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Remedial Design Document for the General Services Area Operable Unit Treatment Facilities Lawrence Livermore National Laboratory Site 300

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February 16, 1998

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Environmental Protection Department
Environmental Restoration Division

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Certification

I certify that the work presented in this report was performed under my supervision. To the best of my knowledge, the data contained herein are true and accurate, and the work was performed in accordance with professional standards.

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1. Introduction

This document includes the Remedial Design (RD) report, Compliance Monitoring Plan (CMP), and Contingency Plan (CP) for the General Services Area (GSA) Operable Unit (OU) Lawrence Livermore National Laboratory (LLNL) Site 300. The GSA OU is situated in the southeast corner of Site 300, a U.S. Department of Energy (DOE)-owned experimental test facility operated by the University of California (Fig. 1). Site 300 is located in the southeastern Altamont Hills of the Diablo Range, about 17 mi east-southeast of Livermore and 8.5 mi southwest of Tracy, California. This RD report is for eastern GSA and central GSA treatment facilities.

Site 300 was placed on the U.S. Environmental Protection Agency's (EPA's) National Priorities List in 1990. In June 1992, the DOE, EPA, the California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board-Central Valley Region (RWQCB) signed a Federal Facility Agreement (FFA) to facilitate compliance with the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 (CERCLA), as amended by the Superfund Amendments and Reauthorization Act of 1986 (SARA). As part of the CERCLA process, the LLNL Environmental Restoration Division (ERD) has prepared a series of documents for the GSA OU: the Site-Wide Remedial Investigation (SWRI) Chapter 14 (Webster-Scholten et al., 1994) characterized the site hydrogeology and contaminant distribution; the GSA Feasibility Study (FS) (Rueth et al., 1995) screened and evaluated possible remedial alternatives; the GSA Proposed Plan (DOE, 1996) presented the conceptual remedial alternatives and preferred remedial alternative for ground water and soil cleanup; and the GSA Record of Decision (ROD) (DOE, 1997) codified and bound DOE and EPA to a cleanup approach for ground water and soil in the GSA.

As discussed in the GSA ROD, the contaminants of concern at the GSA OU are volatile organic compounds (VOCs), primarily trichloroethylene (TCE) and perchloroethylene (PCE). The Applicable or Relevant and Appropriate Requirements (ARARs) for the GSA OU are detailed in the GSA ROD.

Removal actions were initiated in the GSA OU in 1991 to initiate remediation of contaminated soil/rock and ground water. A ground water extraction and treatment system has been operating in the eastern GSA since 1991. Ground water and soil vapor treatment systems have been operating in the central GSA since 1993 and 1994, respectively. Based on the performance evaluations of the existing removal actions for the eastern and central GSA and the progress these removal actions have made in remediating subsurface contaminants, the remedial action treatment technologies and wellfield design selected for remediation of ground water and soil vapor in the GSA consist of an expansion of these existing removal actions to expedite cleanup. The performance of the existing removal actions is discussed in detail in Sections 4.3.1.1, 4.3.1.2, and 4.3.1.3 of the GSA FS and Sections 2.9.2.3 and 2.9.2.4 of the GSA ROD.

The scope and format of this document are based on EPA guidance documents (EPA, 1989; 1990), and on RD reports, the CMP, and CP prepared for the LLNL Livermore Site (Berg et al., 1995; Nichols et al., 1996; McKereghan et al., 1996). As specified by EPA, the RD report contains engineering design specifications for the ground water and vapor extraction and treatment systems, including piping and instrument diagrams (P&IDs), system descriptions, monitoring and construction schedules, and cost estimates. The RD report also includes a Remedial Action Work Plan, Quality Assurance/Quality Control (QA/QC) Plans and Health and Safety Plans (HASPs) for both construction and operation and maintenance (O&M), and the requirements for offsite shipment of hazardous waste and for project closeout. At the request of EPA, DTSC, and RWQCB, the CMP and CP are included as part of the GSA RD document.

This document was prepared by the University of California for DOE with oversight from EPA, DTSC, and RWQCB. The RD report, CMP and CP are primary documents under the FFA for the Site 300.

Section 2 of this report presents the hydrogeology, VOC distribution and wellfield designs for the eastern and central GSA. Sections 3 and 4 present the remedial design for the eastern and central GSA treatment facilities, respectively. Section 5 contains the Remedial Action Work Plan for the eastern and central GSA treatment facilities. Appendices A through H present the following:

1. Waste water discharge and air permits (Appendix A),
2. Construction Quality Assurance/Quality Control (QA/QC) Plan (Appendix B),
3. Construction Health and Safety Plan (Appendix C),
4. Operations and Maintenance Quality Assurance/Quality Control Plan (Appendix D),
5. O&M HASP (Appendix E),
6. Compliance Monitoring Plan (Appendix F),
7. Contingency Plan for the GSA OU (Appendix G), and
8. Details of the GSA soil vapor and ground water modeling analysis (Appendix H).

2. Wellfield Design

The eastern and central GSA ground water and soil vapor extraction wellfield design is based on hydrogeologic analyses, VOC distribution data, and modeling conducted to optimize extraction wellfield design. These are discussed in Sections 2.1 and 2.2, and the extraction well and piezometer locations and design are presented in Section 2.3.

2.1. Hydrogeologic Analysis and VOC Distribution

2.1.1. Hydrogeologic Units in the Eastern and Central GSA

For this RD report, hydrogeologic units were defined and used to design the eastern and central GSA ground water and soil vapor treatment facility wellfields. A hydrogeologic unit is defined, for the purposes of this document, as saturated, permeable rock or sediment consisting of one or more stratigraphic units, which are separated from other permeable sediment/rock above and below by low-permeability sediment/rock This low-permeability rock (or aquitard) which prevents the migration of ground water between hydrogeologic units is typically included as part of the uppermost hydrogeologic unit.

Ninety-eight ground water monitor wells have been installed in the GSA to define, characterize, and monitor the extent and movement of contaminants in ground water. Monitor well locations in the eastern GSA and central GSA are shown in Figures 2 and 3, respectively. Hydraulic tests have been performed on selected wells in the GSA to determine the hydraulic characteristics of the hydrogeologic units and define hydrostratigraphic relationships. In addition, ground water geochemical data from GSA wells were utilized to verify interpretation of the flow paths and hydraulic communication between hydrogeologic units.

Three primary hydrogeologic units have been identified in the GSA based on their hydraulic, physical, and geochemical characteristics. Two of these hydrogeologic units are present only in the central GSA and one is present only in the eastern GSA.

Eastern GSA

Qal-Tmss Hydrogeologic Unit. This hydrogeologic unit is composed of the stratigraphic units: Qal (alluvium), $Tnsc_1$ (Neroly Formation-Siltstone/Claystone), $Tnbs_1$ (Neroly Formation-Lower Blue Sandstone), and the Tmss Siltstone (Cierbo Formation). Depth to water in this unit ranges from 10 to 20 ft below ground surface (bgs). Ground water flow in the alluvium (Qal) and shallow $Tnbs_1$ bedrock is eastward, turning north to follow the trend of the valley. Although the flow velocity is dependent on local hydraulic conductivity, the maximum flow velocity is estimated to range between values of 0.5 to 3 ft/day. As a result of past releases from the debris burial trenches, the shallow water-bearing zone (Qal) contains TCE and PCE. For the most part, the $Tnsc_1$ aquitard is absent in the eastern GSA, and the shallow water-bearing zone (Qal) is in hydraulic communication with the underlying regional aquifer ($Tnbs_1$). As a result, some contamination has migrated downward from the shallow water-bearing zone into the regional aquifer. No contamination has been detected in the basal stratigraphic unit of this hydrogeologic unit: the Tmss siltstone.

Central GSA

Qt-$Tnsc_1$ Hydrogeologic Unit. This shallow water-bearing zone occurs beneath the central GSA portion of the OU and is composed of stratigraphic units Qt (terrace alluvium), $Tnbs_2$ (Neroly Formation-Upper Blue Sandstone), and $Tnsc_1$ (Neroly Formation-Siltstone/Claystone). Depending on topography, depth to water is approximately 10 to 20 ft bgs. Ground water in this shallow aquifer flows south-southeast with estimated flow velocities of 0.05 to 0.10 ft/day. As a result of past releases, this shallow aquifer contains TCE and other VOCs. The VOC plume in this shallow aquifer is separated from the $Tnbs_1$ regional aquifer by a 60- to 80-ft thick aquitard ($Tnsc_1$) in most of the central GSA.

$Tnbs_1$ Hydrogeologic Unit (Regional Aquifer). The regional aquifer occurs in the lower Neroly Formation ($Tnbs_1$). This aquifer is encountered 35 to 145 ft bgs under confined to semi-confined conditions in the central GSA. Ground water flow in this unit is to the south-southeast at a mean flow velocity of 0.3 ft/day. Ground water data indicate that the VOC plume in the shallow aquifer (Qt-$Tnsc_1$) has not affected the regional aquifer in most of the central GSA. West of the sewage treatment pond, however, TCE has been detected in ground water in the regional aquifer where the $Tnsc_1$ confining layer is absent. The low TCE concentrations in the regional aquifer in this area have generally been decreasing since 1990.

VOC distribution and hydraulic properties within these hydrogeologic units were analyzed to select the extraction well and piezometer locations. Details of the geology and hydrogeology of the GSA are discussed in Chapter 14 of the SWRI, Section 1 of the GSA FS, and Section 2 of the GSA ROD.

2.1.2. VOC Distribution

Historical information and analytical data suggest that VOCs, in the dissolved form and/or as Dense Non-Aqueous Phase Liquids (DNAPLs), were released to the ground from release sites located in the eastern and central GSA. These releases include:

- VOCs associated with craft shop debris buried in trenches in the eastern GSA. One debris burial trench was also identified in the central GSA northwest of the sewage treatment pond.
- VOCs in rinse-, process-, and wash-water discharged to four dry wells from the central GSA craft and repair shops. Based on soil and ground water analytical data, the greatest VOC mass is concentrated in the vicinity of the Building 875 former dry wells.

- VOCs released to the ground from a decommissioned drum storage rack north of Building 875.
- VOCs in rinse water discharge from a steam cleaning/sink area east of Building 879.

TCE is the most prevalent VOC in ground water, typically comprising 85-95% of the total VOCs detected. Other VOC contaminants of concern include PCE, 1,2-dichloroethylene (DCE), 1,1-DCE, 1,1,1-trichloroethane (TCA), benzene, bromodichloromethane, chloroform, and Freon 113.

Eastern GSA

In the eastern GSA, the highest VOC concentrations in ground water occur in the vicinity of the debris burial trench area (Fig. 4). A VOC ground water plume extends eastward from the debris burial trench area and has migrated northward in the Corral Hollow alluvium. The plume with VOC concentrations exceeding 5 micrograms per liter (µg/L) currently extends approximately 450 ft north/northeast from the debris burial trench release area. The maximum VOC concentration in ground water as of fourth quarter 1996 was 16 µg/L. TCE has also been detected at low concentrations in ground water in the regional aquifer in the vicinity of the debris burial trenches.

TCE, PCE, and 1,2-DCE have been detected in concentrations up to 0.19 milligrams per kilogram (mg/kg) in borehole soil samples collected in 1989 in the vicinity of the debris burial trenches in the eastern GSA. Due to these low VOC concentrations in soil, no vadose zone remediation is planned in the eastern GSA.

Central GSA

As shown in Figure 5, a VOC ground water plume, consisting primarily of TCE, in the Qt-$Tnsc_1$ shallow aquifer extends from the Building 875 dry well pad and Building 872 and Building 873 dry wells into the Corral Hollow Creek alluvium. There is a smaller ground water plume with significantly lower TCE concentrations to the north associated with the drum storage rack and steam cleaning release sites. The highest ground water TCE concentrations in the central GSA have been detected in the vicinity of the former dry well pad south of Building 875. West of the sewage treatment pond, TCE has been detected in ground water in the $Tnbs_1$ regional aquifer (Fig. 6) where the $Tnsc_1$ confining layer is absent. The maximum VOC concentrations in ground water from monitor wells as of fourth quarter 1996 were 340 µg/L in the Qt-$Tnsc_1$ hydrogeologic unit and 33 µg/L in the $Tnbs_1$ hydrogeologic unit.

The highest TCE concentrations in soil/rock (up to 360 mg/kg) in the central GSA were detected in the vicinity of the Building 875 former dry wells at a depth of 20 to 35 ft near the contact between the $Tnbs_2$ water-bearing zone and the underlying $Tnsc_1$ confining layer.

Details of the nature and extent of contamination in the GSA are discussed in Chapter 14 of the SWRI, Section 1 of the GSA FS, and Section 2 of the GSA ROD.

2.2. Ground Water and Soil Vapor Modeling

To estimate the hydraulic capture areas of the planned GSA ground water extraction locations shown in Figure 7, ground water flow paths were calculated using results from the two-dimensional, numerical ground water flow model, MODFLOW (MacDonald, 1988). Because the ground water modeling using MODFLOW was restricted to two-dimensional analysis, modeling did not include ground water extraction and reinjection in the $Tnbs_1$ regional aquifer. The results of the simulation are shown in Figure 7. The details of this modeling effort are discussed in Appendix E of the GSA FS (Rueth et al., 1995).

Subsequent to the FS, the three-dimensional (3-D) numerical model Nonisothermal Unsaturated-Saturated Flow, and Transport or NUFT (Nitao, 1997) was used to simulate ground water extraction at the planned central GSA extraction locations, and soil vapor extraction from the seven existing extraction locations in the central GSA. The objectives of this modeling effort were to:

1. Improve the cleanup strategy by optimizing placement of central GSA extraction wells, and
2. Determine impacts of 3-D subsurface processes on estimated time to reach cleanup goals, by incorporating more recent data and a more comprehensive conceptual model. The NUFT conceptual model was calibrated using data from remediation performed to date in the central GSA, which provides the basis for forecasting future subsurface behavior.

Unlike the previous MODFLOW model, NUFT can simultaneously calculate advection, diffusion, and dispersion of aqueous and gaseous TCE phases in 3-D unsaturated and saturated conditions under the effects of both ground water and soil vapor extraction. As vadose zone contamination in the eastern GSA does not significantly contribute to ground water contamination in this area, the eastern GSA was not included in the NUFT modeling effort. The results of the NUFT model, as well as the model domain and grid, model calibration, and assumptions are discussed in more detail in Appendix H of this RD report.

The NUFT modeling results verify that migration of VOCs in the heterogeneous central GSA subsurface is dominated by mobile-immobile fluid processes; that is, contaminants in fine-grained sediments with zero ground water velocity migrate by only molecular diffusion, which is very slow relative to the migration that occurs in enjoining coarse-grained sediments with significant ground water velocities. Therefore, cleanup times by the pump and treat technologies used at the GSA sites are known to depend sensitively upon 3-D subsurface heterogeneity effects. Results from our 3-D NUFT simulations indicate cleanup times at the central GSA of approximately 30 years. These results are approximate because the time history is limited and the VOC concentration and subsurface property data used in both the definition and calibrations of the conceptual model are spatially sparse. Uncertainties in the conceptual model calibration and forecasts will become smaller as the time history and spatial resolution of data become greater. In previous two-dimensional (2-D) modeling results, presented in the FS, the estimated cleanup time was approximately 55 years. The results presented there were from a less realistic conceptual model and were subject to greater uncertainty than in the present 3-D analyses. With continued monitoring and characterization measurements, NUFT simulations can help to both forecast stagnation zones and accelerate attainment of remediation goals by simulating modified wellfield pumping cycles and/or configurations to either avoid or remove stagnation zones during operations in both the vadose and saturated zones. The need for installing ground water and soil vapor extraction wells, in addition to those planned in this RD document, will thus be assessed as remediation progresses by comparing actual VOC mass removal and concentration reductions to those predicted in the NUFT model.

2.3. Extraction Wells and Piezometers

The eastern and central GSA ground water and soil vapor extraction wellfield design was based on the hydrogeologic analyses, contaminant distribution data and modeling discussed above. The existing GSA extraction wellfield will be expanded to include a total of 22 ground water extraction wells and seven soil vapor extraction wells designed to maximize VOC mass removal from the subsurface to achieve ground water cleanup standards of Maximum Contaminant Levels (MCLs) (Fig. 7). Piezometers may be installed to help evaluate the extent of hydraulic capture and remediation effectiveness, and to identify areas of little or no ground water flow.

2.3.1. Extraction Well Location and Design

Eastern GSA

Ground water concentrations exceed cleanup standards in the eastern GSA in the vicinity of the former debris burial trench area, east of the sewage treatment pond (Fig. 4). A ground water extraction system has been operating in the eastern GSA since July 1991 to reduce VOC concentrations in ground water. The existing ground water extraction well array consists of three wells, W-26R-03, W-25N-01, and W-25N-24, which pump a total of up to 45 gallons per minute (gpm) (Tables 1 and 2). Based on modeling and field data associated with the existing extraction system, the eastern GSA extraction well configuration shown on Figure 7 sufficiently captures the plume in the eastern GSA to meet cleanup standards. The portion of the plume downgradient of the eastern GSA extraction wells that is not being actively captured has been attenuating since ground water extraction was initiated resulting in a retreat of the plume isoconcentration contours. We anticipate this trend will continue. Therefore, no additional alluvial extraction wells are considered necessary at this time.

VOC concentrations in the regional aquifer have been significantly decreasing as a result of existing alluvial ground water remediation. In this area, the alluvial and underlying regional aquifer are hydraulically connected, and contamination in the regional aquifer is a result of downward vertical migration of contaminants in the alluvial aquifer. Extraction wells in the regional aquifer in the debris burial trench area have not been installed, because pumping in the regional aquifer could accelerate/facilitate downward vertical contaminant migration from the overlying source in the alluvium into the $Tnbs_1$. If remediation of the alluvial aquifer does not appear effective in removing VOCs from ground water in the regional aquifer in the future, direct remediation of the regional aquifer in the eastern GSA will be considered.

Further details of the existing eastern GSA ground water extraction and treatment system and system performance to-date is contained in Section 2.9.2.4 of the GSA ROD (DOE, 1997).

Central GSA

A total of 19 ground water extraction wells are planned for contaminant removal in the central GSA. Seven of these wells are currently operating extraction wells. The remaining 12 extraction wells will consist of monitor wells to be converted to extraction wells and newly installed wells as shown in Table 1. Two extraction wells have been added to the preliminary wellfield design proposed in the ROD based on the NUFT modeling results. The modeling results indicated that by installing two additional wells in the vicinity of the Building 875 dry well pad area, VOC mass removal rates could be significantly increased. However, in order to shorten cleanup time to the 30 years predicted by the NUFT model, it may be necessary to utilize additional extraction wells in the future, as discussed in Appendix H.

The existing and proposed extraction wells are shown on Figure 7 and listed in Table 1. The purposes of these ground water extraction wells are to maximize contaminant removal in source areas and prevent plume migration in both the $Qt\text{-}Tnsc_1$ shallow aquifer and $Tnbs_1$ regional aquifer. Ground water extraction from the source area and plume control wells in the $Qt\text{-}Tnsc_1$ and $Tnbs_1$ hydrogeologic units will continue until ground water cleanup standards are met.

Currently, the existing ground water extraction system pumps a total of approximately 0.3 gpm from the seven extraction wells located in the vicinity of the Building 875 dry well pad. This very low flow rate is a result of the successful dewatering of the shallow aquifer in this area as part of a CERCLA removal action which has been ongoing since 1993. The majority of the water extracted is pumped from well W-875-08, while the other Building 875 dry well pad wells are able to maintain the dewatered state with minimal intermittent pump operation. Extraction from the new ground water extraction wells will increase the total central GSA flow rate from the current 0.3 gpm to approximately 10 gpm.

As shown in Table 1, ground water monitor well W-7P will be converted to an extraction well in order to reduce VOC concentrations in the $Tnbs_1$ regional aquifer west of the sewage treatment pond. However, extraction from this well may not be initiated until extraction from the Qt-$Tnsc_1$ hydrogeologic unit stabilizes capture zones and further reduces contamination in this shallow aquifer.

Once ground water extraction from $Tnbs_1$ well W-7P is initiated, treated ground water will be reinjected into well W-7C, screened downdip and upgradient of W-7P. Based on well development data, an extraction rate from well W-7P of about 4.5 gpm is anticipated. Reinjection into well W-7C would not exceed the rate of extraction from well W-7P. Reinjection will enhance natural contaminant flushing toward extraction well W-7P and expedite remediation of the $Tnbs_1$ regional aquifer. Hydraulic testing will be performed prior to reinjection to ensure that reinjection will not adversely affect remediation effectiveness or accelerate plume migration.

Design specifications for the central GSA extraction wells are presented in Table 2; extraction well locations are shown on Figure 7.

The seven existing ground water extraction wells, which have successfully maintained a dewatered zone in the immediate vicinity of the Building 875 dry well pad area, are also used for soil vapor extraction (SVE). Dewatering has exposed more soil/rock to the applied vacuum of SVE, thereby significantly enhancing VOC source mass removal. Soil vapor extraction from these existing simultaneous ground water-soil vapor extraction wells will continue to maximize VOC mass removal in the Qt-$Tnsc_1$ hydrogeologic unit in the Building 875 dry well pad area. The dewatered zone will continue to be maintained while SVE is operating. Because the highest VOC concentrations in soil/rock and ground water are found in the immediate vicinity of the Building 875 dry well pad, SVE efforts will continue to be focused in that area. The necessity of performing SVE at other locations in the GSA OU will be evaluated as remediation progresses.

Further details of the existing central GSA ground water and soil vapor extraction and treatment systems and system performance to-date are contained in Section 2.9.2.4 of the GSA ROD (DOE, 1997).

2.3.2. Piezometer Location and Design

In addition to the installation of more ground water extraction wells, new piezometers may need to be installed for measuring water levels near the extraction wells to help evaluate the extent of hydraulic capture and remediation effectiveness, and to identify areas of little or no ground water flow. Locations for these piezometers, as well as the number necessary, will be determined after ground water extraction from the expanded extraction system begins and hydraulic testing is conducted, in order to optimize piezometer placement. Thus, the piezometers are not shown on well location figures. Proposed piezometer locations will be discussed with the regulatory agencies and approved prior to installation.

The piezometer configuration will be designed to monitor the cumulative drawdown for each hydrogeologic unit, rather than the drawdown achieved by individual extraction wells. Thus, some piezometers may monitor multiple extraction wells.

Whenever possible, existing monitor wells will be incorporated into the piezometer network.

3. Remedial Design for the Eastern GSA Ground Water Extraction and Treatment System

The eastern GSA ground water treatment system is located in the southeast portion of Site 300 as shown on Figure 7. The principal contaminants of concern (COCs) in the eastern GSA are TCE, PCE, bromodichloromethane, chloroform, cis-1,2-DCE, 1,1,1-TCA, and 1,1-DCE. TCE and PCE are the only COCs whose concentrations in ground water currently exceed their respective cleanup standards. The treatment facility was designed to remove VOCs from ground water extracted from the eastern GSA alluvial water-bearing zone to meet the discharge requirements specified in the National Pollutant Discharge Elimination System (NPDES) permit issued by the RWQCB. The eastern GSA ground water extraction and treatment system consists of:

- The ground water extraction wellfield described in Section 2.3.
- Water distribution piping.
- A particulate filtration system.
- Aqueous-phase granular activated carbon (GAC) treatment units, as described in Section 3.1.

The discharge of treated water and schedule/cost estimates are discussed in Sections 3.2 and 3.3, respectively.

3.1. Design Specifications, Performance Standards, and Controls and Safeguards

The design specification performance standards, controls and safeguards for the eastern GSA ground water extraction and treatment system and associated piping are described in Sections 3.1.1 through 3.1.3.

3.1.1. Design Specifications

The eastern GSA treatment system consists of three aqueous-phase GAC units connected in series. This system was designed to treat up to 50 gpm of ground water at the expected influent concentrations. Design influent concentrations are shown in Table 3, and are based on recent data trends. Equipment specifications for the treatment system are presented in Table 4. The piping and instrumentation diagram (P&ID) is shown in Figure 8.

From the well heads, ground water is pumped through 1-1/2 in. inside-diameter stainless steel pipe (Fig. 8). Well pumps are 1/2 and 1 horsepower (hp) Grundfos submersible pumps.

Prior to entering the first GAC canister, the ground water passes through a five-micron filtration system to remove suspended particles from the ground water.

Influent water passes from the filtration system to three aqueous-phase GAC canisters connected in series. Each GAC canister contains 1,000 pounds (lb) of GAC with approximately 3- to 5- pound per square inch (psi) pressure drop per canister at 45-gpm flow. The influent water passes through the first GAC canister for sorption of VOCs. The second and third GAC canisters are safeguards against breakthrough of VOCs into the effluent before detection. When VOCs are detected between the second and third GAC canister above the effluent discharge limits (Table 5), the GAC in the first canister will be replaced with new, clean GAC and the first GAC canister will be placed in the third position. The remaining, partially saturated GAC canisters will move up in position (e.g., the third GAC canister moves to the second position and the second GAC canister moves to the first position) to optimize GAC usage. Process piping upgrades to facilitate rotation of the GAC canisters, as shown in Figure 8, will be implemented after the RD is approved. The three-way ball valves shown in Figure 8 may be replaced by an appropriate number of two-way ball valves depending on cost and availability.

Routine monitoring, scheduled on an engineering judgment basis, will be conducted between the first and second and second and third canisters. Monitoring of effluent from the third GAC canister will be conducted according to NPDES permit requirements. The spent GAC will be removed by a vendor for regeneration or offsite disposal at a Resource Conservation and Recovery Act (RCRA)-permitted facility. DOE/LLNL will comply with the Offsite Rule (40 CFR 300.440) for the offsite shipment of CERCLA waste.

Following treatment in the GAC units, the liquid effluent is discharged to the surface waters of Corral Hollow Creek.

3.1.2. Performance Standards

Performance standards are set at the effluent discharge requirements to ensure that discharge standards are met. Periodic monitoring of influent and effluent concentrations is required. GAC replacement and possible subsequent adjustments to flow rates may be necessary. The treatment system monitoring and effluent discharge requirements are presented in the NPDES permit, Appendix A. DOE/LLNL will comply with any revisions to the NPDES permit that may result from the permit renewal process. Sample port locations are identified in Figure 8.

As shown on Figure 9, mass removal rates predicted in 2-D forecasts are expected in future years to decline as VOCs bound in the fine-grained matrix become the only source left to be remediated. This figure is based on the 2-D MODFLOW/MT3D computer simulations presented in the GSA FS (Rueth et al., 1995). The differences seen in Figure 9 between calculated and actual mass removal are associated with approximation of the actual 3-D subsurface system by a 2-D conceptual model. The most significant factor in the 2-D conceptualization is that physical effects of VOCs being bound in a fine-grained sediment matrix with coarse-grained sediments are approximated by averaging the heterogeneous hydraulic conductivity and VOC dispersion parameters over the vertical dimension. The general nature and magnitude of the differences seen in Figure 9 lie within expected bounds of 2-D model approximations. Results in Figure 9 are consistent with a recognized general tendency for actual mass removal performance to exceed simulation estimates with this type of 2-D model application. Notwithstanding the spatial distributional variances caused by vertical averaging, the predicted cumulative mass removed through this year (year 7), 3.5 kg, and the actual cumulative mass removed through this year, 4.5 kg, are in reasonable agreement.

3.1.3. Controls and Safeguards

The eastern GSA ground water treatment system is designed to be fail safe; i.e., the failure of any components, energy source (mechanical or electrical), or loss of control signal will cause the system to shut down safely. The treatment facility is equipped with interlocks and an interlock control panel. If one of the components listed below malfunctions, the entire system automatically shuts down. The operator determines and corrects the problem before the system can be manually restarted.

A system shutdown involves de-energizing the well pumps. A system shutdown would be initiated by the following interlocks:

- Thermal overload on pump motors due to low flow rates of water into the well from the surrounding aquifer.
- Low flow rates in the combined influent line.

- Loss of power to controls and instrumentation.
- High pressure at the particulate filter influent due to blockage of the discharge line. The high pressure interlock switch will be incorporated after regulatory approval of the RD design is received.

In addition, all pipelines will be visually monitored for leaks daily. A preventative maintenance schedule for the treatment system is presented in Appendix D.

3.2. Treated Ground Water Discharge

The treated ground water will continue to be discharged to Corral Hollow Creek, and will meet the discharge requirements specified in RWQCB Waste Discharge Requirement (WDR) Order No. 97-242 (NPDES Permit No. CA 0082651) for discharge to the surface waters (Appendix A). If acceptable to the RWQCB, a portion of the treated water from the eastern GSA treatment facility may occasionally be discharged to the sewage treatment pond as makeup water during the summer months. The treated water may also be used for onsite irrigation.

3.3. Construction and Startup Schedules and Cost Estimates

3.3.1. Schedule

We have completed the eastern GSA treatment facility design, construction, and start up. Table 6 shows the completion dates.

3.3.2. Cost Estimates

The cost for treatment system design, construction and startup, and estimated costs for treatment system O&M are shown in Table 7.

4. Remedial Design for the Central GSA Ground Water and Soil Vapor Extraction and Treatment Systems

The central GSA ground water and soil vapor extraction and treatment systems are located in the southeast portion of Site 300 as shown in Figure 7. The principal COCs in the central GSA are TCE, PCE, benzene, bromodichloromethane, chloroform, cis-1,2-DCE, 1,1,1-TCA, and 1,1-DCE. TCE and PCE are the only COCs whose concentrations in ground water currently exceed their respective cleanup standards. The treatment facilities are designed to remove VOCs from ground water and soil vapor extracted from the central GSA Qt-Tnsc$_1$ water-bearing zone to meet the discharge requirements specified in the Substantive Requirements for waste water discharge issued by the RWQCB. This dual-phase design allows for extraction of DNAPLs, if present, using soil vapor extraction by extending the vadose zone to include deeper previously saturated areas where DNAPLs may reside. Soil vapor extraction has been identified as a technology that can effectively remediate DNAPLs in the vadose zone.

Two remediation systems are used to remove and treat VOCs from the subsurface: 1) a ground water extraction and treatment system, and 2) a soil vapor extraction and treatment system.

The ground water extraction and treatment system consists of:

- A ground water extraction wellfield described in Section 2.3.
- Water distribution pipelines.
- A pre-treatment storage tank.
- A commercially available air stripper, a particulate filter, two vapor-phase GAC units, and an emissions stack which are all housed in a portable treatment unit (PTU) transportainer.
- A post-treatment storage tank.
- A post-treatment storage tank discharge pump.
- A discharge line.
- A series of discharge spray nozzles.
- An additional post-treatment storage tank pump and discharge line for water transfer to a re-injection well to be installed following the wellfield expansion, as described in Section 4.1.1.1.

The soil vapor extraction and treatment system consists of:

- A soil vapor extraction wellfield described in Section 2.3.
- Vapor distribution pipelines.
- An air-intake valve.
- A water knock-out drum.
- A vacuum pump.
- Four vapor-phase GAC units in series.
- A stack to discharge the treated vapor stream to the atmosphere, as described in Section 4.1.1.2.

The discharge of treated water and soil vapor and schedule/cost estimates are discussed in Sections 4.2 and 4.3, respectively.

4.1. Design Specifications, Performance Standards, and Controls and Safeguards

The design specification performance standards, controls and safeguards for the central GSA ground water and soil vapor extraction and treatment systems and associated piping are described in Sections 4.1.1 through 4.1.3.

4.1.1. Design Specifications

4.1.1.1. Central GSA Ground Water Extraction and Treatment System

The central GSA ground water extraction and treatment system is designed to treat up to 50 gpm of extracted ground water, at the expected influent concentrations. Design influent concentrations are shown in Table 3, and are based on historical data trends. Equipment specifications for the treatment system are presented in Table 4. The P&ID for the ground water extraction and treatment system is shown in Figure 10.

From the well heads, ground water is pumped through 3-in. inside-diameter polyvinyl chloride (PVC) pipes leading into the pre-treatment tank. The pre-treatment tank has a capacity of approximately 3,000 gal for 3 days of storage, and will be outfitted with level sensing devices. The pre-treatment tank is scheduled to be replaced, at which time the PVC pipes leading from the well heads will be manifolded into a single PVC pipe for transfer of extracted ground water into the tank.

Ground water is pumped from the pre-treatment storage tank to the PTU. Prior to entering the air stripper, the ground water passes through a five-micron filtration system to remove suspended particles from the ground water.

To help control scale build-up in the air stripper and piping, various methods may be employed including carbon dioxide (CO_2), or sequestering agents such as polyphosphate, as well as regular maintenance and cleaning. Depending on the scale control method used, monitoring of the system effluent pH may be necessary. Additional treatment (i.e., CO_2 injection) may be required to adjust system effluent pH levels to meet permit requirements.

Following filtration and injection of scale-control agents, the influent is aerated through a series of air blown trays, stripping out the VOCs. The air stripper is a commercially available Shallow-tray Model No. 2331, or equivalent. The supply air for aeration comes from a single blower with an expected output of 300 cubic feet per minute (cfm) with a pressure of 18-in. water column. The blower is a component of the air stripper package.

The VOC-laden vapors generated in the air stripper are treated in two vapor-phase GAC canisters connected in series. A water trap has been installed in the pipeline between the air stripper and the first GAC unit for moisture control. The vapor-phase GAC canisters contain 140 lb of GAC with a 2.4-in. of water pressure drop per canister at 300-cfm flow. The effluent vapor stream passes through the first vapor-phase GAC canister for sorption of residual VOCs. The second GAC canister is for protection of breakthrough from the first canister before detection. After the GAC canisters, the treated vapor stream will be discharged through a stack to the atmosphere. When VOCs are detected between the first and second GAC canister above the effluent discharge limits (Table 5), a clean GAC canister will be placed in the second position. The first GAC canister will be removed, and the second, partially saturated GAC canister will move to the first position to maximize GAC usage. The vapor-phase GAC will be delivered to the LLNL Hazardous Waste Management Division (HWMD) for regeneration or disposal at an offsite RCRA-permitted facility. DOE/LLNL will comply with the Offsite Rule (40 CFR 300.440) for the offsite shipment of CERCLA waste.

The sump of the air stripper contains the level control for the discharge pump (Fig. 10). The level control system consists of a float switch that turns the discharge pump on and off. If needed for control, an alternative level control system will consist of a level-sensing device in the sump, which is a closed-loop feedback system, and controls the speed of the air stripping tank discharge pump to keep the water level in the tank constant. The discharge pump is a component of the air stripper package, and will be a 45-gpm, 3-hp pump equipped with a second float for shutoff in the event of a pump sensor failure (i.e., the first float switch fails).

The liquid effluent is transferred by pump to a post-treatment storage tank for batch discharge. The post-treatment storage tank has a capacity of approximately 20,000 gal, and will be outfitted with level-sensing devices. When post-treatment storage tank contents reach a significant portion of the tanks capacity, liquid effluent is pumped to a discharge line and discharged to the ground surface through a series of spray nozzles designed to prevent erosion.

The post-treatment storage tank discharge pump is a 15-hp pump capable of pumping the discharge water over a 200-ft incline to reach the discharge location. A portion of the post-treatment storage tanks capacity will be pumped through a separate discharge line to a $Tnbs_1$ re-injection well, W-7C. The quantity of water to be injected will be equal to that extracted from the $Tnbs_1$ extraction well W-7P.

It is uncertain at this time whether extraction and reinjection of ground water from the $Tnbs_1$ regional aquifer will start at the same time as the central GSA wellfield expansion or wait until alluvial aquifer extraction stabilizes capture zones and further reduces contamination in the alluvial aquifer. Hydraulic testing would be performed prior to reinjection to ensure that reinjection would not adversely affect remediation effectiveness or accelerate plume migration. In addition, prior to reinjection, ground water would be analyzed to ensure that concentrations of inorganic compounds do not exceed levels found in water extracted from the $Tnbs_1$ regional aquifer, if ground water from this aquifer is mixed with water from the shallow aquifer during treatment and/or storage. DOE/LLNL will submit proposed revisions to the Substantive Requirements or a revised monitoring plan which includes monitoring for hydraulic and water quality effects of injection to the RWQCB for approval prior to initiating reinjection.

4.1.1.2. Central GSA Soil Vapor Extraction and Treatment System

The central GSA soil vapor extraction and treatment system is designed to treat up to 150 cfm of soil vapor at the expected influent concentrations. Design influent concentrations are shown in Table 3, and are based on recent data trends. Equipment specifications for the treatment system are presented in Table 4. The P&ID for the soil vapor extraction and treatment system is shown in Figure 11.

A 2-hp radial blower is used to extract soil vapor from wells and pump the contaminated vapor stream through GAC treatment units. For moisture control, a water knock-out drum has been installed before the vacuum pump. A high water level switch will be added to the knock-out drum. To prevent system overheating, an air intake valve is manifolded into the system before the water knock-out drum.

The VOC-laden vapors are treated in four vapor-phase GAC canisters connected in series. The vapor-phase GAC canisters contain 140 lb of GAC with a 1.0-in. of water pressure drop per canister at 150-cfm flow. The effluent vapor stream passes through the first vapor-phase GAC canister for sorption of residual VOCs. The second, third, and fourth GAC canisters are for protection of breakthrough from the first canister before detection. After the GAC canisters, the treated vapor stream is discharged through a stack to the atmosphere. When VOCs are detected between the third and fourth GAC canister above the effluent discharge limits (Table 5), a clean GAC canister will be placed in the fourth position. The first GAC canister will be removed, and the remaining partially saturated GAC canisters will move up in position to maximize GAC usage (e.g., the fourth GAC canister moves to the third position, the third canister to the second position, and the second canister to the first position). The spent vapor-phase GAC canister will be delivered to the LLNL HWMD for regeneration or disposal at an offsite RCRA-permitted facility.

4.1.2. Performance Standards

Performance standards are set at the effluent discharge requirements for the ground water and soil vapor treatment facilities. To ensure these standards are met, periodic monitoring of influent and effluent concentrations is required. GAC replacement and possible subsequent adjustments to in-flow rates or blower rates may be necessary. System performance will also be monitored to evaluate whether DNAPLs act as a continuous source of contamination as described in Section F-6.2.3 of Appendix F.

The treatment system monitoring and effluent discharge requirements are presented in the Substantive Requirements for waste water discharge issued by the RWQCB and the air permits issued by the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) contained in Appendix A. Sample port locations are identified in Figures 10 and 11. Performance baselines have been established initially by computer simulations that are discussed in Appendix H and is shown in Figures 12 and 13. The early history (1994–1997) of measured mass removed is less than the model-estimated mass removal shown in Figures 12 and 13. The differences are, however, narrowing with time and are presently consistent with known uncertainties in both initial contaminant concentration and subsurface property distributions. So long as the differences remain narrow as remediation progresses with increasing well field concentration history and with improvements in spatial resolution of physical properties, we expect that the evolving NUFT model can be used effectively to guide well field operation decisions in efforts to optimize mass removal.

4.1.3. Controls and Safeguards

The central GSA treatment system is designed to be fail safe; i.e., the failure of any components or energy source (mechanical or electrical), or loss of control signal will cause the system to shut down safely. The treatment facility is equipped with interlocks and an interlock control panel. If one of the components listed below malfunctions, the entire system will automatically shut down. The operator will need to determine and correct the problem before the system can be manually restarted.

