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# **Characterization Summary Report for the Building 865 Study Area at Lawrence Livermore National Laboratory Site 300**

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**September 30, 2006**



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**Re: Characterization Summary Report for the Building 865 Study Area at Lawrence Livermore National Laboratory Site 300**

Dear Ms. Setian, Mr. Soto, and Ms. Timm:

The U.S. Department of Energy (DOE) and Lawrence Livermore National Laboratory (LLNL) are submitting this Characterization Summary Report for the Building 865 study area at LLNL Site 300. This letter report summarizes the results of environmental investigations performed in the Building 865 study area to determine if contamination has been released to the environment as a result of past activities. The results of this remedial investigation are organized into nine sections:

1. Introduction.
2. Background
3. Characterization and Remediation Activities.
4. Physical Setting.
5. Geology.
6. Hydrogeology.
7. Nature and Extent of Contamination.

8. Summary

9. Recommendations.

Hydrogeological, chemical, and radionuclide data collected between January 1, 1988 and March 31, 2006 were used to complete this assessment. The ground water elevation and analytical data collected as part of this characterization effort for the Building 865 study area are presented in Attachment A. A description and the results of the fate and transport modeling of the migration of Freon 113 and Freon 11 in ground water are presented in Attachment B.

## 1. Introduction

Site 300 is a U.S. DOE experimental test facility operated by the University of California and is located 17 miles east of Livermore and 8.5 miles southwest of Tracy, California (Figure 1). LLNL Site 300 was placed on the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA) National Priorities List in 1990. Environmental investigations have been conducted under the joint oversight of the U.S. Environmental Protection Agency (EPA) – Region IX, the California Regional Water Quality Control Board (RWQCB) – Central Valley Region, and the California Department of Toxic Substances Control (DTSC) – Northern California Coastal Cleanup Operations Branch. A Federal Facility Agreement (FFA) is in place between DOE and these regulatory agencies (U.S. DOE, 1992) governing cleanup operations at LLNL Site 300.

The Building 865 study area is located in the north-central portion of Site 300 (Figure 1). The Building 865 Complex was constructed during 1980 to 1982. Building 865 facilities were used to conduct high-energy laser tests and diagnostics in support of national defense programs. The Building 865 Complex housed a 275-foot linear electron accelerator called the Advanced Test Accelerator (ATA). The ATA was designed to produce a repetitively-pulsed electron beam for charged particle beam research. In 1988, large-scale operations of the ATA were discontinued and much smaller experiments were conducted until 1995. Neither fissile nor high explosive (HE) materials were used at the Building 865 Complex. However, short-lived radioactivity was induced by the accelerator. The Building 865 Complex and ATA were slated for decontamination and decommissioning (D&D) during 2005-2006, but this activity has been delayed. Figure 2 shows the locations of buildings, ground water monitor wells, and springs in the Building 865 study area.

Figure 3 shows the locations of the facilities that existed during operations including:

- A Waste Accumulation Area (WAA).
- A control and support building (Building 865A).
- An electrical supply substation.
- Electrical fabrication shop (Building 865C).
- Diagnostic support buildings (Buildings 865B, 865D, and 865G).

- Laser houses (Building 865E and 865H).
- Radioactive materials storage (Building 865G).
- A modular office trailer (T8656).
- The 656-foot-long tunnel beneath Building 865A and 865E contained the accelerator, which consisted of a pulse-forming unit, an electron injector, and numerous accelerator modules.

## 2. Background

As part of the characterization investigation at the Building 865 Complex, DOE/LLNL reviewed historical records, and interviewed LLNL employees that worked at this facility when it was in operation. This information was used to identify historic operations and areas of chemical use and/or storage that could have released contaminants to the environment at the Building 865 Complex. This section summarizes past operations and activities at potential releases sites including the :

- Waste accumulation area and ATA storage tent (Section 2.1).
- Electrical supply substation transformer pad (Section 2.2).
- Building 865A machine shop and materials assembly room (Section 2.3).
- Solvent rack, Freon 113 tank, and tensile block wash area (Section 2.4).
- Oil conditioning system and tanks 865-T1A1, 865-T1A2, and 865-T1A3 (Section 2.5).
- Cooling tower sludge disposal area (Section 2.6).
- Storm drain outfall (Section 2.7).
- Accelerator tunnel (Section 2.8).
- Former surface impoundment and retention tanks 865-R1U1, 865-R1A1, 865-R1A2, and 865-R1A3 (Section 2.9).
- Rinsewater tank 865-R1U2 (Section 2-10).
- Former diesel tank (Section 2.11).

Figure 3 depicts the locations of these sites that are generally presented in the text in order of location from northwest to southeast. The principal liquid chemicals used in operations at Building 865 were Freon 113 (1,1,2-trichloro-1,2,2-trifluoroethane) that was used as a degreaser, and insulating mineral oil. While Building 865 was operational, activities conducted at Building 865A produced as much as 300 pounds of solid hazardous waste, 100 gallons of waste oils, and 2,000 gallons of Freon 113 or oil-contaminated wash down water each month. Based on its presence in ground water samples, Freon 11 (trichlorofluoromethane) was also a component of the Freon liquid used at Building 865.

## **2.1. Waste Accumulation Area (WAA) and ATA Storage Tent**

The WAA and ATA storage tent were located about 100 feet (ft) southwest of Building 865A. Drums of solid hazardous waste, waste oils, and Freon-contaminated wash down water were stored in the WAA from approximately 1988 to 1995. The WAA was operated in accordance with the Resources Conservation and Recovery Act (RCRA) requirements. Hazardous wastes were transported by truck to the LLNL Livermore Site for treatment or disposal at an offsite permitted facility. The WAA was formally closed under California Title 22 requirements in August 1995 (Tageson, 2006). The ATA storage tent was located directly adjacent to the WAA and was used to store equipment and parts associated with experiments conducted at the Building 865 Complex. Because there is no documentation or physical evidence of chemical releases from the WAA or ATA storage tent area, the WAA/ATA storage tent area is not considered a release site and was not investigated further. Therefore, it is not discussed further in this document.

## **2.2. Electrical Supply Substation Transformer Pad**

In October 1991, oil contamination was identified in shallow soil during the construction of a concrete berm around the electrical supply substation transformer on the northeast side of Building 865A. This soil was subsequently excavated to a depth of 3 ft, and disposed offsite as hazardous waste. Because potential contamination was identified in the vicinity of the electrical supply substation transformer, this area was evaluated as a potential release site.

## **2.3. Building 865A Machine Shop and Materials Assembly Room**

A machine shop and the materials assembly room were located at the north end of the Building 865A. Solvents and bright-dip cleaning were used in the machine shop. A floor drain connected the machine shop to retention tank 865-R1U1. The surface impoundment received liquid overflow from tank 865-R1U1. The surface impoundment was later replaced by tanks 865-R1A1, 865-R1A2, and 865-R1A3.

There is no documentation or evidence of contaminant releases in the immediate vicinity of the Building 865A machine shop and materials assembly room, therefore these facilities are not considered release sites and were not investigated further. Therefore, they are not discussed further in this document. However, the rinsewater from these facilities that was discharged to retention tank 865-R1U1 and the surface impoundment were evaluated as potential release sites. The surface impoundment and these retention tanks are discussed in more detail in Section 2.9.

## **2.4. Solvent Rack, Freon 113 Tank, and Tensile Block Wash Area**

Three chemical use sites were located immediately southwest of Building 865A and the Materials Assembly Room: (1) a solvent rack on a concrete pad contained drums of acetone, methyl ethyl ketone, and insulating oil, (2) a 345-gallon waste Freon 113 tank, and (3) a solvent wash bin that was used to wash tensile blocks (large electrical components). In 1988, these sites were removed and the use of Freon 113 as a solvent was discontinued. The tensile

block wash area was directly outside the Machine Shop/Material Assembly Room rollup door and just southeast of the former solvent rack location. Between 1986 and 1988, at least 20 tensile blocks were washed with Freon 113 outdoors to remove insulating oil. No containment was used during the washing process. The storm drain grate immediately southwest of the solvent rack was connected to the storm drain outfall located on Figure 3. In July 1996, 35 cubic yards (yd<sup>3</sup>) of oil-, diesel-, and toluene-contaminated soil were removed from a 38 ft long, 5 ft wide, and 5 ft deep excavation. The excavated soil was characterized, and disposed in the nearby Altamont Landfill (Galles, 1996). The excavation was located immediately south of the concrete pad for the solvent rack and included soil around the storm drain grate. The analytical data collected during this excavation is discussed in Sections 7.1 and 7.2. Because activities were conducted in vicinity of the solvent rack, Freon 113 tank, and tensile block wash area that may have resulted in the release of contaminants to the environment, these chemical use sites were evaluated as potential release sites.

