these catagories:

- Site Preparation
- Plant 2 Excavation
- Utility Modification and Rerouting
- Ordnance Operations
- Site Backfill and Restoration

During Plant 2 remedial action activities, no quality control audits were performed and nine Non-Conformance Reports were issued and are retained in the TERC Central Files maintained by IT, Kansas City. Twenty-three Field Work Variances to the Plant 2 WASD (IT, 1999a) were proposed, approved, and documented in the Field Work Variance Log. Any deviations to the Plant 2 WASD (IT, 1999a) were correctly documented as Field Work Variances. Remedies to document changes to plans are discussed in Section 4.3.

4.0 Construction Activities

This section summarizes the remedial action construction activities completed at Plant 2, from the initial excavation boundary surveying through final grading and repaving. It also states the volume of material excavated and transported for disposal, explains the contamination-control measures implemented, and discusses lessons learned during this remedial action. Major construction equipment used to perform the work is listed in Table 4-1.

4.1 Remedial Activities

Prior to beginning excavation activities, the excavation limits as defined in the design (see Figure 2-1) were located by a surveyor and marked in the field. Initial excavation began in the main excavation (see Figure 2-1). Soil was removed to design excavation depths using a track excavator and then loaded into haulers. The soil was then transported either to the Material Handling Building for conditioning prior to placement at the loadout facility or transported directly to the loadout facility located on the eastern edge of Plant 7S and loaded into railcars. Soil removal within an excavation area continued until the base of the design excavation depth limit was reached.

Once the design excavation depth limit was attained, surface radiological screening was conducted in accordance with the Final Status Survey Plan for Plants 1 and 2 and the SLDS City Property (CEMVS, 1999a) to determine if radiologically impacted soil had been removed to ROD remediation criteria. If the screening identified surface contamination, additional soil was removed until the surface screening confirmation was achieved.

Once acceptable surface screening results were achieved, soil samples were collected from the bottom and sides of the excavation for analysis at the on-site field laboratory. If soil sample laboratory analysis results indicated radionuclide concentrations above ROD remediation criteria, the areas were re-excavated and resampled. When radionuclide concentrations in an area were identified as being below ROD remediation criteria, the USACE was notified that the excavation area was available for Class 1 Final Status Survey sampling. The excavation-base elevation contours and excavation limits are shown in Figure 2-1.

Two small additional areas of soil in the southeast corner of the main excavation and the northwest corner of the main excavation were found to have radionuclide concentrations exceeding ROD remediation criteria and all accessible soil was subsequently excavated. A total of 10,660 loose cubic yards (yd^3) of soil was removed from Plant 2. A summary of excavated soil volumes is provided on Table 4-2.

Excavated soil transported to the soil storage and loadout facility was loaded into lined railcars for transport to and disposal at Envirocare of Utah, a low-level radioactive waste disposal facility. A liner of reinforced polyethylene was draped over the inside of the railcar. The liner was of sufficient size to allow for the sides and ends to be overlapped and secured on top of the loaded railcar. This created a complete enclosure of the contaminated soil for transport, thus preventing releases to the environment and exposure to weather. A total of 17,518 tons of excavated material was sent to Envirocare for disposal. All required Envirocare railcar manifesting and waste documentation was prepared prior to the release of each rail car for transport and are retained in the TERC Central Files maintained by IT, Kansas City. Following demonstration that soils above ROD remediation criteria had been removed, IT received authorization to backfill from the USACE. Backfilling operations consisted of placing approved deep backfill material into excavated areas in 8-in. lifts for cohesive soil and 12-in. lifts for non-cohesive soils and compacting. Backfill material consisted of general bank-run material classified as CL or CL-ML under the Unified Soil Classification System. During wet weather, commercially available crushed aggregate was used as an alternate backfill material. As discussed in Section 3.1.2, the crushate and off-site backfill material source were tested for hazardous characteristics and SLDS COCs as required by the ROD (CEMVS, 1998a).

Final Status Surveys were completed in Plant 2 MARSSIM Class 2 Areas as discussed in Appendix B of this PRAR. During this sampling, several small areas (see Figure 2-1) were identified that contained soils with COC concentrations above the ROD remediation criteria. These soils were removed and the location resampled to confirm that the soils were below ROD remediation criteria.

Following placement of general backfill material, a crushed-aggregate base course was placed and compacted. The Plant 2 area was then resurfaced with asphalt mix as specified in the WASD (IT, 1999a) to match the edges of the existing pavement.

4.2 *Contamination Control Measures*

Contamination control measures were used during the Plant 2 remedial action activities to minimize occupational exposure and protect the surrounding environment. Control measures included access restrictions, personnel and perimeter monitoring, storm-water and erosion-control measures, and dust control. The following sections discuss the contamination control measures implemented during the Plant 2 remedial action.

4.2.1 *Access Restrictions*

Access restrictions were implemented to prevent unauthorized entry into potentially hazardous areas. The restrictions implemented include the following:

- Restriction of traffic not directly related to the Plant 2 remediation effort
- Placement of temporary fencing and barricades and posting of warning signs around the work areas to exclude non-project-related pedestrian traffic and to prevent entrance during off-work hours
- Placement of barricades for radiological control and posting of radiological warning signs
- Designated personnel and vehicle entrance/exit control point

The following section discusses exposure monitoring conducted during remedial action activities at Plant 2.

4.2.2 *Exposure Monitoring*

During the remediation field effort, personal and perimeter air monitoring, noise monitoring, and radiation exposure monitoring were conducted to evaluate the potential for occupational and general public exposures Perimeter air monitoring was conducted by collecting daily air samples during excavation activities, near the Plant 2 excavations and at the soil storage and loadout facility. An offsite background sample was also collected on a weekly basis for comparison purposes. Details of the air sampling program are provided in the *Site Safety and Health Plan, FUSRAP St. Louis Downtown Site, St. Louis, Missouri* (SSHP) (IT, 1999c) and *Sampling and Analysis Program Plan for the St. Louis Downtown Sites* (CEMVS, 1999c). All results demonstrated that air emissions were within permissible limits. Air monitoring results are retained in the TERC Central Files maintained by IT, Kansas City.

In addition, various worker personal air samples were collected during excavation activities for analysis of radiological COCs and arsenic, cadmium, and lead. All results from the personal air sampling demonstrated that exposures were below action levels. Personal air sampling results are retained in the TERC Central Files maintained by IT, Kansas City.