A ground water extraction and treatment system shutdown involves de-energizing the following equipment:

- Air stripper discharge pump.
- Blower.
- Surface and re-injection well discharge pumps.
- Scale control injection.
- Influent control valve.
- Pre-treatment storage tank transfer pump, if present.

A ground water extraction and treatment system shutdown would be initiated by the following interlocks:

- Low water flow rate.
- High water flow rate.
- Low air pressure in the air stripper sump.
- High air pressure in the air stripper sump.
- Loss of power to controls and instrumentation.
- High water level in air stripper sump.

In addition, all pipelines will be visually monitored for leaks on a daily basis. A preventative maintenance schedule for the treatment system is presented in Appendix D.

A soil vapor extraction and treatment system shutdown involves de-energizing the vacuum pump. A soil vapor extraction and treatment system shutdown would be initiated by the loss of power to controls and instrumentation or a high level in the water knock-out vessel. In addition, all above-ground pipelines will be visually monitored on a daily basis for signs of wear that may result in leakage. A preventative maintenance schedule for the treatment system is presented in Appendix D.

4.2. Treated Ground Water and Vapor Stream Discharge

The treated ground water from the central GSA treatment system will continue to be discharged to the ground surface in a canyon located in the eastern GSA, and will meet the discharge requirements specified in the Substantive Requirements for waste water discharge issued by the RWQCB (Appendix A). In addition, a portion of the treated water may be re-injected into the $Tnbs_1$ aquifer well W-7C. Re-injection would be performed in accordance with RWQCB requirements.

If acceptable to the RWQCB, a portion of the treated water from the central GSA ground water treatment system may occasionally be discharged to the sewage treatment pond as makeup water during the summer months. Treated water may also be used for onsite irrigation.

The treated vapor stream from the ground water and soil vapor treatment systems will be discharged to the atmosphere in accordance with the air permits issued by the SJVUAPCD (Appendix A).

4.3. Construction and Startup Schedules and Cost Estimates

4.3.1. Schedule

We have completed the design, construction, and startup of the initial central GSA extraction wellfield, and ground water and soil vapor extraction and treatment systems. Table 8 presents the completion dates as well as the scheduled dates of the planned wellfield expansion.

4.3.2. Cost Estimates

The cost for design, construction, and startup of the central GSA ground water and soil vapor extraction and treatment systems, and estimated costs for the wellfield expansion and treatment system O&M are shown in Table 7.

5. Remedial Action Workplan

The Remedial Action Workplan for the eastern and central GSA treatment facilities includes QA/QC plans and HASPs for construction and O&M, which are attached in Appendices B, C, D, and E. Included also are the extraction well pumping strategy, requirements for onsite storage and offsite shipment of hazardous waste, preliminary remediation completion criteria, and procedures for facility and well closure. The monitoring and reporting programs are discussed in the CMP (Appendix F).

5.1. Quality Assurance/Quality Control and Health and Safety Plans

The QA/QC Plan and the HASP for construction are presented as Appendices B and C of this document. The QA/QC Plan for construction defines the quality objectives and areas of responsibility for the proposed modifications to the central GSA remediation system. The HASP for these remediation system modifications defines areas of responsibility for health and safety during modification activities and references existing LLNL Health and Safety documents which address construction/modification health and safety issues.

The QA/QC Plan for O&M of the eastern and central GSA treatment facilities is presented in Appendix D. This plan describes the organizational structure, responsibilities, and authority for O&M QA/QC, and the objectives, quality goals, and QA elements for O&M of the eastern and central GSA treatment facilities. Appendix E contains the HASP for O&M of the eastern and central GSA treatment facilities. This plan presents: 1) organizational structure and responsibilities, 2) hazard analyses and control measures, 3) training requirements for the eastern and central GSA treatment facility O&M, and 4) emergency safety procedures.

5.2. Monitoring and Reporting

The monitoring and reporting planned for the eastern and central GSA treatment facilities is discussed in detail in the Compliance Monitoring Plan (CMP) included as Appendix F of this document. The CMP includes discussions of the following components:

- Ground water, soil vapor, and treatment facility data collection including:
  - Self-monitoring of treatment facilities required by the RWQCB and SJVUAPCD,
  - Ground water quality sampling and monitoring schedule,
  - Soil vapor sampling and monitoring schedule,
  - Capture zone monitoring,
- Data management,
- QA/QC and Standard Operating Procedures,
- Data analysis, and
- Reporting.

5.3. Extraction Well Pumping Strategy

Current simulations of long-term pumping and contaminant transport suggest that at least 30 years of sustained ground water pumping may be required to achieve cleanup standards in the GSA as defined in the ROD. For the central GSA, current simulations of long-term pumping and contaminant transport suggest that at least 30 years of sustained ground water pumping coupled with soil vapor extraction may be required to achieve cleanup standards. Modeling predicts that cleanup standards in the eastern GSA will be achieved within 10 years of initiation of remediation. Modeling results are summarized in Appendix E of the GSA FS and in Appendix H of this RD.

In the eastern GSA, the three existing ground water extraction wells will continue to be pumped at a combined flow of approximately 45 gpm to achieve both mass removal and the hydraulic capture of the VOC plume, thus preventing further migration of the VOC plume.

Ground water and soil vapor extraction in the central GSA is designed to reduce ground water VOC concentrations to cleanup standards in both the Qt-Tnsc$_1$ and Tnbs$_1$ hydrogeologic units. A total of 19 extraction wells will pump ground water at a combined flow of approximately 10 gpm in the central GSA. Soil vapor will be extracted from the existing simultaneous ground water-soil vapor extraction wells in the Building 875 dry well pad area. The soil vapor extraction system is designed to reduce vadose zone contamination, including potential DNAPLs, in unsaturated bedrock, to concentrations protective of ground water, and to reduce potential inhalation risk inside Building 875.

Cleanup progress will be periodically evaluated and compared to the progress predicted in the FS modeling and the NUFT modeling presented in Appendix H of this RD. The wellfield configuration and pumping rates may be modified to optimize mass removal rates, maximize treatment and minimize dilution of contaminants, ensure hydraulic capture in water-bearing zones exceeding cleanup standards, and eliminate stagnation zones. If the ROD-specified remediation does not show that cleanup is proceeding as modeling predicts, remediation methods will be revisited. As discussed in Section 2.3.1, if remediation of the alluvial water-bearing zone does not appear effective in removing VOCs from ground water in the regional aquifer in the eastern GSA, direct remediation of the regional aquifer in that area will be considered.

Well condition will be addressed by evaluating pumping rates, specific capacity, and turbidity annually. As required, extraction wells and monitor wells will be rehabilitated or replaced. These activities will be reported in the GSA treatment facility quarterly reports, as appropriate.

Based on the results of LLNL pilot studies and data from other sites, the VOC concentrations in ground water and soil vapor are expected to decrease rapidly at first, then decrease very slowly or stabilize. Estimates of VOC mass removal from ground water over time at the eastern GSA is shown in Figure 9. The VOC removal rates for the eastern GSA were estimated using results from the two-dimensional, numerical ground water flow model, MODFLOW (MacDonald, 1988). Estimates of VOC mass removal at the central GSA over time from soil vapor and ground water are shown in Figures 12 and 13, respectively. The VOC removal rates for the central GSA were estimated using results from the three-dimensional NUFT model (Nitao, 1997). Actual VOC removal rates will depend on the VOC concentrations in extracted ground water and long-term well yields.

Cyclical pumping (e.g., alternating periods when the system is on and off) may be utilized as the primary method to maximize VOC removal efficiency from both ground water and soil vapor. Ground water extraction wells may be periodically shut off and the water levels allowed to recover. During the pump-off cycles, VOCs will desorb into the ground water from the sediments that were dewatered near the pumping wells. Cycling the pumps may increase VOC removal efficiency near source areas, where most of the VOCs occur in the shallower water-bearing units. Different pump-on and pump-off cycles may be evaluated to determine the optimum periods of pumping and non-pumping to maximize VOC mass removal efficiency.

Similarly, soil vapor extraction wells may be periodically shut off to allow VOCs in soil to re-equilibrate in soil vapor. A SVE rebound test, conducted in the central GSA, demonstrated that VOC concentrations increased or 'rebounded' during a temporary shutdown of the SVE system (Fig. 14). Cyclic operation of the SVE system may therefore, increase VOC removal efficiency. As with ground water extraction, different extraction and rebound cycles may be evaluated to determine the optimum cyclic operations periods. Optimization may also include expanding the area of influence to maximize the rate of contaminant removal from soil vapor by increasing the flow rate.

Cyclical pumping of both ground water and soil vapor will also be utilized to minimize or eliminate stagnation zones. Stagnation zones are areas in the subsurface in which contaminants in ground water or soil vapor are unaffected by pumping due to competition between extraction wells. Periodic alterations in pumping configurations will help to remove contaminants trapped in these stagnation zones. For the SVE system, this may include extracting from some SVE wells while using other wells as air inlet wells to expedite the elimination of soil vapor stagnation points.

Laboratory and field studies may be conducted to evaluate the effectiveness of other methods to enhance contaminant mobility and mass removal. If other methods are evaluated and shown to be beneficial and cost-effective, they will be implemented with regulatory agency approval.

5.4. Requirements for Onsite Storage and Offsite Shipment of Hazardous Waste

Particulate filters and GAC containing sorbed VOCs will be shipped offsite for regeneration or disposal, and will be managed as hazardous waste, if appropriate. Aqueous-phase GAC in the eastern GSA treatment facility will be replaced as needed to remain in compliance with the RWQCB NPDES permit discharge limits. Vapor-phase GAC from the central GSA treatment facility will be replaced as needed to remain in compliance with the SJVUAPCD air discharge limit of 6 $ppm_{v/v}$. LLNL can temporarily store hazardous waste onsite for up to 90 days. Shipment and disposal are in accordance with Department of Transportation (DOT) 49 Code of Federal Regulations (CFR) and EPA 40 CFR, respectively. Additionally, waste shipments are made according to California Code of Regulations, Title 22 requirements. The spent vapor-phase GAC from the central GSA facilities will be packaged and labeled for shipment by LLNL's HWMD. HWMD operates a hazardous waste treatment and storage facility under interim status and has submitted a RCRA Part B permit application to the DTSC. (California is a RCRA-authorized State.) Once packaged, the GAC will be shipped to a RCRA-permitted facility for regeneration or disposal. The spent aqueous-phase GAC from the eastern GSA treatment facility will be removed from the 1,000-lb capacity container onsite by the vendor. The vendor will ship the spent GAC to a RCRA-permitted facility for regeneration or disposal. DOE/LLNL will comply with the Offsite Rule (40 CFR 300.440) for the offsite shipment of CERCLA waste.

5.5. Requirements for Closeout

As specified in the ROD, GSA ground water cleanup will be complete when ground water samples from the plume demonstrate that negotiated cleanup standards are achieved. Soil vapor remediation will continue until:

1. It is demonstrated that VOC removal from the vadose zone is no longer technically and economically feasible in order to meet the aquifer cleanup standards sooner, more cost effectively, and more reliably, and
2. The additive VOC inhalation risk inside Building 875 reaches acceptable levels.

When VOC concentrations in ground water have been reduced to cleanup standards, the ground water extraction and treatment system(s) will be shut off and placed on standby. VOC concentrations may rise in ground water after extraction ceases due to slow desorption from fine-grained sediments. Therefore, ground water post-closure monitoring will be performed for five years after pumping ceases. Should VOC concentrations in ground water rebound above cleanup standards, reinitiation of remediation efforts will be discussed with the regulatory agencies. The ground water system will be restarted and operated until cleanup standards are achieved, unless all parties agree otherwise. Several pumping cycle iterations may be required to achieve the cleanup standards.

The SVE system will be operated until it is demonstrated that VOC removal from the vadose zone is no longer technically and economically feasible in order to meet the aquifer cleanup standards sooner, more cost effectively, and more reliably. Factors to be considered in this evaluation are discussed in Section 2.9.3.2 of the GSA ROD. The demonstration that the vadose zone cleanup has been achieved to the point where the remaining vadose zone contaminants no longer cause concentrations in leachate to exceed the aquifer cleanup standards will be made through contaminant fate and transport modeling, trend analysis, mass balance, and/or other means. When this demonstration has been made, the SVE system will be shut down and only the ground water extraction and treatment system will operate. Should site conditions change or ground water monitoring indicate that soil vapor concentrations have rebounded and will cause the ground water to exceed ground water cleanup standards, the soil vapor system will be restarted and operated, as appropriate, until such conditions cease.

Cleanup will be considered complete when contaminant concentrations in ground water remain below the cleanup standards for five years. Cleanup completion will be determined in conjunction with the regulatory agencies.

After concurrence with the regulatory agencies that cleanup is complete, most of the GSA extraction wells and piezometers will be decommissioned. Wells will be closed by *in-situ* casing perforation and pressure grouting, or by well removal as appropriate, consistent with the approved *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs)* SOP 1.7 (Dibley and Depue, 1997). Wellhead abandonment will include removal of any protective covers, instruments, concrete pads, etc., and the upper two to three ft will be filled with low-permeability soil to restore grade. A minimal monitoring network, consisting of perhaps 10 to 20% of the existing wells, will remain in place for general ground water quality monitoring. Most of these monitor wells will be located at former downgradient plume margins, site boundaries, and in former source areas.

After remediation is complete, the eastern GSA ground water treatment system and central GSA ground water and soil vapor treatment systems and their influent and discharge piping will be decontaminated, dismantled, and salvaged, or used at other locations. The portions of the process equipment and piping that contact ground water will not contain hazardous VOC concentrations because the equipment will have been thoroughly flushed with ground water containing VOC concentrations below MCLs. Any wash water containing hazardous materials will be collected, sampled, and disposed at one of several RCRA-permitted facilities. GAC with sorbed VOCs will be disposed according to the specifications described in Section 5.4 "Requirements for Onsite Storage and Offsite Shipment of Hazardous Waste."

6. References for LLNL Facilities Standards, Specifications, and Guide Documents

6.1. General

Designs, construction drawings, and specifications will conform to and comply with the applicable requirements of the latest adopted edition of the references listed herein, which will be considered minimum requirements.

6.2. Regulations

U.S. Department of Energy (DOE)

DOE 5480.7A	Fire Protection Program
DOE 6430.1A	General Design Criteria

Code of Federal Regulations (CFR)

10 CFR 435	Energy Conservation Standards
29 CFR 1910	Occupational Safety and Health Standards (OSHA)
29 CFR 1910.7	Definitions and Requirements for a Nationally Recognized Testing Laboratory (NRTL)
47 CFR 15	Telecommunication (FCC Rules, Part 15)

State of California Department of Labor (DOL)

DOL Labor Code	Division 5—Safety in Employment Chapter 9—Miscellaneous Labor Provisions

California Code of Regulations (CCR)

CCR Title 8	Industrial Relations; Chapter 4, Subchapter 6
CCR Title 20	Public Utilities; Chapter 53—Energy Conservation in New Building Construction

University of California, Lawrence Livermore National Laboratory (UCRL)

UCRL 15910	Design and Evaluation Guidelines for Department of Energy Facilities Subjected to Natural Phenomena Hazards
UCRL 15714	Suspended Ceiling System Survey and Seismic Bracing Recommendations

6.3. Codes

American Concrete Institute (ACI)

ACI 318	Building Code Requirements for Reinforced Concrete

American Institute of Steel Construction (AISC)

AISC	Steel Construction Manual (Allowable Stress Design)

American National Standards Institute (ANSI)

ANSI A58.1	Building Code Requirements for Minimum Design Loads for Buildings and Other Structures

American Welding Society (AWS)

AWS D 1.1	Welding Code—Steel

International Conference of Building Officials (ICBO)

ICBO UBC	Uniform Building Code
ICBO UMC	Uniform Mechanical Code
ICBO UPC	Uniform Plumbing Code

National Fire Protection Association (NFPA)

NFPA 70	National Electrical Code
NFPA 90A	Installation of Air Conditioning and Ventilating Conditioning Systems

6.4. Standards

American Concrete Institute (ACI).

ACI 347 Recommended Practice for Concrete Form Work

American Society for Testing and Materials

American Water Works Association.

Construction Specifications Institute.

National Electric Manufacturers Association.

Sheet Metal and Air Conditioning Contractors National Association, Inc.

6.5. LLNL Manuals and Reports

M-010 LLNL Health and Safety Manual

LLNL Site Development and Facilities Utilization Plan

LLNL Landscape Master Plan and Design Guidelines

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Figures

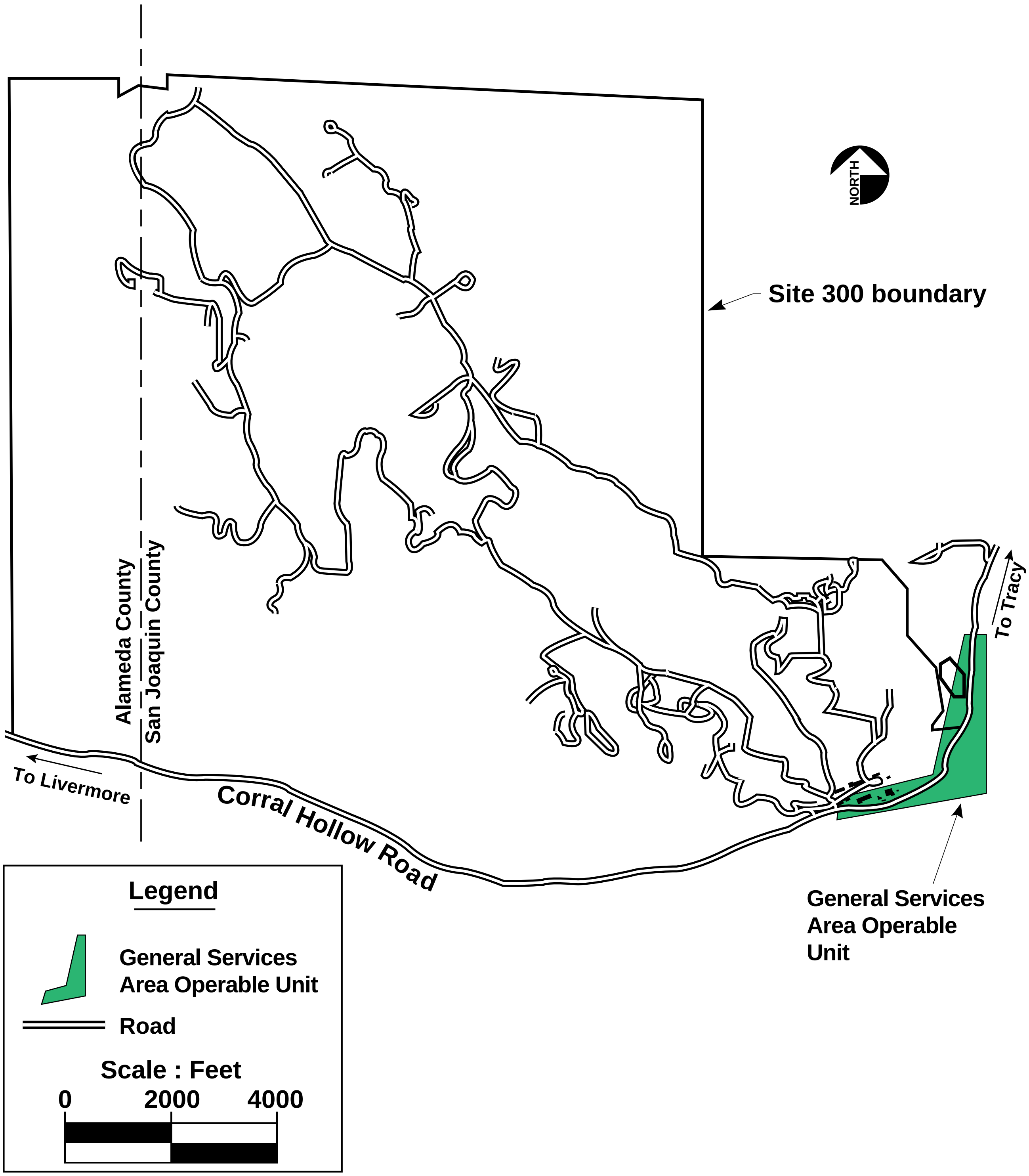

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Figure 1. Location of the General Services Area OU at LLNL Site 300.

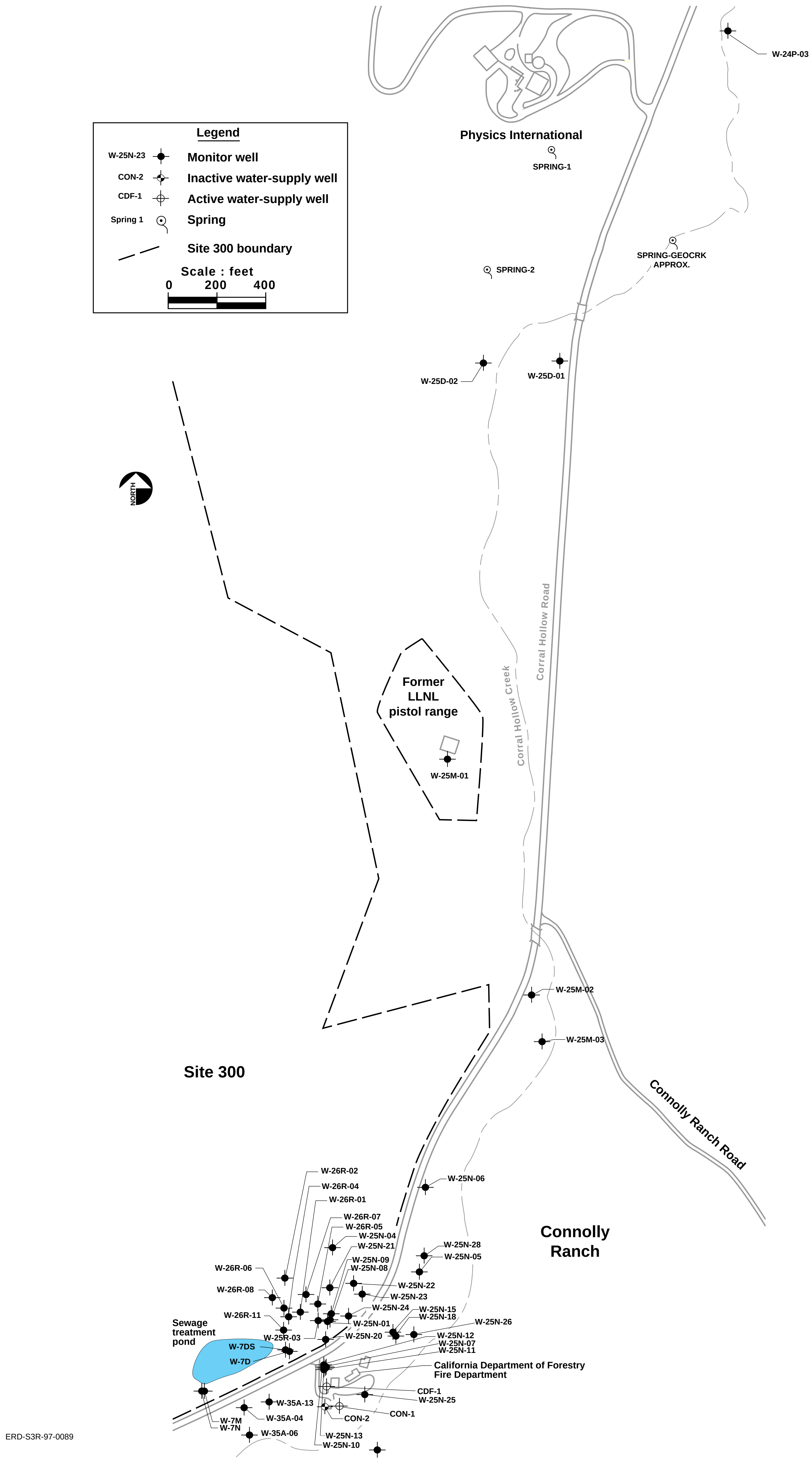

Figure 2. Eastern GSA monitor well locations.

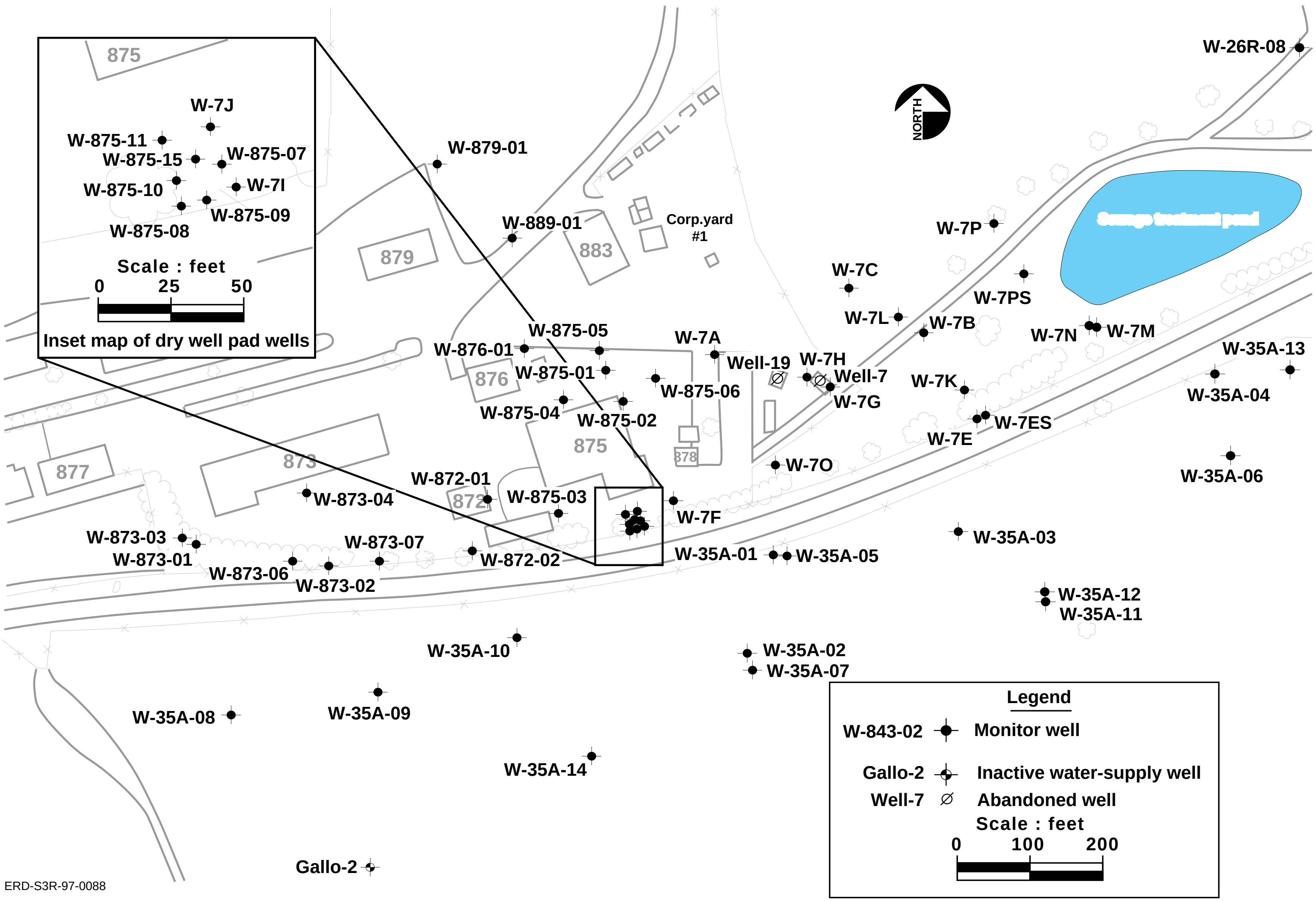

Figure 3. Central GSA monitor well locations.

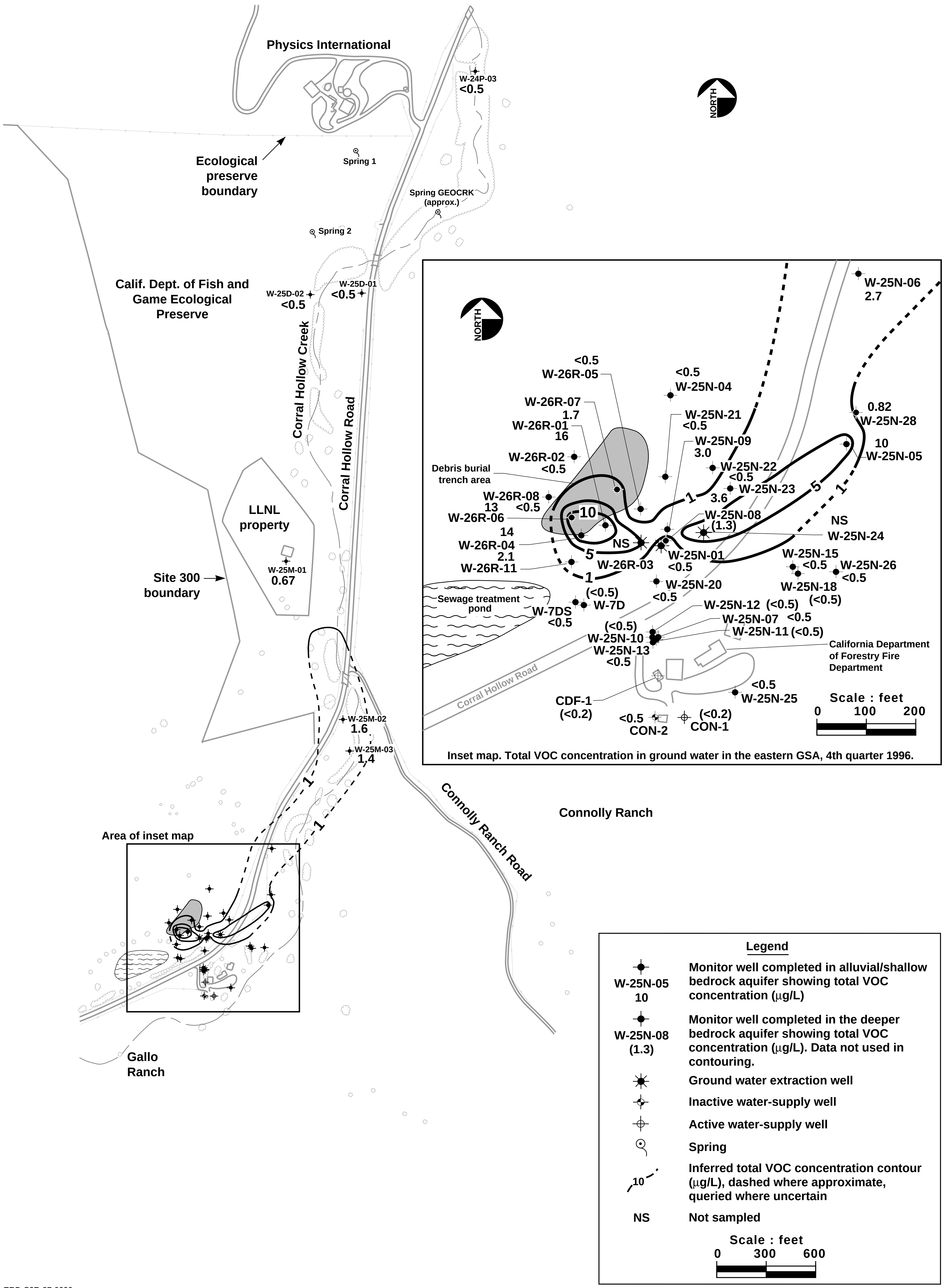

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Figure 4. Total VOC concentrations in ground water in the eastern GSA and vicinity (4th quarter 1996).

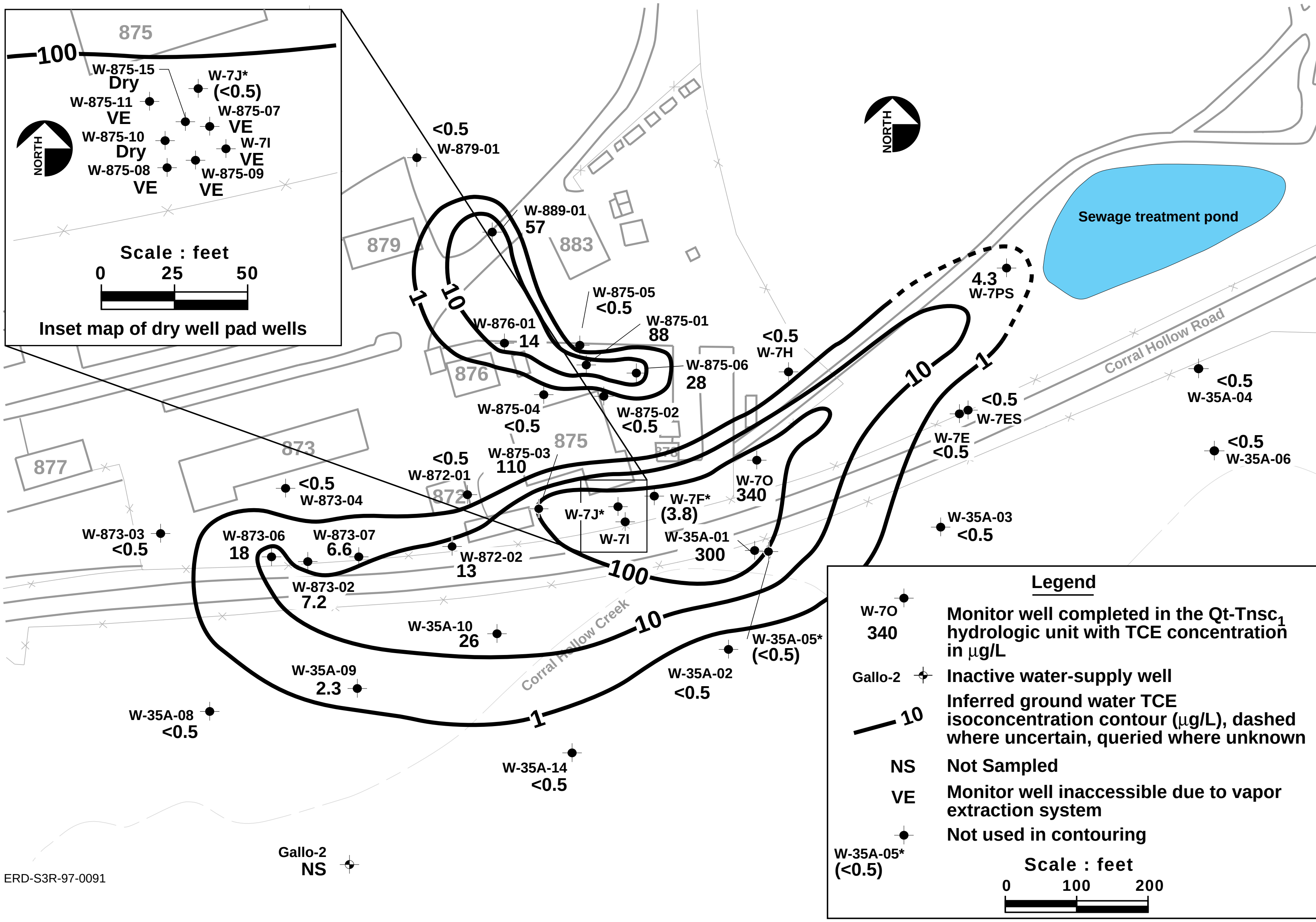


Figure 5. TCE concentrations in ground water from the Qt-Tnsc$_1$ hydrogeologic unit in the central GSA, (4th quarter 1996).

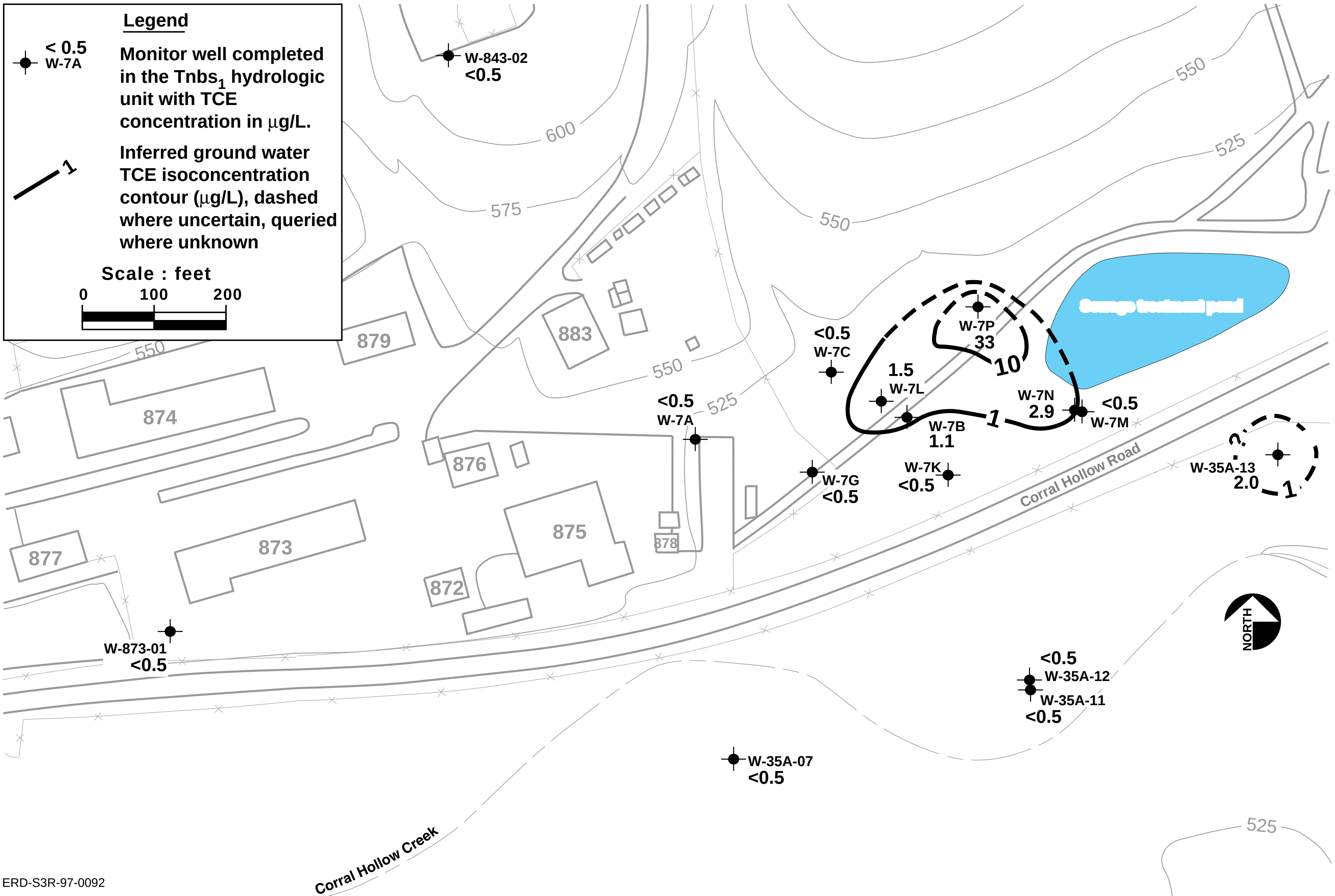


Figure 6. TCE concentrations in ground water from the Tnbs$_1$ hydrogeologic unit in the central GSA, (4th quarter 1996).