## **2.5. Oil Conditioning System (OCS) and Tanks 865-T1A1, 865-T1A2, and 865-T1A3**

An oil conditioning pad and several vacuum pumps were located on the southwest side of Building 865A. The OCS holding tank area is a potential release site because Freon 113 was used to remove oil stains on the concrete pad. A 1,750-gallon steel tank (865-T1A1) and two smaller tanks (865-T1A2 and 865-T1A3) containing insulating oil were removed from service. Overflow of the rinsewater used to hose down the OCS drained into tank 865-R1U1. All liquids were removed from the tanks, which were subsequently steam-cleaned. The concrete pad was also steam-cleaned. The tanks were not officially closed because they were considered non-hazardous by San Joaquin County (Castro, 2006). Approximately 3 cubic feet (ft<sup>3</sup>) of soil were removed from the grated drain at the OCS, revealing that the floor of the drain was concrete. The 3 ft<sup>3</sup> of soil was shipped to Ensco for disposal as a non-Resource Conservation and Recovery Act (RCRA) waste contaminated with 1 to 2% petroleum hydrocarbons. The catch basin was then filled with 8 inches of gravel and topped with 4 inches of grout (Jackson, 1999). Jackson (1999) states that although Susan Timm of the RWQCB requested that the soil be cleaned from the storm drain, in an October 5, 1998 telephone conversation, Ms. Timm agreed that the drain could be sealed with concrete. Thus, after removal of 3 ft<sup>3</sup> of soil from the drain, the remainder was sealed beneath gravel and concrete. Because activities were conducted in vicinity of the oil conditioning system and tanks 865-T1A1, -T1A2, and -T1A3 that may have resulted in the release of contaminants to the environment, these chemical use sites were evaluated as potential release sites.

## **2.6. Cooling Tower Sludge Disposal Area**

A cooling tower with a discharge rate of 23,000 gallons per day (gpd) was located on the southwest side of Building 865A. Water from the cooling tower discharged into the ephemeral drainage channel that parallels the east side of Route 3. This discharge created a wetlands habitat for California red-legged frogs, a Federal endangered species. The discharge of water from the cooling tower was discontinued in 1996. From 1993 to 2005,

potable water was continuously released to the ephemeral drainage channel to maintain the wetland habitat for the frogs. This discharge was discontinued in 2005 upon completion of red-legged frog habitat in Elk Ravine south of Building 812 that was constructed in consultation with the U.S. Fish and Wildlife Service.

While the cooling tower was operating from 1982 until 1993, sludge that accumulated in the bottom of the cooling tower was routinely disposed on the ground about 50 ft northwest of the tower. About 150 pounds per year or a total of 1,800 pounds of sludge were placed on the ground in this location. In 1994, the RWQCB was notified of this practice and cooling tower sludge was subsequently containerized and transferred offsite for disposal. Total threshold limit concentration (TTLC) and soluble threshold limit concentration (STLC) metals analytical results for the containerized sludge samples indicated zinc was present at 26,000 milligrams per kilogram (mg/kg) TTLC and 456 milligrams per liter (mg/L) STLC. These zinc concentrations exceeded the TTLC and STLC hazardous waste criteria of 5,000 mg/kg and 250 mg/L, respectively. Therefore, the sludge was handled and disposed as a hazardous waste (Fisher, 1994).

In 1994, soil from the sludge disposal area northwest of the cooling tower was sampled and analyzed for metals. The results of the metal analysis are discussed in Section 7.1 and 7.2. In 1994, after receipt of the analytical data, several inches of soil were removed from the sludge disposal area and transported offsite to a hazardous waste disposal facility (Fisher, 1994).

Because activities were conducted in vicinity of cooling tower sludge disposal area that may have resulted in the release of contaminants to the environment, these chemical use sites were evaluated as potential release sites.

## **2.7. Storm Drain Outfall**

A storm drain is located approximately 130 ft southwest of Building 865A. Wastewater that may have contained Freon 113 and oil entered a storm grate near the material assembly room and the tensile block washing area of Building 865A. The storm drain would have directed this water southward to the ephemeral drainage channel that runs along the east side of Route 3 (Figure 3). Soil samples were collected from the drainage channel and analyzed for Freon 113 and oil. The analytical results for these soil samples are discussed in Section 7.2. Because wastewater was discharged to the storm drain outfall that may have resulted in the release of contaminants to the environment, this area was evaluated as potential release sites.

## **2.8. Accelerator Tunnel**

A 656-foot-long tunnel was located beneath Buildings 865A and 865E. At present, numerous components that were activated by the electron beam still remain in the tunnel and will be removed as a part of a future decontamination and decommissioning activity. Activated materials consist primarily of aluminum beam pipes containing sodium-22 ( $^{22}\text{Na}$ ). In 1995, the estimated total quantity of  $^{22}\text{Na}$  in the facility was 1 millicurie (Biesecker, 1995). Sodium-22 has a half-life of 2.6 years and is primarily a weak beta particle emitter. This

material will remain until final decommissioning of the Building 865 Complex. The material is isolated from water and the atmosphere and does not represent an exposure risk to workers. A visual inspection of the facility and interviews with program personnel have indicated that during the operational years of ATA, the floor of the tunnel was coated annually with an impervious epoxy as part of the facility maintenance program (Woods, 1995). In addition, the tunnel was outfitted with functional floor drains that were connected to a retention tank system located near the southwest corner of Building 865A or to surface impoundments located southwest of Building 865D. The retention tank system and surface impoundment are discussed in the subsequent section.

Because the  $^{22}\text{Na}$  in the accelerator tunnel has been and continues to be isolated from environmental media and does not pose an exposure risk, the accelerator tunnel facility is not considered a release site and was not evaluated further. Therefore, it is not discussed further in this document.

### **2.9. Surface Impoundment and Retention Tanks 865-R1U1, 865-R1A1, 865-R1A2, and 865-R1A3**

The bermed area located southwest of Building 865D was the original location of a surface impoundment and 550-gallon carbon steel underground tank 865-R1U1.

Approximately 25 gallons of rinsewater was released during a performance test of tank 865-R1U1 in December 1990. Fill material near this tank was excavated to sandstone bedrock and replaced with clean fill. Tank 865-R1U1 was subsequently moved to its current subsurface location (Figure 3), immediately northeast of the former surface impoundment. Washdown rinsewater is collected in tank 865-R1U1 from floor drains within the epoxy-lined tunnel, oil conditioning pad, and machine shop. A precision test of tank 865-R1U1 and the associated piping was last conducted on December 8, 1992 and indicated that the tank and piping were found to be product-tight (Castro, 2006). The tank continues to receive rinsewater and is still in service.

Prior to 1985, excess rinsewater from tank 865-R1U1 was retained in a 7,000-gallon capacity, rubber-lined surface impoundment. From 1982 to 1985, the rinsewater occasionally contained a large fraction of insulating oil. The insulating oil was used for transferring heat in the electrical transmission lines and accelerator modules. Some Freon 113 was also present in the rinsewater because it had been used as a solvent for cleaning accelerator modules and other experimental apparatus. Butylated hydroxyl toluene was a constituent of the insulating oil. The surface impoundment was removed in 1985 and the surrounding soil was excavated and disposed as hazardous waste.

In late 1985, the surface impoundment was replaced with three 4,000-gallon aboveground retention tanks (865-R1A1, 865-R1A2, and 865-R1A3), located within a 3-ft high rectangular berm that had been sprayed with gunite cement. Operation of the three-tank system resulted in oil stains on the gunite surface. During a tank upgrade evaluation conducted by LLNL in 1990, extensive oil and grease contamination was identified on the gunite in the bermed area where the former rinsewater surface impoundment and three aboveground tanks had been located. Much of the earthen berm was excavated in 1990.

In the fall of 1990, tanks 865-R1A1, 865-R1A2, and 865-R1A3 were moved from the bermed area to a new location immediately adjacent to Building 865A (Figure 3). The tanks on west side of building were drained and the concrete pad and trench were steam-cleaned. The tanks ceased operation in 1995 and did not require regulatory closure because the rinsewater was not considered hazardous by San Joaquin County (Castro, 2006).

Because activities were conducted in vicinity of the former surface impoundment and retention tanks 865-R1U1, 865-R1A1, 865-R1A2, and 865-R1A3 that may have resulted in the release of contaminants to the environment, these areas were evaluated as potential release sites.

#### **2.10. Rinsewater Tank 865-R1U2**

A 135-gallon capacity concrete rinse water tank (865-R1U2) is located beneath Building 865A (Figure 3). The tank was installed in 1980 and received rinsewater from the floor drains within Building 865A. The tank is still operational and was last precision tested on December 9, 1992. The tank and piping were found to be product-tight (Castro, 2006). Because there is no documentation or physical evidence of chemical releases from rinsewater tank 865-R1-U2, it is not considered a release site and was not investigated further. Therefore, it is not discussed further in this document.

#### **2.11. Former Diesel Tank 865-D1U1**

A 4,000-gallon underground diesel tank 865-D1U1 was formerly located adjacent to Building 865D (Figure 3). In 1994, the tank was tested and found to be product-tight. The tank was removed in October 1994 and closed under the authority of San Joaquin County (San Joaquin County, 1995). During removal, diesel-contaminated soil was noted in the excavation. The diesel contamination was likely the result of overfilling of the tank. Soil sampling and analysis was conducted after excavation of the affected soil (Jackson, 1994). All contaminated soil was excavated and bioremediated onsite or disposed offsite. Because former diesel tank 865-D1U1 and associated contaminated soil was removed and the tank area formally closed, it is not considered a release site and was not investigated further. Therefore, it is not discussed further in this document.

### **3. Characterization and Remediation Activities**

Environmental investigations in the Building 865 study area began in 1996 when milestones for this area were added to the Site 300 FFA schedule (U.S. DOE, 1992). The site characterization work performed in the study area included:

- Records searches and interviews with current and former employees.
- Geological mapping.
- Drilling, geophysical logging, and collection of soil and rock samples from boreholes.