Noise monitoring was conducted every six months during multiple phases of excavation operations. Details of the noise monitoring program are provided in the *Site Safety and Health Plan, FUSRAP St. Louis Downtown Site, St. Louis, Missouri* (SSHP) (IT, 1998c). All results demonstrated that noise levels were within permissible limits. Noise monitoring results are retained in the TERC Central Files maintained by IT, Kansas City..

In order to obtain a representative sample of dose, personnel entering the contamination area wore thermoluminesent dosimeters (TLDs). The TLDs indicated that radiation exposure to personnel were within the acceptable limits established in the SSHP (IT, 1999c). TLD results are retained in the TERC Central Files maintained by IT, Kansas City.

4.2.3 Storm-Water and Erosion Control

Storm-water and erosion-control measures were implemented in accordance with the Plant 2 WASD (IT, 1999a) and the *Environmental Protection Plan, FUSRAP St. Louis Downtown Site, St. Louis, Missouri* (IT, 1998e). The storm-water and erosion-control measures implemented included the use of sediment fences and containment ponds and placement of clean fill around the downslope edges of the excavations as added protection for runoff to be used as needed. Also, sandbags were placed on the pavement upstream of the excavation to prevent runoff from entering the excavation. Water was pumped out of the excavation into holding tanks staged in the area, and treated to meet MSD discharge criteria before being released. During light to moderate precipitation events, some pooling occurred in the excavation. During heavy precipitation events, extreme accumulation of water occurred.

4.2.4 Dust Control

Dust-control measures implemented at Plant 2 included both operational and administrative controls. Operational controls included:

- Minimizing material free-fall during transfer of soil from excavation equipment (loaders and excavators) to hauling units and/or stockpiles

- Performing dry decontamination of truck tires prior to departure of the vehicle from the excavation area

- Water-spraying haul roads

Administrative controls consisted of maintaining speed limits on haul roads.

4.2.5 Contamination Control

To prevent personnel contamination and contamination releases from the radiologically restricted excavation areas, several engineering controls were implemented during remedial activities as follows:

- All workers within a radiologically restricted area used modified Level-D personal protective equipment consisting of pants, sleeved shirts, hard hats, safety glasses, steel-toed boots, Tyvek, booties, overshoes, and gloves.

- All personal protective equipment was removed prior to exiting a radiologically restricted area.

- Decontamination stations were placed at the exit of radiologically restricted areas.

- All workers and equipment were surveyed for radiological contamination prior to exiting a radiologically restricted area.

- Vehicles were surveyed for contamination and dry decontaminated (if contaminated) before leaving a radiologically restricted area.

- Daily boundary surveys were performed at contamination area boundaries, and weekly haul-route surveys were performed to confirm that engineering controls were effective.

These controls are further detailed in the SSHP (IT, 1998c) and Materials Handling and Transportation Plan (IT, 1998f). In addition to the engineering controls, worker awareness of contamination control was heightened through daily safety meetings and specific worker training.

4.3 Lessons Learned

Many problems and challenges occurred during the Plant 2 remedial action activities. Some of the problems were unavoidable; others may have been avoided by alternate design or construction techniques. Experience gained from the Plant 2 remedial action shows that some of the "unavoidable" problems are at least predictable. While it may be difficult or impossible to design for many problem situations, designs can include contingency planning from lessons learned, resulting in lesser impacts and timely recovery from problems. Many other problems may be avoided through design and/or by altering construction techniques. The following sections discuss some of the significant problems and challenges that occurred during the Plant 2 activities, the lessons learned from them, and how these lessons have been implemented in subsequent design and remedial action activities.

4.3.1 Water Management

One of the many problems encountered during the activities at the Plant 2 work area was the quantity of water that required management. A less widespread but related problem was the detection of unexpected COCs in the water that resulted in treatment-process difficulties.

The quantity of water to be managed at the site was excessive for several reasons, the most significant of which are as follows:

- Seepage from existing site utilities
- Ruptured potable- and fire-suppression-system water lines
- Storm-water collection in open excavations
- Inadvertent treatment of saline wastewater at the treatment plant

4.3.1.1 Seepage from Utilities

Many sewers and water lines cross the Plant 2 site and contributed unwanted water to the excavation throughout the remedial action. Some of the excess water likely originated from old sewers that leaked when disturbed as the excavation approached or intercepted them. Due to sediment buildup in the sewers, it became difficult or impossible to use standard sewer plugs to isolate sewer lines. Consequently, stopping the flow of sewage from broken sewer lines and the construction of sewer by-pass systems was difficult. These factors resulted in significant quantities of water to manage. Grout was added to sewers and manholes to plug them when standard mechanical plugs failed. Though not the solution of choice, grouting was necessary at the time due to the inability to use mechanical plugs.

Possible future actions to avoid or lessen sewer problems include the use of sewer-system surveys to identify problem sections. Such surveys would ideally be performed during remedial design to allow solutions such as advance cleaning of manholes and/or pipes and the design/procurement of specialty plugs before beginning excavation.

4.3.1.2 Ruptured Water Lines

During the excavation, potable water and fire-suppression-system water lines ruptured from various causes. In one instance, an old fire-suppression-system water line spontaneously ruptured, possibly weakened by exposure to air. In other instances, construction equipment struck and burst buried pipes. The precise location and configuration of many of these lines were not known accurately in advance.

Advance reconnaissance and identification of line locations should be accomplished in the future by thorough review of existing plans, surveys with specialty line locating and geophysical equipment, and, if necessary, temporary, localized excavation to verify utility type and location. These techniques will allow advance line-rerouting design so that lines can be quickly exposed at the appointed time for reroute construction and the excavation quickly backfilled. This approach also will minimize the possibility of old lines spontaneously bursting from corrosion accelerated by exposure to air and accidental line breaks caused by excavation equipment. Additional techniques such as the periodic use of metal detectors and hand-digging by construction personnel during excavation near known lines will also help to avoid line breaks caused by equipment.

4.3.1.3 Storm-Water Collection

The large size of the open excavation also increased the amount of water collected from storms. Future designs will allow large excavations to be divided into manageable survey units. Individual units may be excavated, released, and backfilled sequentially before excavating the next unit.

At times, inadequate diversion of storm-water runoff added to the quantity of water to be managed. Immediate problems were corrected by the addition of sandbags where storm water drained into the excavation. Subsequent designs have included storm-water management plans that call for advance placement of sandbags and observation of the work site during storm events so that designs can be adjusted to allow for actual conditions.