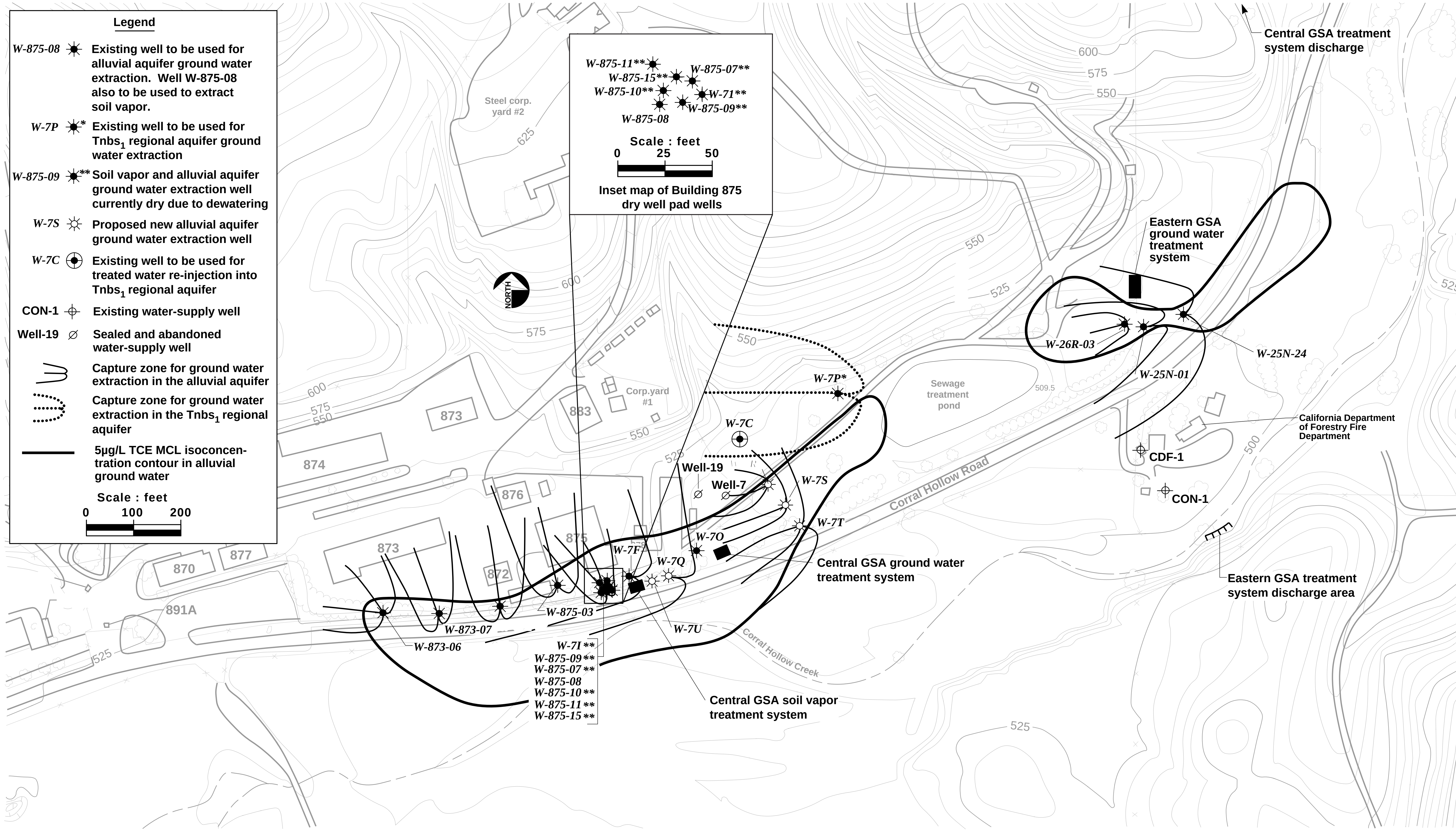


Figure 7. Locations of existing and proposed ground water extraction and reinjection wells, soil vapor extraction wells, treatment systems, and modeled capture zones.

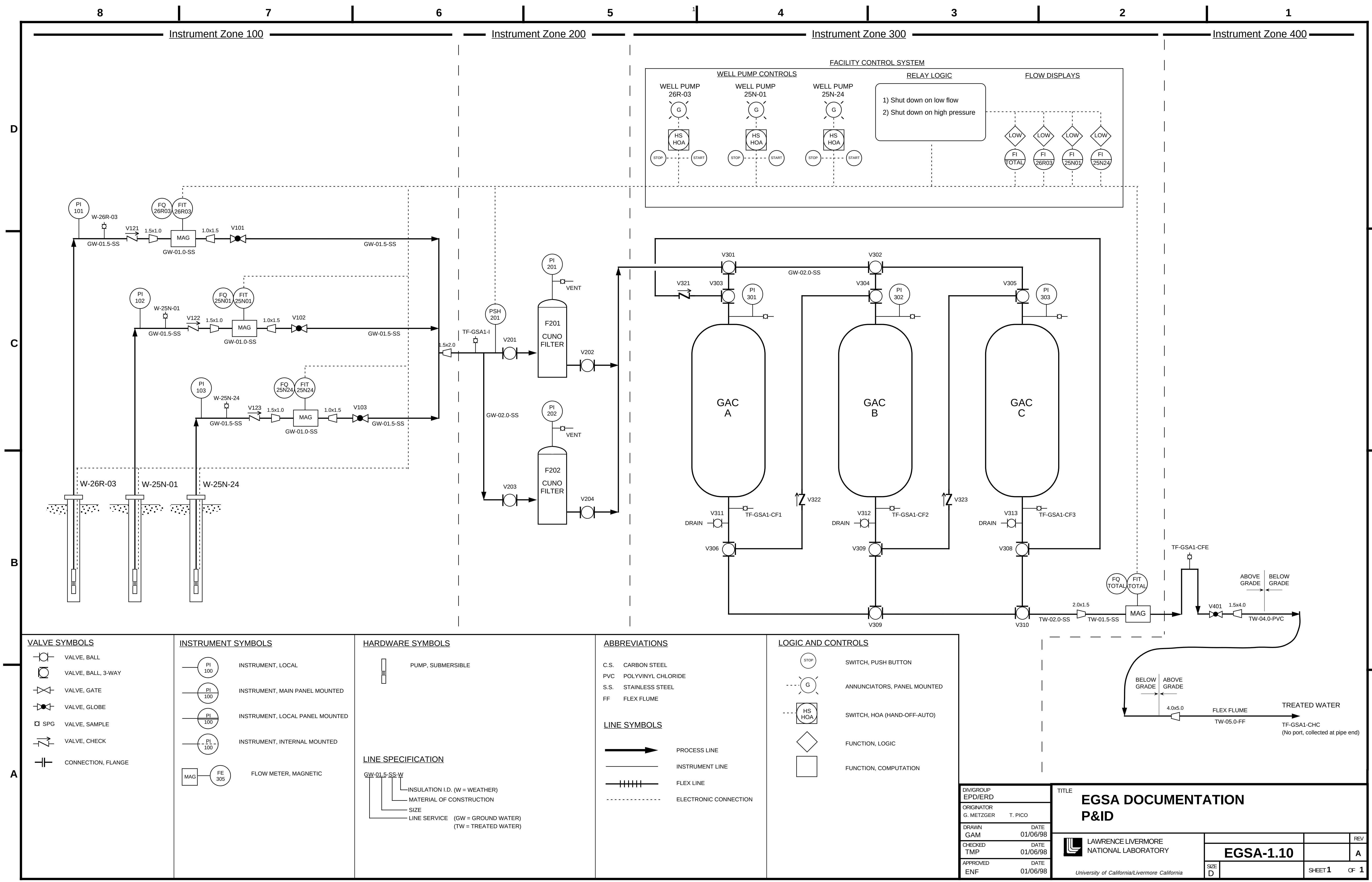
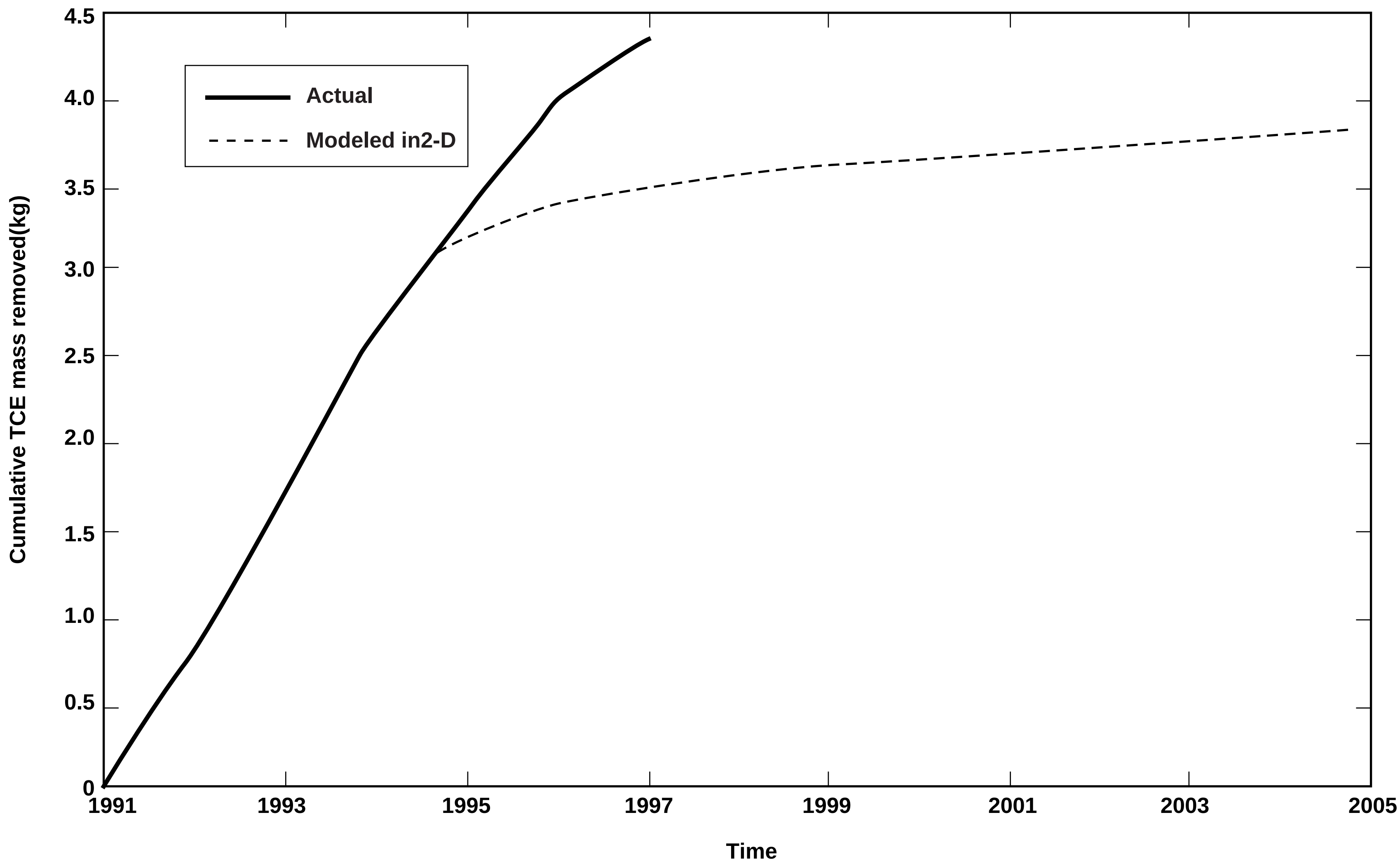


Figure 8. Eastern GSA ground water extraction and treatment system piping and instrument diagram.



ERD-S3R-97-0110

Figure 9. Comparison of 2-D modeled estimates versus actual GWE TCE cumulative mass removal for the eastern GSA.

VALVE SYMBOLS

- VALVE, BALL
- VALVE, GATE
- VALVE, GLOBE
- VALVE, DIAPHRAGM
- VALVE, NEEDLE
- SPG VALVE, SAMPLE
- VALVE, CHECK
- S VALVE, SOLENOID
- S VALVE, SOLENOID, 3-WAY
- VALVE, BALL
- VALVE, BALL, 3-WAY
- VALVE, BUTTERFLY
- DAMPER

INSTRUMENTATION SYMBOLS

- PI 100 INSTRUMENT, LOCAL
- PI 100 INSTRUMENT, MAIN PANEL MOUNTED
- PI 100 INSTRUMENT, LOCAL PANEL MOUNTED
- PI 100 INSTRUMENT, INTERNAL MOUNTED
- MAG FE 305 FLOW METER, MAGNETIC
- 8 FE 305 FLOW METER, TOTALIZING, TURBINE OR PADDLE
- PD FQ 305 FLOW METER, POSITIVE DISPLACEMENT

EQUIPMENT SYMBOLS

- COMPRESSOR, RING
- PUMP, CENTRIFUGAL
- PUMP, SUBMERSIBLE, ELECTRICAL
- LSH LSL PUMP, SUBMERSIBLE, PNEUMATIC
- REGULATOR, PRESSURE
- BL;OWER, AIR

PIPING SYMBOLS

- OR CAM-LOCK
- CONNECTION, FLANGE
- CONNECTION, HOSE

LINE SYMBOLS

- PROCESS PIPING
- PROCESS PIPING, SECONDARY
- AIR SUPPLY LINE
- PNEUMATIC SIGNAL
- FLEXIBLE PIPING
- ELECTRONIC CONNECTION
- ELECTRICAL HEAT TRACE

LINE SPECIFICATION

SV-01.5-SS-W

- INSULATION I.D. (W = WEATHER)
- MATERIAL OF CONSTRUCTION
- SIZE (INCHES)
- LINE SERVICE (SV = SOIL VAPOR)
  (TV = TREATED VAPOR)
  (VAP = UN-TREATED VAPOR)

ABBREVIATIONS

- C.S. CARBON STEEL
- GAC GRANULAR ACTIVATED CARBON
- LG LEVEL GAUGE
- PTU PORTABLE TREATMENT UNIT
- PVC POLYVINYL CHLORIDE
- S.S. STAINLESS STEEL

LOGIC AND CONTROLS

- YS 123 PROGRAMMABLE LOGIC CONTROL, INPUT
- YC 123 PROGRAMMABLE LOGIC CONTROL, OUTPUT
- LT 123 AI COMPUTER/DAS, ANALOG INPUT
- AO 123 AO COMPUTER/DAS, ANALOG OUTPUT
- LS 123 DI COMPUTER/DAS, DIGITAL INPUT
- DO 423 DO COMPUTER/DAS, DIGITAL OUTPUT
- R ANNUNCIATOR, PANEL MOUNTED
- HS HOA SWITCH, HOA (HAND-OFF-AUTO)
- ON OFF FUNCTION, LOGIC

DRAWING CONTROL

- TO/FROM: PTU INTERLOCK SYSTEM — CONTINUATION FLAG, BI-DIRECTIONAL
- TO: PORTABLE TREATMENT UNIT (PTU) INFLUENT PORT — CONTINUATION FLAG, UNI-DIRECTIONAL
- CONTINUATION SEE: CGSA-1.10-2 — CONTINUATION DRAWING NUMBER
- Instrument Zone 200 — DESCRIPTOR, INSTRUMENT ZONE

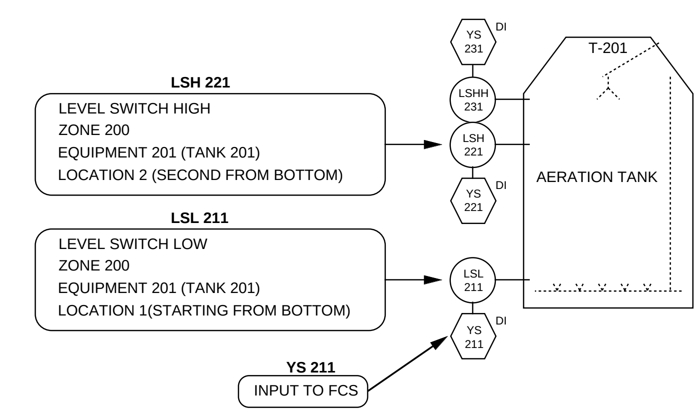
INSTRUMENT AND LOOP NUMBERS

INSTRUMENT LETTER IDENTIFICATION TABLE

	FIRST LETTER MEASURED ON INITIATING VARIABLE	SECOND LETTER READOUT FOR OUTPUT FUNCTION	SUCCEEDING LETTERS (IF REQUIRED)
A	ANALYSIS	ALARM	ALARM
B	BURNER		
C	CONDUCTIVITY	CONTROL (LER)	CONTROL (LER)
D	DENSITY/DAMPER	DIFFERENTIAL	
E	VOLTAGE (ELECT)	PRIMARY ELEMENT	
F	FLOW	RATIO/BIAS	RATIO/BIAS
G	GAGING (DIMENSIONAL)	GLASS	
H	HAND (MANUAL)		HIGH
I	CURRENT (ELECT)	INDICATE	INDICATE
J	POWER	SCAN (NER)	
K	TIME	CONTROL STATION	
L	LEVEL	LIGHT	LOW
M	MOISTURE/MASS		MIDDLE/INTERMEDIATE
N			
O			
P	PRESSURE	POINT (TEST)	
Q	QUANTITY	TOTALIZE/QUANTITY	
R		RECORD	RECORD
S	SPEED/FREQUENCY	SAFETY/SWITCH	SWITCH
T	TEMPERATURE	TRANSMITTER	TRANSMITTER
U	MULTI-POINT/VARIABLE	MULTI-FUNCTION	MULTI-FUNCTION
V	VISCOSITY	VALVE	VALVE
W	WEIGHT	WELL	
X	SPECIAL	SPECIAL	SPECIAL
Y	INTERLOCK	RELAY/COMPUTE	RELAY/COMPUTE
Z	POSITION	DAMPER OR LOUVER DRIVE	

L	SH	211	A
FIRST LETTER	SUCCEEDING LETTERS	LOOP NUMBER	SUFFIX
FUNCTIONAL IDENTIFICATION		LOOP IDENTIFICATION	
INSTRUMENT IDENTIFICATION OR TAG NUMBER			

LOOP NUMBERS ARE DERIVED FROM THE ZONE/EQUIPMENT/LOCATION SCHEME AS FOLLOWS:



DIV/GROUP	TITLE	CGSA DOCUMENTATION WATER PHASE P & ID
ORIGINATOR T. PICO		
DRAWN GAM DATE 01/06/98	LAWRENCE LIVERMORE NATIONAL LABORATORY	CGSA-1.10-1 REV A
CHECKED TMP DATE 01/06/98	University of California/Livermore California	SIZE D SHEET 1 OF 4
APPROVED ENF DATE 01/06/98		

Figure 10. Central GSA ground water extraction and treatment system piping and instrumentation diagram

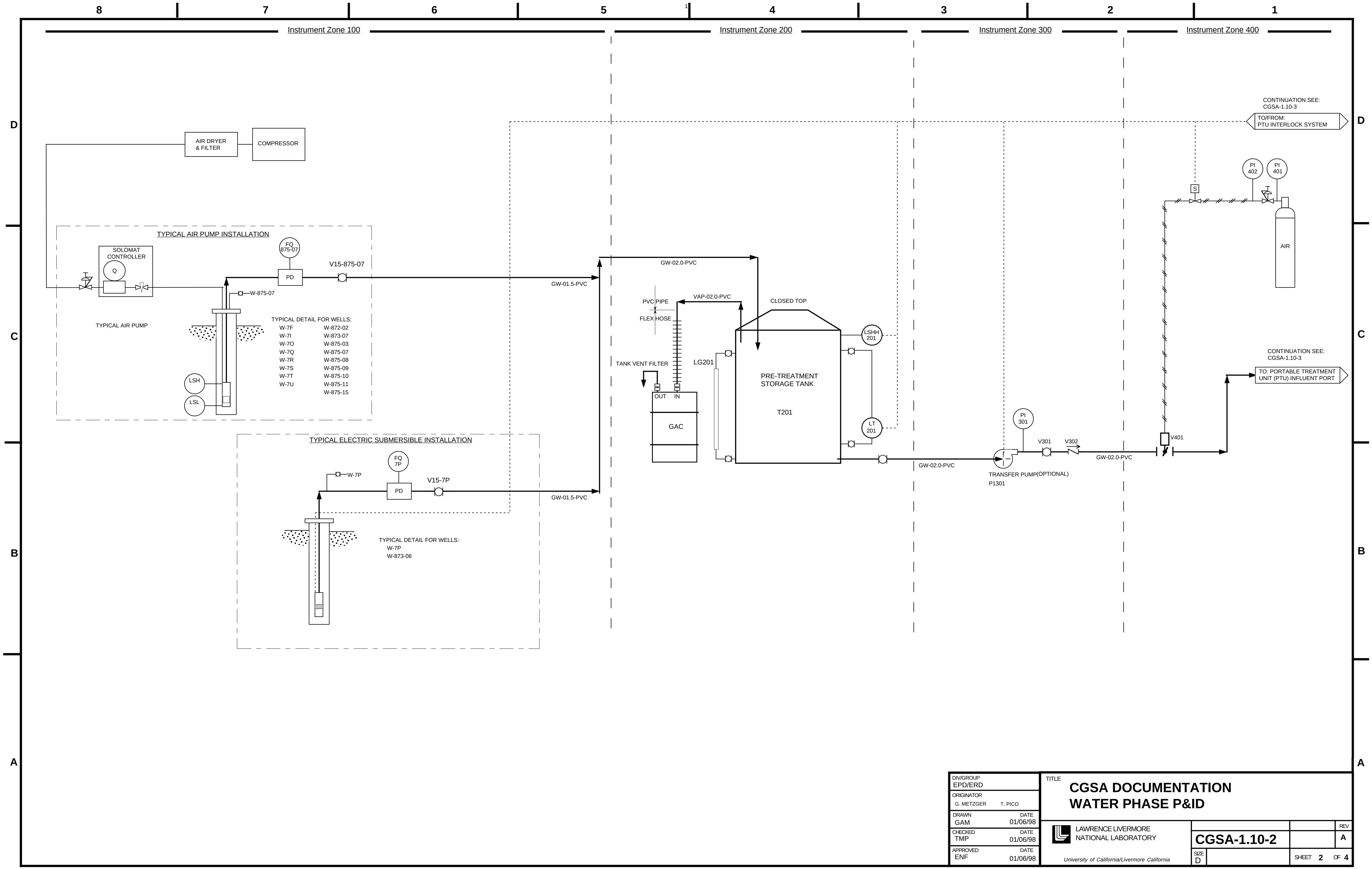


Figure 10. (Continued)

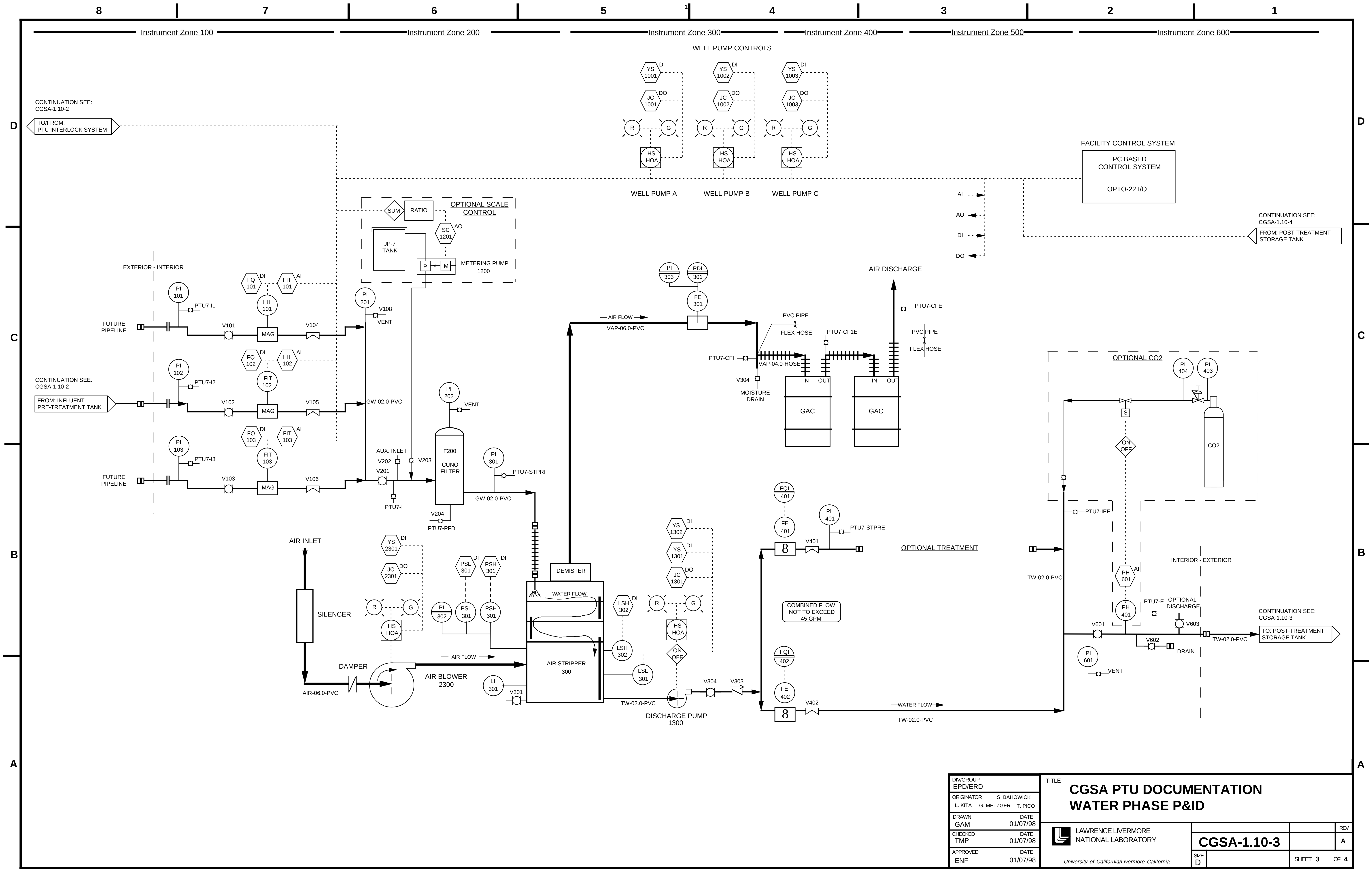


Figure 10. (Continued)

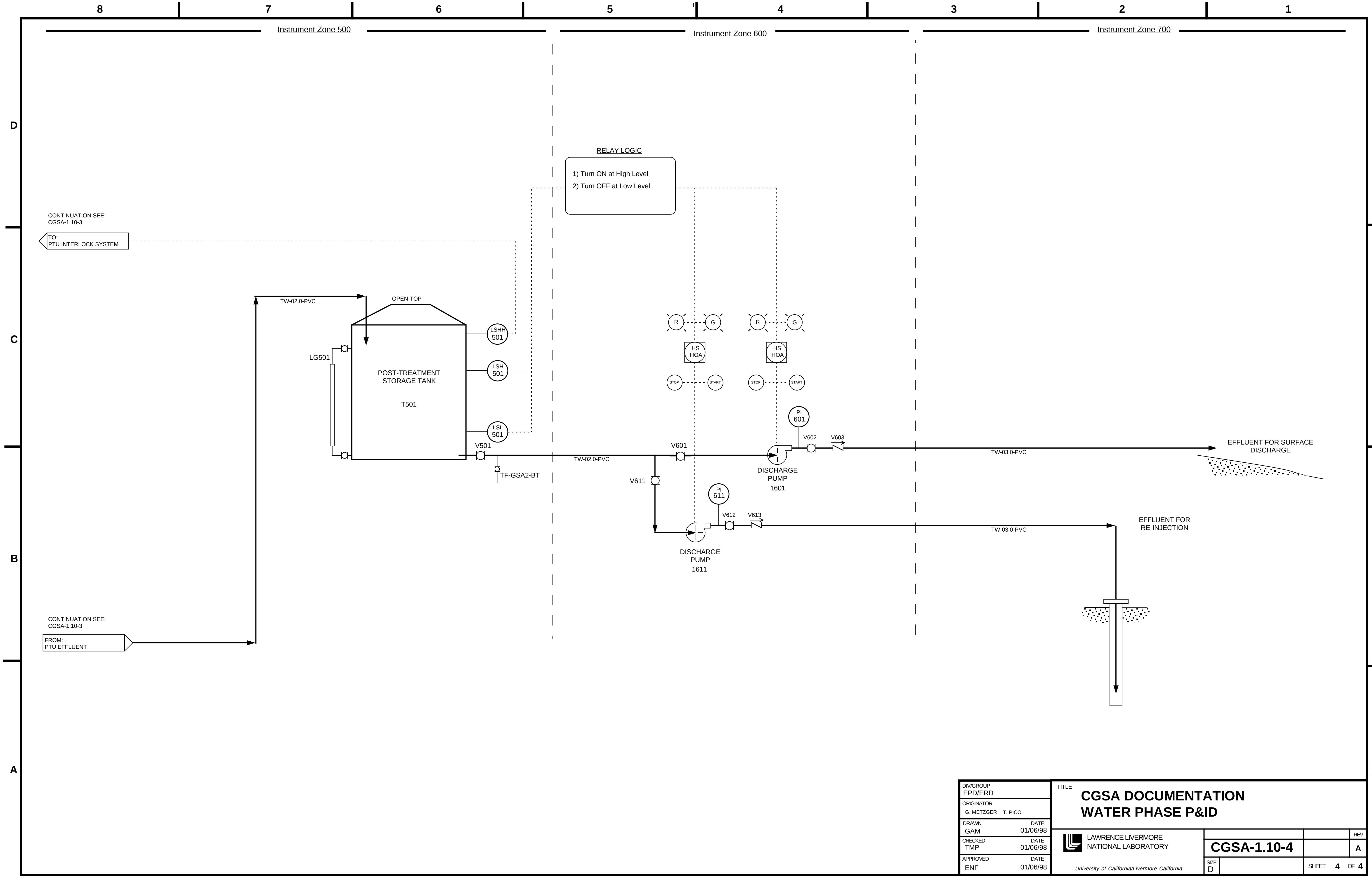


Figure 10. (Continued)

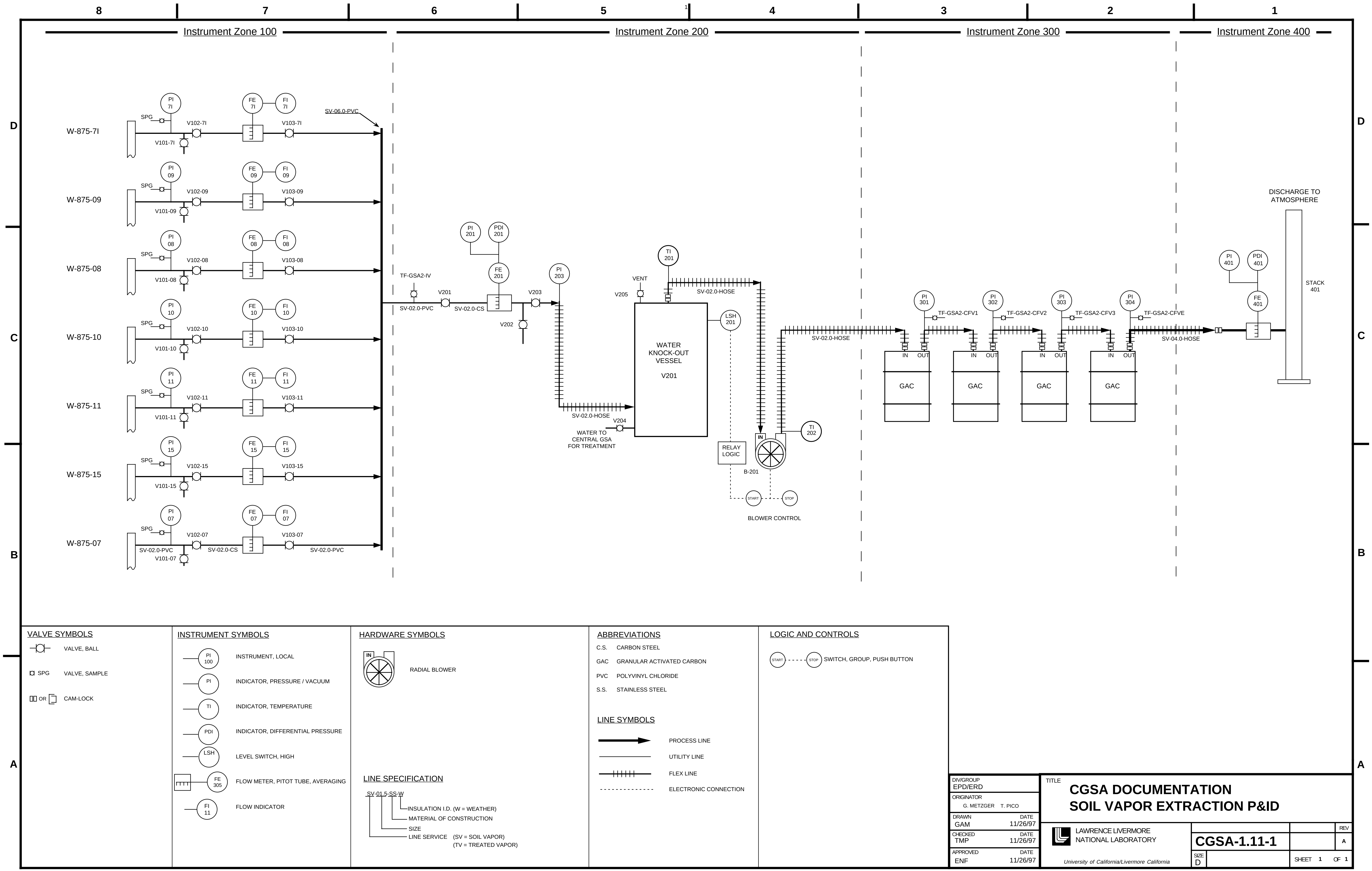


Figure 11. Central GSA soil vapor extraction and treatment system piping and instrumentation diagram.

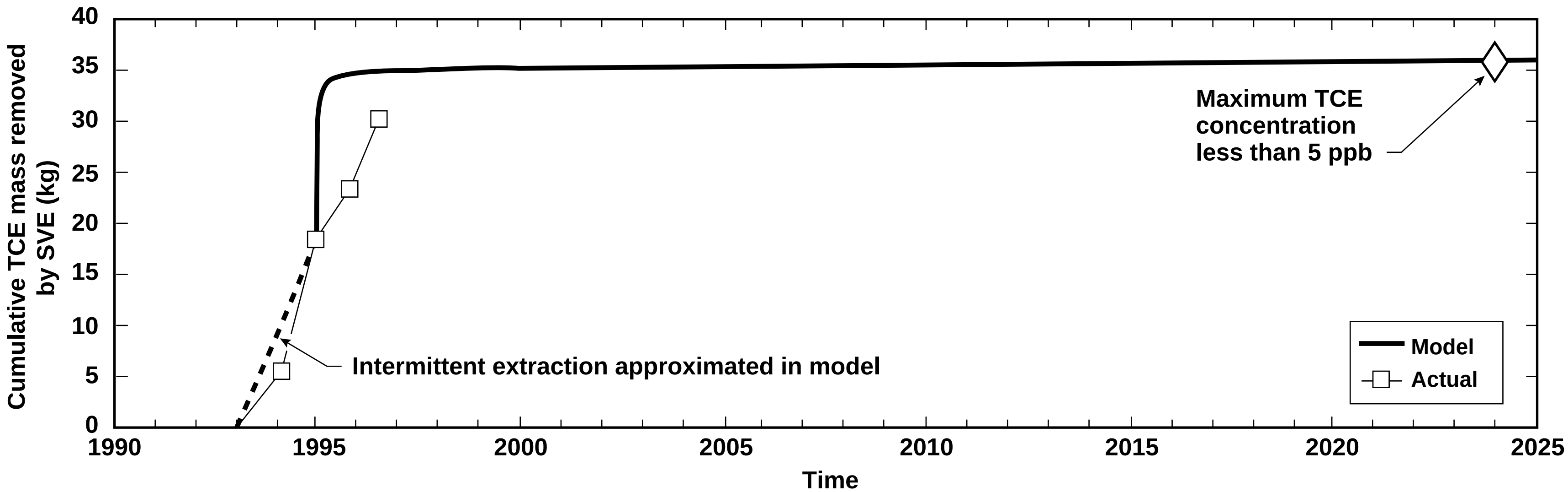


Figure 12. Predicted and actual cumulative TCE mass removed by soil vapor extraction (SVE).

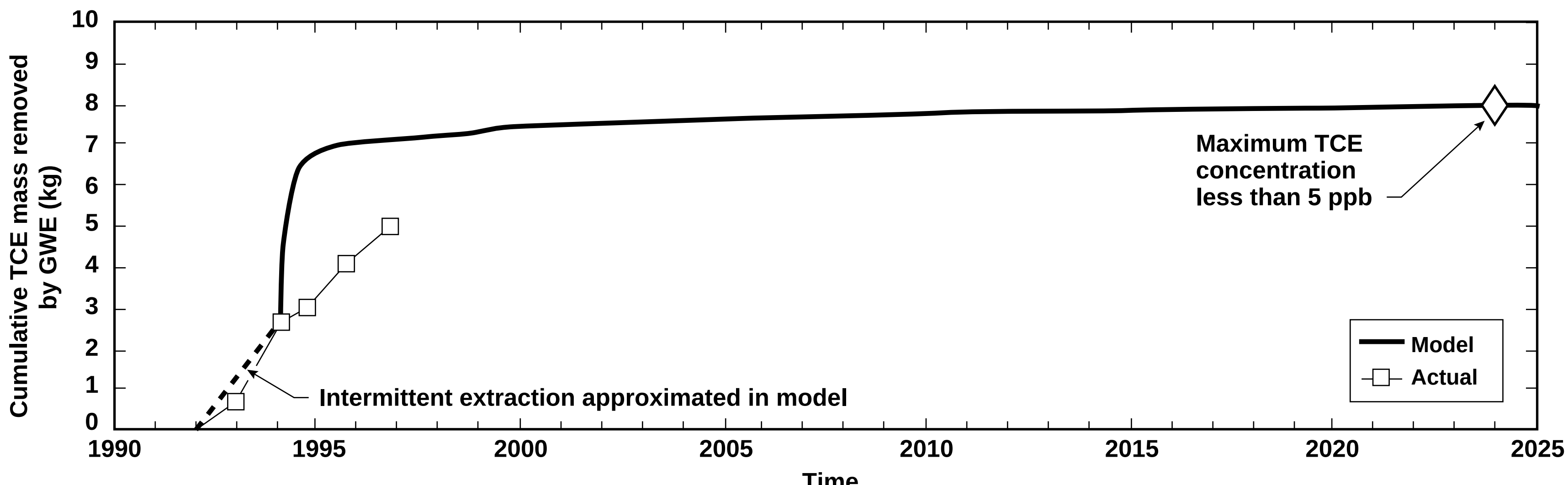


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Figure 13. Predicted and actual cumulative TCE mass removed by ground water extraction (GWE).