- Installing ground water monitor wells.
- Correlating stratigraphic units and hydrostratigraphic units.
- Sampling and chemical/radiological analysis of soil, rock, and water.
- Measuring ground water elevations.
- Hydraulic testing.

Previous remedial activities included:

- Excavating and disposing of contaminated soil.
- Removing and disposing of waste.
- Flushing tanks and pipes and removing tanks.

Table 1 contains a summary of investigation and cleanup activities conducted at the Building 865 study area. Table 2 contains completion data for monitor wells installed in the Building 865 study area.

## 4. Physical Setting

The Building 865 study area covers approximately 0.4 square miles in north-central Site 300 (Figure 1). The local topography and locations of roads, buildings, ephemeral drainages, and monitor wells are shown on Figure 2. The physical locations of chemical use and storage at the Building 865 Complex are shown on Figure 3. Physical characteristics of the study area are shown on the geologic map presented as Figure 4. These features are described in more detail in Section 5.

The Building 865 Complex facilities are located on the northeast side of Elk Ravine and northwest of the Pit 1 and 2 Landfills. Elk Ravine trends northwest-southeast in the western portion of the study area. Except for Building 865E, all buildings are situated on a cut-and-fill slope about 1,100 ft above mean sea level (MSL). The hills to the northeast rise to over 1,300 ft above MSL. A shallow northwest-southeast oriented channel runs within Elk Ravine along the southwest side of the building complex (Figure 2). Due to the rugged terrain, safe and accessible drilling locations are often limited to paved areas near buildings, fire trails, and other dirt roads.

The climate at Site 300 is classified as semi-arid. Rainfall averages 10 to 11 inches per year, most of which falls during winter storms. During these storms, ephemeral water may flow within the drainage in Elk Ravine. Surface water flowing locally in channels after rainfall events quickly infiltrates into the ground after traveling short distances. Surface water, rarely if ever, is continuous to the confluence of Elk Ravine and Corral Hollow at the southeastern boundary of Site 300.

## 5. Geology

Site 300 is located within the Coast Range Physiographic Province of north-central California. The province is characterized by a sub-parallel system of northwest-southeast trending ridges and valleys. Rocks at Site 300 are principally comprised of terrestrial and estuarine sediments of Miocene-to-Pliocene age. Quaternary alluvium occurs as fill within the floors of valleys. The geology of the Building 865 study area is complex. There are several major shear zones of faulting, two major folds, and a number of stratigraphic units that are folded and offset by faulting. One of the most notable features in the area is the northwest-southeast-oriented Elk Ravine Fault Zone; the southwest branch of the Elk Ravine Fault occurs within the study area (Figure 4). The East Firing Area Syncline extends west-east beneath the Building 865 Complex and plunges east and southeast. The Patterson Anticline crosses Site 300 west-to-east about a thousand feet south of the Building 865 Complex. These faults and folds are discussed in more detail in Section 5.2.

### 5.1. Stratigraphy

Quaternary alluvium (Qal) and weathered bedrock (WBR) occur as stream channel sediment and underlying decomposed bedrock within Elk Ravine and the short canyons that run tributary to it (Figure 4). Rocks beneath the Building 865 study area are principally comprised of two formations: (1) the Neroly Formation and (2) the underlying Cierbo Formation. In the higher elevation areas, there is also a semi-lithified veneer of Pliocene sediment. A type-section including the major water-bearing stratigraphic units in the study area is presented in Figure 5.

The uppermost bedrock stratigraphic unit is a sandstone unit of the lower Neroly Formation ( $Tnbs_1$ ) that contains interbeds of claystone and siltstone. Within the  $Tnbs_1$  stratigraphic interval is a conglomerate subunit ( $Tnbs_1$ -cong). Below the base of the  $Tnbs_1$  unit is a sandstone unit with minor interbeds of claystone and siltstone ( $Tnbs_0$ ). Beneath the  $Tnbs_1$  and  $Tnbs_0$ , at the base of the Neroly Formation, is a siltstone and claystone-dominated unit ( $Tnsc_0$ ). The Neroly Formation rests on an erosional contact with massive sandstones and interbedded siltstones and claystones of the underlying Cierbo Formation ( $Tmss$ ).

Figure 6 is a geologic cross-section through the Building 865 study area. It presents a summary of correlations that were made using sequence stratigraphic analysis (Ehman, 2006) in which cyclic sequences of distinct rock units observed in borehole core are defined across the study area. Borehole geophysical logs and optical televiewer imaging assisted in defining stratigraphic contacts. The section line for the cross-section is shown on Figures 4 and 6. Relevant characteristics of each stratigraphic unit present beneath the Building 865 study area are described below.

#### 5.1.1. Quaternary Alluvium (Qal/WBR)

The alluvial deposits of the Qal/WBR stratigraphic unit are composed of sand, silt, sandy clays, and gravelly sands and silts. The maximum thickness of alluvial deposits in the Building 865 study area is about 15 to 20 ft within portions of Elk Ravine. Weathered Neroly Formation bedrock underlies colluvium, principally on east-facing slopes, and alluvium in valley bottoms.

### **5.1.2. Pliocene Non-Marine Unit (Tps)**

The Tps unit is present on hilltops and is composed of semi-lithified dense silty sands, with channel deposits of dense silty and sandy gravel, silty to clean, fine-to-coarse-grained sand, and minor sandstone and conglomerate. These sediments were only penetrated in the borehole for one well in the study area (W-865-2133), where the unit is 16 ft thick. Elsewhere in the study area, the unit may be as much as 25 ft thick.

### **5.1.3. Neroly Formation Lower Blue Sandstone Unit (Tnbs<sub>1</sub>) and Conglomerate subunit (Tnbs<sub>1</sub>-cong)**

The lower Tnbs<sub>1</sub> sandstone rests above the sandstone of the Tnbs<sub>0</sub> unit. The Tnbs<sub>1</sub> unit is composed of massive sandstones and gravelly sandstones with interbeds of siltstone and claystone. The Tnbs<sub>1</sub>-cong subunit occurs as an extensive channel fill within the Tnbs<sub>1</sub> and is well-exposed in the eastern end of Doall Ravine and less well-exposed on the hills southeast of Building 865 and on the slopes on the west side of Elk Ravine just north of Doall Ravine. The Tnbs<sub>1</sub>-cong rests on a sharp, erosive contact above sandstones and siltstones in the Tnbs<sub>1</sub> stratigraphic interval (Figures 5 and 6). The conglomerate subunit is composed of well-cemented pebble-to-cobble clast-supported andesite and basalt conglomerate with interstratified sandstone and gravelly sandstone. The thickness of the Tnbs<sub>1</sub>-cong varies, but is locally up to 50 feet thick. The conglomerate is overlain by fining upward channel fill packages of gravelly sandstone, sandstone, siltstone and claystone of the Tnbs<sub>1</sub>. The thickness of the Tnbs<sub>1</sub> stratigraphic interval varies from about 100 to almost 300 ft. Fractures are common, especially in the finer-grained lenses and within the conglomerate. The Claystone Marker Bed (CMB) is a 10-ft thick claystone within Tnbs<sub>1</sub> that separates the Upper and Lower Tnbs<sub>1</sub>.

### **5.1.4. Neroly Formation Basal Blue Sandstone Unit (Tnbs<sub>0</sub>)**

The Tnbs<sub>0</sub> sandstone at the base of the Tnbs<sub>1</sub> stratigraphic interval overlies siltstones and claystones of the Tnsc<sub>0</sub> unit. The Tnbs<sub>0</sub> unit is a dark grayish brown to dark bluish gray, fine-to-medium-grained sandstone that is parallel-laminated and is generally between 10 to 20 ft thick. Portions of this unit may be fractured. The Tnbs<sub>0</sub> unit is the main water-bearing unit in the study area.

### **5.1.5. Neroly Formation Lower Claystone Unit (Tnsc<sub>0</sub>)**

The lower claystone unit of the Neroly Formation (Tnsc<sub>0</sub>) underlies the Tnbs<sub>0</sub> unit and is located above the Cierbo Formation (Figures 5 and 6). The unit is comprised of dark greenish-gray claystone, siltstone, clayey siltstone, and silty claystone with thin, discontinuous silty sandstone and sandy siltstone interbeds. The clayey siltstones and silty claystones are fractured and typically have a sheared appearance in core. Where completely penetrated within the study area, the Tnsc<sub>0</sub> unit is approximately 60 to 100 ft thick.

### 5.1.6. Cierbo Formation (Tmss)

The Cierbo Formation (Tmss) was encountered in the drilling of several boreholes and is not exposed at the surface in the Building 865 study area. The unit is distinguished by the presence of light gray quartzose sandstones, as opposed to the blue-gray volcanic-rich sandstones of the overlying Neroly Formation. The Cierbo Formation consists of fine- to medium-grained, light gray to light olive gray sandstones with clayey siltstone and silty claystone interbeds. Because the sandstone is very friable, recovery during drilling tends to be fair to poor. The clayey siltstone and silty claystone interbeds are often fractured. Where completely penetrated, north of the study area at well NC7-50 (Figure 2), the Cierbo Formation is approximately 140 ft thick.

## 5.2. Geologic Structure

Two major structures dominate the Building 865 study area: (1) the Elk Ravine Fault Zone and (2) the East Firing Area Syncline. The Elk Ravine Fault zone extends northwest to southeast through the study area and affects both the bedrock stratigraphy and the present day topography.