4.3.1.4 Saline Wastewater

MI operations involving salt-tank cleaning inadvertently impacted the SLDS water treatment plant when saline sewer effluent seeped into the excavation through a failed grout sewer plug. When pumped out and sent to the water treatment plant, the saline water caused a regeneration of resin in the plant's ion-exchange system. This resulted in a higher concentration of dissolved radionuclides in the effluent than in the raw influent water. The immediate problem was handled by changing out the resin and mixing the remaining saline wastewater with non-saline water to diminish the salinity to non-critical levels.

In the future, water to be treated will be checked with a combination pH/conductivity meter to determine if the water is saline. Also, improved dialog with MI operational personnel will alert IT personnel to unusual occurrences that might have undesirable consequences.

4.3.2 Availability of Trained Work Force

The initial approach to obtaining 40-hour HAZWOPER- and Radworker-trained plumbers and pipefitters was to procure them from the local market without offering any government-sponsored training. These procurement efforts resulted in no qualified offers, which negatively affected the remedial action activities, forcing IT to focus excavation activities on areas away from utilities. To provide qualified workers, IT prepared a new solicitation that included government-sponsored training of the successful vendor. With this latter effort, properly trained plumbers and pipefitters were retained to staff the remedial effort, both for planned and emergency services. To avoid being without a qualified workforce in the future, IT will provide periodic training to subcontracted craft labor, as necessary, to maintain a qualified workforce.

4.3.3 Rail Traffic Management

Operational delays were experienced due to stopped trains blocking the roadway used for delivery and receipt of excavated material. The rail-line dispatcher was contacted and notified that a train was blocking an active roadway, and in the Plant 2 schedule and subsequent schedules haul times were modified to allow for such events.

4.3.4 Equipment Decontamination

Decontamination of haulers, water trucks, and water tanks became a time-consuming process due to muddy excavation conditions causing large amounts of contaminated muddy soil to adhere to surfaces. Coating the inside of the hauler beds and buying or leasing liners for the water trucks and water tanks will minimize the time required for the decontamination process.

4.3.5 Geotechnical Presence

The changing nature of the excavation required a continuous geotechnical review that was not always available locally. Geotechnical and other engineering services have now been procured from the local marketplace to ensure timely review of situations involving potential slope-stability and foundation-endangerment problems.

5.0 Final Inspection

IT Corporation scheduled and completed the final inspection of Plant 2 when repaving and final topographic surveys were complete. The final inspection confirmed that all construction activities had been completed in accordance with the design document with the exception of the asphalt grading. The asphalt was subsequently regraded to plan specifications. A final as-built map will be produced by IT showing post-remedial-action site conditions and submitted to the USACE.

6.0 Summary of Project Costs

This section presents the budgeted and actual costs for remedial activities at Plant 2. As illustrated in Table 6-1, the actual costs were approximately 1 percent higher than budgeted. Two factors contributed to this offset. The first factor is that transportation and disposal costs were approximately 37 percent under budget. Considerably fewer rail cars were needed to ship the excavated 10,210 yd^3 versus the estimated shipment of 19,600 yd^3. The second factor is that excavation and backfill were approximately 176 percent over budget, due to the following:

- Excavation was delayed for approximately three months due to the discovery of ordnance. Costs continued to accumulate during a time of no production. When the effort resumed, night work was required to reduce risk and, as a result, production slowed.

- Unexpected underground utilities and water-line breaks encountered at Plant 2 made water control and treatment a major portion of the Plant 2 effort. The magnitude of this work was not reflected in the original budget.

7.0 References

American Society for Testing and Materials (ASTM), 1997a, *Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3))*, D1557-91, West Conshohocken, PA.

American Society for Testing and Materials (ASTM), 1997b, *Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)*, D2487-98, West Conshohocken, PA.

American Society for Testing and Materials (ASTM), 1997c, *Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils*, D4318-98, West Conshohocken, PA.

American Society for Testing and Materials (ASTM), 1997d, *Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*, D2216-98, West Conshohocken, PA.

Bechtel National, Incorporated (BNI), 1994, *Remedial Investigation Report for the St. Louis Downtown Site, St. Louis, Missouri*, DOE/OR/21949-280, Oak Ridge, TN, January.

Bechtel National, Incorporated (BNI), 1990, *Radiological, Chemical, and Hydrogeological Characterization Report for the St. Louis Downtown Site in St. Louis, Missouri*, Revision 1, DOE/OR/20722-258, Oak Ridge, TN, September.

IT Corporation (IT), 1999a, *Plant 2 Remedial Action Work Area-Specific Description and Design Package, FUSRAP St. Louis Downtown Site, St. Louis, Missouri,* Revision 2, Overland Park, KS.

IT Corporation (IT), 1999b, *Contractor Quality Control Plan, FUSRAP St. Louis Downtown Site, St. Louis, Missouri*, Revision 1, Overland Park, KS.

IT Corporation (IT), 1999c, *Site Safety and Health Plan, FUSRAP St. Louis Downtown Site, St. Louis, Missouri*, Revision 1, Overland Park, KS.

IT Corporation (IT), 1999e, *Environmental Protection Plan, FUSRAP St. Louis Downtown Site, St. Louis, Missouri*, Revision 1, Overland Park, KS.

IT Corporation (IT), 1999f, *Materials Handling and Transportation Plan, FUSRAP St. Louis Downtown Site, St. Louis, Missouri*, Revision 1, Overland Park, KS.

IT Corporation (IT), 2000, *Remedial Action Work Description for Isolated Areas of Elevated Radiological Activity, Plants 1 and 2, St. Louis Downtown Site, St. Louis, Missouri,* Revision 1, Overland Park, KS.

Oak Ridge National Laboratory (ORNL), 1981, *Radiological Survey of the Mallinckrodt Chemical Works, St. Louis, Missouri*, DOE/EV-005/27, ORNL-5715, Oak Ridge, TN, December.

Science Applications International Corporation (SAIC), 1995, *Remedial Investigation Addendum for the St. Louis Site, St. Louis, Missouri*, DOE/OR/21950-132, September.

U.S Army Corps of Engineers, St. Louis District (CEMVS), 1999a, *Radiological Final Status Survey Plan for Accessible Soils at the St. Louis Downtown Site*, St. Louis, MO.