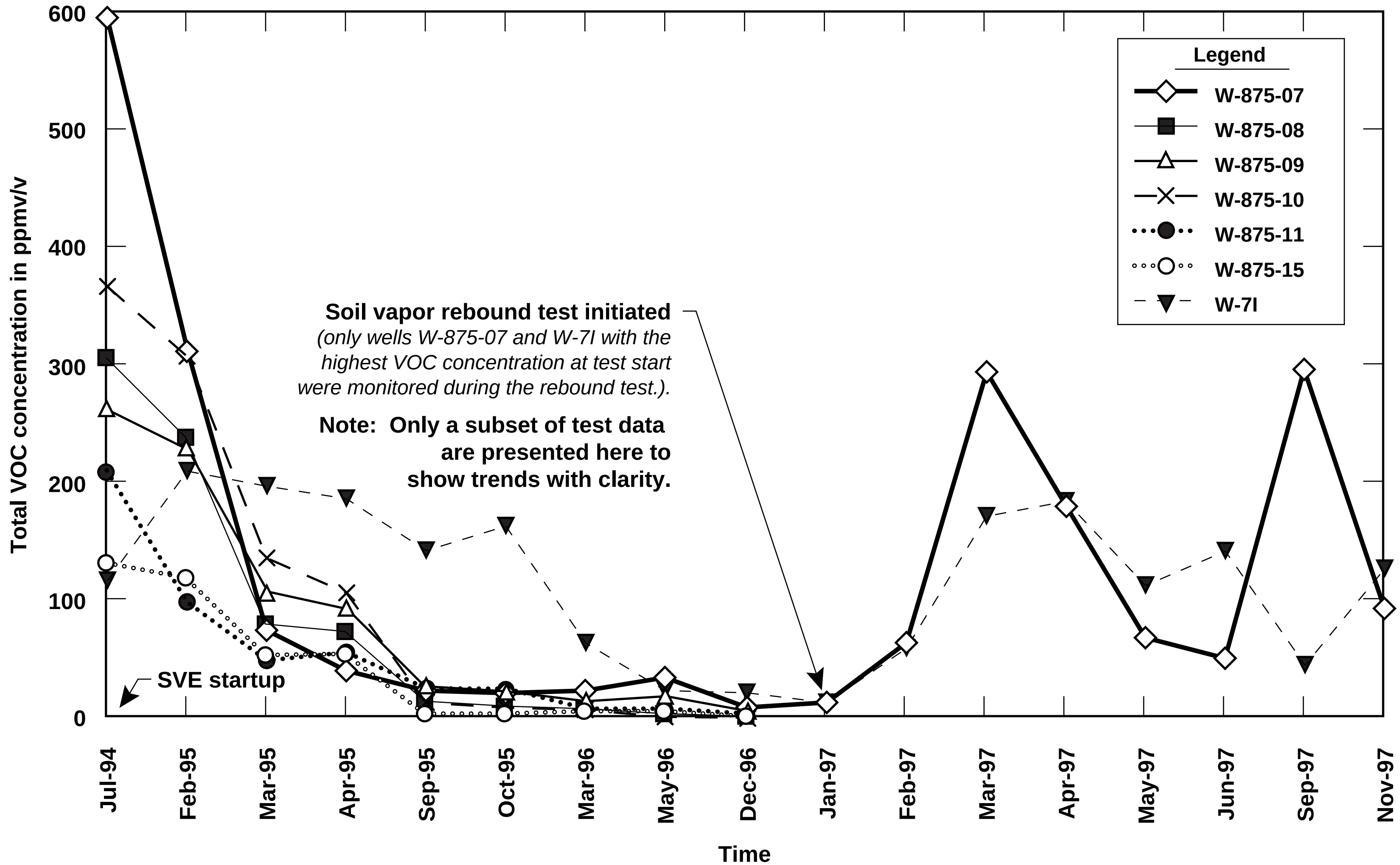

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Figure 14. Total VOC concentrations from central GSA soil vapor extraction (SVE) wells.

Tables

Table 1. Extraction wells for remediation of the GSA.

Well status	Central GSA Qt-Tnsc$_1$ hydrogeologic Unit		Central GSA Tnbs$_1$ hydrogeologic unit		Eastern GSA Qal-Tmss hydrogeologic unit	
	Source area wells	Plume migration control wells	Source area wells	Plume migration control wells	Source area wells	Plume migration control wells
Existing extraction well	Building 875 dry wells: W-875-07, W-875-08, W-875-09, W-875-10, W-875-11, W-875-15, W-7I[a]	NA	NA	NA	Debris Burial Trench Area: W-26R-03, W-25N-01, W-25N-24	W-26R-03, W-25N-01, W-25N-24
Existing monitor well to be converted to an extraction well	Building 875 dry wells: W-7O, W-7F, W-875-03 Building 872 dry well: W-872-02 Building 873 dry well: W-873-06, W-873-07	NA	Central GSA debris burial trench: W-7P	NA	NA	NA
New extraction wells to be installed	Building 875 dry wells: W-7Q, W-7U	W-7R, W-7S, W-7T	NA	NA	NA	NA
New reinjection well	NA	NA	NA	W-7C	NA	NA

[a] These wells will also be utilized for soil vapor extraction at the Building 875 dry well pad area.

Table 2. Design specifications for the GSA extraction wells.

Extraction well name	Date completed	Well type and status	Total depth (ft)	Perforated interval (ft)	Sand-pack interval (ft)	Hydro-geologic unit	Estimated maximum long-term steady-state yield (gpm)	Pump type[c]	Pump intake depth (ft)	Activation priority[d]
Eastern GSA										
W-26R-03	08/04/89	Active GW extraction	46	23.5-34.5	19.0-34.5	Qal-Tmss	25[a]	1 hp Grundfos pump	33.1	Currently active
W-25N-01	07/08/88	Active GW extraction	41.5	23.0-36.0	22.0-37.5	Qal-Tmss	10[a]	.5 hp Grundfos pump	35.5	Currently active
W-25N-24	11/27/91	Active GW extraction	33.5	19.0-29.0	18.0-31.5	Qal-Tmss	10[a]	.5 hp Grundfos pump	28.8	Currently active
Central GSA										
W-875-07	03/06/92	Active GW & SVE extraction	34.5	23.5-33.5	22.5-34.0	Qt-Tnsc$_1$	<1[a]	Solo pnuematic pump	33.5	Currently active
W-875-08	03/13/92	Active GW & SVE extraction	50.25	20-50	19-50	Qt-Tnsc$_1$	1[a]	Solo pnuematic pump	49.25	Currently active
W-875-09	03/23/92	Active GW & SVE extraction	41.0	20-40	16.5-41	Qt-Tnsc$_1$	(Dry out)[a]	None (well dry)	NA	Currently active
W-875-10	03/26/92	Active GW & SVE extraction	41.5	20-40.5	17.4-41.5	Qt-Tnsc$_1$	(Dry out)[a]	None (well dry)	NA	Currently active
W-875-11	03/31/92	Active GW & SVE extraction	41.0	20-40.5	14.5-40.5	Qt-Tnsc$_1$	(Dry out)[a]	None (well dry)	NA	Currently active

Table 2. (Continued)

Extraction well name	Date completed	Well type and status	Total depth (ft)	Perforated interval (ft)	Sand-pack interval (ft)	Hydro-geologic unit	Estimated maximum long-term steady-state yield (gpm)	Pump type[c]	Pump intake depth (ft)	Activation priority[d]
W-875-15	04/17/92	Active GW & SVE extraction	41.0	18.5-39.5	15-41.0	Qt-$Tnsc_1$	(Dry out)[a]	None (well dry)	NA	Currently active
W-7I	08/15/89	Active GW & SVE extraction	43.5	33.5-43.5	29.5-43.5	Qt-$Tnsc_1$	<1[a]	Solo pnuematic pump	42.0	Currently active
W-7F	04/28/88	Active MW-Proposed GW extraction	53.0	37.0-52.0	35.0-53.0	Qt-$Tnsc_1$	2-5[b]	TBD	TBD	1
W-7O	02/18/92	Active MW-Proposed GW extraction	28.5	25.0-27.5	23.5-27.5	Qt-$Tnsc_1$	2-5[b]	TBD	TBD	2
W-875-03	12/06/89	Active MW-Proposed GW extraction	40.5	30.5-35.5	29.5-35.5	Qt-$Tnsc_1$	<1[b]	TBD	TBD	3
W-7P	04/08/94	Active MW-Proposed GW extraction	31.0	20.0-30.0	20.0-30.0	$Tnbs_1$	4.5[b]	TBD	TBD	4

Table 2. (Continued)

Extraction well name	Date completed	Well type and status	Total depth (ft)	Perforated interval (ft)	Sand-pack interval (ft)	Hydro-geologic unit	Estimated maximum long-term steady-state yield (gpm)	Pump type[c]	Pump intake depth (ft)	Activation priority[d]
W-872-02	08/24/90	Active MW-Proposed GW extraction	50.0	39.0-44.5	37.5-44.5	Qt-Tnsc$_1$	<1[b]	TBD	TBD	5
W-873-06	08/15/90	Active MW-Proposed GW extraction	50.0	36.0-46.0	29.0-46.0	Qt-Tnsc$_1$	1.4[b]	TBD	TBD	6
W-873-07	8/22/90	Active MW-Proposed GW extraction	50.0	41.0-46.0	39.0-46.0	Qt-Tnsc$_1$	1[b]	TBD	TBD	7
W-7Q	TBI	Proposed GW extraction	TBD	TBD	TBD	Qt-Tnsc$_1$	TBD	TBD	TBD	8
W-7R	TBI	Proposed GW extraction	TBD	TBD	TBD	Qt-Tnsc$_1$	TBD	TBD	TBD	10
W-7S	TBI	Proposed GW extraction	TBD	TBD	TBD	Qt-Tnsc$_1$	TBD	TBD	TBD	11

Table 2. (Continued)

Extraction well name	Date completed	Well type and status	Total depth (ft)	Perforated interval (ft)	Sand-pack interval (ft)	Hydro-geologic unit	Estimated maximum long-term steady-state yield (gpm)	Pump type[c]	Pump intake depth (ft)	Activation priority[d]
W-7T	TBI (1998)	Proposed GW extraction	TBD	TBD	TBD	$Qt\text{-}Tnsc_1$	TBD	TBD	TBD	12
W-7U	TBI	Proposed GW extraction	TBD	TBD	TBD	$Qt\text{-}Tnsc_1$	TBD	TBD	TBD	9
W-7C	TBI	Proposed GW injection	TBD	TBD	TBD	$Tnbs_1$	TBD	NA	NA	13

[a] Estimated yield based on average extraction well yields. Yields may vary seasonally in response to water table fluctuations.

[b] Estimated yield based on pumping test results. Actual longterm pumping rates will generally be lower.

[c] Indicates type of pump currently installed in existing extraction wells.

[d] Ativation priority is the estimated order in which extraction wells will be connected to the treatment facility. Activiation priority is based on whether the well currently exists, engineering design and cost, and the known or anticipated VOC concentration in ground water at the extraction location.

Notes:

GW = Ground water.

hp = Horsepower.

MW = Monitor well.

NA = Not applicable.

SVE = Soil vapor extraction.

TBD = To be determined.

TBI = To be installed.

Table 3. Eastern and central GSA treatment system design ground water influent concentrations.

Extraction well	Recent average TCE concentrations in ground water[a] (μg/L)	Recent average PCE concentrations in ground water[a] (μg/L)	Modeled Extraction flow rate (gpm)[c]	Flow weighted average TCE concentration in ground water (μg/L)	Flow weighted average PCE concentration in ground water (μg/L)
Eastern GSA					
W-25N-01	4.4	0.3	12.5		
W-25N-24	12.0	0.8	12.5		
W-26R-03	9.7	0.7	21.0		
			46	TCE = 8.9	PCE = 0.6
Central GSA					
W-7F	3.8	1.6	0.10		
W-7I	6.1	<0.5	0.10		
W-7O	340	22	0.15		
W-7P	33	2.1	4.5		
W-7Q[b]	1,000	100	0.10		
W-7R[b]	10	1	0.15		
W-7S[b]	50	5	0.11		
W-7T[b]	10	1	0.10		
W-7U[b]	340	22	0.05		
W-872-02	13	<0.5	0.30		
W-873-06	18	<0.5	1.4		
W-873-07	6.6	<0.5	0.70		
W-875-03	110	4.2	0.15		
W-875-07	2,770 [d]	380	0.10		
W-875-08	2,770 [d]	380	0.12		
W-875-09[e]	2,770 [d]	380	0.09		
W-875-10[e]	2,770 [d]	380	0.10		
W-875-11[e]	2,770 [d]	380	0.15		
W-875-15[e]	2,770 [d]	380	0.07		
			8.5	TCE = 248	PCE = 31

[a] Average concentrations are based on monitoring data collected during fourth quarter 1996 or most recent sampling.

[b] Because these wells are not yet installed, average TCE concentrations are based on interpretation of isoconcentration contour maps for data collected during fourth quarter 1996. PCE concentrations are estimated to be 10% of TCE concentrations.

[c] Flow rates are based on system performance and estimated performance for future extraction wells.

[d] Estimated TCE concentrations in existing ground water extraction wells are based on ground water treatment system influent concentrations. We are unable to sample extraction wells due to extremely low flow or dry-out conditions.

[e] These wells historically dry out very quickly, but for treatment system modeling and design, we conservatively assume a low flow rate.

Table 4. Eastern and central GSA treatment system equipment specifications.

Equipment	Specifications[a]
Eastern GSA Ground Water Extraction and Treatment System	
Well pumps	Two 16S10 Grundfos electrical submersible 1 hp pumps, and one 16S05 Grundfos electrical submersible, 1/2 hp pump.
Influent pipeline from extraction wells to the treatment facility	Schedule 40 stainless steel 1-1/2- and 2-in. inside diameter.
Particulate filter canister	Cuno Model No. 12 DC3, stainless steel, 230-gpm maximum, or equivalent, 150 psi maximum operating pressure at 200 degrees F.
Particulate filter cartridges	Cellulose cartridge or equivalent nominal 5-micron filter.
Aqueous-phase GAC	Three 1,000-lb Westates Carbon Inc. Model No. PV-35-2 GAC units, with maximum flow capacity of 50 gpm.
Water flow meters	Rosemount Model No. 8732, 15 volts DC.
Well pressure gauges	Ashcroft, 0 to 200 psi.
GAC pressure gauges	Ashcroft, 0 to 60 psi.
Cuno filter pressure gauges	USG, 0 to 30 psi.
Discharge line	Approximately 7 ft of 2-in. stainless steel piping connected to 100 ft of 4-in. CetainTeed weather-resistant PVC piping connected to 600 ft of 5-in. Flexfume hose.
Central GSA Ground Water Extraction and Treatment System	
Well pumps	Up to nineteen 16S10 Grundfos electrical submersible 1 hp pumps or 16S05 Grundfos electrical submersible, 1/2 hp pump, or for very low flow wells constant displacement SOLO pneumatic pumps attached by air-line to an air compressor.
Influent pipeline from extraction wells to pre-treatment storage tank	1-in. PVC piping.
Pre-treatment storage tank	3,000 gal steel tank or equivalent.

Table 4. (Continued)

Equipment	Specifications[a]
Transfer pump	1/2 to 1-1/2 hp, 220 volt, 0- to 45 gpm.
Influent pipeline from transfer pump to PTU	2-in. PVC piping.
PTU Building	Cargo type shipping container, 19.5- × 7.8- × 7.8-ft inside dimensions.
Particulate filter canister	Cuno Model No. 12 DC3, stainless steel, 230-gpm maximum, or equivalent, 150 psi maximum operating pressure at 200 degrees F.
Particulate filter cartridges	Cellulose cartridge or equivalent nominal 5-micron filter.
Air stripper	Shallow Tray Model No. 2331, 45 gpm maximum flow rate, 300 cfm at 18-in. water column, inlet screen and damper, 316L, stainless steel demister or equivalent. Supply blower will be an American Fan Co. A.F. Model VP-1-06-18.5A, 5 hp, 3,500 rpm, 3 phase, 208 volts alternating current, totally closed fan-cooled motor or equivalent.
Stripper sump level control sensor	MTS magnetic level sensor or equivalent.
Air stripper discharge pump and motor	Bell and Gossett pump Series 15120-11/2 BC, 3-5 hp, 1,750 rpm, 208 volts alternating current, 60 hertz, 3-phase motor with 5 to 45 gpm at 100-ft total dynamic head, or equivalent.
Vapor-phase GAC	Two 140-lb Carbtrol Model No. G3S (steel) GAC units, 4.5 in. water at 450 cfm, or equivalent, 4-in. inlet/outlet connections.
Emissions stack	6-in. PVC pipe/hose, with 6-in. flange out the top of the PTU.
Scale control and pH adjustment (if needed)	Polyphosphate or equivalent sequestering agent, or carbon dioxide system.
Programmable logic controller	486 personal computer with Paragon control software and OPTO-22 I/O, or equivalent.
Water flow meters	Signet Model No. P58640, digital, battery operated.
Water flow meter / totalizer	Precision, mechanical.

Table 4. (Continued)

Equipment	Specifications[a]
Effluent pipeline from treatment facility to the post-treatment storage tank	2-in. PVC piping.
Post-treatment storage tank	20,000 gallon steel Baker tank, or equivalent.
Post-treatment storage tank discharge pump	California Hydronics Model No. 11\4BC, 15 hp, 36 rpm, 175 psi.
Discharge line from post-treatment storage tank discharge pump to surface discharge location	3-in. CertainTeed weather-resistant PVC piping.
Flow meter / totalizer on discharge line from post-treatment storage tank to surface discharge	Precision, mechanical totalizer, 95 pmm series, 2 in.
Spray nozzles	1-1/2-in. fire-hose nozzles.
Post-treatment storage tank discharge pump for re-injection	1/2 to 1 hp, 220 volt, 0- to 10 gpm.
Discharge line from post-treatment storage tank to re-injection well	Approximately 60 ft of 1-in. PVC piping.
Central GSA Soil Vapor Extraction and Treatment System	
Influent pipeline from extraction wells to the treatment facility	2-in. PVC piping.
Air-intake valve	2-in. PVC pipe.
Water knock-out drum	85 gallon drum with fabric and a liquid effluent valve on the lower side of the drum.
Radial blower	Fuji Model No. 503A, 2 hp blower.
Vapor-phase GAC	Four 140-lb Carbtrol Model No. G3S (steel) GAC units, 4.5 in. water at 450 cfm, or equivalent, 4-in. inlet/outlet connections.

Table 4. (Continued)

Equipment	Specifications[a]
Effluent pipeline from treatment facility to the discharge tower	3-in. PVC corrugated hose.
Emissions stack	10-5/8-in. diameter steel stack with vertical height of 15 ft.

[a] If a specific model is not available, an equivalent device that satisfies the intended function will be procured.

Table 5. Eastern and central GSA treatment system effluent discharge limits.

Criteria	Limit
Eastern GSA Ground Water Extraction and Treatment System	
Total VOC in liquid effluent	Daily maximum – $\leq$ 5.0 μg/L
	Monthly median – $\leq$ 0.5 μg/L
Flow rate for liquid effluent	Between May 1 and October 1 of each year, the discharge shall not create a continuous flow in Corral Hollow Creek where it flows through the Department of Fish and Game's Corral Hollow Ecological Reserve.
Central GSA Ground Water Extraction and Treatment System	
Total VOC in liquid effluent	Daily maximum – $\leq$ 5.0 μg/L
	Monthly median – $\leq$ 0.5 μg/L
Flow rate for liquid effluent	Shall not exceed the design capacity determined during proof-of-system phase without prior approval from the RWQCB
VOCs in vapor effluent	Shall not exceed 6.0 $ppm_{v/v}$
Flow rate for effluent gas	Shall not exceed 705 scfm
Central GSA Soil Vapor Extraction and Treatment System	
VOCs in vapor effluent	Shall not exceed 6.0 $ppm_{v/v}$
Flow rate for effluent gas	Shall not exceed 400 scfm

Table 6. Eastern GSA ground water extraction and treatment system design, construction, and startup completion dates.

Activity	Completion date[a]
Design	1995
Construction	1996
System start-up	1997

[a] All dates presented are for the aqueous-phase Granular Activated Carbon system which replaced the sparge tank treatment system.

Table 7. Eastern and central GSA cost summaries.

Item	Capital costs	Annual O&M
Eastern GSA ground water extraction and treatment system		
Capital costs		
Site preparation (including labor and materials to grade site, install cement pad, graded rock, installation of electrical lines and power connections, and landscape area)	50,000	
Treatment system construction/installation[a] (including design, purchase of major system components, plumbing and electrical materials, well head modifications, and construction/installation labor)	115,000	
Startup	10,000	
Capital costs subtotal	*175,000*	
10% MPC	17,500	
Capital costs subtotal	*192,500*	
O&M		
Labor		
ERD personnel (including project management, system and wellfield optimization analysis, compliance reporting, data management, and operation and maintenance labor)		125,000
Plant support		2,000
Labor subtotal		*127,000*
54% G&A/OPC		68,580
Materials		
Electricity		3,000
Pumps		750
Filters		200
Filter housing		550
Carbon replacement		1,500
Miscellaneous maintenance (including well head plumbing, piping, and electronics)		5,000
Sample analyses (including treatment facility, receiving waters, monitor wells, water level measurement data, and QA/QC)		50,000
Materials subtotal		*61,000*

Table 7. (Continued)

Item	Capital costs	Annual O&M
10% MPC		6,100
O&M subtotal		*262,680*
6.38% LDRD charge	12,282	16,760
Total cost	*204,782*	*279,440*
Central GSA ground water extraction and treatment system		
Capital costs		
Site preparation (including labor and materials to grade site, install cement pad, and graded rock and installation of electrical lines and power connections)	104,000	
Treatment system construction/installation[b] (including design, purchase of major system components, plumbing and electrical materials, well head modifications, and PTU construction/installation labor)	150,000	
Startup	20,000	
Well field expansion design	100,000	
Well field expansion construction (includes drilling and installation of 5 extraction wells, 1 injection well, and 10 piezometers, and converting 7 monitor wells into extraction wells)	315,000	
Pipeline design and construction	250,000	
Permitting (includes injection well permit, treatment facility permit modification, and miscellaneous permit expenses [i.e., electrical inspections, treatment facility schematics, etc.])	10,000	
Re-start	50,000	
Capital costs subtotal	*999,000*	
10% MPC	99,900	
Capital costs subtotal	*1,098,900*	
O&M		
Labor		
ERD personnel (including project management, system and wellfield optimization analysis, compliance reporting, data management, and operation and maintenance labor)		200,000
Plant support		2,500

Table 7. (Continued)

Item	Capital costs	Annual O&M
Labor subtotal		*202,500*
54% G&A/OPC		109,350
Materials		
Electricity		5,000
Pumps		10,000
Filters		200
Filter housing		550
pH and scale control (if needed)		2,000
Holding tank rental		6,000
Miscellaneous maintenance (including well head plumbing, piping, electronics, and PTU components)		15,000
Sample analyses (including treatment facility, monitor wells, water level measurement data, and QA/QC)		70,000
HWM (includes GAC removal, replacement, and transportation container costs)		400
Materials subtotal		*109,150*
10% MPC		10,915
O&M subtotal		*431,915*
6.38% LDRD charge	70,110	27,556
Total cost	*1,169,010*	*459,471*
Central GSA soil vapor extraction and treatment system		
Capital costs		
Site preparation (including labor and materials to grade site, install cement pad, and ramp and installation of electrical lines and power connections)	15,000	
Treatment system construction/installation[b] (including design, purchase of major system components, plumbing and electrical materials, well head modifications, and construction/installation labor)	40,000	
Startup	50,000	
Capital costs subtotal	*105,000*	
10% MPC	10,500	
Capital costs subtotal	*115,500*	
O&M		
Labor		

Table 7. (Continued)

Item	Capital costs	Annual O&M
ERD personnel (including project management, system and wellfield optimization analysis, compliance reporting, data management, and operation and maintenance labor)		50,000
Plant support		2,000
Labor subtotal		*52,000*
54% G&A/OPC		28,080
Materials		
Electricity		2,500
Vacuum pump		300
Miscellaneous maintenance (including well head plumbing, piping, and electronics)		5,000
Sample analyses (includes treatment facility influent, soil vapor extraction wells and QA/QC)		15,000
HWM (includes GAC removal replacement, and transportation container costs)		2,500
Materials subtotal		*25,300*
10% MPC		2,530
O&M subtotal		*107,910*
6.38% LDRD charge	7,369	6,885
Total costs	*122,869*	*114,795*

[a] Does not include well installation costs, which were part of the eastern GSA removal action.

[b] Does not include well installation costs, which were part of the central GSA removal action.

MPC = Material Procurement Charge.

HWM = Hazardous Waste Management.

G&A/OPC = General Administrative/Organizational Personnel Charge cost.

LDRD = Laboratory Directed Research and Development cost

Table 8. Central GSA ground water and soil vapor extraction and treatment system and wellfield expansion design and construction schedule.

Activity	Completion/schedule date
Design	1995
Construction	1996
System start-up	1997
Well field expansion design	1998–99
Well field expansion construction	1999
System re-start	1999–2000

Appendix A

1. **Eastern GSA Waste Discharge Requirement Order No. 97-242**
2. **Central GSA Substantive Requirements for Waste Discharge**
3. **San Joaquin Valley Unified Air Pollution Control District Air Permits for the Central GSA Ground Water and Soil Vapor Extraction and Treatment Systems**

(Electronic version not available—Contact ERD for hard copies (925) 424-6783)

Appendix B

Construction Quality Assurance/ Quality Control Plan

Appendix B

Construction Quality Assurance/ Quality Control Plan

B-1. Introduction

This Construction Quality Assurance/Quality Control (QA/QC) plan has been developed in support of the central and eastern General Services Area (GSA) ground water and vapor treatment systems. Because these facilities have already been constructed as part of the GSA removal actions, this plan will apply only to any future construction activities. The QA/QC objectives are to:

- Assure excellence in construction design and implementation, and
- Provide the QA/QC requirements to meet all programmatic and institutional needs.

The QA/QC program provides confidence that these objectives will be achieved and that achievement will include due consideration for health, safety, property, and the environment.

B-2. QA/QC Processes and Procedures

Detailed construction QA/QC processes and procedures are addressed in one or more of the following documents, which are incorporated by reference into this plan:

- U.S. Department of Energy (DOE) Order 5700.6C, Quality Assurance Program (DOE, 1992).
- Lawrence Livermore National Laboratory (LLNL) Environmental Protection Department (EPD) Quality Assurance Management Plan (QAMP) (LLNL, 1996).
- LLNL Site 300 Environmental Restoration Project Quality Assurance Project Plan (QAPP) (Carlsen et al., 1992).
- LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs) (Dibley and Depue, 1997).
- LLNL Construction Manager Manual - Subcontracted Construction Projects, Plant Engineering Department (LLNL, 1989).
- LLNL Construction Inspectors Policy and Procedure Manual, Plant Engineering Department (LLNL, 1990).

Table B-1 shows the 11 elements of the EPD QAMP, which implements DOE Order 5700.6C, and their applicability to any future construction related activities for the central and eastern GSA ground water and vapor treatment systems. The construction QA/QC plan follows the Environmental Restoration Project QAPP approved by the U.S. EPA.

B-3. Organization

This section documents the organizational structure, functional responsibilities, and lines of communication for those aspects of construction related activities for the central and eastern GSA ground water and vapor treatment systems that affect quality.

Figure B-1 shows the organizational structure for construction QA/QC activities. The descriptions below generally describe the QA/QC responsibilities of those involved in carrying out the QA/QC program for the construction of the central and eastern GSA ground water and vapor treatment systems. Project personnel as shown in Figure B-1 have the following responsibilities:

- The U.S Department of Energy (DOE) is the Principal Responsible Party for the LLNL Site 300 for CERCLA related activities. Environmental restoration activities at Site 300 are conducted by LLNL Environmental Restoration Division (ERD) by University of California staff, hereafter referred to as LLNL, under the direction of the DOE Site 300 Remedial Project Manager (RPM). The DOE RPM coordinates these activities through the U.S. Environmental Protection Agency, and California Department of Toxic Substances Control and the Regional Water Quality Control Board RPMs.
- The LLNL Environmental Protection Department (EPD) Quality Assurance Manager provides oversight and monitors QA related activities of divisions within the EPD, including ERD. The Quality Assurance Manager reports the results of quality verification to the EPD Department Head who, in turn, relays this information to DOE.
- The LLNL ERD Division Leader is responsible for implementing the EPD and ERD QA programs as it relates to activities in the division and ensuring that nonconforming conditions are promptly addressed and documented. The ERD Division Leader reports to both the EPD Department Head and to DOE.
- The LLNL ERD Site 300 Project Leader is responsible for ensuring that approved procedures related to QA are used during activities in the project and division and ensuring that nonconforming conditions are promptly addressed and documented. The Site 300 Project Leader issues the QA/QC plan and periodically reviews its implementation. The Site 300 Project Leader reports to the ERD Division Leader on QA conformance and other QA-related issues.
- The LLNL ERD Quality Assurance Implementation Coordinator is responsible for the development and implementation for the QA/QC plan, establishment and control of the applicable QA/QC requirements, coordination with appropriate project personnel to assure compliance within groups over which the quality organization has no administrative control, and development of tracking and reporting systems to provide management visibility of implementation activities and results. The Quality Assurance Implementation Coordinator maintains direct communication and liaison with the EPD Quality Assurance Manager and has line authority through the ERD Division Leader for the implementation of the QA Program within the division.
- The LLNL Quality Assurance Engineer is responsible for providing direction to the Task Leader, Remediation Engineer, and Technician Supervisor in the selection and installation of the equipment and remediation systems to meet QA objects and ensuring

that construction meets design criteria specified in the design documents. The Quality Assurance Engineer reports directly to the Quality Assurance Implementation Coordinator on construction QA/QC related activities.

The Quality Assurance Implementation Coordinator and Quality Assurance Engineer constitute the independent quality assurance reviewers as defined in the EPD Quality Assurance Management Plan. The Quality Assurance Management Plan requires that design/technical reviews are conducted by competent, independent reviewers other than those involved in the original design activity although they may be from the same organization. Additional QA audits of ERD activities are regularly conducted by the DOE. The ERD Division Leader may assign an outside (non-LLNL), independent QA team as appropriate (i.e., when the necessary technical expertise to conduct design review is not available within the LLNL organization).

- The LLNL Task Leader is responsible for coordinating facility construction. The Task Leader reports directly to the Site 300 Project Leader.
- The LLNL Remediation Engineer is responsible for writing design criteria for equipment and flow rates to treat water and vapors, as well as providing oversight for construction activities. The Remediation Engineer is the equivalent to the Remedial Design Engineer. The Remediation Engineer reports to the Task Leader regarding facility design and construction.
- The LLNL Plant Engineering Project Manager (PEPM) is responsible for coordinating Plant Engineering activities, if any. The PEPM reports functionally during any assigned construction activities to the ERD Site 300 Project Leader and the Task Leader. The PEPM is Plant Engineering's primary contact with ERD for the assigned project. He/she is responsible for coordinating and executing the project assigned to him/her.
- The LLNL ERD Technician Supervisor is responsible for the supervision and oversight of day-to-day construction activities. The Technician Supervisor is the equivalent to the Remedial Action Constructor. The Technician Supervisor reports to the Task Leader regarding construction-related activities.

B-4. References

Carlsen T. M., M. Ridley, and V. Kiszka (1992), *Quality Assurance Project Plan, Lawrence Livermore National Laboratory Site 300 Environmental Restoration Project*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-RA-103160 Rev. 1).

Dibley V., and R. Depue (Eds.) (June 1997), *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs),* Lawrence Livermore National Laboratory, Livermore Calif. (UCRL-MA-109115 Rev. 3).

LLNL (December 1996), *Environmental Protection Department (EPD) Quality Assurance Management Plan (QAMP),* Rev. 4.

LLNL (1989), *Construction Manager Manual - Subcontracted Construction Projects*, Plant Engineering Department.

LLNL (1990), *Construction Inspectors Policy and Procedure Manual*, Plant Engineering Department.

U.S. DOE (1992), DOE Order 5700.6C, Quality Assurance Program, Office of Nuclear Safety Policy and Standards.

Table B-1. Applicability of the EPD QAMP elements to the construction of the central and eastern GSA ground water and vapor treatment systems.

EPD QAMP requirement	Title	Applicable ?
Element 1	EPD Quality Assurance Program Description	Yes
Element 2	Personnel Training and Qualification	Yes
Element 3	Quality Improvement	Yes
Element 4	Document and Records	Yes
Element 5	Work Processes	Yes
Element 6	Design Control	Yes
Element 7	Procurement	Yes
Element 8	Inspection and Acceptance Testing	Yes
Element 9	Management Assessment	Yes
Element 10	Independent Assessment	Yes
Element 11	Sampling and Analysis	No

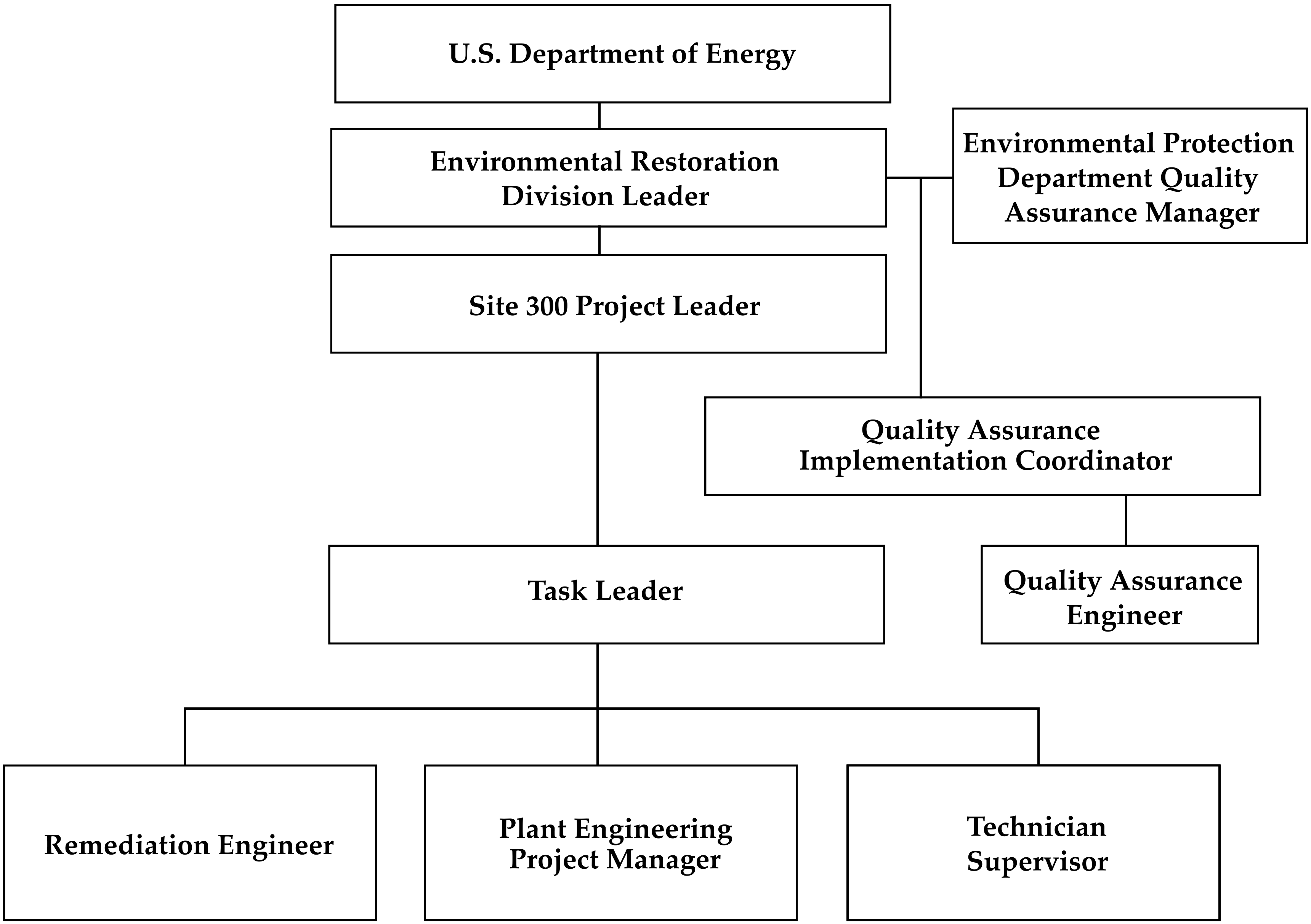

Figure B-1. Organization structure for construction QA activities.

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Appendix C

Construction Health and Safety Plan

Appendix C

Construction Health and Safety Plan

C-1. Health and Safety Plan

Safety procedures are required to construct the ground water and soil vapor extraction and treatment systems for the central General Sevices Area (GSA) and the ground water treatment system for the eastern GSA. This Health and Safety Plan (HASP) also serves as an administrative tool to summarize many of the requirements that are pertinent to the eastern GSA and central GSA treatment facility construction. Because these facilities have already been constructed as part of the GSA removal actions, this HASP will apply only to any future construction activities. Any potential health and safety hazards and the control of such hazards during construction are addressed in one or more of the following documents:

- Lawrence Livermore National Laboratory (LLNL) Health and Safety Manual (LLNL, 1996).
- LLNL Health and Safety Manual, Supplement 1.11 - Construction Subcontractor Safety Program (LLNL, 1991).
- LLNL Environmental Restoraton Division (ERD) Site Safety Plan for Lawrence Livermore National Laboratory CERCLA Investigations at Site 300 (LLNL, 1997).

Ed Folsom, phone number (510) 422-0389, LLNL pager number 02892, and home phone number (510) 490-7028, is responsible for the safety of this operation and for assuring that all work is performed in conformance with this HASP. In the absence of the responsible individual, John Greci, phone number (510) 422-3034, LLNL pager number 05240, or John Kilmer, phone number (510) 423-5043, LLNL pager number 00921, shall assume these responsibilities.

C-2. References

LLNL (1996), LLNL Health and Safety Manual.

LLNL (1991), LLNL Health and Safety Manual, Supplement 1.11—Construction Subcontractor Safety Program.

LLNL (1997), *Site Safety Plan for Lawrence Livermore National Laboratory CERCLA Investigations at Site 300*, Lawrence Livermore National Laboratory, Livermore, Calif. (UCRL-21172 Rev. 2).

Appendix D

Operations and Maintenance Quality Assurance/Quality Control Plan

Appendix D

Operations and Maintenance Quality Assurance/Quality Control Plan

D-1. Introduction

This Quality Assurance/Quality Control (QA/QC) plan has been developed in support of the Operations and Maintenance (O&M) for the central and eastern GSA ground water and vapor treatment systems. The purpose of the plan is to define the quality objectives and areas of responsibility to operate and maintain these facilities. This plan meets the O&M requirements of DOE Order 5700.6C, and the Environmental Protection Department (EPD) Quality Assurance Management Plan (QAMP, 1996).

D-2. Organization

This section documents the organizational structure, functional responsibilities, levels of authority, and lines of communications for those aspects of the O&M of the central and eastern GSA ground water and vapor treatment systems that affect quality.