Neroly Formation rocks within and on both sides of the Elk Ravine Fault Zone possess a very shallow dip that is difficult to accurately measure in outcrop. Trenching across the fault north of Pit 1 in 1988 detected the fault offsetting bedrock but not offsetting alluvial material (Hoffman, 1988). Although fault dip was measured as 28° to the southwest, the surface trace of the fault appears relatively straight, suggesting a steeper-dipping fault zone. The apparent offset is down on the northwest side of this fault. A shear zone within eastern Doall Ravine, about 200 ft west of Pit 2 showed a measured orientation of 209° and a vertical dip (Dugan, 1994). Cross-section A-A' (Figure 6) crosses the Elk Ravine Fault zone and shows the southwestern shear zone as vertical. Detailed stratigraphic analysis delineated offset of stratigraphic units along this shear zone.

The East Firing Area Syncline trends west-east beneath the Building 865 Complex and plunges east and southeast within the study area. Both the East Firing Area Syncline and the Elk Ravine Fault affect ground water flow within the Building 865 study area.

## 6. Hydrogeology

The hydrogeology of the Building 865 study area is controlled by stratigraphy, structure, and topography. The areal distribution of strata and the folding created by the East Firing Area Syncline, offset along the southwestern branch of the Elk Ravine Fault Zone, and fracturing play important roles in the location and hydraulic character of water-bearing zones. Section 6.1 describes the characteristics of the hydrostratigraphic units (HSUs) present within the Building 865 study area. Section 6.2 discusses ground water elevations and recharge and discharge in the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU. A description of hydraulic parameters for the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU is presented in Section 6.3.

## 6.1. Hydrostratigraphic Units (HSUs)

For the purposes of this Characterization Summary report, saturated stratigraphic units are grouped into HSUs. An HSU is a water-bearing zone that exhibits similar hydraulic and chemical properties within particular stratigraphic units. Based on the distribution of saturation in stratigraphic units, water elevation analysis, stratigraphic correlation, and fault and fracture geometry, three HSUs have been defined for the Building 865 study area:

1. Qal/WBR HSU (Section 6.1.1.).
2. Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU (Section 6.1.2.).
3. Tmss HSU (Section 6.1.3.).

Completion data for monitor wells installed in the Building 865 study area are presented in Table 2. Ground water elevation data are presented in Table A-1. The hydraulic and hydrogeologic characteristics of these HSUs are summarized in Table 3 and are described in this section and Sections 6.2 through 6.3.

### 6.1.1. Qal/WBR HSU

The Qal/WBR HSU consists of unconsolidated Qal sediments and an upper veneer of weathered bedrock of the Neroly Formation that occupy the valley bottom within Elk Ravine and subsidiary drainages. Saturation is likely intermittent and occurs in the deepest and thickest portions of the Qal/WBR. Zero to 5 ft of ephemeral, unconfined ground water may be present in the Qal/WBR HSU at a depth of 0 to 20 ft below ground surface (bgs). Ground water in this HSU generally follows the topography of the valley bottoms, flowing south-southeast in Elk Ravine. Only one well in the study area (W-865-07) is completed within the Qal/WBR HSU. Based on topography, this well is upgradient of the Building 865 Complex.

### 6.1.2. Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU

The Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU is the principal water-bearing zone within the study area. As shown in Figure 6, the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU is 5 to 10 ft thick and is generally under unconfined conditions at a depth of 90 to over 350 ft bgs. It is present at a depth of about 100 to 120 ft beneath the immediate vicinity of the Building 865 Complex. In the eastern portion of the study area, such as near wells W-865-2133 and W-865-2224, the saturated thickness of this HSU increases up to 120 ft and becomes confined about 500 ft east of W-865-2121. Well W-865-2133 is completed in Tnbs<sub>1</sub> strata and has the same potentiometric surface elevation as adjacent well W-865-2224, which is completed deeper within the Tnbs<sub>0</sub> unit. The confining layer appears to be an unfractured, 30-ft thick claystone present at 90 to 120 ft at wells W-865-2133 and W-865-2224.

The potentiometric surface contours for ground water in the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU are shown on Figure 7. The main geologic structures that influence the extent and direction of ground water flow in the study area are the: (1) northwest-trending Elk Ravine Fault, and (2) eastward-trending East Firing Area synclinal axis. West of the Building 865 Complex, the general ground water flow direction is to the east with a gradient of about 0.1. Although the ground water

gradient magnitude and direction do not significantly change across the Elk Ravine Fault, the depth to ground water drops by 20 to 30 ft across the fault in the central part of the study area. Ground water flows east-northeast from the Building 865 Complex and the gradient decreases significantly to about 0.02 north of Pit 1 in the vicinity of the W-865-2121 and W-865-2133 wells. To the north, the extent of ground water in the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU is controlled and limited by the intersection of the water table with the southward-dipping base of the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU along the northern flank of the East Firing Area syncline. Saturation was not observed within the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU during the drilling of the boreholes for wells NC7-50 and W-896-1806. The underlying Tnsc<sub>0</sub> stratigraphic unit is primarily unsaturated in the study area.

What appears to be discontinuous, perched water-bearing zone was encountered within the upper Tnbs<sub>1</sub> sandstone and was observed during the drilling of well W-865-2133 at a depth of about 89 to 94 ft bgs. Perched ground water was also encountered in the Tnbs<sub>0</sub> strata in well W-896-1806. The ground water elevations and recovery rates for these water-bearing zones indicate that they are not hydraulically connected with the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU. Depth to ground water in these water-bearing zones is variable and the direction of ground water flow within these discontinuous lenses is not known. The maximum saturated thickness encountered in these water-bearing zones is about 5 ft and borehole data indicate they are not continuous over a large area. Because of the discontinuous extent and variable saturation, these water-bearing zones do not constitute mappable HSUs.

### **6.1.3. Tmss HSU**

A continuous, confined water-bearing zone is inferred to occur within the deeper underlying Tmss HSU. Saturated conditions were encountered at a depth of 122-132 ft bgs in the Tmss HSU during the drilling and installation of well W-865-06. There are no other wells screened within Tmss in the study area. However, the Tmss HSU, which is screened in other wells west and south of the study area has a strong upward gradient.

## **6.2. Ground Water Elevations and Recharge and Discharge**

Water elevation hydrographs for selected wells within the primary water-bearing zone at the Building 865 study area, the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU (Figure 8), were constructed to evaluate responses of water elevations to rainfall.

The hydrograph for well K1-09 is representative of other wells (K1-05, K1-07, and K1-08) screened in the area prior to 2000. Water elevations gradually declined during the low rainfall years of 1987 through 1992 but began rising following the higher rainfall in 1993. Water elevations again declined in 1994 but began rising in response to the higher rainfall observed during 1995 through 2000.

Hydrographs for wells W-865-02 and W-865-05, both completed in 2000, show similar responses to the low rainfall during 2000 through 2004, though well W-865-02 shows slightly lower responses to the higher rainfall in 2005. Wells W-865-2002 and W-865-2003, completed in 2004, show similar water elevation responses to rainfall to the other wells depicted.

The response time of less than a year to higher rainfall seasons indicates that direct recharge likely occurs in the valley bottoms of Elk Ravine and subsidiary drainages. A north-trending canyon located east of Building 865 appears to be a significant source of recharge to the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU. As shown on cross-section A-A' (Figure 7) the saturated thickness in this HSU increases significantly between wells W-865-2121 and W-865-2133.

Discharge from the Tnbs<sub>1</sub>/Tnsc<sub>0</sub> HSU likely occurs via evapotranspiration where this HSU crops out and discharges at springs north and east of the study area. As has been shown in previous reports documenting contamination within the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU in northern Site 300, such as the Final Remedial Investigation/Feasibility Study for the Site 300 Pit 7 Complex (Taffet et al., 2005), there is no continuous pathway for ground water in the HSU to reach the City of Tracy or its water-supply wells. Ground water within the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU ultimately flows southeast and discharges south of Building 812 at Spring 6 and as shallow flow in Qal/WBR within Elk Ravine and Corral Hollow.

### 6.3. Hydraulic Characterization of the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU

A total of 67 hydraulic tests have been conducted in 41 different wells in the Building 865 study area and surrounding areas (Table 4). The objective of these tests was to determine hydraulic parameters, such as hydraulic conductivity and maximum sustainable yield, and if possible, to determine hydraulic communication between wells. Twenty-seven of the 41 wells tested are completed within the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU, which contains the Freon 113 and Freon 11 in ground water within the Building 865 study area.

As summarized in Table 4, results vary from well to well. This variation is associated with the location of each well and the HSU the well screen intersects. In areas where the saturated thickness is limited and the formation lacks secondary porosity, well yields are typically low. In areas where screens intersect fracture networks, wells typically yield higher flow rates.

Most of the wells immediately east and northeast of the Building 865 Complex were not suitable for hydraulic testing because of very low well yields, or limited saturated thickness. For these wells, water elevation response during well development and/or purging during sampling events were used to evaluate the hydraulic characteristics of the strata within the screened intervals.