U.S Army Corps of Engineers, St. Louis District (CEMVS), 1999b, *Sampling and Analysis Program Plan for the St. Louis Site*, St. Louis, MO.

U.S. Army Corps of Engineers, St. Louis District (CEMVS), 1999c, *Sampling and Analysis Program Plan for the St. Louis Sites,* January, St. Louis, MO.

U.S. Army Corps of Engineers, St. Louis District (CEMVS), 1998, *Record of Decision for the St. Louis Downtown Site, St. Louis, Missouri*, Berkeley, MO.

U.S. Department of Defense, U.S. Department of Energy, U.S. Environmental Protection Agency, U.S. Nuclear Regulatory Commission (DOD et al.), 1997, *Multi-Agency Radiation Survey and Site Investigation Manual*, NUREG-1575, EPA 402-R-97-016, Washington DC.

U.S. Environmental Protection Agency (EPA), 1992, *9355.0-39FS, Remedial Action Report – Documentation for Operable Unit Completion*, Washington, D.C.

Tables

Table 1-1
Remedial Action Objectives for the St. Louis Downtown Site

Media	Remedial Action Objective
Soil	Prevent exposures from surface residual contamination in soils greater than limits prescribed by 40 Code of Federal Regulations Part 192. Eliminate or minimize the potential for humans or biota to contact, ingest, or inhale soil containing contaminants of concern (COCs). Eliminate or minimize volume, toxicity, and mobility of impacted soil. Eliminate or minimize the potential for migration of radioactive materials off site. Comply with applicable or relevant and appropriate requirements. Eliminate or minimize potential exposure to external gamma radiation.
Ground water	Remove sources of COCs in the upper, nonlithified soil unit. Continue to maintain low concentrations of COCs in the Mississippi Alluvial Aquifer.

U.S. Army Corps of Engineers, St. Louis District, 1998, *Record of Decision for the St. Louis Downtown Site, St. Louis, Missouri*, Berkeley, MO.

Table 1-2
ROD Remediation Criteria for Plant 2

Constituent of Concern	Surface Soil (<0.5 feet depth)	Shallow Soil[a] (0.5 to 6 feet depth)	Deep Soil (greater than 6 feet depth)
Radium-226 or Thorium-230[b]	5 pCi/g[c] above background	15 pCi/g above background	50 pCi/g above background of Radium-226
Radium-228 or Thorium-232[b]	5 pCi/g above background	15 pCi/g above background	100 pCi/g above background of Thorium-230
Uranium-238	50 pCi/g above background	50 pCi/g above background	150 pCi/g above background
Arsenic	60 mg/kg[d]	60 mg/kg	2,500 mg/kg
Cadmium	17 mg/kg	17 mg/kg	400 mg/kg

U.S. Army Corps of Engineers, St. Louis District, 1998, *Record of Decision for the St. Louis Downtown Site, St. Louis, Missouri*, Berkeley, MO.

[a] Shallow soils are defined by location. Shallow soils found in work areas west of the St. Louis Railroad Association tracks on Mallinckrodt Inc. property and at the locations of former locations of Buildings 116, 117, 704, 705, 706, and 707 are defined as 0.5 to 6 feet bgs. At all other locations shallow soils are defined as 0.5 to 4 feet bgs.

[b] Remediation criteria are based on the highest concentration of the two radionuclides.

[c] picoCuries per gram

[d] milligrams per kilogram

Table 2-1

Chronology of Plant 2 Remedial Action Activities

Dates	Activities
10/12/98 to 2/25/99	Preparation and Completion of Plant 2 WASD Rev 0 and Rev 1
1/11/99 to 1/29/99	Concrete Removal
2/3/99 to 2/11/99	Sheet Pile Installation
2/3/99 to 4/4/00	Plant 2 Excavation
3/19/99 to 5/30/00	Plant 2 Sampling
12/8/99 to 3/14/00	Plant 2 Area Restoration
MAIN EXCAVATION	
SURVEY UNIT 1	
12/2/98 to 12/7/98	Fencing
1/11/99 to 1/29/99	Area 2 Concrete Removal
2/18/99 to 8/27/99	Excavated Area 50/51
11/10/99 to 11/15/99	USACE Unexploded Ordnance Contractor mobilization
11/15/99 to 12/7/99	Excavation
2/3/99 to 2/11/99	Sheet Piling Installation (including tie backs)
11/29/99 to 12/6/99	Backfill South Side Pipe and Build Ramp
11/29/99 to 12/6/99	Confirmation/Verification Sampling/ Mapping
12/8/99 to 1/10/00	Backfill with Crushate to 6 feet bgs
3/28/00 to 4/20/00	Backfill to Surface
5/1/00 to 5/4/00	Place Sub-Base for Paving
5/18/00 to 5/19/00	Paving
5/19/00	Complete Survey Unit 1
SURVEY UNITS 2 AND 3	
12/14/99 to 12/15/99	Construct Sump and Drain near MH-217
12/15/99 to 12/15/99	Break Sewer at MH-217
12/21/99 to 12/21/99	Install Herculite in Survey Unit 1 and Survey Unit 2
1/24/00 to 1/24/00	Break Sewer at MH-219
5/22/00 to 5/23/00	Pave Survey Unit 2 – Phase 1
5/24/00 to 6/21/00	Pave Survey Unit 2 – Phase 2
STRIP 1	
12/7/99 to 1/12/00	Excavate
3/13/00 to 3/15/00	Backfill with Crushate to 6 feet bgs
3/16/00 to 4/10/00	Backfill to Surface
STRIP 2	
1/13/00 to 1/25/00	Excavate
3/13/00 to 3/15/00	Backfill with Crushate to 6 feet bgs
3/16/00 to 4/10/00	Backfill to Surface
STRIPS 3 AND 4	
1/24/00 to 2/8/00	Excavate
4/4/00 to 4/13/00	Backfill with Crushate to 6 feet bgs
4/20/00 to 4/27/00	Backfill to 4 feet bgs
4/27/00 to 5/16/00	Backfill to Surface