Figure D-1 shows the organizational structure for QA activities. The descriptions below generally describe the QA responsibilities of those mainly involved in carrying out the QA program for the O&M of the central and eastern GSA ground water and vapor treatment systems. The LLNL ERD Site 300 Project Leader, the Quality Assurance Engineer, the Task Leader, and other individuals shown in Figure D-1 have the following responsibilities:

- The Site 300 Project Leader (S300 PL) issues this QA plan and periodically reviews its implementation. The S300 PL may request an independent review or formal audit of the QA program.
- The Quality Assurance Implementation Coordinator (QAIC) is responsible for the development and implementation of the QA plan, establishment and control of the QA document files, coordination with appropriate project personnel to assure compliance within groups over which the quality organization has no administrative control, and development of tracking and reporting systems to provide management visibility of implementation activities and results.
- The Quality Assurance Engineer (QAE) is responsible for providing direction in the O&M of remediation systems to meet QA objectives.
- The Task Leader (TL) is responsible for overseeing facility startup and monitoring its performance and operations.
- The Remediation Engineer (RE) is responsible for providing technical direction in the O&M of treatment systems, reviewing and tracking failure of equipment and systems and

determining the root cause of failures. The RE is also responsible for implementing the changes to the preventative maintenance schedule to reduce facility maintenance cost and downtime.

- The LLNL Plant Engineering Project Manager (PEPM) reports functionally during any assigned maintenance activities to the ERD S300 PL and the TL. The PEPM is Plant Engineering's primary contact with ERD for the assigned project. He/she coordinates and executes the project assigned to him/her. He/she is responsible for approving minor technical field design changes related to treatment facility modifications and/or O&M activities.
- The Technician Supervisor (TS) is responsible for the day-to-day operation and maintenance of the treatment facility. This includes scheduling required maintenance and ensuring completion in a timely fashion.
- State Certified Analytical Laboratories using EPA methods are responsible for providing independent chemical analytical results on water samples. For the central and eastern GSA ground water treatment systems, these samples are submitted as part of the monitoring program required by LLNL's discharge permits, in addition to operational testing samples collected prior to the official operation of a facility and routine samples taken to evaluate facility performance.

D-3. Quality Assurance Program

This section covers the objectives, quality goals, and the QA elements. The procedures for implementation of QA requirements are included in this plan, in the ERD Standard Operating Procedures (SOPs), or in the central and eastern GSA ground water and vapor treatment systems O&M manuals (under development).

The objectives of the project supported by this QA plan are to:

- Assure excellence in maintenance services and operations to achieve quality, and
- Provide the QA requirements to meet all programmatic and institutional needs.

This QA plan defines the process for providing confidence that these QA objectives will be achieved and that achievement will include due consideration for health, safety, property, and the environment.

Table D-1 shows the 11 elements of the EPD QAMP, which implements DOE Order 5700.6C, and their applicability to the operation and maintenance of central and eastern GSA ground water and vapor treatment systems.

The SOPs and the central and eastern GSA ground water and vapor treatment systems O&M manuals (under development) provide the procedures to implement the applicable elements of the EPD QAMP. In addition, they include lists of the QA auditable records, including the responsible personnel, that are required to document compliance with the requirements of the EPD QAMP.

D-4. Operations and Maintenance

D-4.1. Scope

The central and eastern GSA ground water and vapor treatment systems will be operated to treat ground water and vapor containing VOCs. The water will be treated to meet the requirements specified by the Regional Water Quality Control Board (RWQCB), and the vapor will be treated to meet the requirements specified by the San Joaquin valley Unified Air Pollution Control District (SJVUAPCD). Therefore, O&M activities at this facility shall be controlled by quality procedures designed to meet these requirements.

D-4.2. Operations

The S300 PL is responsible for ensuring the quality of operations at these facilities. The TS is responsible for ensuring that all field operations, including maintenance and operations, are performed with the appropriate quality procedures and are completed in a timely fashion.

Each treatment facility, per its respective permits, has a required monitoring program as described in Appendix A and the CMP (Appendix F). This involves monitoring the performance of the soil vapor treatment system to meet the SJVUAPCD vapor discharge requirements. Water samples are collected to monitor the performance of the ground water treatment systems in meeting RWQCB waste discharge requirements. The TS is responsible for ensuring that the technicians are properly trained to collect these samples according to documented procedures.

The central and eastern GSA ground water and vapor treatment systems have their own set of operating procedures. These procedures, which are being developed as part of the O&M manuals, cover the different modes of operation including startup, shutdown, normal operation, safety considerations, and maintenance procedures.

An operational logbook is kept at each facility. The logbook entries include the operating parameters of each system (i.e., temperature, pressure, etc.), the number and type of samples taken, maintenance performed on the system, and all adjustments made by the operators to the system.

D-4.3. Maintenance

Two types of maintenance are performed at the central and eastern GSA ground water and vapor treatment systems:

- Preventive.
- Corrective.

D-4.3.1. Preventive Maintenance

Preventive maintenance is performed on those treatment facility components that need routine servicing and are part of systems related to quality. The preventive maintenance schedule is kept at the facility with the operations procedures. The TS is responsible for ensuring that preventive maintenance is scheduled and completed on schedule to minimize downtime. Maintenance will be performed by LLNL Plant Engineering and/or ERD personnel, and will follow the requirements set in the O&M manual to ensure the maintenance functions are performed as planned.

Table D-2 is a tentative schedule of the preventive maintenance for the central and eastern GSA ground water and vapor treatment systems.

D-4.3.2. Corrective Maintenance

Corrective maintenance is performed when a system component fails or is beginning to fail and the quality of facility operations could be compromised if operation continues. Using the graded approach, root cause analysis is performed when a component fails before the corrective maintenance action commences. This is to ensure that the nature of the problem is understood and can be prevented. This root cause analysis is also used to modify the preventive maintenance plan where appropriate. The results of the root cause analyses are documented in the daily facility operations logbook. As with preventive maintenance, corrective maintenance is performed by Plant Engineering personnel or ERD personnel in accordance with this QA/QC plan.

All corrective maintenance actions and their times of completion are recorded in the facility daily operations logs. Once complete, the specific component or system is started up and operated. This ensures that the maintenance was correctly performed and that system quality is maintained. An entry in the facility log is made, indicating that an operational check was made following preventive or corrective maintenance and the performance of the new component is noted. If successful, the system is allowed to resume normal operations.

When the O&M manuals for the central and eastern GSA ground water and vapor treatment systems are developed, they will indicate the required spare parts for system components that have relatively high risk of failure or a long lead time for procurement. These components are to be maintained on site to prevent extended shutdown of the treatment system.

D-4.3.3. Maintenance Support

Maintenance support activities including the identification and control of O&M materials, inspection and testing of treatment facilities, monitoring of operating status, control of processes, and control of measuring and test equipment will be implemented as outlined in the central and eastern GSA ground water and vapor treatment systems O&M manuals (under development).

D-5. References

U.S. DOE (1992), DOE Order 5700.6C, Quality Assurance Program, Office of Nuclear Safety Policy and Standards.

LLNL (December 1996), Environmental Protection Department (EPD) Quality Assurance Management Plan (QAMP), Rev. 4, Lawrence Livermore National Laboratory.

Dibley, V., and R. Depue (Eds.) (1997), *LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs),* Lawrence Livermore National Laboratory Livermore, Calif. (UCRLMA-109115 Rev. 3).

Operations and Maintenance Manual for the central and eastern GSA ground water and vapor treatment systems (under development).

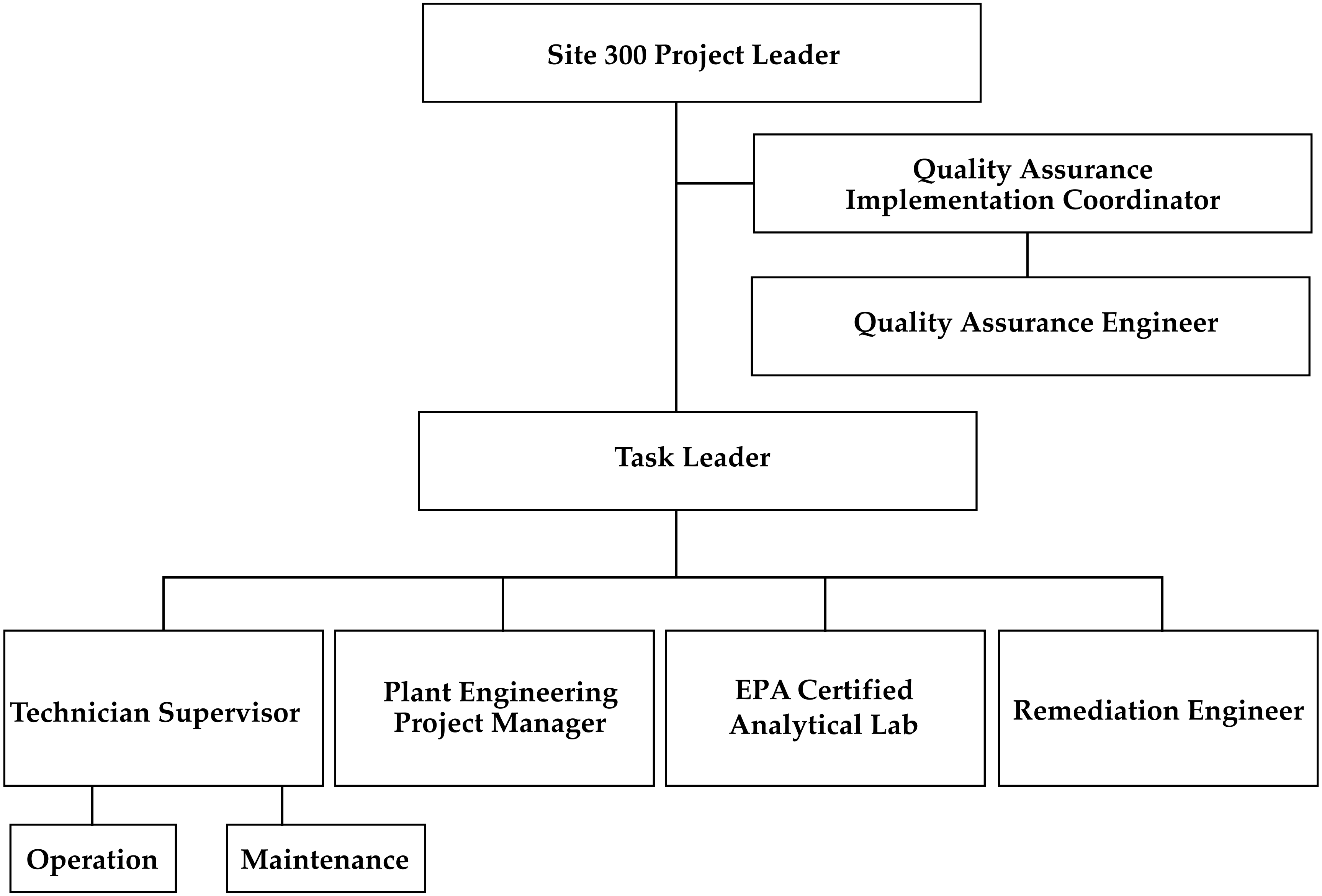

Figure D-1. Organization chart for O&M QA/QC for the central and eastern GSA treatment facilities.

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Table D-1. Applicability of the EPD QAMP elements to the operation and maintenance of the central and eastern GSA ground water and vapor treatment systems.

EPD QAMP requirement	Title	Applicable ?
Element 1	EPD Quality Assurance Program Description	Yes
Element 2	Personnel Training and Qualification	Yes
Element 3	Quality Improvement	Yes
Element 4	Document and Records	Yes
Element 5	Work Processes	Yes
Element 6	Design Control	Yes
Element 7	Procurement	Yes
Element 8	Inspection and Acceptance Testing	Yes
Element 9	Management Assessment	Yes
Element 10	Independent Assessment	Yes
Element 11	Sampling and Analysis	Yes

Table D-2. Preventive maintenance for the central and eastern GSA ground water and vapor treatment systems.

Action	Frequency/comments
Inspect variable speed submersible pump	Annually
Perform preventive maintenance for air stripper and associated piping (central GSA)	Annually
Check aqueous-phase granular activated carbon (GAC) units and associated piping (eastern GSA)	Weekly
Check discharge lines	Weekly
Monitor pump controller	Weekly
Monitor level sensors	Weekly
Monitor pressure indicator	Weekly
Monitor pH meter	Weekly
Monitor flow indicator	Weekly
Inspect miscellaneous hoses, seals, fittings, etc.	Weekly
Perform preventive maintenance for wellhead demister	Annually
Perform preventive maintenance for well pumps	Quarterly
Perform preventive maintenance for vacuum and pressure gauges	Annually
Perform preventive maintenance for temperature sensors	Annually
Perform preventive maintenance for temperature Indicators	Annually
Perform preventive maintenance for air flow sensor	Annually
Perform preventive maintenance for process air heater	Annually
Check vapor-phase GAC (central GSA)	Weekly
Check electrical breakers and disconnects[a]	Annually
Perform preventive maintenance for vapor extraction blower	Annually
Perform preventive maintenance for programmable logic controller (PLC)	Annually
Inspect sampling ports	Before use
Clean organic debris from area surrounding the building	As needed

[a] All electrical system maintenance to be performed by a qualified electrician or electrical technician.

Appendix E

Operations and Maintenance Health and Safety Plan

Appendix E

Operations and Maintenance Health and Safety Plan

This Appendix contains the Operations and Maintenance (O&M) Health and Safety Plan (HASP) for the eastern General Services Area (GSA) ground water treatment facility (TF) and the central GSA ground water and soil vapor TFs.

E-1. Reason for Issue

Safety procedures are required to operate and maintain the air-stripping system, water filtering system, and soil vapor extraction and treatment system for the central GSA TF and the aqueous-phase Granular Activated Carbon (GAC) units for the eastern GSA TF. This HASP also serves as an administrative tool to summarize many of the requirements of the Lawrence Livermore National Laboratory (LLNL) Health and Safety Manual that are pertinent to the eastern GSA and central GSA TF O&M.

E-2. Work to be Done and Location of Activity

E-2.1. Location of Treatment Facilities

Both the eastern and central GSA Tfs are located in the southeast portion of LLNL Site 300. The eastern GSA ground water TF is located approximately 300 ft northeast of the sewage treatment pond. The central GSA soil vapor and ground water TFs are located approximately 50 ft and 200 ft, respectively, east of the Building 875 dry well pad area.

E-2.2. Treatment Objectives and Methods

The eastern GSA and central GSA TFs are used to remove volatile organic compounds (VOCs) from contaminated ground water and soil vapor to meet permit discharge requirements. Ground water containing VOCs will be pumped from extraction wells utilizing submersible pumps generating from < 0.1 to 25 gallons per minute (gpm) output. In the central GSA, a shallow tray air stripping unit will be used to treat VOCs in ground water extracted from 19 extraction wells. In the eastern GSA, aqueous-phase GAC units will be used to treat VOCs in ground water extracted from three extraction wells

In the central GSA, vapor-phase GAC units are used to treat VOCs in soil vapor extracted from seven dual ground water-soil vapor extraction wells in the Building 875 dry well pad area. Soil vapor will be extracted from these extraction wells utilizing a 2-horsepower vacuum pump.

E-2.3. Particulate Filtration

Extracted ground water from both the eastern and central GSA wellfields passes through two 5-micron filters that have differential pressure gauges across them in the range of 0 to

25 pounds per square inch (psi). This filtration process is designed to remove particulates from ground water that could reduce treatment system efficiency.

E-2.4. Scale and pH Control

In the central GSA ground water TF, polyphosphate, carbon dioxide, or other approved additives may be injected into the TF influent flow as needed to reduce the formation of precipitates in the treatment system. In both the eastern and central GSA ground water TFs, carbon dioxide may be injected into the effluent to reduce the formation of precipitates in the discharge lines and/or to achieve a pH within the discharge limits, if necessary.

E-2.5. Ground Water Treatment Process

In the central GSA ground water TF, water is forced to pass through an air-stripping tank to treat VOCs. VOCs are removed from the water by injecting air into the bottom of the air stripper trays and subjecting the water to intense aeration, driving VOCs into the vapor phase. The VOC-laden vapor is then treated as discussed in E-2.7. In the eastern GSA TF, water passes through two to three 1,000-lb. GAC units where VOCs are removed from the water stream and adsorbed to the carbon.

E-2.6. Discharge of Treated Ground Water

Treated ground water from the central GSA is discharged to bedrock in a remote canyon located in the eastern GSA. Treated ground water from the eastern GSA is discharged to Corral Hollow Creek. A portion of the treated water from the eastern or central GSA TF may occasionally be discharged to the sewage treatment pond as makeup water during the summer months or used for on-site irrigation.

E-2.7. Vapor Treatment Process

In the central GSA ground water TF, vapor from the air stripping tank passes through demister pads to remove the water droplet fraction. The air stream then passes through vapor-phase GAC canisters that trap the VOCs. In the central GSA soil vapor TF, extracted soil vapor passes through a water knock-out drum to reduce water content in the vapor. The VOCs are then removed by passing the contaminated vapor stream through carbon beds where the VOCs are adsorbed to the carbon.

E-3. Responsibilities

Ed Folsom, phone number (510) 422-0389, LLNL pager number 02892, and home phone number (510) 490-7028, is responsible for the safety of this operation and for assuring that all work is performed in conformance with this HASP and applicable sections of the LLNL Health and Safety Manual and Environmental Protection Handbook. In the absence of the responsible individual, John Greci, phone number (510) 422-3034, LLNL pager number 05240, or John Kilmer, phone number (510) 423-5043, LLNL pager number 00921, shall assume these responsibilities.

Any changes in operations that improve or do not significantly affect safety and environmental controls may be approved by the responsible individual(s) listed above, and the LLNL Environmental Safety & Health (ES&H) team leader. The responsible individual will ensure that this action is documented in a memorandum. Any changes in the operation that increase the hazard level, introduce additional hazards, or decrease safety shall not be made until a revision to this HASP has been reviewed and approved consistent with the LLNL Environmental Restoration Division review and approval process.

Before starting operation, the responsible individual shall verify and document that the operating personnel have read and understand the HASP.

E-4. Hazard Analysis

E-4.1. Noise Hazard

Irreversible hearing loss can occur due to long-term exposure to noise from operating fans and blowers. Noise can also aggravate pre-existing hypertension.

E-4.2. Electrical Hazard

A 480, 208/230, and 110 VAC electrical power supply is used to operate the central and eastern GSA ground water treatment systems and the central GSA vapor extraction system. Electrical shock and injury may occur if personnel come into contact with exposed energized parts.

E-4.3. Seismic Hazard

Personnel may be injured during an earthquake due to falling equipment or missile hazards (equipment or materials moving energetically due to seismic forces).

E-4.4. Pressure Hazard

None is anticipated.

E-4.5. Chemical Hazard

None is anticipated.

E-4.6. Confined Space

Not applicable.

E-5. Hazard Control

E-5.1. Noise Hazard Control

E.5.1.1. Noise Protection

The facility operator will be required to wear noise protection when working within the noise hazard area, if required by LLNL Industrial Hygiene personnel.

E.5.1.2. Noise Safety Precautions

The facility operator is required to follow noise safety precautions outlined in the LLNL Health and Safety Manual, Section 10.08 and Supplement to 10.08.

E-5.2. Electrical Hazard Control

E-5.2.1. Access Control

Inadvertent contact with energized equipment is prevented by limiting access to the breaker switches. All breaker switches are contained in cabinets with keyed locks.

E-5.2.2. Electrical System Maintenance Safety Procedures

Only qualified electricians or electrical technicians perform maintenance activities on the electrical systems for the treatment facilities. These personnel will follow safety precautions as outlined in the Health and Safety Manual, Chapter 23, “Electricity,” and the Electronics Engineering Department–Electrical Safety Policy, LED-61-00-01-A1A. These personnel will also follow the LLNL Lockout and Tag program as defined in Chapter 26.13 of the Health & Safety Manual whenever any work is to be done that would expose them to energized equipment.

E-5.3. Seismic Hazard Control

Equipment will remain securely bolted to concrete pads to avoid damage and injury during an earthquake. To preclude injury from missile hazards (equipment or materials moving energetically due to seismic forces), any equipment or materials stored at a height of 5 ft or more shall be seismically restrained.

E-6. Environmental Concerns and Controls

E-6.1. Ground Water Extraction and Treatment Systems

Concern: Discharge of untreated ground water.

Controls:

- Interlocks shut off the system and the flow of air and water if physical damage to the treatment system occurs.
- Scheduled sampling per waste discharge permit monitors treated ground water discharge.
- Facility operator inspects the system periodically.

E-6.2. Soil Vapor Extraction and Treatment System

Concern: Atmospheric discharge of untreated vapor.

Controls:

- Scheduled monitoring per air permit monitors treated vapor discharge.
- Facility operator inspects the system periodically.

E-7. Training

E-7.1. Basic Facility Operator Courses

The following courses are required for all GSA TF operators:

- HS-0039—SARA/OSHA Training (40-hour course with yearly refreshers).
- HS-0001—New Employee Safety Orientation.
- HS-1620—Standard First Aid (First Aid Certification valid for 2 years).
- HS-5300—Back Care Workshop.
- HS-4360—Noise Safety

E-7.2. Selective Training Courses

The following courses may be required when they apply to the tasks assigned to the facility operator:

- HS-0006—Hazardous Waste Handling Practices (refresher training required annually).
- HS-4150—Confined Space.
- HS-4240—Chemical Safety.
- HS-5030—Pressure Orientation (required every 5 years).
- HS-5220—Electrical Safety (required every 5 years).
- HS-5245—Lock and Tag Procedure (refresher training required every 5 years).

E-7.3. Training Responsibilities and Documentation

Training courses identified in this section do not qualify a person to operate the treatment equipment and treatment systems located in the eastern GSA and central GSA. Only the responsible individual(s) identified in Section E-3 of this HASP will determine if and when a person is qualified to operate the treatment facilities. Once qualified, each technician's personnel file is updated to reflect their status as a treatment facility operator.

The responsible individual, or designee, shall ensure that all required training (including on-the-job training if applicable) is completed and documented in the LLNL Repository of Completed Courses. Untrained personnel may work under the supervision of a trained person until the required training is completed.

E-8. Maintenance

Items requiring periodic maintenance do not impact the safety of the operation. Interlocks shall be tested annually.

E-9. Quality Assurance

O&M activities at the central and eastern GSA TFs shall be controlled by quality procedures designed to meet ground water and vapor treatment and discharge requirements specified in the waste discharge permits for ground water and air discharge permits. Controls to prevent the discharge of untreated ground water or vapor and meet quality objectives include:

- Annual interlock function checks shall be performed by the Facility Electronics Staff or Plant Engineering Electronic Engineering Staff. Test documentation shall be maintained by the Facility Electronics Supervisor, or designee.
- Scheduled weekly, monthly, quarterly, and annual sampling of water and vapor shall be performed at various points in the ground water and soil vapor extraction and treatment systems ensure compliance and quality.
- TF-related analytical data will be reviewed by the Quality Assurance Coordinator (QAIC) or designee to ensure the data meets quality objectives as discussed in Appendix F, Section F-5.

E-10. Emergency Response Procedures

In the event of an emergency, facility operations personnel will first dial “911” to report to the Emergency Dispatcher, then administer first aid, if necessary, to injured personnel. The Emergency Dispatcher uses reserved telephone lines to promptly relay the emergency call to the following members of the LLNL Emergency Response Team:

- Fire Department.
- Security Department.
- Hazards Control Safety Teams.
- Plant Engineering.
- Health Services.

The Emergency Response Team will go to the scene of the emergency immediately. The phone numbers of individuals to be notified in the event of an emergency during off-shift hours are posted at the eastern and central GSA TFs. The LLNL Health and Safety Manual describes the emergency response procedures.

E-11. Applicable Documents

The following documents and/or sections thereof apply to the safe operation of the eastern and central GSA TFs and are incorporated into this HASP by reference.

E-11.1. Operating manual for the air stripper.

E-11.2. LLNL Health and Safety Manual Sections

Section 1.	LLNL ES&H Policies and Responsibilities
Section 2.	Integrating ES&H into Laboratory Activities
Section 10.08	Hearing Protection
Section 21.	Chemicals

Section 21.04	Facilities and Equipment
Section 21.05	Handling Solid and Liquid Chemicals
Section 23.	Electrical Safety
Section 23.1	Introduction
Section 23.2	Applicability
Section 23.3	Requirements/Regulatory Summary
Section 23.4	Methods for Reducing Risks
Section 23.5	Responsibilities
Section 23.6	Training
Section 23.7	LLNL Contacts
Appendix 23-B	Effects of Electrical Energy on Humans
Appendix 23-C	Electrical Equipment Compliance Criteria

E-11.3. LLNL Electronics Engineering Department—Electrical Safety Policy, LED-61-00-01-A1A

E-11.4. LLNL Site 300 Safety Plan, January 1997

E-11.5. LLNL Operational Safety Procedure (OSP) No. L-63, Treatability Testing

E-11.6. LLNL Health and Safety Manual Supplements

Section 10.08	Hearing Conservation
Section 11.07	Personnel Safety Interlocks
Section 26.13	LLNL Lockout and Tag Program

Appendix F

Compliance Monitoring Plan

Appendix F

Compliance Monitoring Plan

F-1. Introduction

This Compliance Monitoring Plan (CMP) was prepared for operating ground water treatment systems (GWTSs) in the eastern and central General Services Area (GSA), and a soil vapor extraction (SVE) system in the central GSA. This plan describes the procedures to monitor ground water and vadose zone remediation, manage data, report remedial activities and results in order to assess the progress of the activities toward remedial objectives stated in the GSA Operable Unit (OU) Record of Decision (ROD) (U.S. DOE, 1997). It also discusses the methods used to interpret the data as well as what data to collect. This CMP is intended to be a flexible document that will accommodate changes in technology and regulations that are likely to occur over the course of the cleanup.

Because no guidance documents for a CMP are available, this plan follows concepts discussed by the U.S. Environmental Protection Agency (1992a, 1992b, 1992c, 1993, 1994), Gorelick et al. (1994), Hoffman (1993), Keely (1989), and the Lawrence Livermore National Laboratory (LLNL) Livermore Site CMP (DOE, 1996).

Section 2 of the CMP describes remediation objectives and implementation. Section 3 describes data collection. Sections 4 through 6 discuss data management, quality assurance, and analysis. Sections 7 and 8 describe reporting and budget issues. Section 9 lists LLNL Livermore Site and Site 300 Environmental Restoration Project Standard Operating Procedures (SOPs) (Dibley and Depue, 1995; revisions and new SOPs in progress).

F-2. Objectives and Implementation

The data to be collected and the procedures to evaluate this data with regards to the progress of remediation efforts in achieving GSA remediation objectives are summarized below, as well as a description of the implementation of these procedures are addressed.

F-2.1. Objectives

This document describes data objectives, monitoring activities, procedures for collecting and interpreting data, and periodic evaluation and reporting of remediation progress. The U.S. Department of Energy (DOE)/LLNL plan to assess the changes in contaminant distribution and other data as remediation proceeds and, if needed, will propose changes to the remediation design.

This CMP specifies the methods by which DOE/LLNL will monitor, interpret, and assess the progress of remedial actions at the GSA to:

- Determine to what extent the ROD objectives have been achieved.

- Evaluate the effectiveness of existing remedial actions.
- Evaluate scheduled and other proposed changes to ongoing remedial actions.
- Determine when specific cleanup actions should cease by comparing site data against Applicable or Relevant and Appropriate Requirements (ARARs) or cleanup standards.
- Indicate and analyze deviations from expected performance.

Because the remedial activities at the GSA OU are expected to operate for many years, the project will continue to evaluate and assess current advances in related areas, e.g., remote sensing, water level measurements, chemical analysis, databases, geographic information systems, fate and transport modeling, geophysical methods, etc. Proven advances in these areas will be incorporated into the remediation when appropriate, with concurrence from the regulatory agencies.

F-2.2. Implementation

This CMP outlines the procedures necessary to monitor the progress of remediation and to determine when cleanup standards established in the ROD are attained. The data collection, management, Quality Assurance/Quality Control (QA/QC) and analysis procedures described in this CMP are those already in use by the project, and are planned to continue to be used over the cleanup period. Procedures for data collection, data management, data analysis, and reporting are described in the following sections.

F-3. Data Collection

Chemical (contaminant), fluid (ground water and soil vapor), and subsurface material property data are required to track the progress of remedial actions and to monitor the site after active remediation ceases. Collection of these data is described below.

F-3.1. Chemical Data

To track the progress of remediation, chemical data on ground water, soil vapor, and treatment facilities are collected as described in the following sections.

F-3.1.1. Ground Water Extraction and Monitor Wells

Ground water concentrations will be determined by analyzing samples collected from sampling extraction and monitor wells to track changes in plume concentration and size that result from remediation and natural processes such as dispersion, degradation, adsorption, diffusion, and advection. Chemical analyses will be performed according to: (1) EPA Methods or, (2) analytical methods contained in the SOPs. Results will be evaluated according to QA/QC procedures contained in the Site 300 Quality Assurance Project Plan (QAPP) (Carlsen et al., 1992). Measured ground water concentrations will be used to prepare contaminant isoconcentration contour maps, prepared semi-annually, and compared with ground water concentrations estimated from a flow and transport model agreed upon by DOE and the regulatory agencies. These comparisons enhance our understanding of the response of contaminant concentrations to ground water extraction so that calibrated interpolations and extrapolations can then be used to manage the extraction wellfield to produce the most cost-effective and expeditious remediation achievable.

Ground water concentrations at extraction and monitor wells will be measured at a sampling frequency dependent on: (1) the rate of observed or expected changes in concentrations in each well and other nearby wells, (2) the location of the well, and (3) the purpose or current use of the well. Based on data from previous remediation, significant changes in ground water contaminant concentrations are expected to occur over time intervals of months to years. Quarterly sampling (or at a higher frequency, if needed) is performed at locations where rapid changes are occurring or more frequent monitoring is appropriate. Where concentration changes are slow, samples will be collected less frequently. Samples are collected from certain water-supply wells monthly.

The current sampling plan for GSA ground water wells is shown in Tables F-1 and F-2. This plan is consistent with the ground water monitoring requirements of the current Substantive Requirements and National Pollutant Discharge Elimination System (NPDES) permit for the GSA GWTSs. DOE/LLNL will comply with any revisions to the NPDES permit that may result from the permit renewal process. In addition, DOE/LLNL will discuss with the regulatory agencies other possible changes in the CMP following the wellfield expansion scheduled to occur in 1999 through 2000. Possible changes to the CMP may include, but not be limited to: (1) the addition of a monitoring schedule for the new central GSA ground water extraction wells, and (2) changes in the sampling frequency or parameters of existing ground water extraction or monitor wells in order to better assess how the new extraction system is affecting ground water flow, contaminant migration, and ground water quality. DOE/LLNL will notify the regulatory agencies and solicit their input on sampling frequency and parameter changes at any time changes to the CMP are considered. Currently, all monitor wells are used to characterize and track the onsite and offsite plumes.

F-3.1.2. Soil Vapor Extraction and Monitoring Points

Volatile organic compound (VOC) concentrations in soil vapor measured before, during, and after remedial action will be used to evaluate the performance of vadose zone extraction and treatment systems. Based on treatability test data and experience at other sites, contaminant concentrations in soil vapor are anticipated to change over time intervals of weeks under stressed conditions (i.e., during soil vapor extraction), or months to years under natural conditions. Samples may be collected more frequently during contaminant rebound tests. The current soil vapor sampling plan is shown in Table F-3. A figure showing current vadose zone soil gas isoconcentration contours and the zone of influence for the SVE system will be provided in the first quarter 1998 report for the GSA treatment facilities. Soil vapor sampling in the GSA is not currently required under a specific permit. Currently, all soil vapor extraction (SVE) wells are sampled quarterly. These sampling results will be included in the quarterly reports. In addition, existing soil vapor monitoring points in the vicinity of Building 875 will be monitored periodically for trichloroethylene (TCE) and perchloroethylene (PCE) to evaluate the effectiveness of SVE in mitigating risk inside Building 875. The CMP is a dynamic monitoring program which will allow for adjustment to the SVE system to optimize contaminant removal. Therefore, the monitoring frequency for soil vapor monitoring points may vary depending on site conditions.

F-3.1.3. Treatment System Influent and Effluent

As stipulated by the self-monitoring requirements of each GWTS and SVE system, influent and effluent sampling and/or monitoring will be used to evaluate facility performance and to meet discharge permit requirements. Influent media will be ground water or soil vapor. Treated effluent will be water, vapor, and/or air stripper offgas. The current treatment system monitoring requirements are shown in Table F-4, and are consistent with the requirements of the Substantive Requirements, NPDES permit, and the San Joaquin Valley Unified Air Pollution Control District (SJVUAPCD) Permit to Operate for the GSA.

F-3.2. Fluid Data

Fluid data collection includes monitoring water levels, soil vapor pressures, and extraction flow volumes.

F-3.2.1. Water Levels

Hydraulic head (water level) measurements will be collected at wells and piezometers to define flow direction, the extent of hydraulic influence, and capture zones for extraction wells. Hydraulic heads can significantly change over time intervals of seconds (e.g., in response to abrupt changes in pumping or injection rates) to months (e.g., as a result of seasonal variations in recharge and evapotranspiration). Therefore, water level measurements may be collected more frequently during pump tests and/or facility startup or shutdown. If necessary, additional measurements will be collected if the configuration of the extraction system is altered (e.g., if a well is turned off or when flow rates are adjusted) to assess whether hydraulic capture and plume containment objectives are being achieved. Ground water elevation (potentiometric surface) contour maps showing inferred extraction well capture zones will be prepared and submitted with quarterly reports as indicated in Table F-5. Where there is little or no change in pumping rates and locations, the water levels and capture zones are anticipated to remain fairly stable. When water levels are stable, water level measurements may be collected less frequently with regulatory concurrence. Table F-6 presents the current plan for water level measurements in the GSA. This plan is consistent with the requirements of the Substantive Requirements and NPDES permit for the GSA.

F-3.2.2. Soil Vapor Pressures

Soil vapor pressure will be measured at extraction wells and appropriate soil vapor monitoring points to define flow direction and calculate flow velocity, the extent of pressure influence, and capture volumes. Pressure measurements will be made as appropriate during system operation, and these measurement may be made more frequently during performance testing. Additional measurements will be made as necessary if the configuration of the extraction system is altered (e.g., if a well is turned off or when flow rates are adjusted) to assess whether the vapor extraction objectives are being achieved. Soil vapor pressure monitoring is currently not specifically required. The results of any soil vapor pressure monitoring will be reported on the next quarterly report after the measurements are taken.

F-3.2.3. Extraction Flow Quantities

Water and soil vapor flow volume measurements will be collected as required from each extraction and injection well using flow rate meters, totalizing meters, and/or calculated from differential pressure and applied vacuum readings (vapor only). Measuring the water or soil vapor volume from each extraction and injection well is necessary to estimate contaminant removal rates and to estimate the impact of each well on subsurface flow conditions. Table F-7 shows the current extraction flow quantity measurement plan for the GSA. This plan is consistent with the requirements of the Substantive Requirements and NPDES permit for the GSA.

F-3.3. Subsurface Material Properties

Hydraulic data (e.g., pumping rates, water levels, hydraulic conductivity, and moisture content), descriptive geologic data, and geophysical data are required to analyze and estimate hydraulic capture zones and contaminant concentration distributions, and to compare these estimates with the field-measured data. These data and hydraulic estimates help us evaluate remediation performance and assess risk as the cleanup proceeds.

Collection of pumping rate and water level data is described above in Sections 3.2.1 and 3.2.3. Hydraulic conductivity values are calculated from pumping tests, and occasionally from lab tests on soil cores. These data will be collected as needed as determined by DOE/LLNL hydrogeologists. Moisture content data are generated from lab tests. These data are collected when needed for vadose zone analysis and modeling. Geologic data (lithologic descriptions on well logs) will continue to be collected from all boreholes. Geophysical data (resistivity, spontaneous potential, gamma, and/or induction logs) will be collected from boreholes specified by DOE/LLNL hydrogeologists.

F-4. Data Management

This section describes the structure and flow of data in the data management system used by ERD to store and archive data. Compliance monitoring data will be managed using the systems and procedures described below.

F-4.1. Overview

The ERD database was originally developed on a VAX 6310 with VMS operating system using INGRES relational database software. A second database was added to serve Sample Planning and Chain-of-Custody (CoC) Tracking (SPACT) needs. In 1993, the databases were merged into one relational database, EPDData, accessed by different software applications. In 1996 the database was transferred to the UNIX operating system.

EPDData handles sample tracking, sample location, media, analytical results, and some geological information. This production database is maintained on a Sun Sparc 20 with OpenIngres relational database software. Applications are developed on a separate Sun Sparc Station before implementation on the production database. Two read-only, date-stamped, archive databases are also on a separate Sun Sparc 20. These two read-only databases are copied from the production database twice a week.

The flow of data, both hard copy and electronic, follows a model which tracks information from sampling plan through storage to archiving. The data management process includes CoC tracking, analytical result receipt, the application of quality control procedures, data presentation, and the electronic use of data in decision support tools, such as risk assessment and compliance monitoring.

There are many advantages of this integrated centralized data management system. The use of such a system promotes and provides a consistent data set of known quality. Single entry for multiple use allows quality assurance and quality control to be performed equally for all data.

F-4.2. Structure and Flow

A sampling and analysis plan is developed to establish the sampling method, frequency, type, location, and requested analyses. Field log books and CoC forms confirm the collection of samples and requested analyses as dictated by the plan. A document control number is assigned to the samples based on the field log book used. A carefully controlled system of field log book labels permits electronic tracking of an environmental sample from field collection through analytical result receipt as well as tracing back to the log book for any given analyte, should details of sampling conditions be needed. Samples are sent on to analytical laboratories where they are given unique log numbers. SPACT tracks the flow of the sampling information. The important fields in each SPACT record are document control number, analytical laboratory, analytical lab log number, sampling location identification, sampling date, and the analysis requested. SPACT also tracks invoice information. SPACT records are updated upon receipt of official printed analytical results and invoices. A data record is marked complete only when all analytical results have been received. Completion of a record confirms that all requested analyses have been performed and reported.

Analytical results are stored in separate, but correlated, relational database tables. These tables are accessed by the MONITOR application and are related to SPACT tables by identical fields: document control number, sampling location, sampling date, analytical laboratory and requested analysis. Additional information collected for each sample and analyte includes requester, project, sample media, sample type, units, error, detection limit, dilution factor, and dates of extraction, analysis, and entry, together with comments and special notes. Sources of data in these database tables include geologic borehole logs, surveyor reports, field measurements, laboratory measurements, calculated or reduced data, and test conclusions. Types of data to be stored have included descriptive sample location information, such as coordinates, elevations, lithology, and screened intervals of monitoring installations, as well as measurements and analytical information, including physical and chemical parameters, media identification, and ground water elevation measurements.

Data verification and validation are achieved through a combination of methods. Hand entered data are run through a series of computerized verifications that check for duplication, empty fields, and reported results inconsistent with reported detection limits. Data are also thoroughly checked by a second person before being formally added to the database. Electronically delivered laboratory data are groomed by filling in empty fields and ensuring consistency in fields such as sample location, project, media, and type. Computerized verifications are also run on electronic data and a second person checks sample descriptor fields before data are formally added to the database. Random audits are done to verify electronically delivered results against official printed results. Analytical results in the database are reviewed and validated by qualified chemists.