The majority of wells completed in the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU have very low sustainable flow rates (< 0.5 gallons per minute [gpm]) with the exception of a few wells that can sustain flow rates of 2 or more gpm. For example, the recently installed well W-865-2224 well was air lifted at 3 gpm during well development with minimal drawdown. The screened intervals of these wells likely intersect fractures that are capable of transmitting more water. The bi-modal distribution of estimated hydraulic conductivity and flow rate data are typical of fractured bedrock aquifers such as the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU at the Building 865 area. The average hydraulic conductivity estimated using the wells near Building 865 area is  $1.6 \times 10^{-3}$  centimeters per second (cm/sec) (35 gallons per day per square foot or 4.5 feet per day), with a range of  $1 \times 10^{-2}$  to  $1 \times 10^{-5}$  cm/sec. These values are consistent with the calibrated hydraulic conductivity values used in the numerical model described in Attachment B. Ground water flow (seepage) velocities within the HSU generally vary from 50 to 100 meters per year.

## 7. Nature and Extent of Contamination

Samples were collected from environmental media in the Building 865 study area and analyzed for constituents that may have been released as a result of activities conducted at the Building 865 Complex. The nature and extent of contamination in surface soil, subsurface soil/rock, and ground water are presented in Sections 7.1, 7.2, and 7.3, respectively.

As part of the evaluation of the nature and extent of contamination at the Building 865 study area, a screening-level human health and ecological risk assessment was conducted to identify contaminants of concern (COCs) in environmental media. COCs were identified based on exceedences of regulatory criteria or background concentrations in surface and subsurface soil and exceedences of regulatory criteria, persistence, and frequency of detection in ground water. The risk assessment process and results are included in the discussions for each environmental media (Sections 7.1 through 7.3).

### 7.1. Nature and Extent of Contamination in Surface Soil

Surface soil samples from the Building 865 study area were collected and analyzed for halogenated and aromatic volatile organic compounds (VOCs), total petroleum hydrocarbons (TPH) as diesel and motor oil, and TTLC and STLC metals (Tables A-2 through A-6). Analyses performed were based on chemicals used or that may have been released in each potential source area. In this section, surface soil sampling and analytical results are discussed by proximity to potential source areas as follows:

- Electrical supply substation transformer pad (Section 7.1.1).
- Solvent rack, Freon 113 tank, and tensile block wash area (Section 7.1.2).
- Oil conditioning system and tanks 865-T1A1, -T1A2, and -T1A3 (Section 7.1.3).
- Cooling tower sludge disposal area and drainage channel (Section 7.1.4).
- Storm drain outfall (Section 7.1.5).
- Former surface impoundment and retention tanks 865-R1U1, 865-R1A1, -R1A2, and -R1A3 (Section 7.1.6).

The locations of these potential source areas are shown on Figure 3. Section 7.1.7 discusses surface soil sample data for samples outside of the immediate Building 865 Complex area. Section 7.1.8 discusses the results of the evaluation of COCs in surface soil in the study area.

#### 7.1.1. Electrical Supply Substation Transformer Pad

In 2005, surface soil samples were collected during the drilling of the borehole from well W-865-2003 (Figures 2 and 9) and analyzed for halogenated and aromatic VOCs (Tables A-2 and A-3). The well was located on the southwest sides of Building 865 in the area of the former transformer pad. No VOCs were identified at concentrations in excess of method detection limits.

### **7.1.2. Solvent Rack, Freon 113 Tank, and Tensile Block Wash Area**

In August 1995, a surface soil sample was collected from the vicinity of the tensile block wash area/solvent rack (MS-B865-037) and analyzed for halogenated and aromatic VOCs and TPH (Tables A-2, A-3, and A-4). No VOCs were identified at concentrations in excess of method detection limits. TPH as diesel was detected at a concentration of 1,300 mg/kg in the sample, while TPH as motor oil was not detected. A second surface soil sample collected from this location in February 1996 did not contain TPH as diesel above the 10 mg/kg reporting limit. However, TPH as motor oil was detected at a concentration of 110 mg/kg.

In July 1996, soil was excavated to a 5 ft depth over an area including the site of MS-B865-037 as a cleanup activity (Galles, 1996). Thus, these analytical results were not included in the assessment of contaminant maxima in surface soil presented in Table 5.

In 2005, surface soil samples were collected during the drilling of the borehole for well W-865-2002 (Figures 2 and 9) and analyzed for halogenated and aromatic VOCs (Tables A-2 and A-3). Well W-865-2002 was drilled within the area of the tensile block washdown area and solvent drum rack, adjacent to where soil was excavated to 5 ft in 1996. No VOCs were identified in surface soil at concentrations in excess of method detection limits in this area.

### **7.1.3. Oil Conditioning System and Tanks 865-T1A1, -T1A2, and-T1A3**

No surface soil samples were collected in the vicinity of the OCS and tanks 865-T1A1, -T1A2, and-T1A3 because this area is paved.

### **7.1.4. Cooling Tower Sludge Disposal Area and Drainage Channel**

In 1994, six surface soil samples (MS-B865-002, -004, -008, -010, -012, and -014) were collected from the area where sludge was deposited northwest of the cooling tower (Figure 3). Four samples (MS-B865-016, -018, -020, and -022) were also collected in the drainage channel immediately southeast. These samples were analyzed for TTLC and STLC metals. The analytical results are presented in Tables A-5 and A-6. The STLC data (Table A-6) for these samples were used for waste disposal criteria and were not used for site characterization.

The highest concentrations of TTLC metals in surface soil were identified in the sample from location MS-865-002 (Figure 9). Concentrations of metals in surface soil in the drainage channel generally declined in the downgradient (southeast) direction.

In 1996, soil was excavated from the cooling tower sludge area and disposed at an offsite landfill. Records documenting the exact dimensions of the excavation and the volume of soil removed could not be located.

### **7.1.5. Storm Drain Outfall**

In August 1995, a surface soil sample was collected from the drain outfall near Route 3 (MS-B865-038) and analyzed for halogenated and aromatic VOCs (Tables A-2 and A-3). No VOCs were identified at concentrations in excess of method detection limits.

#### **7.1.6. Former Surface Impoundment and Retention Tanks 865-R1U1, 865-R1A1, -R1A2, and -R1A3**

No surface soil samples were collected in the vicinity of the former Surface Impoundment and Retention Tanks 865-R1U1, 865-R1A1, -R1A2, and -R1A3 because the soil in this area was excavated and disposed offsite in 1985 when the surface impoundment was removed. This area was then sprayed with gunite cement.

#### **7.1.7. Surface Soil Sampling Data Outside Building 865 Complex**

In August 1991, a single surface soil sample was collected from a location approximately 100 ft south of Building 865E (3SS-05-01) and was analyzed for halogenated and aromatic VOCs. No VOCs were identified at concentrations in excess of method detection limits. The sample was collected as part of a sitewide assessment of surface soil that used a random grid to locate the samples.

#### **7.1.8. Evaluation of COCs in Surface Soil**

The surface soil data collected from potential sources areas of the Building 865 Complex discussed in Section 7.1.1 through 7.1.5 above was evaluated to determine if contaminants of concern are present in surface soil. Table 5 lists the maximum concentrations of chemicals detected in surface soil samples collected in the Building 865 study area.

To evaluate human health risk, the maximum concentrations of constituents detected in surface soil were compared to EPA's industrial soil Preliminary Remediation Goals (PRGs) (U.S. EPA, 2004), California Human Health Screening Levels (CHHSLs) (California EPA, 2005), and California State Action Levels (SALs) (California EPA, 2003) (Table 5). To evaluate potential impacts to ecological receptors, the maximum concentrations of constituents detected in surface soil were compared to EPA's ecological SSLs (U.S. EPA 2005a through 2005f, 2006) where concentrations exceeded background levels (Table 6). The maximum concentrations of constituents detected in surface soil were also compared to EPA's Soil Screening Levels (SSLs) using a dilution attenuation factor (DAF) of 20 (U.S. EPA, 2004) to determine potential impacts to ground water (Table 5). Concentrations were also compared with background concentrations in surface soil (Table 5 and 6). These background concentration ranges were calculated during the Site-Wide Feasibility Study (FS) by constructing log probability plots for the analytes (Ferry et al. 1999). The 1994 metals analytical data obtained from the sampling and analysis of MS-B865-002 and the 1995 TPH as diesel and 1996 TPH as motor oil data obtained from the sampling and analysis of MS-B865-037 are not included in Table 5 because the soil was excavated. Identification of COCs in surface soil was based on the presence of a constituent in surface soil that poses a risk to human health or ecological receptors, or a threat to ground water.

Sampling within the cooling tower sludge area and the drainage channel was likely sufficient to define the extent of metals concentrations in surface soil that may have been impacted by sludge disposal. Excavation of some soil in the area reduced the extent of metals in soil. Two surface soil samples did contain cadmium in excess of the 8 mg/kg SSL for protection of ground water and the 7.5 mg/kg CHSSL (Table 5). Except for these two exceedences, metals

concentrations in surface soil do not pose a threat to ground water or exceed human health screening levels. Arsenic did exceed industrial PRGs and CHSSLs in the majority of samples, but only one sample exceeded background concentrations. Surface soil sample concentrations for cadmium, copper, lead, and zinc did exceed background concentrations in one, two, four, and one samples, respectively. However, none of these metals exceeded PRGs or CHSSLs. Of the metals that exceeded background concentrations and therefore required comparison with ecological SSLs: 1) arsenic exceeded the plant SSL (one sample), 2) cadmium exceeded the avian (three samples) and mammalian (three samples) SSLs, 3) copper exceeded all 4 ecological SSLs (one, one, six, and three samples, respectively), and 4) lead exceeded the avian (six samples) and mammalian (one sample) SSLs (Table 6). Ecological SSLs for zinc are still pending.