SE CORNER	
4/4/00 to 4/4/00	Excavate
4/17/00 to 4/19/00	Install New Sewer and Manhole to SE Corner
5/3/00 to 5/11/00	Install Fire Water Line in SE Corner
6/7/00 to 6/15/00	Remove/Reinstall Sewer and MH-219A
6/15/00 to 6/19/00	Backfill
NW CORNER	
6/27/00 to 7/21/00	Remediate and Backfill
AREA #4 – Building 506	
9/21/99 to 9/23/99	Site Preparation
9/23/99 to 9/28/99	Excavation
10/5/99 to 10/21/99	Backfill
10/27/99 to 10/27/99	Paving
AREA #5 – Building 507/509	
9/23/99 to 9/27/99	Site Preparation
9/28/99 to 9/30/99	Excavation
10/6/99 to 10/20/99	Backfill
10/27/99 to 10/27/99	Paving
AREA #2 – Building 501	
9/23/99 to 9/27/99	Site Preparation
10/5/99 to 10/5/99	Excavation
10/7/99 to 10/7/99	Backfill
10/27/99 to 10/27/99	Paving
AREA #1 – KCl Tank	
10/6/99 to 10/7/99	Site Preparation
10/11/99 to 1/25/00	Excavation
2/17/00 to 3/7/00	Backfill
3/8/00 to 3/14/00	Paving

Table 3-1
Plant 2 Backfill Test Parameters

American Society for Testing and Materials (ASTM) D2487, *Classification of Soils for Engineering Purposes (Unified Classification System)*, 1997b.
ASTM D4318, *Liquid Limit, Plastic Limit, and Plasticity Index of Soils,* 1997c.
ASTM D422, *Grain Size Analysis*
ASTM D2216, *Laboratory Determination of Water (Moisture) Content of Soil, and Rock,* 1997d.
Record of Decision contaminants of concern.
volatile organic compounds, semi-volatile organic compounds, pesticides, herbicides, and metal analyte list
ASTM D 1556 *Sand Cone Testing*
Alpha and Gamma Spectroscopy
pH, cyanide reactivity, and sulfide reactivity.

American Society for Testing and Materials (ASTM), 1997a, *Test Method for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3 (2,700 kN-m/m3))*, D1557-91, West Conshohocken, PA.

American Society for Testing and Materials (ASTM), 1997b, *Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)*, D2487-98, West Conshohocken, PA.

American Society for Testing and Materials (ASTM), 1997c, *Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils*, D4318-98, West Conshohocken, PA.

American Society for Testing and Materials (ASTM), 1997d, *Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass*, D2216-98, West Conshohocken, PA.

Table 3-2
Plant 2 Design Requirements

Design Requirement	Requirement Satisfied (Yes/No)
Notification to the Metropolitan St. Louis Sewer District that soil removal work will be completed in the vicinity of their sewer lines.	Yes
Notification to Mallinckrodt Inc. that soil removal activities will be completed.	Yes
Initial topographic survey to establish ground surface elevations.	Yes
Plant 2 work area will be graded smooth to conform with existing topography.	Yes
Final grade will be topographically surveyed to document final grading conditions.	Yes
Repave area	Yes

Table 4-1

Major Equipment Used During Plant 2 Remedial Activities

Air Compressor – 250 ft^3 per minute
Jack Hammer – 60 lb.
300E Ram-Hoe
Komatsu PC 300 Tracked Excavator with 2.75-yd^3 Bucket
3 – Hydrema-910 7.5-yd^3 Dump Trucks
2 – Terex Haulers
CAT 973 Track Loader
Vibratory Hammer
Ingersoll ProPac-Roller
John Deere 650G LPG Dozer
70-ft Boom Rubber-Tired Crane
CAT 426B 4WD Rubber-Tired Loader
4-in. and 6-in. Trash Pumps, Diesel Power
3 – 20,000-Gallon Tank
CAT 980 4WD, Articulated, Rubber-Tired Loader with 5.5-yd^3 Bucket with Bucket Scale
Water Treatment Plant

Table 4-2

Excavated Soil Volumes from Plant 2

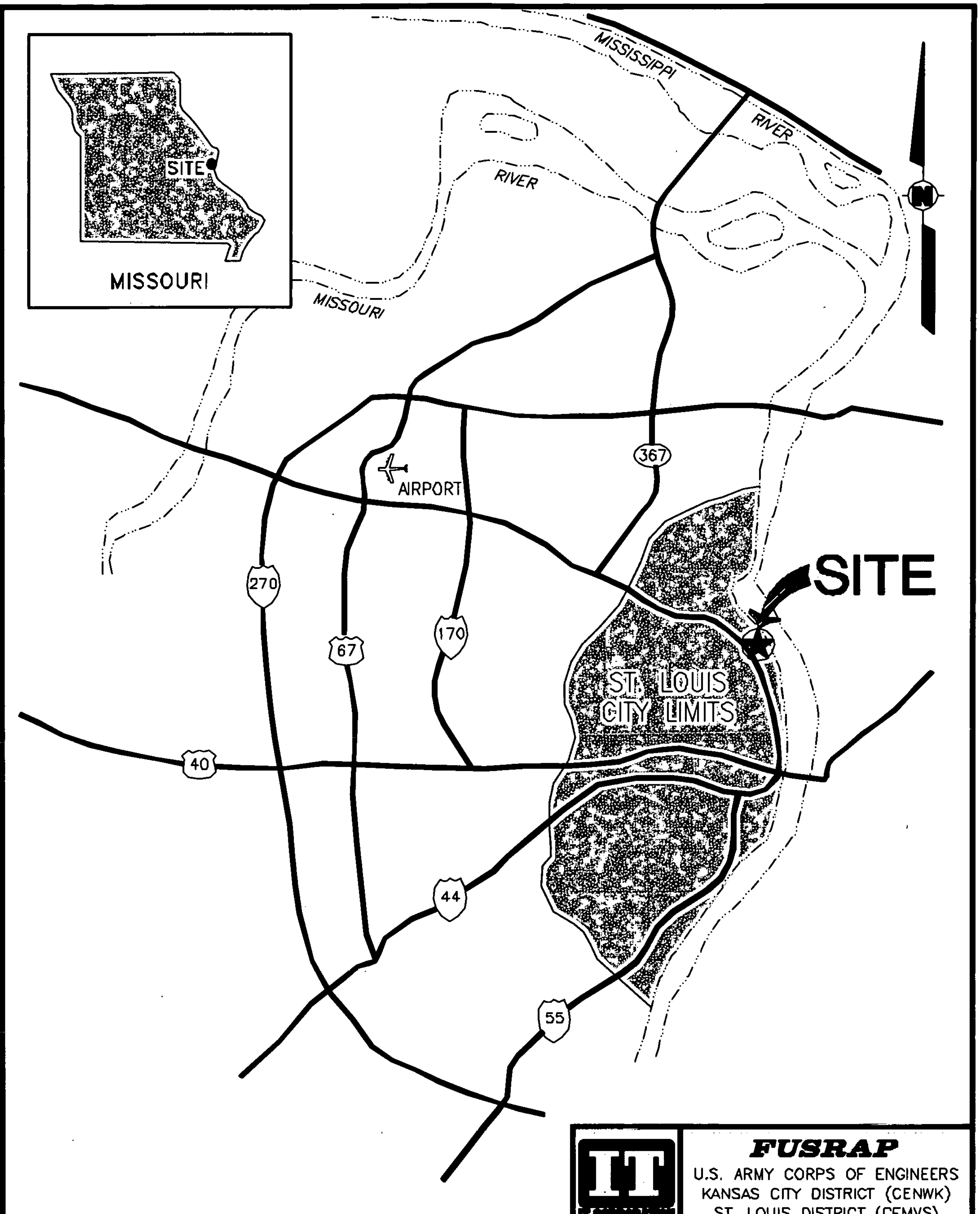
Excavation Area	In-Situ Volume (cubic yards)
Main Excavation	9,277
Area 1	239
Area 2	9
Area 4	16
Area 5	25
Area 6	93
Total	**9,659**