The database also stores all QC data reported from the analytical laboratories for each batch of samples. These data include laboratory control standard recovery, matrix spike and matrix duplicate relative percent difference, duplicate relative percent difference and method blank results. These data are used by ERD chemists to validate analytical results.

The database also contains fields dedicated to quality control. Such fields include flags indicating analytical result qualification and data quality level. The result qualifier flags are absent from a routine report, but may be included to show dilution greater than one, compound detection in method blanks, or any of several other conditions. Data quality levels can range from U.S. Environmental Protection Agency (EPA) approved methods performed by a certified laboratory to quick, approximate field analyses. Original hard copies of data are stored in numerical order by laboratory for easy access.

F-5. Quality Assurance/Quality Control and Standard Operating Procedures

The Site 300 project has been using a QAPP (Carlsen et al., 1992) and Quality Assurance Plan (QAP) (ERD, 1994) that establish and present the framework and requirements for planning, performing, documenting, and verifying work and related data for remediation. The QAPP was prepared for CERCLA compliance and ensures that the precision, accuracy, completeness and representativeness of project data are of acceptable quality. The QAPP was prepared according to EPA guidance and was approved by the regulatory agencies. The QAP is a quality assurance document prepared for DOE and follows the standards of the American Society of Mechanical Engineers National Quality Assurance-1 (ASME NQA-1), “Quality Assurance Program Requirements for Nuclear Facilities” and fulfills the requirements of the EPA Quality Assurance Management Staff (QAMS) 005/80, “Interim Guidelines and Specifications for Preparing Quality Assurance Project Plans.” The QAPP and QAP are intended to be used in conjunction with ERD SOPs and workplans. SOPs have been established for all aspects of well drilling and logging, soil and water sampling, and hydraulic testing. The existing QAPP, QAP, and SOPs are applicable to all pertinent monitoring and reporting activities since the ROD.

F-6. Data Analysis

Several remediation performance measures can be developed using existing data. The existing baseline data is presented in the quarterly reports for the eastern and central GSA treatment facilities. Each performance measure is useful, however, none should be used as the sole performance measure. Performance baselines have been established initially by computer simulations that are discussed in Appendix H and are shown in Figures 12 and 13. The remediation performance measures that DOE/LLNL plan to use are discussed below.

Many of the interpretive methods necessary to assess the progress of remediation in the subsurface require a basic subsurface conceptual model. Such a model can be represented partly by hydrogeologic cross sections and other interpretive renderings such as two- and three-dimensional (3-D) visualizations of the hydrogeology and contaminant distribution. These visualizations are instrumental in understanding and communicating the progress of remediation to regulators and the community.

A representative numerical model also requires a detailed subsurface conceptual model. Flow and transport models are used to identify dominant physical processes that control contaminant fate and migration. When calibrated to field data, such as hydraulic head and contaminant concentrations, models can be used to evaluate the effectiveness of planned and existing remedial systems, and estimate cleanup times and costs.

Data analysis will also include statistical evaluation and examination of data to determine concentration trends.

F-6.1. Volume of Subsurface Material Affected by Remedial Activities

The region of hydraulic capture around extraction wells will be estimated using the hydraulic head distribution as determined by water level measurements. When assessing whether contaminants are being contained by pumping, it is necessary to incorporate the effects of the heterogeneous subsurface to determine vertical and horizontal flow and contaminant migration behavior. Hydraulic head measurements will be analyzed to determine whether containment has been achieved vertically as well as horizontally. Hydraulic head measurements represent 3-D gradient fields, so care will be taken when interpreting the field measurements to separate horizontal and vertical components. For example, only data from measuring points that are within a hydraulically distinct zone (hydrogeologic unit) will be used to interpret hydraulic heads within that unit. Similar techniques will be used to determine the radius of influence of the SVE wells, but vapor pressure, rather than hydraulic head, will be measured.

Many water level measuring points are required to estimate hydraulic capture with a high degree of confidence. It is unlikely that there will be sufficient water level measurement points to thoroughly define hydraulic capture in all areas. An approval numerical model will be run to better define hydraulic capture zones. Other direct or remote sensing techniques will be used to supplement water level data if such methods are shown to be effective. Computer interpolations and extrapolations, applied in conjunction with field monitoring data, will then be used to estimate plume capture.

Analyzing hydraulic head data will help ensure plume containment and identify stagnation zones. Identification of such zones will result in changes in pumping rates and/or locations to ensure complete remediation.

F-6.2. Estimating Contaminant Distribution and Mass in Subsurface Material

The 3-D contaminant distribution in the subsurface is estimated by interpolating site-specific chemical data, such as VOC concentrations in ground water and soil vapor. Estimates of the contaminant mass removed are based on both the volume and contaminant concentration of extracted ground water and soil vapor. The contaminant mass remaining in the subsurface will be estimated by comparing the cumulative mass removed to: (1) original mass estimates presented in Appendix H of this Remedial Design report and the GSA Feasibility Study (Rueth et al., 1995), and (2) subsequent mass estimates based on modeling of contaminant distribution. Estimates of the contaminant mass remaining in the subsurface will be used to revise cleanup time estimates and re-evaluate wellfield configurations.

F-6.2.1. Distribution

The subsurface contaminant spatial distribution can be estimated from available ground water, soil, and soil vapor concentrations using interpolation and extrapolation techniques. Various interpolation methods will be employed to estimate the spatial distribution of field data and create isoconcentration contour maps, hydraulic head contour maps, and various other two- and 3-D visualizations of geologic, chemical, and hydraulic data. Whatever method is used, the impact that the particular interpolation method has on resulting interpretations will be evaluated.

The subsurface sediment has been sampled at more locations than has ground water, so much of the interpretation of the current distribution and mass of the ground water plume is inferred from soil samples. Water and soil vapor samples from wells are repeatable measurements, whereas soil samples from boreholes are not. In addition, previous saturated and unsaturated soil analyses will become less representative of current and future conditions as remediation continues. As a result, the pre-remediation contaminant distribution will, in many locations, be more thoroughly characterized than at any time after remediation has begun.

F-6.2.2. Mass

Contaminant mass removal will continue to be estimated by integrating concentrations and volumes of extracted ground water or soil vapor over time. Mass removal calculations are based on treatment system influent concentration and flow rate. Changes in ground water and soil vapor chemical concentrations through time will be evaluated during the remediation process, and will be used to interpret the effectiveness of remedial actions.

As appropriate, the total estimated contaminant mass removed will be compared to the difference between (1) pre-remediation mass estimates, and (2) mass estimates based on contaminant distribution as remediation progresses.

Mass removal, flow rates, and contaminant distribution will be used to assess the overall effectiveness of each extraction system. Effectiveness will be evaluated by how well the system is reducing contaminants to cleanup standards and how well it is controlling offsite plume migration. If necessary, additional extraction wells may be installed to increase contaminant mass removal rates and/or to improve hydraulic containment of the plume. A separate, subordinate measure of facility performance is the treatment efficiency, which is the measure of concentration reduction achieved in the ground water or soil vapor treated by the facility.

At some extraction wells (i.e., those in former source areas with VOCs in the shallowest ground water), pumps may be periodically shut off and the water levels allowed to recover. During pump-off cycles, VOCs should desorb into the ground water from the sediments that were dewatered near the pumping wells. Cycling the pumps may increase VOC removal efficiency near former source areas, where most of the VOCs occur in the shallower water-bearing sediments. Different pump-on and pump-off cycles may be evaluated to determine the optimum periods of pumping and non-pumping to maximize VOC mass removal efficiency. Vapor flow rates and chemistry data will be collected to evaluate the effectiveness of the vapor extraction systems. Some vapor extraction wells may be periodically shut off to determine if the vapor concentrations increase.

F-6.2.3. DNAPL Evaluation Methods

It is possible that TCE as a Dense Non-Aqueous Phase Liquid (DNAPL) is present in the subsurface at the GSA, most likely directly below the Building 875 dry wells. Unlike dissolved contaminant plumes which can be controlled and remediated using pump-and-treat, DNAPLs are much more difficult to remediate. Dissolved contaminant plumes migrate primarily by dispersion and advection, while DNAPLs tend to migrate downward through an aquifer leaving a "trail" of residual pure-phase contaminant entrapped in the aquifer pores and pooling on top of low permeability units. At the Building 875 dry well area, contaminant concentrations increase with depth through the $Tnbs_2$ sandstone, but drop off rapidly in the underlying claystone aquitard. This may indicate that DNAPLs are pooled on top of the aquitard. The pooled and entrapped DNAPL liquid can remain an active contaminant source for many years after the initial release. Several techniques may be applicable in the GSA to evaluate the mass of DNAPL remaining in the subsurface during remediation. These include but are not limited to:

1. **Ground water monitoring**. Ground water monitoring is the most common technique to delineate and track the movement and remediation of ground water plumes. Ground water concentration measurements also can be used to infer the presence of DNAPLs. DNAPLs are likely to be present if ground water concentrations are from 1 to 10% of the effective solubility of the DNAPL in ground water (982,974 micrograms per liter [µg/L] for TCE). Prior to remediation, TCE concentrations as high as 240,000 µg/L were measured below the Building 875 dry well area (24% of effective solubility). Currently, the estimated concentration of TCE in that area is 1,000 to 3,000 µg/L based on treatment system influent concentrations, or about 0.1 to 0.3% of effective solubility. This may indicate that DNAPLs are no longer present, but obtaining representative ground water samples is complicated by the dewatering. While comparing ground water concentrations to the theoretical effective solubility of TCE may indicate if DNAPL is present, it cannot be used to calculate an estimate of DNAPL mass.

2. **Partitioning tracers**. Partitioning tracers can be used in the saturated and unsaturated zones. Single-well and dual-well partitioning tracer tests have been used in both the petroleum and environmental industries. In partitioning tracer tests, one non-partitioning and several partitioning tracers (with different DNAPL partitioning coefficients) are injected into an aquifer (or vadose zone). The non-partitioning tracer moves at the velocity of water (or vapor stream in the vadose zone), while the partitioning tracers preferentially partition into the DNAPL. The lag in arrival times of the tracer pulses are used as indicators to estimate the amount of residual DNAPL.

3. **Radon-222**. Radon-222 is commonly found in aquifer materials and ground water. This natural tracer has been found to preferentially partition into non-aqueous phase liquids. As a result, this natural ground water tracer can be used to estimate locations of DNAPL contaminants in aquifer by comparing Radon-222 activities in nearby monitor wells. Monitor wells showing relatively low Radon-222 activities are inferred to be located adjacent to DNAPLs; relatively high radon activities would indicate that DNAPLs are not likely to be present.

F-6.3. Post-Closure Monitoring

The data collected and interpreted during compliance monitoring will be used to: (1) verify the assumptions made in conceptual and computational models, (2) reevaluate and improve upon the remediation plans, (3) determine when cleanup standards as stipulated in the ROD have been achieved, and (4) determine when active remediation should cease. When analytic data or models suggest changes to remediation plans, DOE/LLNL will involve the regulatory agencies in evaluating the suggested changes. Changes to remediation plans, and determining when cleanup standards are attained, will require with regulatory concurrence. Post-closure is defined as the period following achievement of cleanup standards, and applies to both ground water and soil vapor.

Data from ongoing field monitoring will be used to indicate when cleanup objectives have been met. When VOCs concentrations are below negotiated cleanup standards and extraction wells are shut off, post-closure monitoring will begin. A selected set of wells will be sampled for five years. If concentrations rise above negotiated levels, extraction will resume at the appropriate wells until standards are again achieved. Cleanup will be considered complete when contaminant concentrations remain below the cleanup standards for five years. U.S. EPA guidance on methods for evaluating the attainment of cleanup standards [U.S. EPA, 1992(b); 1992(c)] will be consulted. When the cleanup is complete all treatment system hardware will be decontaminated, dismantled, and salvaged and extraction and monitor wells will be sealed and abandoned.

F-7. Reporting

Current reporting requirements for the GSA OU are presented in Table F-7.

F-8. Budget

DOE/LLNL will provide updates and inform the regulatory agencies of any change to the budget that affects cleanup at the Remedial Project Managers (RPM) meetings. DOE/LLNL and the regulatory agencies will meet periodically to discuss budget issues and their implications on enforceable milestones.

F-9. Standard Operating Procedure Titles and Revisions

The following SOPs are applicable to the GSA remediation project:

SOP-1.1 Field Borehole Logging .... Rev. 2

SOP-1.2 Borehole Sampling of Unconsolidated Sediments and Rock .... Rev. 2

SOP-1.3 Drilling .... Rev. 2

SOP-1.4 Monitor Well Installation .... Rev. 2

SOP-1.5 Monitor Well Development .... Rev. 2

SOP-1.6 Borehole Geophysical Logging .... Rev. 2

SOP-1.7 Well Closures .... Rev. 2

All Environmental Restoration Project SOPs and SOP revisions are submitted to the U.S. EPA for review and approval.

F-10. References

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U.S. Environmental Protection Agency (1992b), *Methods for Evaluating the Attainment of Cleanup Standards, Volume 1: Soils and Solid Media*, EPA/230/02-89-042, NTIS PB89-234959.

U.S. Environmental Protection Agency (1992c), *Methods for Evaluating the Attainment of Cleanup Standards, Volume 2: Ground Water*, EPA/230/R-92/014, NTIS PB94-138815.

U.S. Environmental Protection Agency (1993), *Guidance for Evaluating the Technical Impracticability of Ground-Water Restoration*, Directive 9234.2-25, Office of Solid Waste And Emergency Response, Washington, D.C.

U.S. Environmental Protection Agency (1994), *Methods for Monitoring Pump-and-Treat Performance*, EPA/600/R-94/123, 102 pp.

Table F-1. Central GSA ground water sampling plan.

Well	Analysis	Frequency
W-35A-01	VOCs (EPA Method 601)	Semiannual
	Metals: Cd, Pb (EPA Methods 200.7, 239.2)	Every two years
W-35A-02	VOCs (EPA Method 601)	Semiannual
	Metals: Zn (EPA Method 200.7)	Every two years
W-35A-03	VOCs (EPA Method 601)	Semiannual
W-35A-04	VOCs (EPA Method 601)	Semiannual
	Metals: Cu (EPA Method 200.7)	Every two years
W-35A-05	VOCs (EPA Method 601)	Semiannual
	Metals: Pb (EPA Method 239.2)	Every two years
W-35A-06	VOCs (EPA Method 601)	Semiannual
W-35A-07	VOCs (EPA Method 601)	Semiannual
W-35A-08	VOCs (EPA Method 601)	Semiannual
W-35A-09	VOCs (EPA Method 601)	Semiannual
	BTEX (EPA Method 602)	Annual
W-35A-10	VOCs (EPA Method 601)	Semiannual
W-35A-11	VOCs (EPA Method 601)	Semiannual
W-35A-12	VOCs (EPA Method 601)	Semiannual
W-35A-13	VOCs (EPA Method 601)	Semiannual
W-35A-14	VOCs (EPA Method 601)	Semiannual
W-7A	VOCs (EPA Method 601)	Semiannual
	Metals: Pb (EPA Method 239.2)	Every two years
W-7B	VOCs (EPA Method 601)	Semiannual
W-7C	VOCs (EPA Method 601)	Semiannual
W-7E	VOCs (EPA Method 601)	Semiannual
W-7ES	VOCs (EPA Method 601)	Semiannual
W-7F	VOCs (EPA Method 601)	Semiannual
W-7G	VOCs (EPA Method 601)	Semiannual
W-7H	VOCs (EPA Method 601)	Semiannual
W-7I	VOCs (EPA Method 601)	Semiannual
	BTEX (EPA Method 602)	Annual
	Metals: Hg (EPA Method 245.2)	Every two years
W-7J	VOCs (EPA Method 601)	Semiannual
W-7K	VOCs (EPA Method 601)	Semiannual
W-7L	VOCs (EPA Method 601)	Semiannual
	Metals: Cu (EPA Method 200.7)	Every two years

Table F-1. (Continued)

Well	Analysis	Frequency
W-7M	VOCs (EPA Method 601)	Semiannual
W-7N	VOCs (EPA Method 601)	Semiannual
	BTEX (EPA Method 602)	Annual
	Metals: Hg (EPA Method 245.2)	Every two years
W-7O	VOCs (EPA Method 601)	Semiannual
	BTEX (EPA Method 602)	Annual
	Metals: Cu, Zn (EPA Method 200.7)	Every two years
W-7P	VOCs (EPA Method 601)	Quarterly
W-7PS	VOCs (EPA Method 601)	Quarterly
W-843-01	VOCs (EPA Method 601)	Semiannual
W-843-02	VOCs (EPA Method 601)	Semiannual
W-872-01	VOCs (EPA Method 601)	Semiannual
	Metals: Cu, Pb (EPA Method 200.7, 239.2)	Every two years
W-872-02	VOCs (EPA Method 601)	Semiannual
W-873-01	VOCs (EPA Method 601)	Semiannual
W-873-02	VOCs (EPA Method 601)	Semiannual
	BTEX (EPA Method 602)	Annual
W-873-03	VOCs (EPA Method 601)	Semiannual
W-873-04	VOCs (EPA Method 601)	Semiannual
	Metals: Pb (EPA Method 239.2)	Every two years
W-873-06	VOCs (EPA Method 601)	Semiannual
	Metals: Cd (EPA Method 200.7)	Every two years
W-873-07	VOCs (EPA Method 601)	Semiannual
W-875-01	VOCs (EPA Method 601)	Semiannual
	Metals: Cd, Cu, Pb, Zn (EPA Methods 200.7, 239.2)	Every two years
W-875-02	VOCs (EPA Method 601)	Semiannual
	BTEX (EPA Method 602)	Annual
W-875-03	VOCs (EPA Method 601)	Semiannual
W-875-04	VOCs (EPA Method 601)	Semiannual
	Metals: Pb (EPA Method 239.2)	Every two years
W-875-05	VOCs (EPA Method 601)	Semiannual
W-875-06	VOCs (EPA Method 601)	Semiannual
W-875-07	VOCs (EPA Method 601)	Semiannual
	BTEX (EPA Method 602)	Annual
	Metals: Pb (EPA Method 239.2)	Every two years

Table F-1. (Continued)

Well	Analysis	Frequency
W-875-08	VOCs (EPA Method 601)	Semiannual
	BTEX (EPA Method 602)	Annual
W-875-09	VOCs (EPA Method 601)	Semiannual
	BTEX (EPA Method 602)	Annual
W-875-10	VOCs (EPA Method 601)	Semiannual
	BTEX (EPA Method 602)	Annual
	Metals: Ba, Pb (EPA Methods 200.7, 239.2)	Annual
W-875-11	VOCs (EPA Method 601)	Semiannual
	BTEX (EPA Method 602)	Annual
	Metals: Ba, Pb (EPA Methods 200.7, 239.2)	Annual
W-875-15	VOCs (EPA Method 601)	Semiannual
	BTEX (EPA Method 602)	Annual
W-876-01	VOCs (EPA Method 601)	Semiannual
W-879-01	VOCs (EPA Method 601)	Semiannual
W-889-01	VOCs (EPA Method 601)	Semiannual

Notes:

Ba = Barium.
BTEX = Benzene, toluene, ethylbenzene, and total xylenes.
Cd = Cadmium.
Cu = Copper.
Hg = Mercury.
Pb = Lead.
VOCs = Volatile organic compounds.

Table F-2. Eastern GSA ground water sampling plan.

Well	Analysis	Frequency
CDF-1	VOCs (EPA Method 601)	Monthly
CON-1	VOCs (EPA Method 601)	Monthly
CON-2	VOCs (EPA Method 601)	Semiannual
W-25D-01	VOCs (EPA Method 601)	Semiannual
W-25D-02	VOCs (EPA Method 601)	Semiannual
W-25M-01	VOCs (EPA Method 601)	Semiannual
W-25M-02	VOCs (EPA Method 601)	Semiannual
W-25M-03	VOCs (EPA Method 601)	Semiannual
W-25N-01	VOCs (EPA Method 601)	Semiannual
W-25N-04	VOCs (EPA Method 601)	Semiannual
W-25N-05	VOCs (EPA Method 601)	Semiannual
W-25N-06	VOCs (EPA Method 601)	Semiannual
W-25N-07	VOCs (EPA Method 601)	Quarterly
W-25N-08	VOCs (EPA Method 601)	Semiannual
W-25N-09	VOCs (EPA Method 601)	Semiannual
W-25N-10	VOCs (EPA Method 601)	Quarterly
W-25N-11	VOCs (EPA Method 601)	Quarterly
W-25N-12	VOCs (EPA Method 601)	Quarterly
W-25N-13	VOCs (EPA Method 601)	Quarterly
W-25N-15	VOCs (EPA Method 601)	Semiannual
W-25N-18	VOCs (EPA Method 601)	Semiannual
W-25N-20	VOCs (EPA Method 601)	Semiannual
W-25N-21	VOCs (EPA Method 601)	Semiannual
W-25N-22	VOCs (EPA Method 601)	Semiannual
W-25N-23	VOCs (EPA Method 601)	Semiannual
W-25N-24	VOCs (EPA Method 601)	Semiannual
W-25N-25	VOCs (EPA Method 601)	Semiannual
W-25N-26	VOCs (EPA Method 601)	Semiannual
W-25N-28	VOCs (EPA Method 601)	Semiannual
W-26R-01	VOCs (EPA Method 601)	Semiannual
W-26R-02	VOCs (EPA Method 601)	Semiannual
W-26R-03	VOCs (EPA Method 601)	Semiannual
W-26R-04	VOCs (EPA Method 601)	Semiannual
W-26R-05	VOCs (EPA Method 601)	Semiannual

Table F-2. (Continued)

Well	Analysis	Frequency
W-26R-06	VOCs (EPA Method 601)	Semiannual
W-26R-07	VOCs (EPA Method 601)	Semiannual
W-26R-08	VOCs (EPA Method 601)	Semiannual
W-26R-11	VOCs (EPA Method 601)	Semiannual
W-7D	VOCs (EPA Method 601)	Semiannual
W-7DS	VOCs (EPA Method 601)	Semiannual

Note:

VOCs = Volatile organic compounds.

Table F-3. GSA soil vapor sampling plan

Location	Analysis	Frequency
SVE wells	TCE and PCE (EPA Method TO-14)	Quarterly

Note:

SVE = Soil vapor extraction.

Table F-4. GSA treatment system self-monitoring sampling plan.

Facility	Media	Analysis	Frequency
Central GSA	GWTS influent and effluent	VOCs (EPA Method 601) TDS (EPA Method 160.1) pH (Field) Specific conductivity (Field) Temperature (Field)	Monthly
	GWTS air stripper offgas	VOCs (Field OVA)	Weekly
	SVE system influent	TCE and PCE (EPA Method TO-14)	Monthly
		VOCs (Field OVA)	Weekly
	SVE system effluent	VOCs (Field OVA)	Weekly
	Receiving water	VOCs (EPA Method 601) Turbidity pH (Field) Dissolved oxygen (Field) Temperature (Field)	Weekly (when present)
Eastern GSA	GWTS influent and effluent	VOCs (EPA Method 601)	Monthly
		TDS (EPA Method 160.1)	Monthly
		pH (Field)	Monthly
		Fish bioassays (EPA/600/4-90/027F) (Effluent only)	Annually
	Receiving water	VOCs (EPA Method 601) Turbidity pH (Field) Dissolved oxygen (Field) Temperature (Field)	Every 2 weeks (when present)

Notes:

GWTS = Ground water treatment system.

OVA = Organic vapor analyzer.

SVE = Soil vapor extraction

TDS = Total dissolved solids.

VOCs = Volatile organic compounds.

Table F-5. GSA Reporting Requirements

Report	Elements	Deadline
Monthly Remedial Project Managers (RPM) Meeting Summary	• Compliance issues and corrective actions, if any • Facility status update • Work performed • Work anticipated • As needed, may include the following: – Performance data – Proposed remediation plan changes – Progress report – Identification of actual or potential problems – Changes in sampling frequency or parameters	Variable. Typically submitted approximately 30 days following each RPM meeting.
Quarterly Reports	• Compliance issues and corrective actions, if any • Ground water monitoring: – Water level elevation data – Potentiometric surface elevation maps – Sampling results – Contaminant isoconcentration maps (second and fourth quarter only) • Ground water extraction and treatment systems: – Operations summary – Modifications or upgrades – Flow rate and volume summary – Influent/effluent sampling results – Contaminant mass removal estimate – Receiving water monitoring results • Soil vapor extraction system: – Operations summary – Modifications or upgrades – Flow rate and volume summary – Influent sampling results – Soil vapor extraction well sampling results – Contaminant mass removal estimate – TCE isoconcentration map for soil vapor[a] – Soil vapor extraction system zone of influence[b] • The final report for each year contains tabular summaries of data obtained during the previous year, if required.	Last day of the month following the quarter in which the samples were taken.
CERCLA 5-Year Review Report	• Status of remedial objectives • Areas of non-compliance • Recommendations • Statement of protectiveness	2002

[a] To be submitted semi-annually.
[b] To be submitted annually.

Table F-6. GSA water level measurement plan.

Location	Frequency
All wells	Quarterly

Table F-7. GSA extraction flow quantity measurement plan.

Facility	Measurement	Frequency
Central GSA	GWTS flow quantity	Daily
	Extraction well water flow quantity	Daily
	SVE system flow quantity	Monthly
	SVE well flow quantity	Quarterly
Eastern GSA	GWTS flow quantity	Daily
	Extraction well water flow quantity	Daily

Notes:

GWTS = Ground water treatment system.

SVE = Soil vapor extraction.

Appendix G

Contingency Plan

Appendix G

Contingency Plan

Summary

Lawrence Livermore National Laboratory (LLNL) and the U.S. Department of Energy (DOE) are currently designing and operating remediation systems to remove volatile organic compounds (VOCs) from soil, rock, and ground water beneath the General Services Area (GSA) Operable Unit (OU) at LLNL Site 300. This Contingency Plan describes how DOE/LLNL and the regulatory agencies plan to address foreseeable problems that may arise during the remediation of the GSA OU. This document also describes plans for modifying remediation systems as the site cleanup progresses and additional information is collected.

This Contingency Plan is one of the final post-Record of Decision (ROD) documents for the GSA OU. There are no Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) Contingency Plan guidance documents; thus, the scope and content of this report were based on the LLNL Livermore Site Contingency Plan (McKereghan et al., 1996) as determined by DOE, LLNL, and the regulatory agencies with input from the community.

Potential contingencies are presented in Section G-2 and are divided into technical and logistical contingencies. Technical contingencies are related to the physical remediation of soil, rock, and ground water at the GSA OU. These include incomplete hydraulic containment of the contaminant plumes, and unanticipated increases in contaminant concentrations. Possible responses to these contingencies include adjusting ground water extraction flow rates or adding additional extraction wells.

Other technical contingencies include the development of innovative remedial technologies and uncontrollable events such as earthquakes or storm-related damage. If these affect implementation or operation of GSA remediation systems, the systems will be modified, replaced, or decommissioned.

To better understand the dominant fate and transport processes that are occurring beneath the GSA OU, LLNL has developed both ground water and soil vapor models. To practically apply these models, many simplifying assumptions were necessary. The results of the modeling efforts have been used to plan and design remediation systems. If, during remediation, it becomes apparent that some of these assumptions are not valid, DOE/LLNL will re-evaluate the model and modify the remediation systems, if necessary.

Logistical contingencies include changes in personnel, funding, regulations, and/or the mission and operation of LLNL. If these significantly affect the remediation effort, they will be evaluated when they occur. Development of any response to a technical or logistical contingency will involve both the regulatory agencies and the community.

A summary of potential contingencies and responses is presented in Table G-1.

Table G-1. Summary of contingencies and potential responses.

Contingency	Response
Technical	
Insufficient hydraulic containment.	Adjust extraction flow rates and/or number/location of extraction wells.
Increasing chemical concentration.	Adjust extraction flow rates and/or number/location of wells. Conduct additional source investigations, if necessary.
Model validation suggests remedial plan modification(s). Chemical mass removal rate less than expected removal rate.	Modify treatment facilities and/or expand remedial wellfield(s). Use alternate remedial strategies or new technologies, if feasible.
Model assumptions not valid.	Update model and re-evaluate remedial plan.
Improved technologies are developed.	Conduct cost-benefit analysis and employ economical- and technology-based actions that are acceptable.
Chemicals in vadose zone impact ground water.	Where vadose zone cleanup is in progress, modify remediation system, if possible. If no vadose zone remediation in progress, conduct source investigation and/or implement remedial action, if necessary.
Additional contaminant sources discovered.	Conduct source investigations where necessary to assess extent of contamination. If ground water is impacted, modify the remedial action plan. If ground water is not impacted, conduct transport modeling to evaluate need for vadose zone remediation.
Uncontrollable events impact monitoring and/or remediation efforts.	Assess damage to infrastructure and, if appropriate, modify, replace, or decommission monitoring and/or remediation system(s).
Logistical	
Personnel changes.	Employ phase-in/phase-out period, if appropriate, to ensure smooth transitions during personnel changes. Review project documentation at transitions and learn current positions on site-related issues that have major impacts.
Insufficient funding affects planned remediation.	Follow established Site 300 remediation priority list. If necessary, milestone dates will be revised through coordination with the regulatory agencies.
Regulations change.	Include DOE/LLNL, regulators, and the community in the process to determine if and how regulatory changes affect the GSA OU cleanup.
Land/ground water use and demand affect monitoring/remediation.	Alter the remedial pumping scheme, and/or negotiate with land owners. Implement contingency point-of-use treatment at existing water-supply wells, if necessary.

Table G-1. (Continued)

Contingency	Response
Changes to the mission and operation of LLNL.	**Future mission and operation of LLNL will include Comprehensive Environmental Response, Compensation, and Liability Act compliance and cleanup implementation as specified in the Site 300 Federal Facility Agreement and the GSA Record of Decision documents.**

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Appendix G

Contingency Plan

G-1. Introduction

This Contingency Plan (CP) for the GSA OU at the LLNL Site 300 was prepared to comply with requirements of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) of 1980 as amended by the Superfund Amendments and Reauthorization Act of 1986. This CP describes how the U.S. DOE, LLNL, and the regulatory agencies plan to address foreseeable problems that may arise during the remediation of soil, rock, and ground water at the GSA OU. This document also generally describes plans for modifying GSA remediation systems as cleanup progresses and additional information is collected.

This document was prepared by the University of California for DOE with oversight from the U.S. Environmental Protection Agency (EPA), the California Department of Toxic Substances Control (DTSC), and the California Regional Water Quality Control Board (RWQCB)–Central Valley Region. No CERCLA CP guidance documents are currently available; hence, the scope of this report is based on the LLNL Livermore Site CP (McKereghan et al., 1996). The Livermore Site CP scope was based on input provided by DTSC (1993) and subsequent discussions with DTSC, EPA, RWQCB, and the community.

This CP is presented as part of the GSA Remedial Design (RD) Report which also includes the Compliance Monitoring Plan (CMP) for the GSA OU. This is one of the final CERCLA-required post-ROD documents for the GSA OU. The first Five-Year Review under CERCLA will be submitted in 2002.

The site history is briefly summarized in the Remedial Design report. Potential contingencies are presented in Section G-2 of this document and are divided into technical and logistical issues.

G-2. Potential Contingencies

Technical and logistical contingencies that might affect the planned remediation of the GSA OU are discussed in this section. Technical contingencies are related to the physical remediation of ground water, rock, and soil at the site. Logistical contingencies include regulatory, planning, and personnel issues.

G-2.1. Technical Contingencies

Potential technical contingencies that may arise during the remediation of rock, soil, and ground water at the GSA OU, and a discussion of uncontrollable events, such as natural disasters, are presented below. DOE/LLNL's planned response is described with each issue.

G-2.1.1. Ground Water Remediation

As described in the GSA ROD (U.S. DOE, 1997), DOE/LLNL are extracting ground water to remove and hydraulically control contaminated ground water beneath the GSA and areas where contaminated ground water has migrated offsite. Ground water modeling and hydraulic tests have been conducted to understand the ground water flow system beneath the site. However, there are uncertainties regarding the effectiveness of any ground water extraction and treatment system, as discussed below.

G-2.1.1.1. Hydraulic Control of Plumes

As discussed in the CMP, the effectiveness of the GSA ground water extraction and treatment facilities will be determined by measuring ground water elevations in extraction wells and surrounding monitor wells and measuring chemical concentrations in ground water extracted from these wells. A list of the wells in each treatment facility area and their respective sampling frequencies and details of the ground water monitoring program are discussed in the CMP.

Ground water elevation contour maps showing the estimated hydraulic capture area of each extraction wellfield are constructed for the GSA treatment facility permit compliance reports. In conjunction with isoconcentration contour maps that show the distribution of contaminants in each hydrogeologic unit, the estimated capture areas will be used to determine whether the plumes are being successfully contained.

If ground water elevation contour maps and/or isoconcentration contour maps indicate insufficient plume hydraulic capture in a particular hydrogeologic unit, the flow rates of nearby extraction wells will be adjusted, if possible, to increase the overall hydraulic capture area and/or eliminate stagnation zones within that hydrogeologic unit. If, after extraction well flow rates have been adjusted, monitoring still indicates inadequate plume capture, DOE/LLNL will modify the remedial strategy (e.g., increase treatment facility capacity, expand the remedial wellfield by constructing new pipelines). The regulatory agencies will be informed of any problems and potential modifications to the remedial system at Site 300 Remedial Project Manager (RPM) meetings.

G-2.1.1.2. Increases in Chemical Concentrations in Ground Water

Ground water chemistry data are inherently variable. Concentration fluctuations over time occur in response to climatic changes (variable precipitation and infiltration rates), changes within the aquifer (variable hydraulic gradients, water levels, sorption/desorption, and contaminant transport rates in response to ground water extraction), and changes in conditions unrelated to the site environment (minor variations inherent in analytic methods and analytical laboratory procedures). Therefore, not all fluctuations in contaminant concentration necessitate extraction well/treatment facility modification.

As discussed in the CMP, DOE/LLNL will continue to monitor chemical concentrations in GSA ground water monitor and extraction wells. DOE/LLNL will analyze trends and variability of chemical concentrations in these wells, and periodically re-evaluate the sampling schedule for ground water monitoring. Currently, each GSA well is sampled annually, semiannually, quarterly, or monthly. If the chemical concentration in a well increases in a consistent and significant manner over time, the relationship between the VOC concentration data, historical data trends, and factors which can affect VOC concentrations in ground water (i.e. climatic changes, changes in the aquifer, etc.) will be evaluated. If appropriate, the sampling frequency will be increased.

If ground water contaminant concentrations above Maximum Contaminant Levels (MCLs) are increasing in a consistent and significant manner for reasons not attributable to remediation efforts (i.e., cyclic pumping), or natural aquifer or laboratory variables, modifications to the remedial action will be considered. If possible, extraction rates will be adjusted to obtain better hydraulic control of the contaminant plume. However, if adjusting the flow rate(s) does not effectively improve hydraulic control of the plume, DOE/LLNL will modify the remedial strategies (e.g., increase treatment facility capacity or expand the remedial wellfield).

Throughout the life of the remediation project, continued efforts will be made to evaluate whether Dense Non-Aqueous Phase Liquids (DNAPLs) act as a continuing source of contamination in the Building 875 dry well pad area. The methodology for evaluation of DNAPLs is discussed in the CMP. The objective of these investigations will be to validate whether the assessment of the location of DNAPLs, as well as effort to remediate DNAPLs, are properly focused. If, following this evaluation, it is determined that DNAPLs are not being effectively remediated, DOE/LLNL will re-evaluate and, if necessary, modify the remedial strategy.

If contaminant concentrations increase in areas outside of active remediation, DOE/LLNL will conduct additional field investigations, if warranted. Based on these investigations, the need for modifications to the remedial action will be evaluated in consultation with the regulatory agencies.

G-2.1.1.3. Ground Water Modeling

To monitor progress of the cleanup, the amount of contaminant mass removed from ground water will be compared to GSA fate and transport modeling results. The results of this model simulation are presented in Appendix E of the GSA FS and Appendix H of this RD document. Uncertainties exist in all numerical simulation results. At the GSA, these are directly related to uncertainties in the estimated amount of contaminant mass beneath the site. Therefore, as discussed in the CMP, the amount of contaminant mass remaining in the subsurface will be revised during remediation using site-specific chemical data. In addition, DOE/LLNL will also examine the mass removal rates of treatment facilities and evaluate if contaminants are effectively being removed using the selected remedial alternative.

If results of these analyses indicate that the selected remedial alternative is not effectively removing contaminant mass, the following options will be considered:

- Modifying or expanding the existing treatment facilities and remedial wellfields,
- Using alternative cleanup strategies, or
- Renegotiating ground water cleanup objectives with the regulatory agencies.

Additional data collected during remediation will be used to validate the fate and transport model assumptions. When site-specific data indicate that the model assumptions are no longer valid, both the conceptual model and calibrations are updated. In addition, simulations may be conducted, as appropriate, to ensure that model results are representative of field observations (i.e., if actual mass removed through ground water extraction is significantly different than the mass removal estimated by numerical simulations). If the updated model results suggest that changes to the remediation strategy are necessary, DOE/LLNL will consult the regulatory agencies. Remediation strategy changes will be made only with regulatory concurrence and after community concerns are reviewed.

G-2.1.2. Soil Vapor Remediation

As discussed in the GSA ROD (U.S. DOE, 1997), DOE/LLNL will use vapor extraction to remove soil vapor containing VOCs from unsaturated sediments (the vadose zone) beneath the central GSA Building 875 dry well pad area. VOCs in soil vapor will be treated at an aboveground treatment facility unless new, cost-effective technologies are developed that will provide *in situ* treatment.

As discussed in the Remedial Action Work Plan (RD Section 5), data from ongoing field monitoring, as well as fate and transport modeling, trend analysis, mass balance and/or other methods will be used to estimate when vadose zone remediation will be considered complete. The following sections describe possible vadose zone remediation issues.

G-2.1.2.1. Impacts of VOCs in Soil Vapor on Ground Water

As described in the GSA ROD (U.S. DOE, 1997), simultaneous ground water extraction (GWE) and soil vapor extraction (SVE) are being utilized to maximize VOC mass removal in the Building 875 dry well pad area. In this area, the bulk of contamination has been detected in the saturated zone at the contact between the sandstone bedrock and the underlying confining layer. An artificial vadose zone was created by extracting ground water until the sandstone bedrock was dewatered. Dewatering has exposed more rock to the applied vacuum of SVE, significantly enhancing VOC removal.

To ensure that contaminants in this unsaturated bedrock will not adversely impact ground water beneath the GSA OU, DOE/LLNL will continue to monitor ground water as remediation progresses. In addition, VOC concentrations in soil vapor will be monitored at dedicated soil vapor sampling points and at SVE wells throughout the life of the SVE remediation. If ground water and/or soil vapor monitoring data indicate that the SVE system is not effectively remediating contaminants, operation of the remedial system will be modified to increase the VOC mass removal rate and the extent of pressure influence, if possible. If monitoring data indicate that system operation modifications are not sufficiently effective, additional measures such as installation of additional soil vapor or ground water extraction wells will be evaluated with regulatory oversight.

If monitoring results indicate that the overall combined SVE/GWE remediation strategy for the Building 875 dry well area is not effective in reducing contaminant concentrations to levels protective of ground water, modifications to the remedial action will be evaluated and discussed with the regulatory agencies.