While metal concentrations in surface soil exceeded background concentrations, PRGs, CHSSLs, and SSLs in a few samples, their extent is limited and localized to only a few sampling locations. Because the surface soil with concentrations exceeding background, PRGs, CHSSLs, and SSLs concentrations may have been removed during soil excavation in these areas, additional surface soil samples will be collected following D&D of the Building 865 Complex to evaluate whether metals are still present in surface soil at Building 865 at concentrations exceeding regulatory standards or background levels (Tables 5 and 6).

## **7.2. Nature and Extent of Contamination in Subsurface Soil and Rock**

Subsurface soil samples from boreholes were analyzed for halogenated and aromatic VOCs, TPH as diesel and motor oil, TTLC and STLC metals, tritium in soil moisture, and uranium isotopes (Tables A-7 through A-13). In this section, subsurface soil and rock sampling and analytical results are discussed by proximity to potential source areas as follows:

- Electrical supply substation transformer pad (Section 7.2.1).
- Solvent rack, Freon 113 tank, and tensile block wash area (Section 7.2.2).
- Oil conditioning system and tanks 865-T1A1, -T1A2, and -T1A3 (Section 7.2.3).
- Cooling tower sludge disposal area and drainage channel (Section 7.2.4).
- Storm drain outfall (Section 7.2.5).
- Former surface impoundment and retention tanks 865-R1U1, 865-R1A1, -R1A2, and -R1A3 (Section 7.2.6).

The locations of these potential source areas are shown on Figure 3. Section 7.2.7 discusses subsurface soil sample data for samples collected from boreholes drilled for the installation of monitor wells located downgradient of the Building 865 Complex. Section 7.2.8 discusses the results of the evaluation of COCs in subsurface soil and rock in the study area.

### **7.2.1. Electrical Supply Substation Transformer Pad**

In August 1995, a subsurface soil sample (MS-B865-031) was collected at a depth of 1.5 ft within soil beneath the northeast corner of the electrical supply substation transformer pad and analyzed for halogenated and aromatic VOCs and TPH (Tables A-7, A-8, and A-9). VOCs and TPH as motor oil were not detected. TPH as diesel was detected at 41 mg/kg in the sample.

Subsurface soil and rock samples were collected in January 2004 from the borehole for well W-865-2003, about 50 ft north of the substation transformer, and analyzed for halogenated and aromatic VOCs. Samples were collected from 5 to 128 ft below ground surface. No VOCs were detected in any samples from the borehole.

### **7.2.2. Solvent Rack, Freon 113 Tank, and Tensile Block Wash Area**

In August 1995, subsurface soil samples were collected from an exposed unpaved area just north of the concrete pad at 1.5 ft bgs (MS-B865-035), from the lowest point (1.5 ft bgs) in a soil-lined drainage ditch (MS-B865-0036), from adjacent to the former solvent rack (MS-B865-037), and beneath the asphalt and adjacent to the Materials Assembly Room door to Building 865A at depths of 1.5 ft and 3 ft bgs (MS-B865-042, -043, -044, and -045). These subsurface soil samples were collected near the locations of the former tensile block wash area and solvent rack and analyzed for halogenated and aromatic VOCs and TPH (Tables A-7, A-8, and A-9). No halogenated VOCs were detected in any of the samples. Toluene was detected from 0.00061 mg/kg to 0.0015 mg/kg in samples from locations MS-B865-042, -043, -044, and -045. Total xylenes were also detected from <0.001 mg/kg to 0.0036 mg/kg in these samples. TPH as diesel was detected from 3.9 mg/kg to 220 mg/kg in samples from locations MS-B865-036, -042, -043, -044, and -045. TPH as motor oil was detected from 4.2 mg/kg to 140 mg/kg in samples from locations MS-B865-035, -042, 043, -044, and -045.

Soils in this area, including the locations of MS-B865-035, -036, and -037, were excavated to a depth of 5 ft (areal dimensions of 38 ft by 5 ft) and disposed (Galles, 1996). Soil from the area including the locations of samples MS-B865-042, -043, -044, and -045 was not excavated. Thus, maximum concentrations of analytes in samples from these latter locations were included in Table 5. Cleanup verification samples were collected from locations MS-B865-035, -036, and -037 at a depth of 5 ft in July 1996. Only a sample from location MS-B865-035 contained TPH as diesel and as motor oil at concentrations of 8.1 mg/kg and 3.7 mg/kg, respectively. A sample collected at 1.5 ft depth from this location in 1995 was non-detect for TPH as diesel.

Subsurface soil and rock samples were collected in January 2004 from the borehole for well W-865-2002, about 20 ft southwest of Building 865A within the tensile block washing area, and analyzed for halogenated and aromatic VOCs. Samples were collected from 5.5 to 95 ft bgs. Freon 113 was detected in the two samples from 75 ft at concentrations of 0.54 and 0.008 mg/kg. Toluene at a concentration of 0.00088 mg/kg was detected in the samples collected at 70 ft. No other VOCs were detected in samples from the borehole.

### **7.2.3. Oil Conditioning System and Tanks 865-T1A1, -T1A2, and-T1A3**

In August 1995, subsurface soil samples were collected at depths between 1 ft and 1.5 ft bgs immediately northwest of the OCS, from the storm drain directly west of the OCS, and from a location southwest of the OCS tank area (MS-B865-032, -033, and -034) and analyzed for halogenated and aromatic VOCs and TPH (Tables A-7, A-8, and A-9). Samples MS-B865-032 and -034 were collected from below the asphalt. The sample from the storm drain (MS-B865-033) was collected from the sediment within the basin, which is surrounded by a concrete area. Toluene was detected in two samples at concentrations of 0.0011 mg/kg and 0.002 mg/kg from MS-B865-032 and -034. The duplicate sample from MS-B865-034 was non-detect for toluene. The only other VOC detected in this area was Freon 113 in the sample from MS-B865-033 at a concentration of 0.031 mg/kg. TPH as diesel was only detected in the duplicate samples from MS-B865-034 at concentrations of 680 mg/kg and 760 mg/kg. TPH as motor oil was detected in samples from MS-B865-032 and -033 at concentrations of 10 mg/kg and 1100 mg/kg, respectively.

In 1999, 3 ft<sup>3</sup> of soil within the storm grate were excavated and the grate was filled with gravel and concrete (Jackson, 1999). Therefore, the soil representing concentrations of chemicals at sample location MS-B865-033 collected from the storm drain west of the OCS was removed. The soil in the vicinity of sample locations MS-B865-032 and -034 that contained toluene and TPH beneath the pavement at the OCS was not removed. Because this soil is located beneath the pavement, it will be evaluated further during the planned D&D activities at Building 865, and may be excavated, if necessary.

### **7.2.4. Cooling Tower Sludge Disposal Area and Drainage Channel**

In 1994, ten subsurface soil samples (MS-B865-006, -007, -009, -011, -013, -015, -019, -028, -029, and -030) were collected from the area where cooling tower sludge was deposited northwest of the cooling tower. Three samples (MS-B865-017, -021, and -023) were collected in the drainage channel to the southeast for analyses of total TTLC metals (Figure 9). Samples from ten of these locations were also analyzed for STLTC metals. The analytical results for these subsurface soil and rock samples are presented in Tables A-10 and A-11. The STLTC data (Table A-11) for these samples were used for waste disposal criteria and were not used for site characterization. The TTLC metals concentration data are all within background concentrations for Site 300 subsurface soil.

### **7.2.5. Storm Drain Outfall**

In February 1996, a subsurface soil sample was collected from the drain outfall (MS-B865-038) north of Route 3 at a depth of 1 ft and analyzed for TPH as diesel and motor oil. These constituents were not detected above the analytical method detection limit in this sample.

### **7.2.6. Former Site of Surface Impoundment and Retention Tanks 865-R1U1, 865-R1A1, -R1A2, and -R1A3**

Subsurface soil samples were collected in 1995 from the former location of the surface impoundment at locations MS-B865-039, -040, and -041. The MS-B865-039 and MS-B865-040 samples were collected at a depth of 2 ft. The sample from MS-B865-041 was collected at a depth of 4 ft. The samples were analyzed for halogenated and aromatic VOC and TPH. None were detected.

### **7.2.7. Downgradient Borehole Sampling Locations**

In December 1999, subsurface soil and rock samples were collected from the borehole for well W-865-02, about 20 ft northeast of Building 865A. Samples were collected from 5 to 130 ft bgs and analyzed for halogenated and aromatic VOCs. No VOCs were detected.

Soil and rock samples were collected in February 2000 from the borehole for well W-865-05 on the hill adjacent to drinking water Tank 5. Samples were collected from 5 to 273 ft bgs and analyzed for halogenated and aromatic VOCs. The sample from 5 ft contained 0.001 mg/kg of total xylenes and 0.0015 mg/kg of 1,4-dichlorobenzene. The sample from 245.1 ft contained 0.0032 mg/kg of methylene chloride that was also detected in the method blank. The samples from 264.7 and 273 ft contained 0.011 mg/kg and 0.014 mg/kg of Freon 113, respectively. These latter two samples were collected from the saturated zone within the Freon 113 plume in ground water. No other VOCs were detected.