Table 6-1

Summary of Budgeted and Actual Costs for Remediation of Plant 2

Cost Item	Budgeted Costs	Actual Costs
Remedial Design	**$71,526**	**$88,518**
Monitoring, Sampling, Analysis	**$88,462**	**$16,764**
- Health and Safety	$22,115	$4,191
- Confirmatory Sampling	$44,232	$8,382
- Verification Sampling	$22,115	$4,191
Mobilization and Site Preparation	**$306,520**	**$181,359**
Excavation and Backfill	**$1,093,719**	**$3,023,830**[a]
Waste Management	**$4,999,315**	**$3,153,793**[a]
- Waste Treatment	$0	$0
- Waste Transportation	$2,983,315	$2,130,967[a]
- Waste Disposal	$2,016,000	$1,022,826[a]
Demolition and Decontamination	**$0**	**$0**
Total	**$6,559,542**	**$6,462,727**[a]

[a] estimated costs



"DO NOT SCALE THIS DRAWING"

FUSRAP

U.S. ARMY CORPS OF ENGINEERS
KANSAS CITY DISTRICT (CENWK)
ST. LOUIS DISTRICT (CEMVS)

IT CORPORATION

FIGURE 1-1

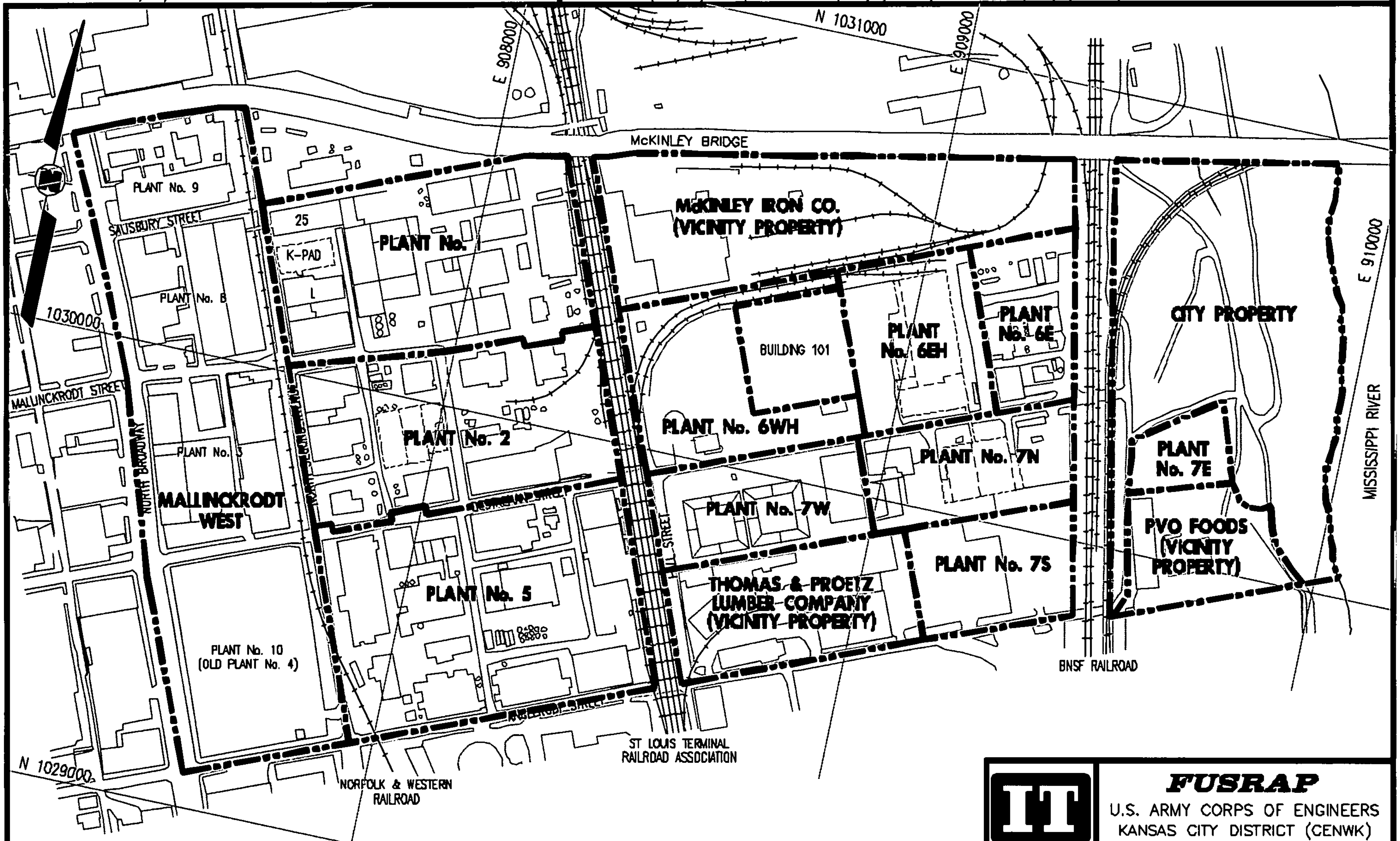
SITE LOCATION MAP
ST. LOUIS DOWNTOWN SITE
ST. LOUIS, MISSOURI