If monitoring indicates that vadose zone contaminants may be impacting ground water in a source area where no vadose zone remediation is occurring nor is planned, additional investigations will be considered. The need for supplemental remedial actions will be evaluated with regulatory oversight and with public notification.

G-2.1.2.2. Increases in VOC Concentrations in Soil Vapor

As with ground water chemistry data, soil vapor chemistry data are also inherently variable. Concentration fluctuations over time occur in response to: 1) climatic changes (variable precipitation and infiltration rates), 2) changes within the unsaturated zone (soil moisture content, water level changes, sorption/desorption), 3) changes in contaminant transport rates in response to soil vapor extraction, and 4) changes in conditions unrelated to the site environment (minor variations inherent in analytic methods and analytical laboratory procedures). Therefore, not all fluctuations in contaminant concentrations necessitate extraction well/treatment facility modification.

As discussed in the CMP, DOE/LLNL will monitor VOC concentrations in GSA soil vapor extraction wells. DOE/LLNL will analyze trends and variability of chemical concentrations in these wells, and periodically re-evaluate the sampling schedule for soil vapor monitoring. Currently, each GSA SVE well is sampled quarterly. If the chemical concentration in an SVE well increases in a consistent and significant manner over time, the relationship between VOC concentration data, historical data trends, and factors which can affect VOC concentrations in soil vapor (i.e. climatic changes, changes within the unsaturated zone, cyclical pumping, etc.) will be evaluated. If appropriate, the sampling frequency will be increased.

If soil vapor VOC concentration increases are known to be associated with a planned remediation optimization effort (i.e. concentration rebounds associated with cyclic extraction from a well to allow VOCs to reequilibrate and maximize mass removal), the soil vapor sampling frequency will not be altered.

If contaminant concentrations in soil vapor are increasing in a consistent and significant manner for reasons not attributable to remediation efforts or natural unsaturated zone or laboratory variables, the need for modifications to the remedial action will be considered. If possible, extraction rates will be adjusted to obtain better mass removal from the unsaturated or dewatered zone. However, if adjusting the flow rate(s) does not effectively increase VOC mass removal, DOE/LLNL will modify the remedial strategies (e.g., increase SVE treatment facility capacity or expand the SVE wellfield).

If contaminant concentrations increase in areas outside of active remediation, as discussed in Section 2.1.4, DOE/LLNL will consider additional field investigations,. Based on these investigations, the need for modifications to the remedial actions will be evaluated in consultation with the regulatory agencies.

G-2.1.2.3. Vadose Zone Modeling

Results from three-dimensional model simulations of the central GSA forecasted that the SVE/GWE remediation strategy would be effective in expediting cleanup of contaminants in the Building 875 dry well area. These simulations were also used to evaluate the efficiency of the vapor extraction system operating at Building 875 dry well pad and to estimate cleanup times, as discussed in Appendix H.

The primary uncertainties in simulation models are related to the assumptions made regarding physical soil properties, source VOC concentrations, and environmental factors such as precipitation and recharge patterns. The model applied here was calibrated by adjusting these parameters until site-specific field measurements were reproduced. If new site-specific field data indicate that the model assumptions are no longer valid, both the model calibration and simulations will be updated.

In the Building 875 dry well pad area, VOCs in both soil vapor and ground water will be monitored throughout the remediation process as discussed in the CMP. Simulation results will be compared to field measurements and the numerical model may be updated and recalibrated, as appropriate, using the new data (i.e., if actual mass removed through SVE differs significantly from mass removal estimated by modeling). If the updated simulation results indicate that existing vadose zone conditions are not protective of ground water, DOE/LLNL will continue to operate the soil vapor extraction system and/or make necessary modifications to the system until it is demonstrated that VOC removal from the vadose zone is no longer technically and economically feasible to meet the aquifer cleanup levels sooner, more cost effectively, and more reliably.

Should future field measurements indicate that VOCs in unsaturated sediments are migrating to ground water in areas other than the Building 875 dry well pad area, a more detailed analysis of migration processes, followed by implementation of the appropriate source remediation measures, will be evaluated.

G-2.1.3. New Technologies

New innovative technologies and remediation techniques for ground water and soil vapor cleanup are being evaluated by various entities, including DOE/LLNL. While many of these techniques and technologies may not be economically feasible, it is possible that a rapid and cost-effective cleanup strategy may be developed that could potentially reduce cleanup time or residual contaminant concentrations. These technologies may be employed at the GSA if site conditions change or technology development and testing indicate a potential for cost-effective and expedited remediation. If a new technology is proven to be effective in laboratory and field studies, and is cost effective, DOE/LLNL will seek regulatory approval to implement it. The community will be informed of any change in technology and their concerns will be reviewed.

G-2.1.4. New Source Remediation

Previously undetected contaminant sources resulting from past releases of hazardous materials may be identified by:

1. Increasing contaminant concentrations in ground water, and
2. High concentrations of contaminants in soil samples collected from boreholes or during preconstruction activities

If ground water contaminant concentrations increase for three consecutive sampling events in an area with little or no previous characterization, DOE/LLNL will assess the need to investigate for a previously undetected source. Most documented past releases have already been identified (Webster-Scholten et al., 1994); hence, an extensive document review will likely not be needed. New contaminant sources from recent releases will be identified by notification from the LLNL department documenting the release. Following initial health and safety assessment by the LLNL Hazards Control Department, samples will be collected to delineate the lateral extent and depth of contamination and determine if the release is of sufficient quantity to potentially affect ground water quality.

If source investigation results indicate that a previously undetected contaminant source has impacted ground water in concentrations above MCLs, DOE/LLNL will modify the remedial action plan in consultation with the regulatory agencies. If ground water has not been impacted in concentrations exceeding MCLs, or if contaminants are not detected in the ground water, DOE/LLNL may conduct fate and transport modeling to determine if vadose zone remediation of the potential source is warranted.

G-2.1.5. Uncontrollable Events

Natural disasters may occur during the GSA ground water cleanup. Natural disasters may include large magnitude earthquakes, floods, or severe atmospheric storm events that could disrupt monitoring or remedial activities. If significant damage occurs to treatment facilities or remedial wellfields, ground water cleanup in particular areas of the GSA may temporarily cease. DOE/LLNL will then evaluate the damage to the remedial infrastructure, estimate the time and funding needed to return to normal operation, and report to the regulatory agencies. When DOE/LLNL and the regulatory agencies agree it is appropriate, damaged infrastructure will be modified, replaced, or decommissioned.

G-2.2. Logistical Contingencies

Logistical contingencies include but are not limited to, changes in personnel, funding, regulations, and land/ground water use and demand, as described below.

G-2.2.1. Personnel

As with any long-term project, personnel changes will occur during the GSA OU cleanup. Past personnel changes at DOE, LLNL, and regulatory agencies have been accommodated while minimizing adverse impact to the project. RPMs and other knowledgeable staff will continue to assist new personnel to familiarize them with the project. This teamwork approach will be employed for any future RPM or LLNL Environmental Restoration Division (ERD) personnel changes. New personnel can refer to the GSA ROD (U.S. DOE, 1997), Site 300 Priority List, the Site 300 Federal Facility Agreement (FFA), the Site 300 Administrative Record, and Standard Operating Procedures (Dibley and Depue, 1997) as guidance for the approved cleanup plan and schedule.

Changes in LLNL contractors have been successfully implemented in the past (e.g., analytical laboratories), and LLNL procurement practices will continue to enable smooth transitions in the future. If DOE/LLNL believe that an outgoing incumbent contractor can provide valuable knowledge to help ensure a smooth transition, LLNL will request a phase-in/phase-out period to allow the incumbent to work directly with the new contractor for a specified period of time.

G-2.2.2. Funding

DOE will take all necessary steps to request timely and sufficient funding to meet its obligations under the GSA ROD. The regulatory agencies will be notified at the RPM meetings of any potential budget shortfalls that may affect GSA deliverables as described in the Site 300 FFA.

G-2.2.3. Regulatory Environment

As presented in the National Research Council report (NRC, 1994), the ability of restoring ground water to MCLs using active pumping is unlikely at most sites. If, at some later date, DOE, U.S. EPA, RWQCB, and DTSC determine that it is technically and/or economically infeasible to 1) reduce VOCs in ground water to the cleanup standards established in the ROD, and/or 2) to reduce VOCs in the vadose zone to levels that no longer cause concentrations in the leachate to exceed aquifer cleanup levels, after all reasonable efforts have been made, these parties may re-evaluate the need to achieve these goals. If changes in cleanup levels are considered due to Technical Impracticability (TI), TI will be evaluated using U.S. EPA's OSWER Directive 9234.2-25, "Guidance for Evaluating the Technical Impracticability of Ground Water Restoration" (EPA, 1993). In addition, if remediation does not show that cleanup is proceeding as predicted, the cleanup goals for chloroform and bromodichloromethane will be revisited. As described below, changes to remediation plans and/or cleanup goals will be made only with regulatory concurrence.

A ROD change may be necessary if new information affects how the GSA OU cleanup should be implemented. Following EPA guidelines (U.S. EPA, 1991), the lead agency (EPA) will determine if the proposed ROD change is 1) non-significant or minor, 2) significant, or 3) fundamental. A non-significant change generally reflects modifications to optimize performance and minimize cost. Non-significant changes are recorded in the post-ROD document file. A significant change is generally a change to a component that does not fundamentally alter the overall remedial approach. For a significant change, an Explanation of Significant Differences (ESD) will be prepared, and a brief description and notice of availability of the ESD will be published in a major local newspaper. The ESD will be available to the public through the Administrative Record and information repository. A fundamental change requires reconsideration of the approach selected in the ROD. For a fundamental change, the public participation and documentation procedures include preparing a Proposed Plan, providing a public comment period, and preparing a Responsiveness Summary.

Community recommendations regarding GSA OU cleanup will be discussed by the regulatory agencies and DOE/LLNL. The regulatory agencies and DOE/LLNL will evaluate community suggestions based on cost and benefit, and will report their findings publicly. As regulations change (e.g., discharge requirements, MCLs, cleanup requirements, etc.), target cleanup levels may increase or decrease accordingly. DOE/LLNL and the regulatory agencies will determine how these changes may affect the cleanup. The community will be informed of any regulatory changes that affect the GSA OU cleanup.

G-2.2.4. Land/Ground Water Use and Demand

If routine monitoring indicates that others may be using contaminated ground water originating from the GSA OU or if ground water use by others is adversely affecting the cleanup, DOE/LLNL will: 1) notify the EPA, RWQCB, and DTSC, 2) acquire all available information on location, magnitude, and duration of the private ground water use and 3) develop a mitigation plan, if necessary. Possible mitigations include altering the remedial pumping scheme, negotiating with land owners, seeking regulatory intervention, and installing point-of-use treatment at existing private water-supply wells, if necessary.

For existing water-supply wells CON-1, CDF-1, and SR-1, point-of-use (POU) treatment will be installed if VOCs are detected in these wells at or above MCLs. The monitoring plan for water-supply wells CON-1 and CDF-1 is discussed in the CMP. In the event that VOCs at or above MCLs are detected and confirmed in wells CDF-1, CON-1, or SR-1, implementation of POU treatment at that well will be discussed with the regulatory agencies and well owner(s).

Wells CDF-1 and CON-1 are located approximately 100 and 200 ft, respectively, from the Site 300 GSA boundary. Due to the close proximity of these wells to the VOC plume, DOE currently has a POU contingency plan in place for these wells in a Memorandum of Understanding that has been reviewed and approved by the well owner.

Well SR-1 is located approximately 1.5 miles downgradient from guard well W-24P-03. No VOCs have ever been detected in ground water collected from W-24P-03, the furthest downgradient well. In addition, the VOC plume has been receding upgradient back toward Site 300 as a result of remediation efforts and is currently over 2 miles from well SR-1. However, if VOCs were detected in guard well W-24P-03, the property owner would be contacted to set up a monitoring and contingency plan similar to that established for wells CON-1 and CDF-1.

Future onsite development may restrict available locations for piezometers, and monitor and extraction wells. Current onsite LLNL planning procedures require thorough environmental review and sampling prior to any significant construction activities, which mitigates the potential for inadvertent development of critical remedial locations.

Offsite land restrictions are expected to have less impact on remedial activities because the highest contaminant concentrations detected in ground water, and therefore the extraction well locations, are all onsite. Modeling indicated that plume capture can be achieved by onsite extraction. To date, the adjacent property owners have been cooperative in allowing the placement of monitor wells on their property adjacent to the GSA.

G-2.2.5. LLNL Mission and Operation

LLNL’s current and future mission and operation will include CERCLA compliance and cleanup implementation as specified in the Site 300 FFA and the GSA ROD. In addition, DOE is committed to honoring its responsibilities for environmental cleanup independent of any possible future decisions regarding the continued existence of LLNL. Recent statements from Congressional representatives and the Administration regarding the importance of the National Laboratories to the nation’s continued scientific and defense interests indicate that LLNL will continue to exist at Site 300 for the foreseeable future.

G-3. References

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Appendix H

Soil Vapor and Ground Water Modeling Analysis

Appendix H

Results of Soil Vapor and Ground Water NUFT Modeling

H-1. Introduction

For the past three years, a soil and ground water remediation program has been underway at the central General Services Area (GSA). The objectives of this remedial action are to:

1. Reduce Volatile Organic Compound (VOC) concentrations in ground water to cleanup standards. Trichloroethene (TCE) is the primary contaminant in the GSA operable unit.
2. Remove VOC mass from ground water.
3. Reduce VOC concentrations in soil vapor to concentrations protective of ground water.
4. Mitigate VOC inhalation risk inside Building 875.

These objectives will be accomplished by:

1. Hydraulic capture of ground water contaminated with VOCs and local dewatering of the saturated zone using ground water extraction (GWE). The purpose of dewatering is to expose a larger volume of the subsurface to soil vapor extraction (SVE).
2. Removing volatilized contaminants from the vadose zone using SVE, primarily beneath the Building 875 dry well VOC release area.

The basic remediation strategy and cleanup standards are established in the GSA Record of Decision (ROD) (DOE, 1997). Ongoing remediation has been successful in significantly lowering VOC concentrations in both soil vapor and ground water. However, as contaminant mass is removed from the subsurface, it becomes increasingly difficult to extract the remaining contaminants. DOE/LLNL has elected to implement conceptual modeling with data-calibrated simulations at the central GSA, as a tool to support the remedial action. The specific objectives of this study are to:

1. Develop a numerical model calibrated to data obtained during three years of remediation in the central GSA.
2. Estimate the time required to achieve the soil vapor and ground water cleanup standards, using the remediation scenario approved in the ROD.
3. Identify remedial optimization measures and strategies that could potentially shorten cleanup time. Optimization measures could include additional extraction wells, cyclic (intermittent) pumping schedules, and modifying extraction well locations.
4. Design a second scenario incorporating these optimization measures and re-estimate cleanup time.

The computer code NUFT, Non-isothermal Unsaturated-Saturated Flow and Transport (Nitao, 1997) was chosen to simulate subsurface contaminant behavior based on its capability to represent multiphase flow and transport in a three-dimensional (3-D) hydrogeologic system. The NUFT code has the ability to simultaneously calculate advection, diffusion, and dispersion of aqueous and gaseous TCE phases in unsaturated and saturated conditions under the effects of SVE and GWE. When suitably calibrated against measurements, the capability of NUFT to simulate both volatilization and sorption of TCE increases the level of confidence in cleanup time estimates. Owing to its capacity to simulate multiple remediation technologies including SVE, GWE, air sparging, and steam injection, the NUFT code has been used at a number of DOE sites.

H-2. Previous Work

Previous remedial simulations in the GSA Feasibility Study (FS) (Rueth et al., 1995) used separate codes to examine flow and transport pathways in the unsaturated and saturated zones under the influence of SVE and GWE.

SVE was simulated in the FS using VENTING, a PC-based program that estimates the mass of contaminants extracted at a specified vapor flow rate and temperature (Johnson et al., 1990a, 1990b). VENTING is based on an analytical solution of the mass balance equation and assumes equilibrium partitioning between all phases (sorbed, nonaqueous, aqueous, and vapor). The estimated time to meet the cleanup standard for soil vapor (360 $ppb_{v/v}$) was 10 years. However, VENTING does not account for diffusion-limited conditions that, if present, would lengthen cleanup time.

Ground water flow was simulated in two spatial dimensions (2-D) using MODFLOW (McDonald and Harbaugh, 1989), coupled with MT3D (Zheng, 1990) to model contaminant transport. Migration of the TCE plume under various possible ground water pumping scenarios was examined, for both the central and eastern GSA. Maximum TCE concentrations in ground water beneath the central GSA was estimated to be less than the Maximum Contaminant Level (MCL) of 5 μg/L after 55 years.

H-3. Three-Dimensional Model Domain and Grid

The 3-D conceptual model for NUFT code simulations domain covers all of the central GSA (Fig. H-1) and is centered on the Building 875 dry well area, the location of the most significant TCE releases in the GSA. Vertically, the domain includes the Qt-$Tnsc_1$ hydrologic unit (Figs. H-2 and H-3), and extends to a depth of approximately 34 ft below ground surface into the upper 2 ft of the Neroly Formation lower siltstone/claystone unit ($Tnsc_1$). The low permeability $Tnsc_1$ unit acts as a barrier to downward contaminant migration. The Neroly lower blue sandstone ($Tnbs_1$) regional aquifer was not included in the model domain.

The model domain is subdivided into 21,280 volume elements of variable size. Relatively small grid spacing is used near the Building 875 dry well release area in order to more accurately calculate ground water drawdown, soil vapor pressure, and contaminant transport. A coarser areal grid covers the outlying regions. To accommodate increases in the volume of the vadose zone as dewatering proceeds and to minimize numerical dispersion, the domain was divided vertically into 20 thin horizontal layers. The thickness of these layers ranged from 0.6 to 3.6 ft.

H-4. Initial Conditions and Assumptions

1. Atmospheric pressure was assigned to all model elements at the ground surface.
2. Constant-head ground water boundaries were simulated by specifying pressures equivalent to 1994 water level measurements. Ground water flow direction in the $Tnbs_2$ unit is toward the southeast at a gradient of 0.02. Mean flow velocity is approximately 17 ft/yr. The low permeability $Tnsc_1$ siltstone/claystone unit was assumed to be a no-flow boundary.
3. Wells were represented by columns of elements assigned a porosity of 0.99.
4. All ground water extraction wells were assigned a fixed pressure head to represent drawdown.
5. All soil vapor extraction wells were assigned an applied vacuum.
6. Five stratigraphic units were incorporated in the model:
   - Quaternary alluvium (Qal)—Unconsolidated stream channel alluvium. Present in the Corral Hollow Creek stream channel south of the terrace deposits.
   - Quaternary terrace alluvium soil (Qt-soil)—Unconsolidated terrace alluvium, generally weathered, finer grained than Qal.
   - Quaternary terrace, alluvium gravel (Qt-gravel)—Unconsolidated terrace alluvium, coarser grained, higher hydraulic conductivity than Qal or Qt-soil.
   - Tertiary Neroly Formation Upper Blue Sandstone ($Tnbs_2$)—Consolidated, fractured. The bulk of the contamination below the Building 875 dry well release area is present in this unit.
   - Tertiary Neroly Formation Lower Siltstone and Claystone($Tnsc_1$)—Consolidated. Acts as a confining layer to prevent the further downward migration of contaminants.
7. Hydraulic properties used in this model were based on laboratory analyses of soil and rock core samples from boreholes drilled near the dry well pad, hydraulic testing, geophysical data, or estimated from soil or lithologic characteristics. These data are listed in Table H-1.
8. Retardation was calculated using the following equation:

$$R = 1 + \frac{\rho_b}{n} K_d$$

where

R = retardation factor (dimensionless)

ρ_b = dry bulk density (g/cm^3)

n = porosity (dimensionless)

K_d = distribution coefficient (cm^3/g)

9. Mechanical dispersion was conservatively assumed to be zero. Therefore, hydrodynamic dispersion results solely from molecular diffusion. Numerically induced dispersion may also be present at unspecified levels in some portions of the model domain.
10. Heterogeneities within stratigraphic units were neglected.
11. Hydraulic effects from the sewage treatment pond were neglected.
12. Isothermal conditions were assumed. The subsurface temperature was set to 20° C.
13. TCE was selected as the indicator chemical for the model. TCE comprises 85 to 95% of the mass of VOCs in the central GSA. The cleanup standard for TCE in soil vapor was assumed to be 360 $ppb_{v/v}$. The ROD cleanup standard for TCE in ground water is 5 µg/L.
14. No biologic or chemical degradation of TCE occurred.
15. Vertically uniform contaminant mass and concentration distributions exist in ground water.
16. Initial ground water contaminant concentrations are shown on Figure H-4. The figure shows concentrations measured in monitor wells, and TCE isoconcentration contours assigned to NUFT at model year zero. The initial NUFT plume was based on ground water concentration data from 1992 and 1994. Results of ground water analyses from 1992 were used at the dry well pad, which has been dewatered and more recent ground water analyses were not available. Analytical data from 1994 were used elsewhere. A TCE ground water concentration of 35,000 µg/L was assigned to a small region beneath the Building 875 dry well release area to account for Dense Non-Aqueous Phase Liquid (DNAPL) and also provide better code calibration to actual contaminant mass removal data.
17. Continuous GWE was assumed to begin in 1994 (model year zero). Intermittent extraction in 1993 was accounted for by appoximating mass removed during that time. Ground water flow rates assigned to the model reflect actual pumping data from extraction wells.
18. The ground water extraction well field is scheduled to be expanded in 1998 (model year 4). The flow rates assigned to these wells were based on lithology, hydraulic tests, length of screened interval, and performance of similar wells.
19. Continuous SVE was assumed to begin in 1995 (model year 1). Intermittent extraction in 1994 was accounted for by appoximating mass removed during that time. Soil water vapor flow rates assigned to the model reflect actual soil vapor flow data from extraction wells.

H-5. Model Calibration

Hydraulic conductivity and the distribution of contaminants in the subsurface were adjusted to calibrate the model to actual soil vapor and ground water data collected since remediation began in 1993. These calibration standards include:

1. TCE concentration in treatment system influent samples.

2. Extraction rates of soil vapor and ground water.

3. TCE mass removed from the subsurface.

Graphs comparing modeled to actual soil vapor and ground water extraction rates removal are presented as Figures H-5 and H-6.

When calibrated to the standards listed above, our simulations estimate that, as of January 1997, 42 kg of TCE would have been removed at the central GSA; 7 kg by GWE and 35 kg by SVE. The total mass of TCE actually removed during the same time period is 35 kg; 5 kg by GWE and 30 kg by SVE. That the model predicts more rapid contaminant mass removal than the facility actually achieved during the first three years of operation is probably due to subsurface heterogeneity, which was not included in this conceptual model. Incorporating heterogeneity in the future may allow better calibrations to actual facility data.

H-6. Simulation Results

Two remediation scenarios were simulated using the same initial TCE concentration and mass distribution. Scenario 1 was based on the remedial action strategy approved in the ROD. Scenario 1 includes continuous SVE and GWE at the Building 875 dry well pad, with eleven additional GWE wells coming on line in model year 4. Extraction of soil vapor and ground water is continuous until ROD cleanup standards are reached. Scenario 1 includes two modifications to the ROD plan: (1) SVE continues until the soil vapor cleanup standard is achieved (10 years of SVE was estimated in the ROD), and (2) two additional GWE wells (W-875-03 and W-7U) are added. Scenario 2 builds on Scenario 1, but includes three additional extraction wells and implements pumping of well W-7O from years 4 to 10 and years 12 to 30 to address stagnation zones. Table H-2 shows the extraction wells and pumping schedules for both scenarios. Locations of extraction wells for both scenarios are shown in Figures H-7 and H-8. Pumping from an extraction well is discontinued when the TCE concentration at that well falls below the cleanup standard. It was assumed that the overall cleanup was achieved when no ground water or soil vapor remained above the respective cleanup standards.

NUFT simulation results for SVE under Scenario 1 indicate that the cleanup standard for soil vapor (360 $ppb_{v/v}$) will be reached in 20 to 25 years. This is longer than predicted in the FS, but the FS model (VENTING) was incapable of simulating a diffusion-limited condition. Once a diffusion-limited condition is reached very little additional contaminant mass is removed, although contaminant concentrations may still be above cleanup standards. The time estimate to reach the soil vapor cleanup standard in Scenario 2 is comparable to that predicted in Scenario 1. The NUFT code calculates the radius of influence of the SVE system to be approximately 30 ft.

For ground water in Scenario 1, NUFT suggests that after 25 years of continuous pumping, a hydraulic stagnation zone forms due to competition between GWE wells; and therefore, further concentration reductions may be very difficult. TCE within this stagnation zone acts like a weak contaminant source, and it may require up to 50 years of pumping to reach ROD cleanup standards. The predicted distribution of TCE in ground water at four time increments is shown in Figure H-9. The 50-year cleanup time estimate is consistent with the MODFLOW/MT3D results presented in the FS.

Scenario 2 is similar to Scenario 1, but implements cyclic pumping of well W-7O. Three additional ground water and soil vapor extraction wells are also included to target the stagnation zone that developed during the continuous pumping of Scenario 1. Under Scenario 2, the stagnation zone described above is eliminated earlier and the estimated time to reach cleanup decreases from 50 to 30 years (Fig. H-10).

The total mass of TCE removed is essentially the same for both scenarios. NUFT estimates that a total of about 46 kg of TCE was present in the subsurface at model year zero (1994), and that approximately 44 kg would be removed by the extraction systems to reach cleanup standards; 36 kg by SVE and 8 kg by GWE. Of the remaining 2 kg of TCE, an undetermined amount would leave the model domain through volatilization at the ground surface. The remainder would be present in the subsurface at concentrations below cleanup standards. Graphs of actual and predicted cumulative TCE mass removed from the subsurface by SVE and GWE are shown as Figures H-11 and H-12, respectively.

H-7. Conclusions

The following conclusions were reached:

1. A combination of SVE and GWE will remove the majority of TCE from beneath the central GSA area. GWE alone may not be sufficient to reduce ground water concentrations below the TCE cleanup standard in a reasonable time frame. Long-term SVE may be required to remove contaminants from the artificial (dewatered) vadose zone to concentrations that will not recontaminate ground water above cleanup standards when GWE ceases and water levels recover.

2. Although a high SVE extraction rate initially flushes vapor phase TCE from higher permeability zones, a diffusion-limited condition is reached quickly. High SVE extraction rates do not significantly shorten cleanup time.

3. Continuous SVE at the Building 875 source area removes TCE vapor from the vadose zone to concentrations protective of ground water. NUFT simulation results for Scenario 1 indicate that the ROD cleanup standard for soil vapor (360 $ppb_{v/v}$) will be reached in 20 to 25 years. This is longer than the prediction presented in the FS, but the FS model (VENTING) was not capable of simulating a diffusion-limited condition.

4. The NUFT code calculates the radius of influence of the SVE system to be approximately 30 ft.

5. The simulation results indicate that continuous ground water extraction (Scenario 1) could achieve cleanup standards in the central GSA within 50 years. This is generally consistent with the results of the MODFLOW/MT3D modeling presented in the FS.

6. A combination of cyclic pumping and additional SVE and GWE wells (Scenario 2) could reduce the estimated time to reach ground water cleanup standards to approximately 30 years by targeting stagnation zones.

7. The total mass of TCE removed is essentially the same for both scenarios. NUFT estimates that a total of about 46 kg of TCE was present in the subsurface at model year zero (1994), and that approximately 44 kg would be removed by the extraction systems to reach cleanup standards; 36 kg by SVE and 8 kg by GWE. Of the remaining 2 kg of TCE,

an undetermined amount would leave the model domain through volatilization at the ground surface. The remainder would be present in the subsurface at concentrations below cleanup standards.

In the FS, it was estimated that over 200 kg of TCE would be removed from the subsurface. However, it is impossible to determine with confidence the actual amount of TCE that was released at the Building 875 dry wells. While the initial NUFT contaminant mass calculation is probably more accurate than the FS estimate, both should be viewed only as very rough approximations. Because each stratigraphic unit was modeled as a homogeneous, isotropic layer, simulated ground water and soil vapor extraction remove a large percentage of the total TCE in the subsurface fairly quickly. Therefore, an accurate estimate of initial TCE mass is not critical to cleanup time estimates determined using this model. Once a diffusion-limited condition is reached, the additional time required to reach cleanup standards is relatively insensitive to initial mass assigned near the release point.

H-8. References

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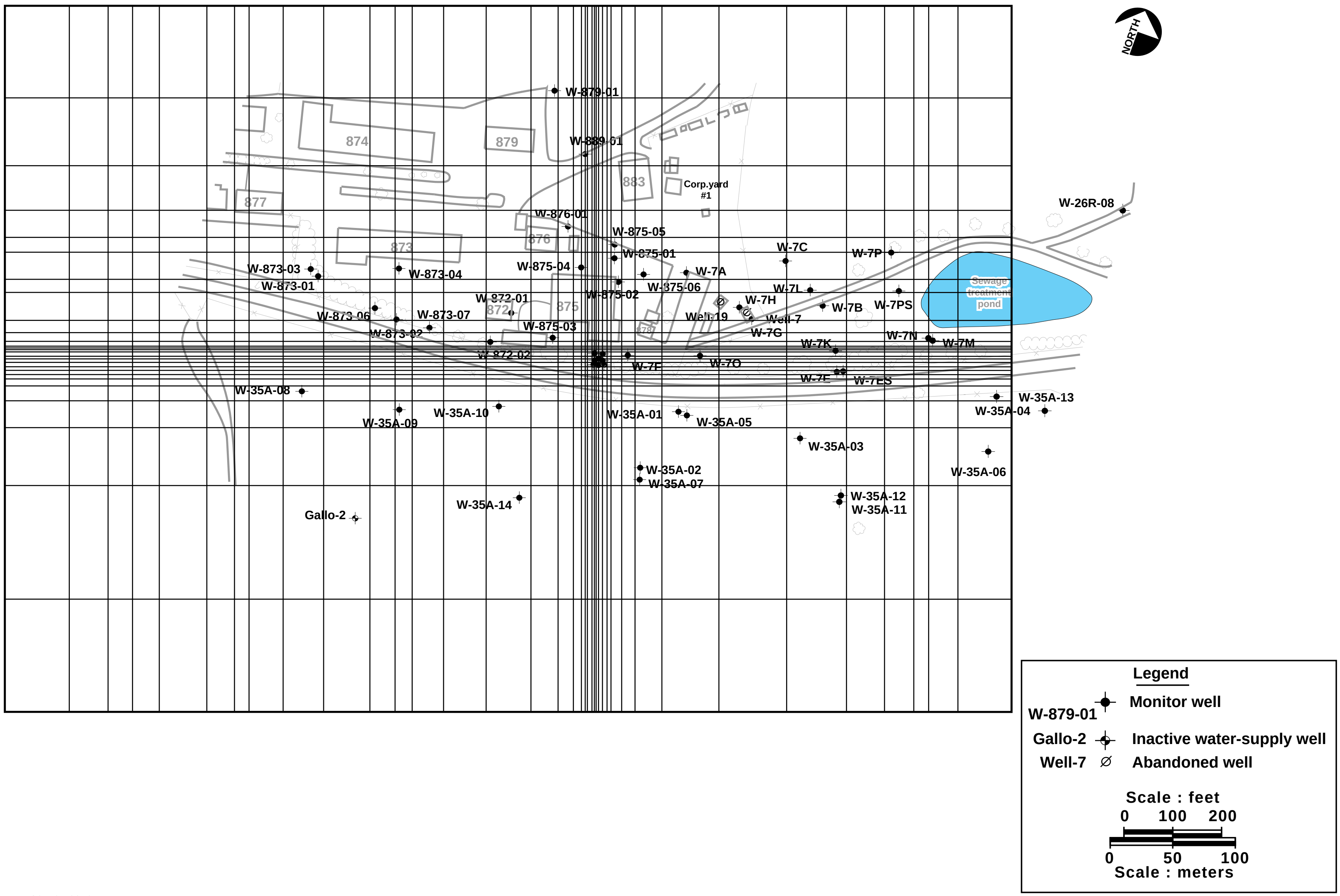

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Figure H-1. Gridded model domain for the central GSA.

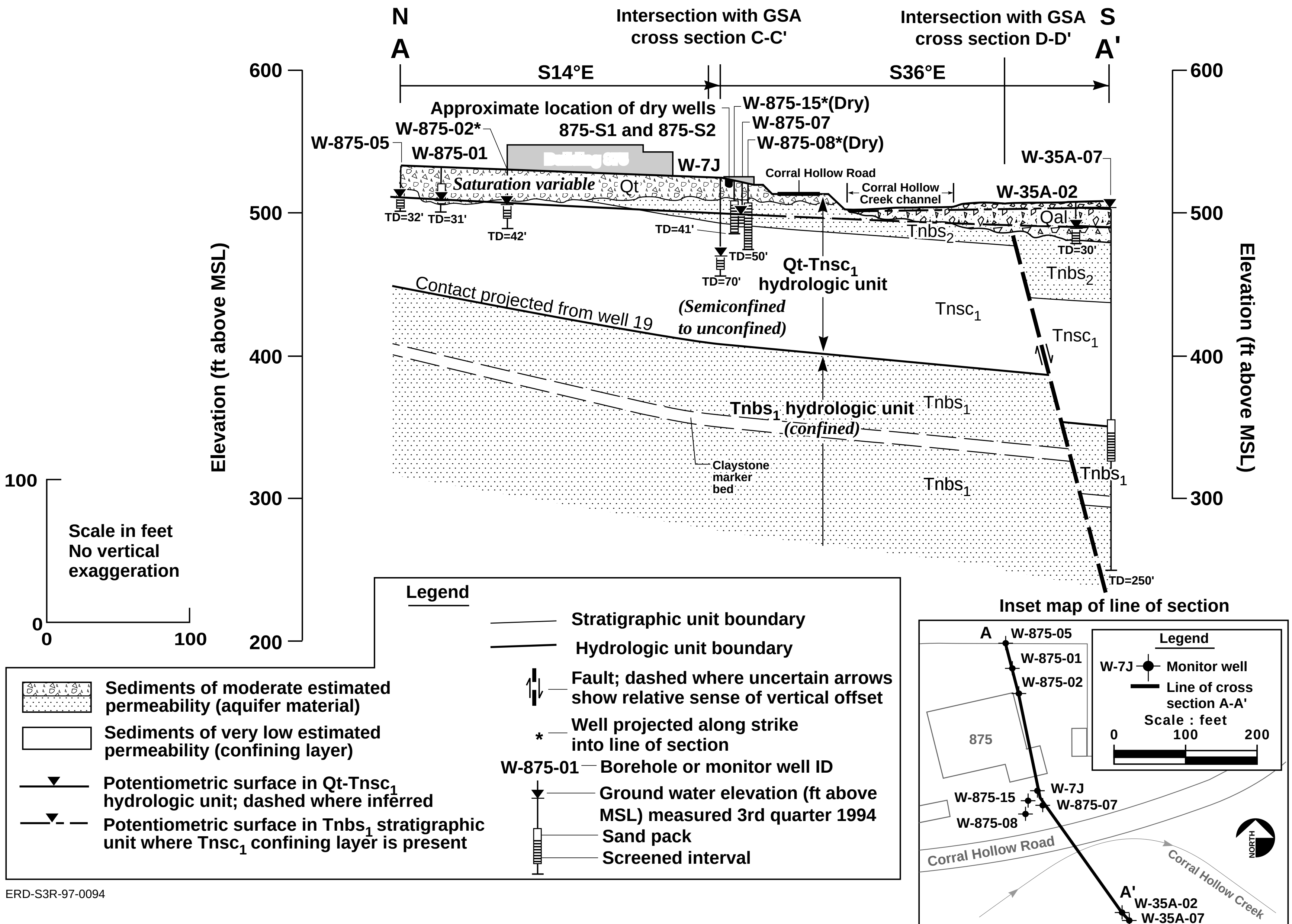

Figure H-2. Hydrogeologic cross section A-A' in the Building 875 dry well area.

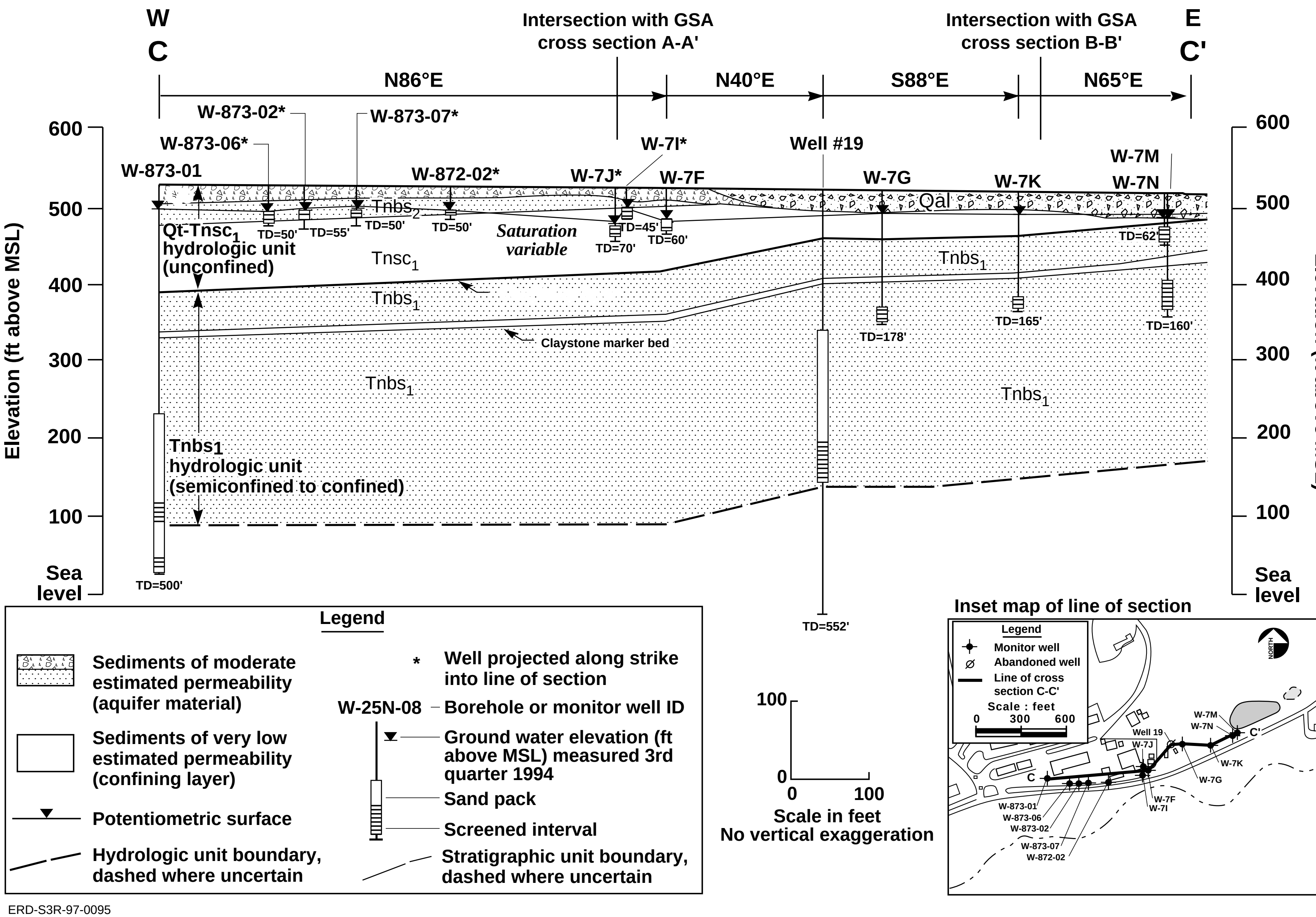

Figure H-3. Hydrogeologic cross section C-C' in the Central GSA.