Subsurface soil and rock samples were collected in January 2004 from the borehole for well W-865-2121, about 1,500 ft northeast of Building 865A, and analyzed for halogenated and aromatic VOCs. Samples were collected from the saturated zone at depths of 343 to 355 ft below ground surface. Toluene was detected at concentrations of 0.0006 mg/kg and 0.0012 mg/kg from the 351 ft and 355 ft depths, respectively. No other VOCs were detected in any samples from the borehole.

Subsurface soil and rock samples were collected from the borehole for wells W-865-01, W-865-03, W-865-04, W-865-06, W-865-07, W-865-1802, W-896-1806, and W-PIT1-02 and analyzed for tritium in soil moisture (Figure 9). Tritium was not detected in excess of detection limits of 2 to 200 pCi/L<sub>sm</sub> or pCi/g (Table A-12). This range of tritium detection limits is within range of background for tritium in soil moisture at Site 300 (Ferry et al., 1999).

Subsurface soil and rock samples were collected in January 2000 from the borehole for well W-865-04, about 2,500 ft northwest of Building 865A, and analyzed for uranium isotopes. Samples were collected from the saturated zone at depths 100 to 152 ft bgs. The maximum total uranium activity detected in the subsurface soil/rock samples was 2.733 pCi/g; within the range of natural background uranium activities. (Table A-13). The uranium-235/uranium-238 (<sup>235</sup>U/<sup>238</sup>U) atom ratios in all five samples indicated the presence of only natural uranium (about 0.0072).

### 7.2.8. Evaluation of COCs in Subsurface Soil and Rock

Table 5 lists the maximum concentrations of constituents detected in subsurface soil/rock in the study area that was not excavated, and the applicable regulatory standards and background concentrations for these constituents and media.

To define COCs in subsurface soil/rock, maximum concentrations of constituents detected in subsurface soil were compared to EPA's SSLs (U.S. EPA, 2004) to determine potential impacts to ground water (Table 5). Concentrations were also compared with background concentrations in subsurface soil (Table 5 and 6). These background concentration ranges were calculated during the Site-Wide Feasibility Study (FS) by constructing log probability plots for the analytes (Ferry et al. 1999). The only potential human health and ecological exposure pathway for contaminants in subsurface soil is for VOCs (e.g., Freon 113) detected in subsurface soil and rock at depths of less than 12 ft bgs. Therefore, VOC concentrations in subsurface soil to a depth of 12 ft bgs were evaluated to determine human health and ecological risk.

TTLIC metals concentration maxima from the cooling tower sludge disposal area were all within background concentration ranges (Ferry et al., 1999). Additionally, all metals concentrations for the subsurface soil are below EPA SSLs (using a DAF of 20) and therefore do not represent a threat to underlying ground water. Because all metals concentrations in subsurface soil were within background concentration ranges, there was no need to compare the maxima with ecological SSLs (Table 6). Therefore, metals are not considered COCs in subsurface soil and rock in the Building 865 study area.

Table 5 also lists the maximum concentrations of TPH and volatile and aromatic organic compounds detected in subsurface soil at the study area excluding the sampling location MS-B865-033, because the soil from this location was excavated in 1999. All maximum concentrations of TPH as motor oil, TPH as diesel, Freon 113, toluene, and total xylene were above background, because these constituents are anthropogenic in origin, the analytical method detection limit is used as the surrogate for background concentrations. The comparison of the maximum concentrations of TPH and halogenated and aromatic VOCs in subsurface soil and rock in the Building 865 study area to EPA's SSLs indicate that these constituents do not pose a threat to ground water. In addition, very little Freon was found in the borehole for well W-865-2002, drilled through the former tensile block wash area which is a confirmed Freon release site, or in the boreholes for wells W-865-02 and W-865-2003 located in close proximity to the building. These data suggest that the Freon has largely migrated to ground water and has not remained in the vadose zone. Because VOCs detected in subsurface soil and rock (e.g., Freon 113) were not present at depths of less than 12 ft bgs, there is no potential for volatilization of Freon to ambient air or risk to human health from the inhalation of volatilized contaminants in the study area. Because there is no risk to human health or threat to ground water posed by TPH and VOCs detected in subsurface soil, the constituents are not considered COCs in subsurface soil and rock in the Building 865 study area. Tritium and uranium activities in subsurface soil and rock in the study area were all within the range of background levels for these constituents, and therefore are not considered COCs in this media.

Based on this analysis, there were no COCs identified in subsurface soil in the Building 865 study area.

### **7.3. Nature and Extent of Contamination in Ground Water**

Ground water samples were collected from monitor wells in the Building 865 study area from January 1, 1988 to March 30, 2006 to determine whether activities at the Building 865 Complex have impacted ground water. Ground water samples were analyzed for the following constituents:

- Halogenated and aromatic VOCs (Section 7.3.1).
- Fuel hydrocarbons (Section 7.3.2).
- Nitrogenous compounds (Section 7.3.3).
- Perchlorate (Section 7.3.4).
- High explosive compounds (Section 7.3.5)
- Metals and other cations, anions, total dissolved solids (TDS), specific conductance, and pH (Section 7.3.6).
- Tritium and uranium isotopes (Section 7.3.7).

Analytical data are tabulated in Tables A-14 to A-23. Section 7.3.8 discusses the results of the evaluation of COCs in ground water in the study area.

#### **7.3.1. Halogenated and Aromatic VOCs Ground Water Analytical Results**

Ground water samples collected from 25 wells in the Building 865 study area were analyzed for halogenated VOCs (Table A-14). Freon 113 is the principal halogenated VOC detected in Building 865 ground water. Freon 113 has been detected in ground water samples from 10 of the 25 wells in the study area, all completed within the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU. The historical maximum concentration of Freon 113 detected in ground water in the study area was 490 micrograms per liter ( $\mu\text{g/L}$ ) in a sample collected from well W-865-05 on February 28, 2002. Ground water samples from this well have consistently contained the highest Freon 113 concentrations in the study area since it was installed in February 2000. In the first quarter 2006, the maximum Freon 113 concentration in ground water in the study area was 290  $\mu\text{g/L}$  in the ground water sample from this well. However, Freon 113 concentrations in Building 865 ground water have always been and continue to be below both the California drinking water Maximum Contaminant Level (MCL) of 1,200  $\mu\text{g/L}$  and the California Public Health Goal (PHG) of 4,000  $\mu\text{g/L}$  (California EPA, 2003). There is no Federal drinking water standard established for Freon 113.

As shown in Figure 10, the Freon 113 plume was approximately 3,000 ft long and 1,200 ft wide during the first quarter of 2006. The distribution of Freon 113 in ground water suggests that sources at the tensile block wash area, the oil conditioning system area, and possibly the former surface impoundment on the southwest side of Building 865A contributed to the Freon 113 detected in ground water. The lateral extent of the Freon 113 plume is bounded to the north by

the extent of saturation within the  $Tnbs_1/Tnbs_0$  HSU. It is bounded in the upgradient and downgradient directions by ground water monitor wells that do not contain Freon 113. The plume is bounded vertically by a dense claystone aquitard within  $Tnsc_0$  strata that hydraulically separate the  $Tnbs_1/Tnbs_0$  HSU from the underlying  $Tmss$  HSU (Figures 5 and 6). The  $Tmss$  HSU is under confining pressure due to this aquitard.

Figure 11 presents a time-series plot of Freon 113 concentrations in ground water samples from the ten  $Tnbs_1/Tnbs_0$  HSU wells in which Freon 113 has been detected.

Wells W-865-2002, and -2003 are located in the vicinity of and immediately downgradient of the former tensile block wash area. Freon 113 concentrations in ground water at these wells are low with a maximum concentration of  $35 \mu\text{g/L}$  in the first quarter of 2006. The low concentrations (up to  $35 \mu\text{g/L}$ ) and stable trend indicate that the former tensile block wash area is not a continued significant source of Freon 113 to ground water. Freon 113 concentrations are higher in wells located further downgradient from this source area, i.e., well W-865-2004, with maximum concentrations of  $180 \mu\text{g/L}$  in the first quarter of 2006.

Wells W-865-02 and -05 are located downgradient of the OCS and former surface impoundment. Freon 113 concentrations are higher in ground water samples from these wells both in the source area and downgradient ground water indicating that the OCS and/or former surface impoundment were more significant sources of Freon 113 than the former tensile block wash area. Freon 113 concentrations are higher in wells located further downgradient from OCS and former surface impoundment, i.e., well W-865-05, with maximum concentrations of  $290 \mu\text{g/L}$  in the first quarter of 2006.

Data from wells with the longest monitoring history in the Building 865 area, i.e., wells K1-05, K1-08, and K1-09, indicate that Freon 113 concentrations peaked during 1997 to 1998 and have been steadily declining since that time. The Freon 113 concentrations observed in samples from these wells peak in time in order of distance away from the Building 865 Complex.

Wells completed beneath and/or downgradient from potential Freon 113 sources, such as the tensile block wash area, the OCS, and the former surface impoundment, show lower fairly stable or generally declining ground water concentrations. Freon use was suspended in 1988 and therefore, 18 years have elapsed since it was released to the environment. Based on the spatial and temporal distribution of Freon 113 in ground water, it is likely that the sources are no longer significant and that any flux of Freon 113 to ground water is diminishing over time.

FEFLOW, a 3-dimensional (3D) finite element model, was used to simulate the fate and transport of Freon 113 in ground water over time. Results and a description of the model are presented in detail in Attachment B. The modeling results indicate that Freon 113 concentrations will be reduced to below the  $0.5 \mu\text{g/L}$  method detection limit in 60 to 70 years. The Freon 113 plume will not migrate offsite during this time period.