X-REF	DRAWN BY	CHECKED BY	APPROVED BY	DRAWING NUMBER
?	A. Smith 8/6/98	K. Matsumoto 6/11/99	D. Landon 6/11/99	775575-A5

PLOT DATE: 7/13/99
PLOT SCALE: 1 = 1

O:\Project\775575\Site Wide - Misc\775575a1.dwg
Plot Date/Time: 09/27/00 10:56am
Format Revised: 11/23/99

DRAWN BY		CHECKED BY		APPROVED BY		DRAWING NUMBER
A. Smith	7/28/98	K. Axstell	1/8/99	D. Deloye	1/8/99	775575-A1



LEGEND:

LIMITS OF WORK AREAS

SCALE

0 300 600 FEET

IT CORPORATION

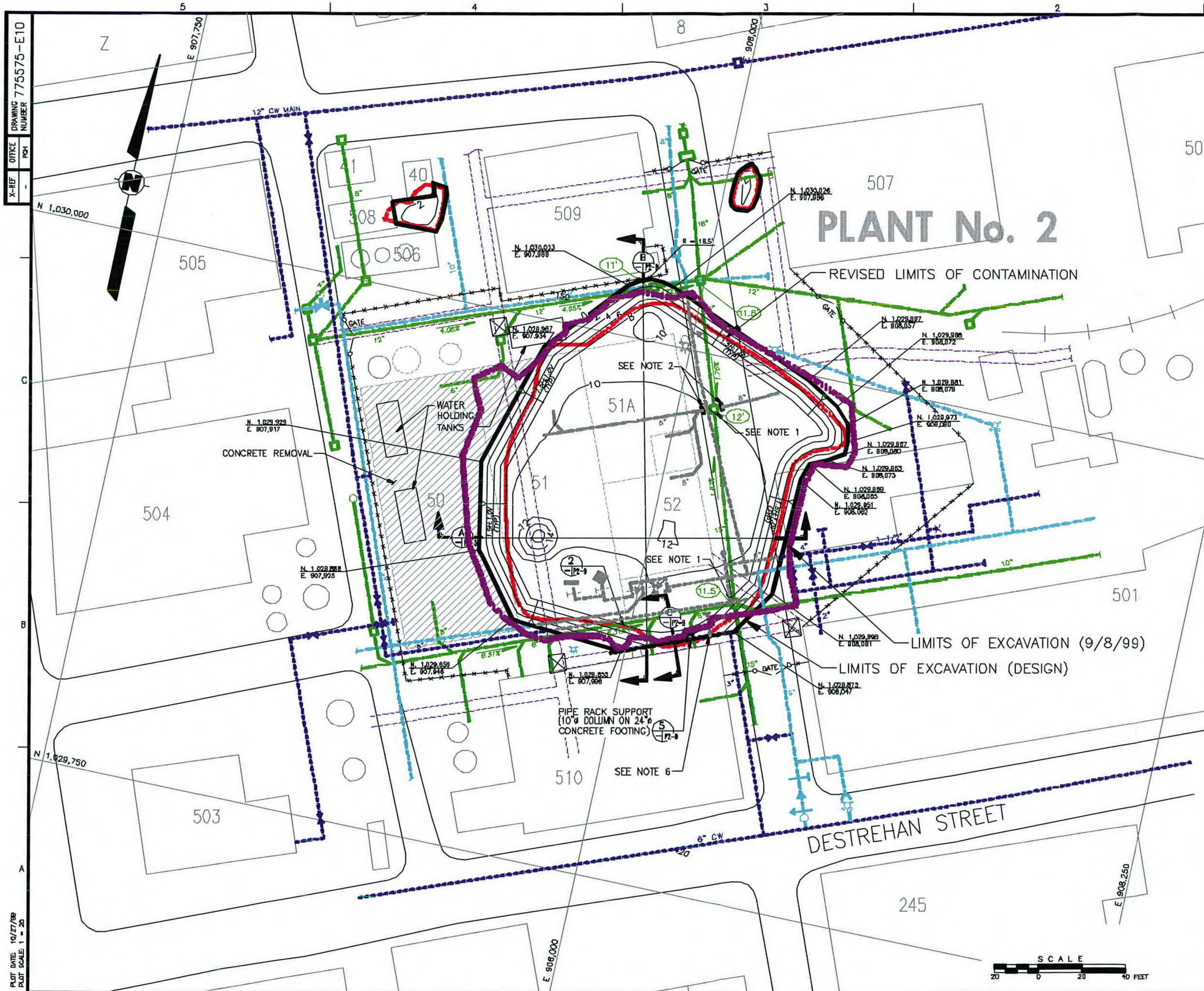
FUSRAP

U.S. ARMY CORPS OF ENGINEERS
KANSAS CITY DISTRICT (CENWK)
ST. LOUIS DISTRICT (CEMVS)

FIGURE 1-2

SITE PLAN - REMEDIAL WORK AREAS

ST. LOUIS DOWNTOWN SITE
ST. LOUIS, MISSOURI



LEGEND:

- REVISED LIMITS OF CONTAMINATION
- —12— DEPTH OF EXCAVATION
- LIMITS OF EXCAVATION
- SPRINKLER PIPING AND ALARM VALVE LOCATION
- SEWER LINE SYSTEM
- WATER LINE
- PIPE RACK
- SHEET PILE
- TEMPORARY 4' CHAIN-LINK FENCE
- STREET WASHER
- HYDRANT
- CATCH BASIN/MANHOLE
- DEPTH TO TOP OF SEWER PIPE
- SHUTOFF VALVE
- PIPE RACK SUPPORT
- NUMBER INDICATES DETAIL, LETTER INDICATES ELEVATION OR SECTION
- SHEET WHERE ELEVATION, SECTION, OR DETAIL IS DRAWN
- SHEET WHERE ELEVATION, SECTION, OR DETAIL IS TAKEN
- (– INDICATES SAME SHEET)

NOTES:

1. REMOVE SECTIONS OF MANHOLE AS EXCAVATION PROCEEDS, DECON AND SAVE FOR REUSE DURING BACKFILLING.
2. PLUG THE SEWER PIPE AND REMOVE UPSTREAM SEWER PIPE PERMANENTLY.
3. PROVIDE EARTH DIKE (DETAIL 3, SHEET P2-9) AS NECESSARY AROUND THE EXCAVATION TO DIVERT RUN-ON WATER.
4. VERIFY AND REMOVE AFFECTED ROOF DRAINS FROM BUILDING 510 PRIOR TO SHEET PILE DRIVING. RE-ESTABLISH ROOF DRAINS/SEWER CONNECTIONS AFTER THE REMOVAL OF SHEET PILING.
5. PROVIDE RAMPS AND MAINTAIN A MINIMUM OF 2' COVER (ALONG WITH THE USE OF TIMBER FRAME) OVER SEWER LINE FOR ACCESS AS NECESSARY.
6. REMOVE AS NECESSARY, THE ABANDONED 3"ø WATER LINE PRIOR TO SHEET PILE DRIVING.