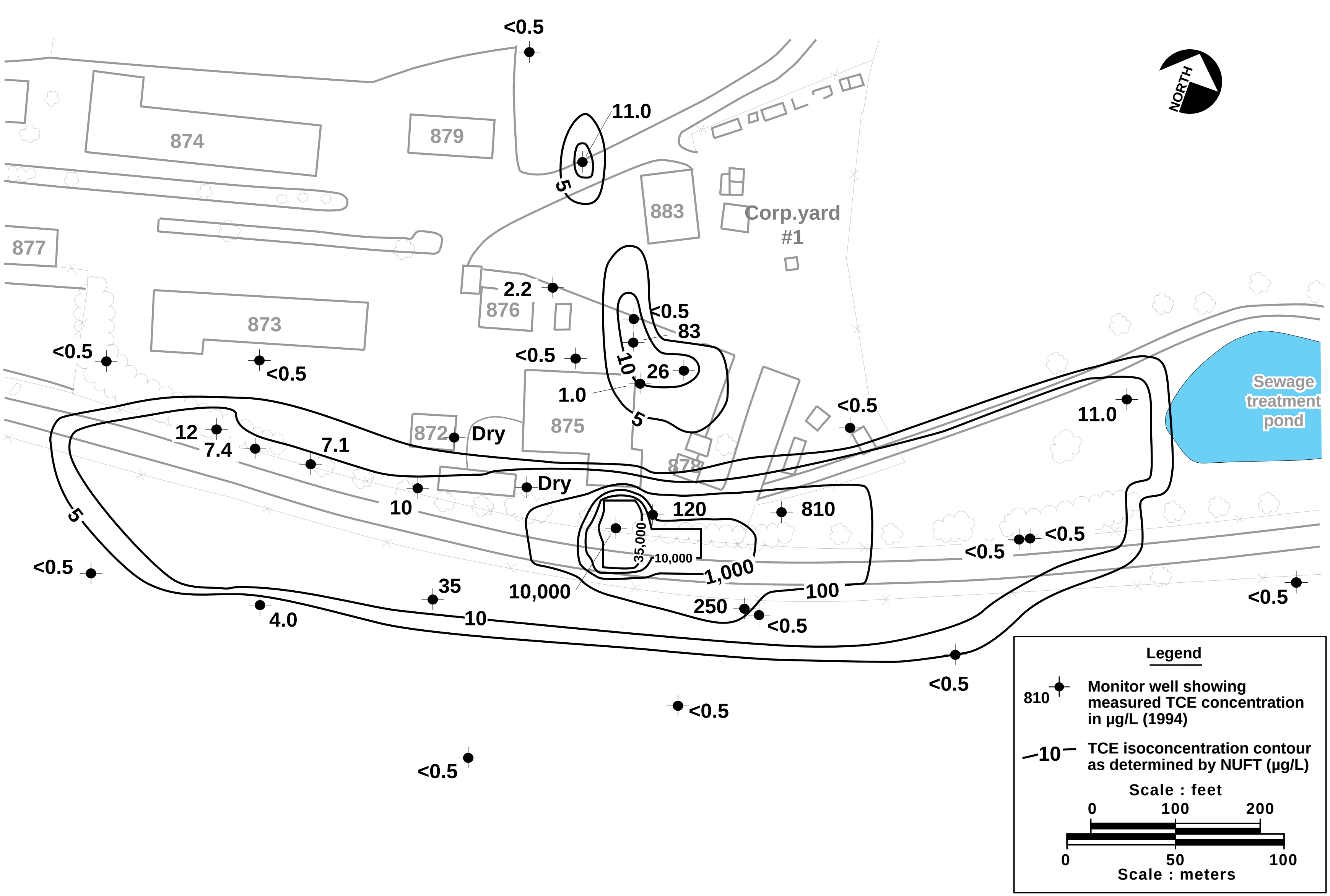

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Figure H-4. Comparison of measured TCE concentration in ground water to initial NUFT isoconcentration contours in the Tnbs$_2$ stratigraphic unit. (model year 0).

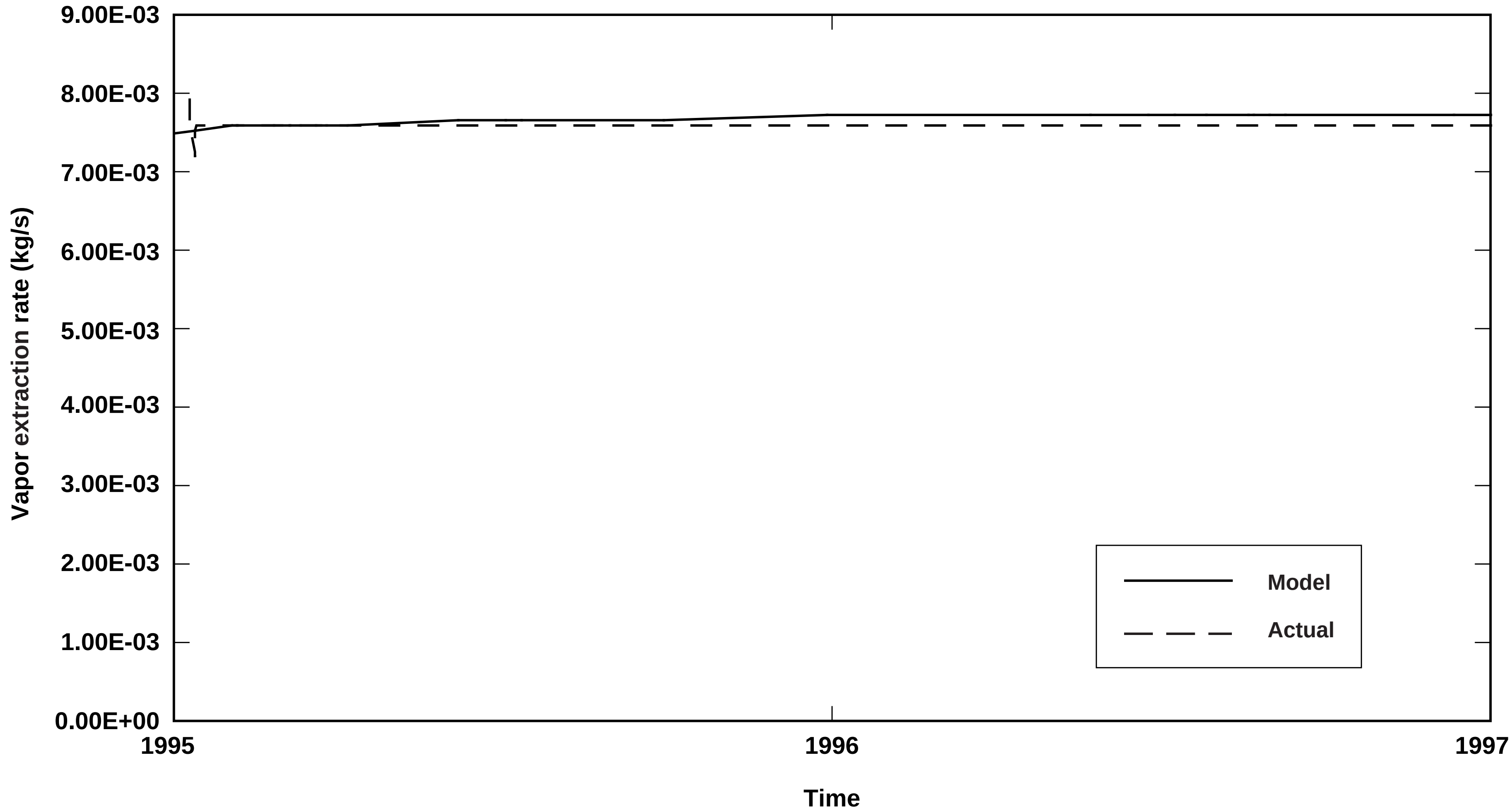

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Figure H-5. Comparison of modeled to actual soil vapor extraction rates.

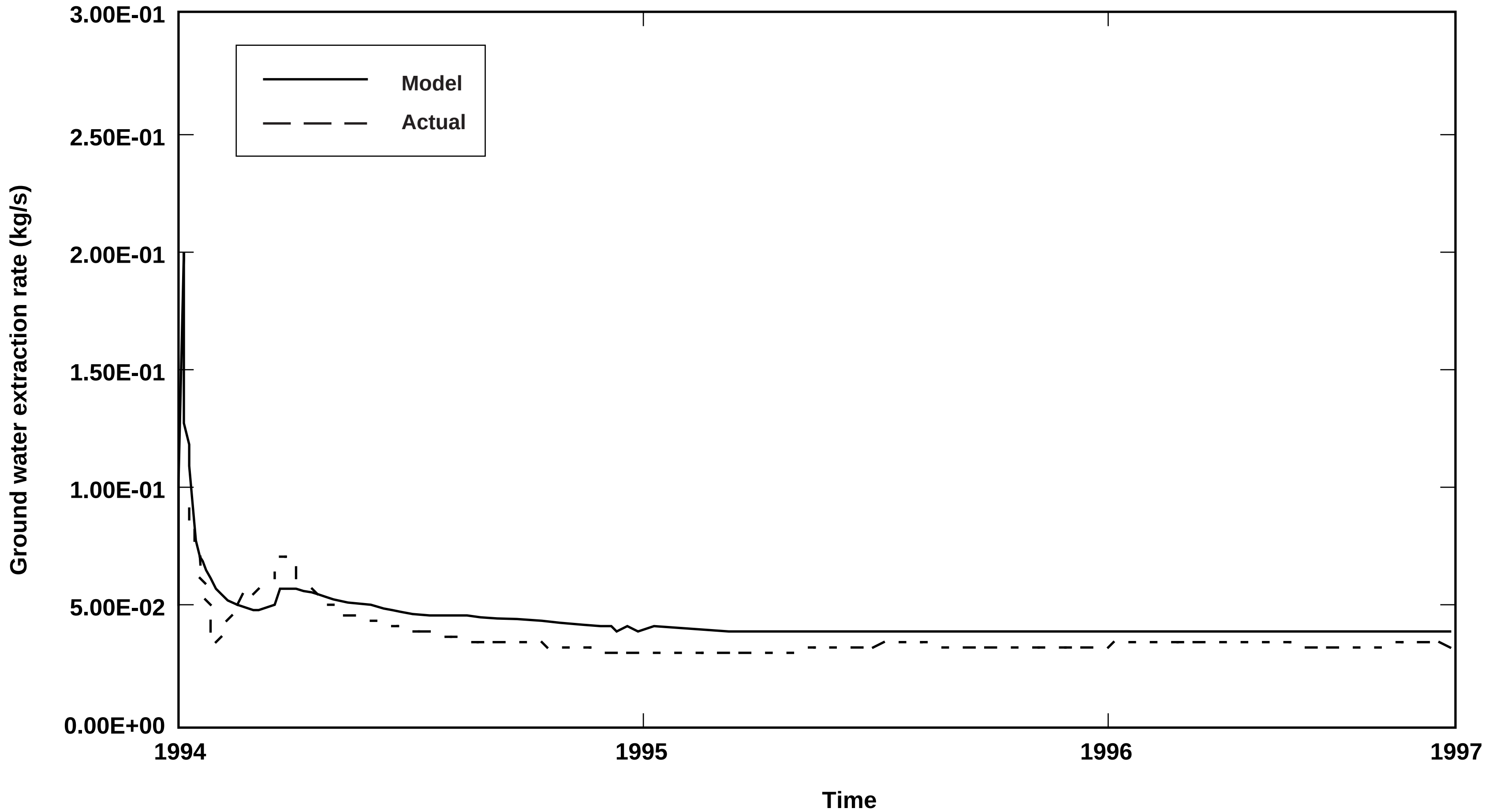

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Figure H-6. Comparison of modeled to actual ground water extraction rates.

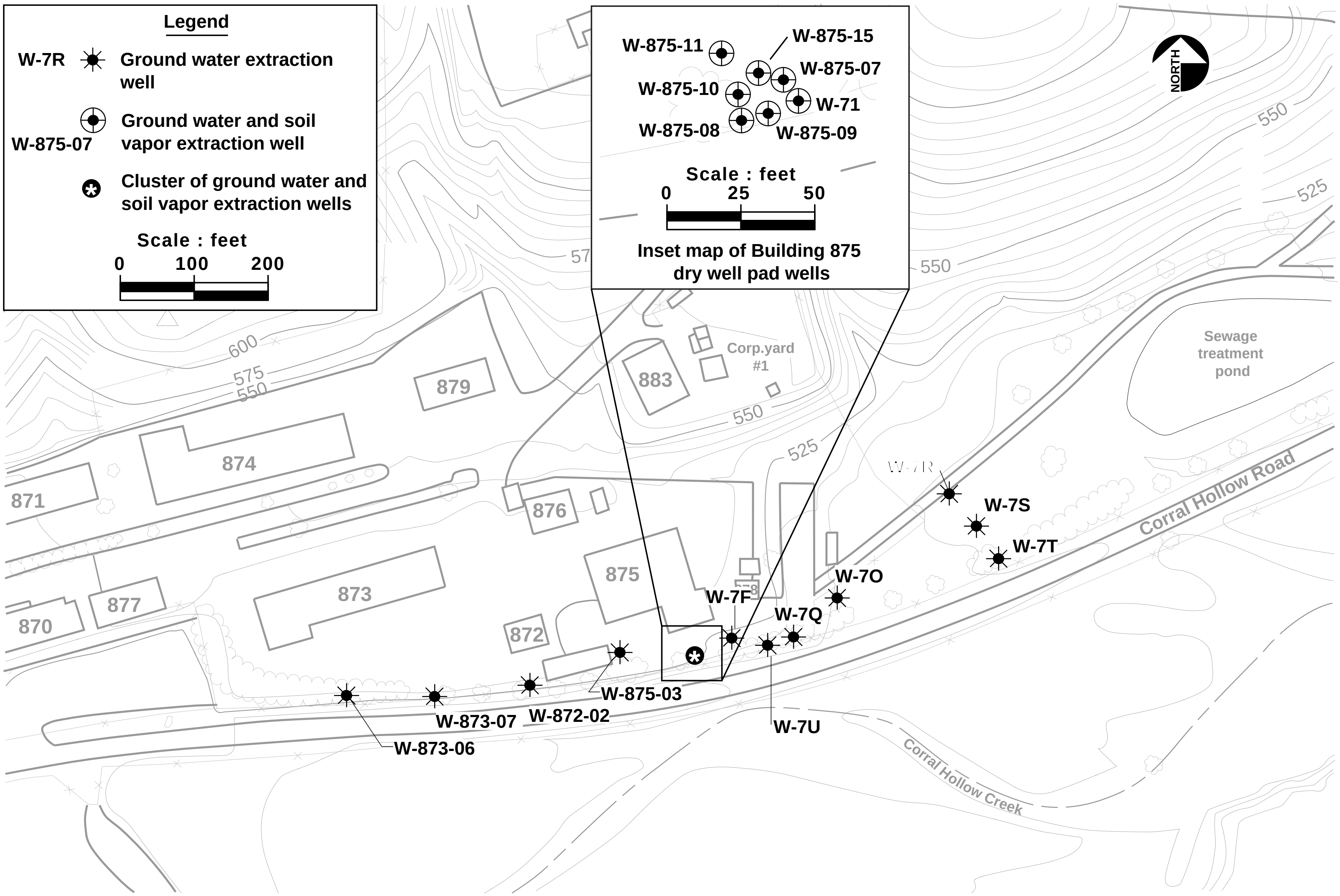


Figure H-7. Locations of ground water and soil vapor extraction wells (NUFT Scenario 1).

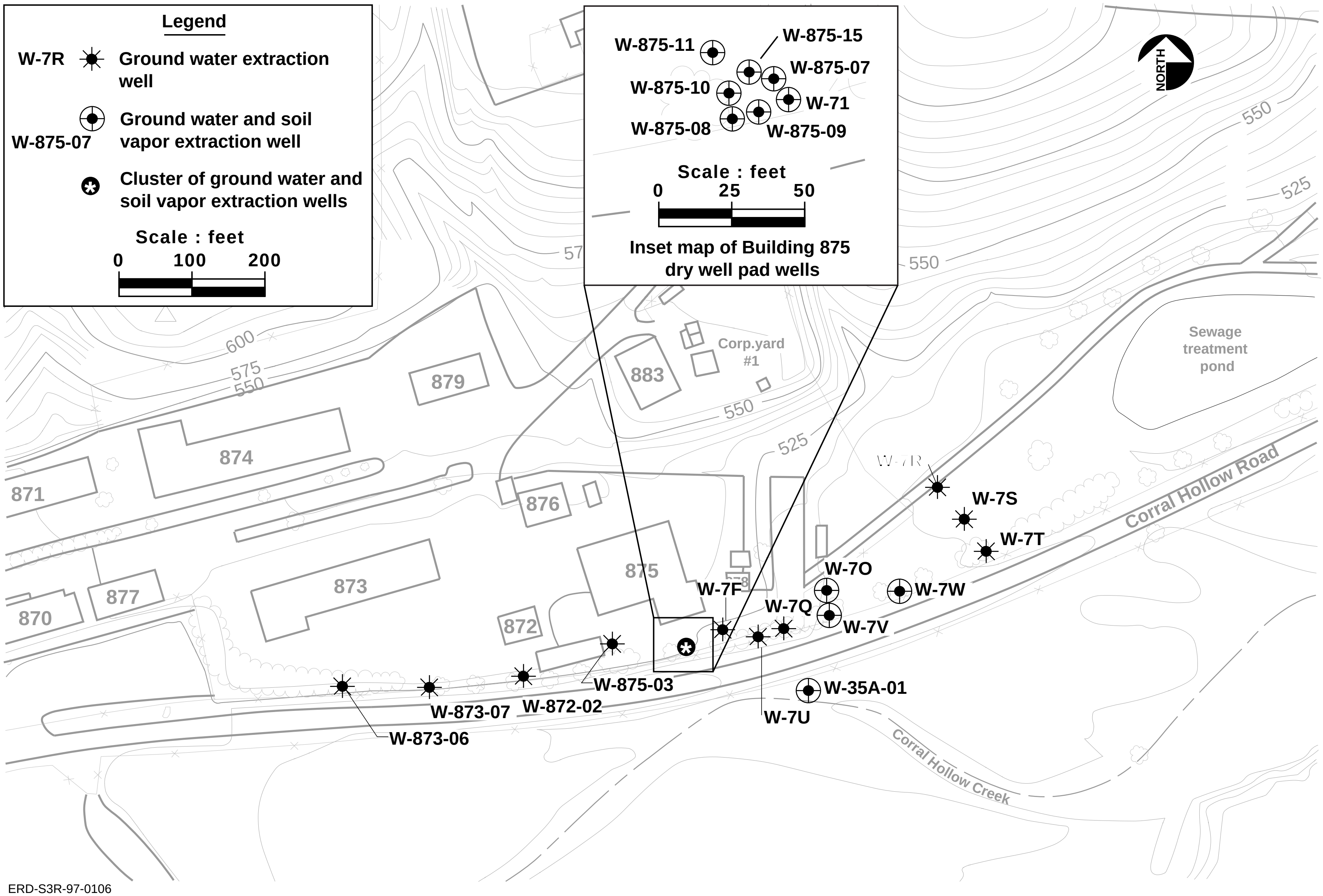
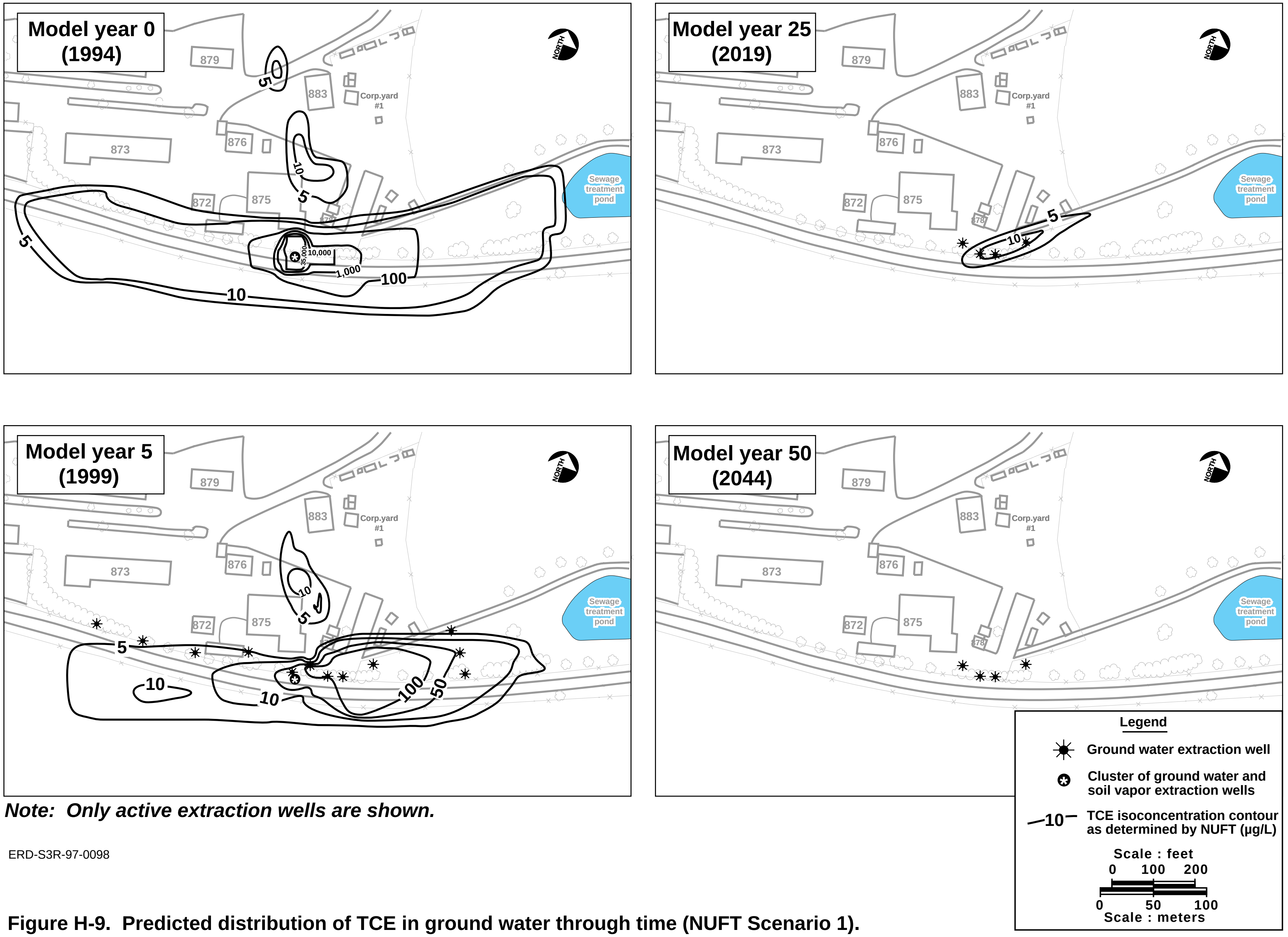


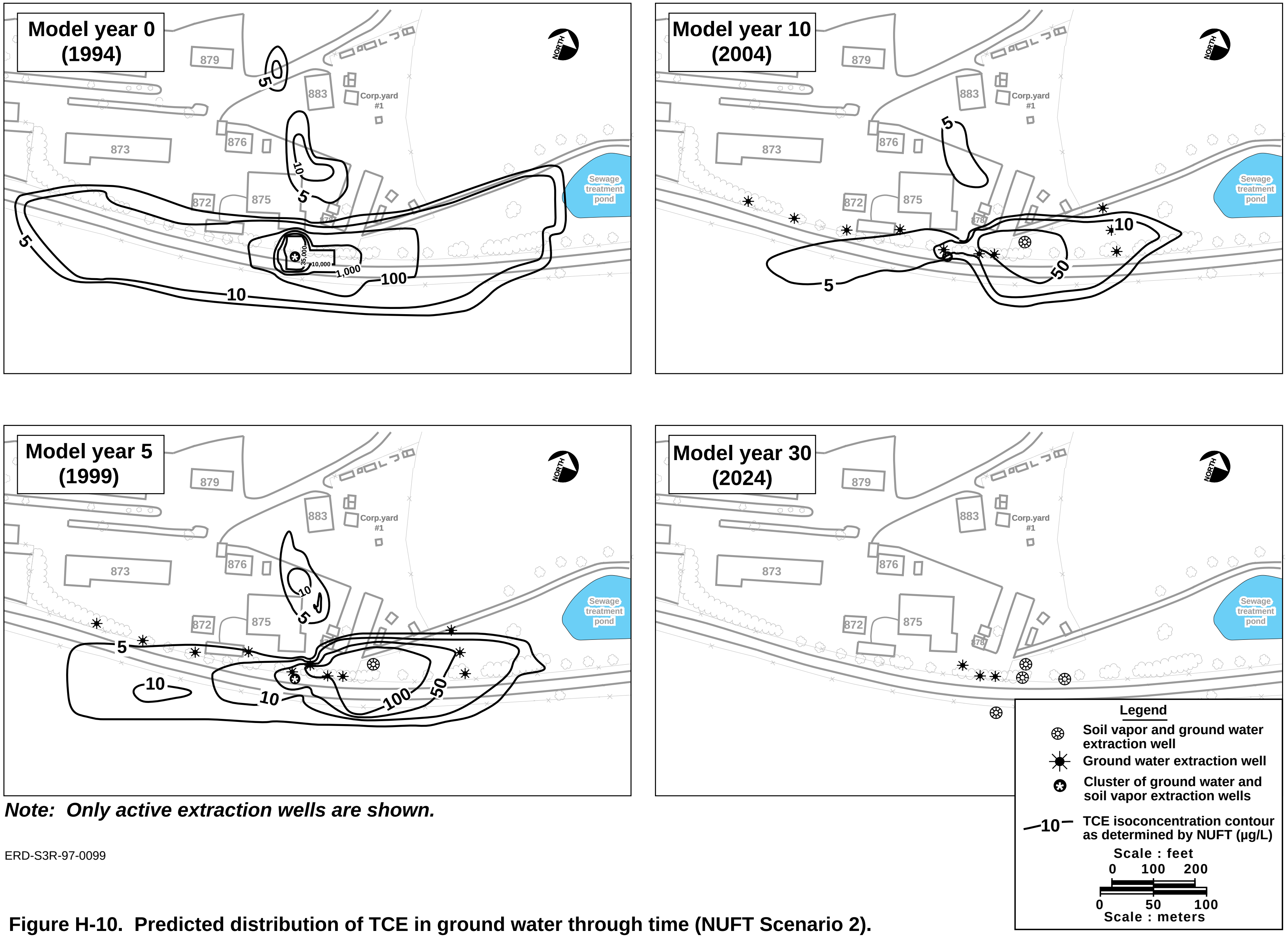
Figure H-8. Locations of ground water and soil vapor extraction wells (NUFT Scenario 2).



Note: Only active extraction wells are shown.

ERD-S3R-97-0098

Figure H-9. Predicted distribution of TCE in ground water through time (NUFT Scenario 1).



Note: Only active extraction wells are shown.

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Figure H-10. Predicted distribution of TCE in ground water through time (NUFT Scenario 2).

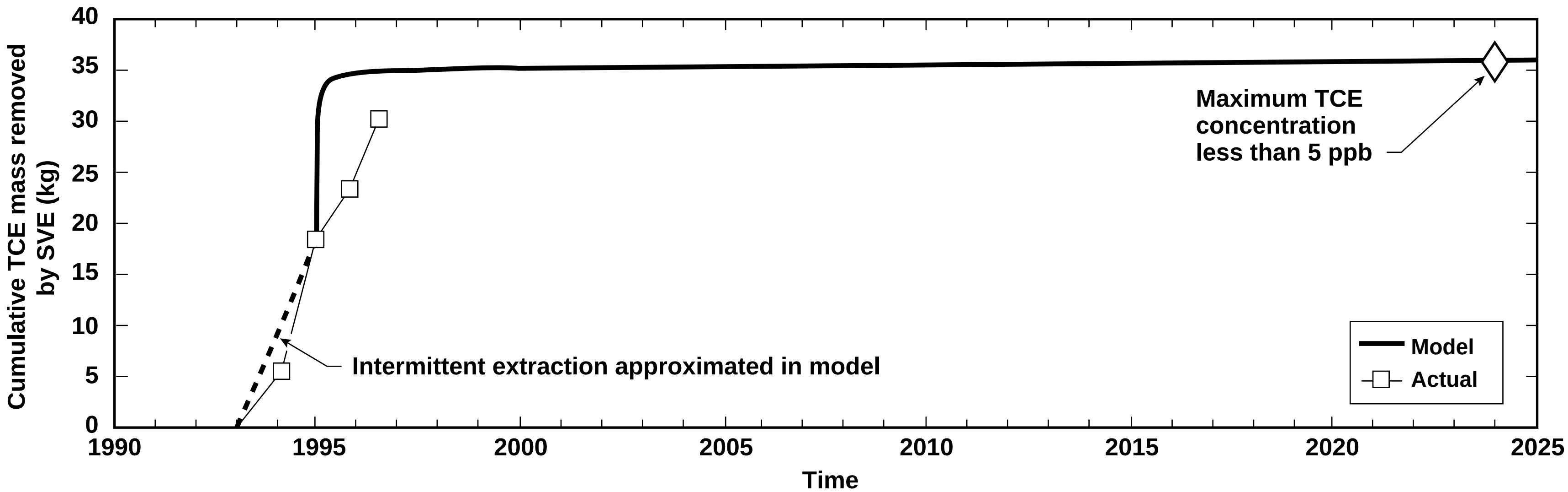

Figure H-11. Predicted and actual cumulative TCE mass removed by soil vapor extraction (SVE).

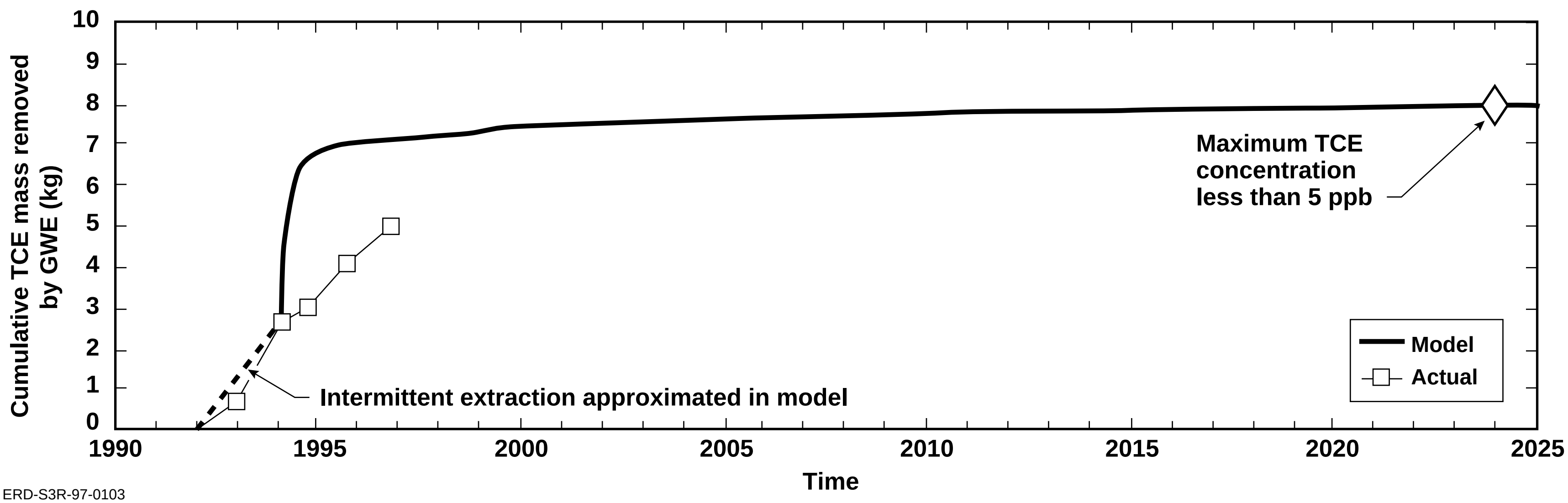

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Figure H-12. Predicted and actual cumulative TCE mass removed by ground water extraction (GWE).

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Table H-1. Physical properties used in the NUFT model.

Unit	Porosity[a] (dimensionless)	Hydraulic conductivity[b] (cm/s)	Dry bulk density[a] (g/cm^3)	TCE distribution coefficient (cm^3/g)	TCE retardation factor (dimensionless)
Qt-soil	0.31	9.31E-04	1.82	0.42[c]	3.5
Qt-gravel	0.30	2.55E-03	1.84	0.08[c]	1.5
Qal	0.36	4.39E-05	1.84	0.54[c]	3.8
$Tnbs_2$	0.36	9.65E-04	1.69	0.54[a]	3.5
$Tnsc_1$	0.44	2.50E-06	1.49	1.18[c]	5.0

[a] Laboratory measured data (Ridley, 1996).

[b] Initially derived from laboratory, hydraulic testing, and geophysical data. Adjusted during calibration.

[c] Estimated from soil or lithologic characteristics.

Table H-2. GWE and SVE wells and pumping schedules for Scenarios 1 and 2.

Extraction well	Scenario 1		Scenario 2	
	Extraction well type	Pumping schedule[c] (model years)	Extraction well type	Pumping schedule[c] (model years)
W-875-07	GWE and SVE	0–25	Same as Scenario 1	0–25
W-875-08				
W-875-09				
W-875-10				
W-875-11				
W-875-15				
W-7I				
W-873-06[a]	GWE	4–10	Same as Scenario 1	Same as Scenario 1
W-872-02[a]				
W-873-07[a]				
W-875-03[a]				
W-7R[b]				
W-7S[b]				
W-7T[b]				
W-7F[a]	GWE	4–50	Same as Scenario 1	4–30
W-7U[b]				
W-7Q[b]				
W-7O[a]	GWE	4–50	GWE and SVE	4–10
				12–30
W-35A-01[a]	Not included	N/A	GWE and SVE	12–30
W-7V[b]				
W-7W[b]				

Note:

N/A = Not available.

[a] Existing monitor well to be converted to extraction.

[b] Possible future extraction well.

[c] Extraction wells cease pumping when cleanup standards are achieved at that well.

Acronyms and Abbreviations

Acronyms and Abbreviations

1,1-DCE	1,1-dichloroethylene
1,2-DCE	1,2-dichloroethylene
1,1,1-TCA	1,1,1-trichloroethane
2-D	two-dimensional
3-D	three-dimensional
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ARAR	Applicable or Relevant and Appropriate Requirement
AWS	American Welding Society
Ba	barium
BTEX	benzene, ethylbenzene, toluene, xylenes
CCR	California Code of Regulations
Cd	Cadmium
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act
cfm	cubic feet per minute
CFR	Code of Federal Regulations
CGSA	Central General Services Area
CMP	Compliance Monitoring Plan
CO_2	carbon dioxide
CoC	Chain-of-Custody
COC	Contaminant of Concern
CP	Contingency Plan
CPR	cardiopulmonary resuscitation
Cu	Copper
DNAPL	Dense Non-Aqueous Phase Liquids
DOE	U.S. Department of Energy
DOL	U.S. Department of Labor
DOT	U.S. Department of Transportation
DTSC	California Department of Toxic Substances Control
EGSA	Eastern General Services Area
EPA	U.S. Environmental Protection Agency
EPD	Environmental Protection Department
ERD	Environmental Restoration Division
ES&H	Environmental Safety & Health
ESD	Explanation of Significant Differences
F	Farenheit
FFA	Federal Facility Agreement
Freon 113	trichlorotrifluoroethane
FS	Feasibility Study
ft	feet, foot
ft/yr	feet per year
GA/LDRD	General Administrative/Laboratory Directed Research and Development
GAC	granular activated carbon
gal	gallon(s)
gpm	gallons per minute
GSA	General Services Area
GWE	ground water extraction
GWTS	ground water treatment system
HASP	Health and Safety Plan
Hg	mercury

hp	horsepower
hr	hour(s)
HWM	Hazardous Waste Management
HWMD	Hazardous Waste Management Division
I/O	input/output
ICBO	International Conference of Building Officials (ICBO)
in.	inch(es)
K_d	distribution coefficient
kg	kilograms
lb	pound(s)
LLNL	Lawrence Livermore National Laboratory
MCL	Maximum Contaminant Level
µg/L	micrograms per liter
mg/kg	milligrams per kilogram
MPC	Materials Procurement Charge
NEPA	National Environmental Policy Act
NFPA	National Fire Protection Association
NPDES	National Pollution Discharge Elimination System
NUFT	Nonisothermal Unsaturated-Saturated Flow and Transport
O&M	operations and maintenance
OSHA	Occupational Safety and Health Administration
OSWER	U.S. EPA Office of Solid Waste and Emergency Response
OU	operable unit
OVA	organic vapor analyzer
Pb	lead
PCE	perchloroethylene
PE	Plant Engineering
PEPM	Plant Engineering Project Manager
P&ID	piping and instrument diagram
POU	point-of-use
$ppm_{v/v}$	parts per million on a volume per volume basis
psi	pounds per square inch
PTU	portable treatment unit
PVC	polyvinyl chloride
QA	quality assurance
QAE	Quality Assurance Engineer
QAIC	Quality Assurance Implementation Coordinator
Qal	Quaternary Alluvium
QAM	Quality Assurance Manager
QAMP	Quality Assurance Management Plan
QAMS	EPA Quality Assurance Management Staff
QAP	Quality Assurance Plan
QAPP	Quality Assurance Project Plan
QA/QC	quality assurance/quality control
QC	quality control
Qt	Quaternary Terrace Deposits
RCRA	Resource Conservation and Recovery Act
RD	Remedial Design
RE	Remediation Engineer
ROD	Record of Decision
RPM	Remedial Project Manager
RWQCB	California Regional Water Quality Control Board
S300 PL	Site 300 Project Leader
SARA	Superfund Amendments and Reauthorization Act
scfm	standard cubic feet per minute
SJVUAPCD	San Joaquin Valley Unified Air Pollution Control District
SOP	Standard Operating Procedure
SPACT	Sample Planning and CoC Tracking

SVE	soil vapor extraction
SWRI	Site-Wide Remedial Investigation
TCE	trichloroethylene
TDS	total dissolved solids
TF	treatment facility
TI	technical impracticability
TL	Task Leader
Tmss	Miocene Cierbo Formation
$Tnbs_1$	Miocene Neroly Formation - Lower Blue Sandstone Member
$Tnbs_2$	Miocene Neroly Formation - Upper Blue Sandstone Member
$Tnsc_1$	Miocene Neroly Formation - Middle Siltstone/Claystone Member
TS	Technician Supervisor
UCRL	University of California Radiation Laboratory
VAC	volts in alternating current
VOC	volatile organic compound
WDR	Waste Discharge Requirement
Zn	zinc