Revisions			
Symbol	Descriptions	Date	Approved

IT CORPORATION

FUSRAP

U.S. ARMY CORPS OF ENGINEERS KANSAS CITY DISTRICT

U.S. ARMY CORPS OF ENGINEERS ST. LOUIS DISTRICT

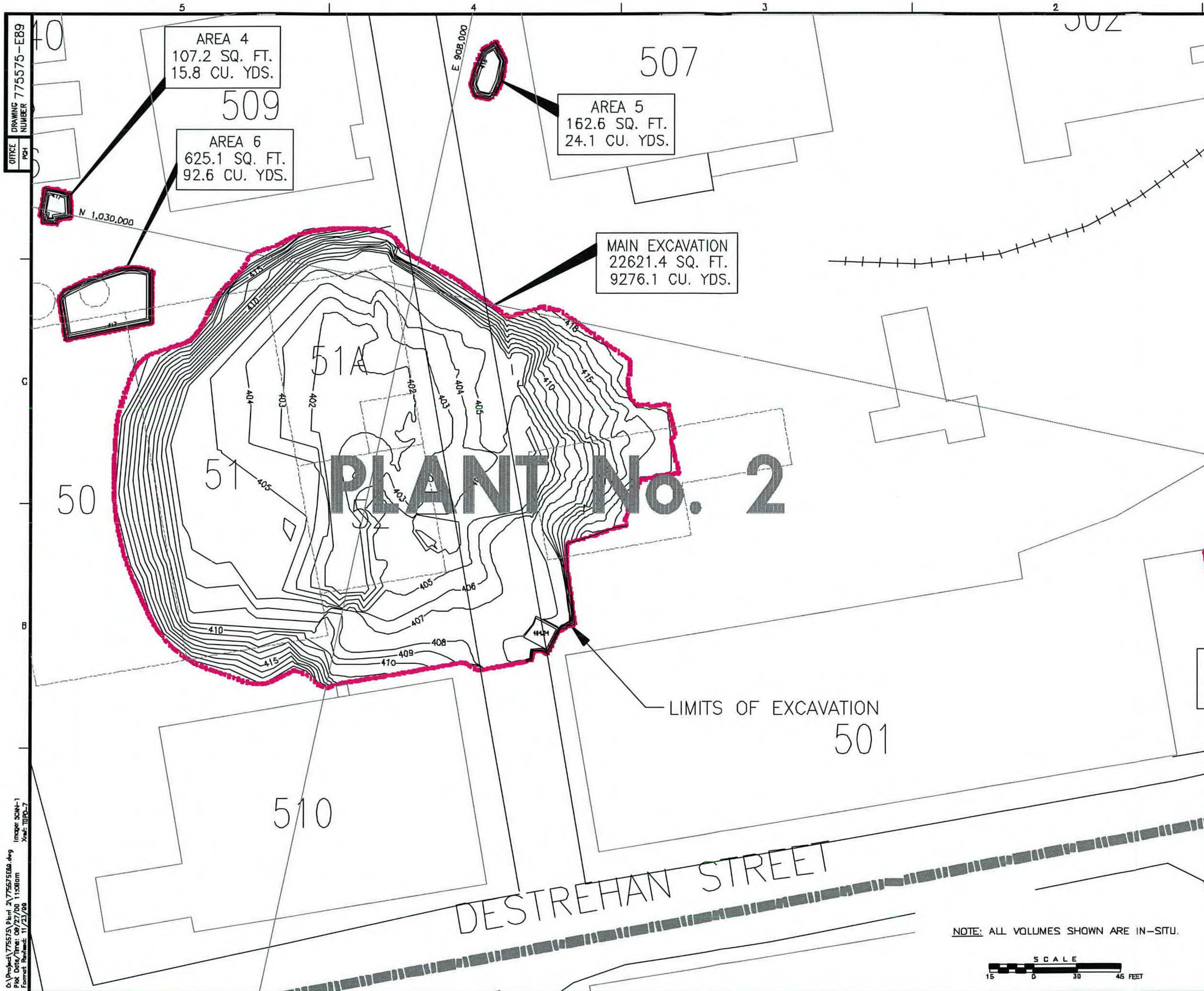
EXCAVATION PLAN

PLANT NO.2
ST. LOUIS DOWNTOWN SITE
ST. LOUIS, MISSOURI

Designed by: Lin Liu	Scale: AS SHOWN	Sheet reference number:	FIGURE 1–3
Drawn by: ACS/BBO	Date: 11/18/98		Contract No.
Checked by: Pete Verma	Drawing Number 775575-E10		
Approved by: Daniel Hsu			

X-REF – OFFICE PGH DRAWING NUMBER 775575-E10

PLOT DATE: 10/27/99 PLOT SCALE: 1 = 20



Symbol	Descriptions	Date	Approved
1	ADDED VOLUME IN CUBIC YARDS	8/25/00	K. BEACH

FUSRAP

U.S. ARMY CORPS OF ENGINEERS KANSAS CITY DISTRICT

U.S. ARMY CORPS OF ENGINEERS ST. LOUIS DISTRICT

FINAL EXCAVATION PLAN
PLANT NO.2
ST. LOUIS DOWNTOWN SITE
ST. LOUIS, MISSOURI

Designed by: K. Matsumoto
Drawn by: A. Smith
Checked by: K. Matsumoto
Approved by: K. Beach
Scale: AS SHOWN
Date: 8/26/00
Drawing Number 706550-E88
Sheet reference number: FIGURE 2-1
Contract No.

AR-047