Freon 11 is also present in ground water in the Building 865 study area, although its lateral extent is less than that of the Freon 113 plume. Freon 11 has been detected in ground water samples from four of the 25 wells in the study area, all completed within the  $Tnbs_1/Tnbs_0$  HSU. The historical maximum concentration of Freon 11 detected in ground water in the study area was  $5.1 \mu\text{g/L}$  in a sample collected from well W-865-2004 on March 15, 2006. In the first

quarter 2006, the maximum Freon 113 concentration in ground water in the study area was 3.4  $\mu\text{g/L}$  in the ground water sample from this well. Freon 11 concentrations in Building 865 ground water have always been and continue to be well below both the California MCL of 150  $\mu\text{g/L}$  and the California PHG of 400  $\mu\text{g/L}$  (California EPA, 2003). There is no Federal drinking water standard established for Freon 11.

As shown in Figure 12, the Freon 11 ground water plume in the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU was approximately 1,400 ft long and 900 ft wide in the first quarter of 2006. The Freon 11 plume occurs entirely within the extent of the larger Freon 113 plume. Freon 11 was likely a component of the Freon mixture used at Building 865.

FEFLOW, a 3-D finite element model, was also used to simulate the fate and transport of Freon 11 in ground water over time. Results and a description of the model are presented in detail in Attachment B. The modeling results indicate that Freon 11 concentrations will be reduced to below the 0.5  $\mu\text{g/L}$  method detection limit in 10 to 15 years. The Freon 11 plume will not migrate offsite during this time period.

Tetrachloroethylene (PCE) was detected in ground water samples from three wells in the study area. These wells, W-865-02, W-865-05, and W-865-2004, are all completed in the Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU. The historical maximum concentration of PCE detected in ground water was 10  $\mu\text{g/L}$  in a sample collected from well W-865-2004 on March 30, 2005. In the first quarter 2006, the maximum PCE concentration in ground water in the study area was 7.5  $\mu\text{g/L}$  in a ground water sample from this well; exceeding both the 5  $\mu\text{g/L}$  MCL and 0.9  $\mu\text{g/L}$  PHG for PCE. PCE concentrations in wells W-865-02 and -05 have been below the MCL but slightly above the PHG both historically and in the first quarter of 2006 PCE is considered a COC in ground water, though the extent of PCE is limited to three wells proximal to the Building 865 Complex and concentrations are stable to declining over time.

Trichloroethylene (TCE) has been sporadically detected in ground water samples from three wells in the study area (K1-02B, K1-09, and W-865-01) at concentrations ranging from 0.5  $\mu\text{g/L}$  to 3.8  $\mu\text{g/L}$ . TCE was detected in only five of the 181 samples collected from these wells and has never been detected above the 5  $\mu\text{g/L}$  State and Federal MCL in any well. TCE has not been detected at concentrations above the analytical method detection limit of 0.5  $\mu\text{g/L}$  since 1990 in well K1-09, since 1999 in well W-865-01, which is upgradient of Building 865, and since 2003 in well K1-02B, which is downgradient of Pit 1.

One sample collected from well W-865-01 on August 6, 2003 contained 2  $\mu\text{g/L}$  of chloroform. This detection of chloroform is likely a laboratory artifact and is not included in the COC assessment.

No other VOCs have been identified in ground water samples collected from the Building 865 study area wells.

Ground water samples were collected from 29 wells in the Building 865 study area and analyzed for aromatic hydrocarbons (Table A-15). Aromatic VOCs were not detected in any of the ground water samples. Assuming that the compounds analyzed for are constituents of oils and greases that may have been released to soil and rock at the facility, the absence of aromatic

VOCs in ground water beneath and downgradient of the Building 865 Complex suggests that these substances have not impacted ground water.

### **7.3.2. Fuel Hydrocarbons Ground Water Analytical Results**

Ground water samples were collected from 5 wells in the Building 865 study area and analyzed for fuel hydrocarbons (Table A-16). Oil and grease was not detected in any samples in excess of the 5 mg/L reporting limit.

### **7.3.3. Nitrogenous Compounds Ground Water Analytical Results**

Ground water samples were collected from 26 wells in the Building 865 study area and analyzed for nitrogenous compounds (Table A-17). The historical maximum nitrate (as  $\text{NO}_3$ ) concentrations detected in ground water was 146.2 mg/L in a sample collected from well K1-09 on July 26, 1993. It appears that nitrate analytical results for all ground water samples collected on that day, i.e., from wells K1-02B through K1-09, were elevated relative to historical analytical results. The maximum historical nitrate concentration, not counting samples collected on that date, is 110 mg/L in a sample collected from well W-PIT1-01 on May 25, 1999. Historically, nitrate concentrations in excess of the 45 mg/L State MCL have been detected in ground water upgradient, cross-gradient, and downgradient of the Building 865 Complex. For example, nitrate was detected in upgradient wells W-865-03 and W-865-1804 at historical maximum concentrations of 66 mg/L and 70 mg/L, respectively. In addition, the maximum historical nitrate concentration in ground water in the study area was detected in well W-Pit1-01 that is located cross-gradient from any potential contaminant sources in the Building 865 Complex. These wells are all located in areas that could not be impacted by any possible anthropogenic sources of nitrate indicating elevated levels of natural nitrate in the ground water.

Figure 13 is a map of the distribution of nitrate in ground water during the first quarter 2006. In the first quarter 2006, nitrate was detected at concentration exceeding the MCL in three  $\text{Tnbs}_1/\text{Tnbs}_0$  HSU wells, W-865-05, W-865-2004, and W-865-2121. The maximum nitrate concentration during this quarter was 64 mg/L in the ground water sample collected from well W-865-2204 on February 21, 2006.

### **7.3.4. Perchlorate Ground Water Analytical Results**

Ground water samples were collected from 26 wells in the Building 865 study area and analyzed for perchlorate (Table A-18). Historically, perchlorate has been detected in ground water samples from four of the 25 wells in the study area at concentrations exceeding the 6  $\mu\text{g/L}$  State PHG (California EPA, 2005). These wells, W-865-02, K1-02B, W-PIT1-01-01, and W-PIT1-02, are all completed within the  $\text{Tnbs}_1/\text{Tnbs}_0$  HSU. The historical maximum concentration of perchlorate detected in ground water in the study area was 9.6  $\mu\text{g/L}$  in a sample collected from well K1-02B in January 2006. During the first semester of 2006, perchlorate was detected at a concentration exceeding the PHG in a ground water sample from well K1-02B (Figure 14). While perchlorate was also detected in samples from wells W-865-02 and W-PIT1-02 during the first semester of 2006, perchlorate concentrations in the duplicate samples

collected from these wells on the same day were below the PHG. Perchlorate has not been detected in samples from any other wells in the Building 865 study area at concentrations above the 4  $\mu\text{g/L}$  analytical method detection limit.

Wells K1-02B, W-PIT-01, and W-PIT1-02 are all located cross-gradient from any possible sources at Building 865. Perchlorate was detected only once (January 2006) at a concentration of 9.5  $\mu\text{g/L}$  in a sample from well W-865-02 that is located directly downgradient of the Building 865 Complex. However, perchlorate was not detected above the 4  $\mu\text{g/L}$  analytical detection limit in the duplicate sample collected from this well the same day.

The distribution of perchlorate in ground water does not suggest a source at Building 865. Additional ground water samples will be collected from well W-865-02 to confirm whether a local source exists. DOE/LLNL will continue to monitor for perchlorate in ground water at wells K1-02B, W-PIT-01-01, and W-PIT1-02, located downgradient of the Pit 1 Landfill, to evaluate whether releases may have occurred from the landfill.

### **7.3.5. HE Compounds Ground Water Analytical Results**

Samples from 23 wells have been collected and analyzed for the HE compounds high melting explosive (HMX) and research department explosive (RDX). Limited analyses for trinitrotoluene (TNT) were also conducted. Table A-19 contains HE compound concentration data for these ground water samples. HMX and RDX were detected in a single ground water sample collected from Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU well W-865-02 in March 29, 2000 at concentrations of 34 and 17  $\mu\text{g/L}$ , respectively. Because only one sample from this well was analyzed for HE compounds, additional ground water samples will be collected from this well during the fourth quarter of 2006 for HMX and RDX analysis. HMX was detected in a single sample collected from well K1-02B on July 20, 2004. RDX was detected in a single sample collected from well K1-03 on April 13, 2005. No HE compounds were detected in subsequent samples collected from these wells or in any samples from other wells in the Building 865 study area. There are no State or Federal drinking water MCLs or State PHGs established for HMX or RDX. TNT was not detected in any ground water samples from study area wells.

### **7.3.6. Metals, Cations and Anions, and General Water Quality Parameters in Ground Water**

Ground water samples from 27 wells have been analyzed for metals and cations. Table A-20 contains metals and cation concentration data for water samples collected at Building 865. Metals concentrations in Building 865 study area water ground samples did not exceed any regulatory criterion, and are well within background ranges or below detection limits.

Table A-21 presents anion concentrations and general water quality parameters for water samples collected at Building 865. All concentration data tabulated in Table A-21 is well within natural ranges.

### 7.3.7. Radionuclides in Ground Water

Ground water from wells in the Building 865 study area were analyzed for tritium, uranium isotopes and  $^{235}\text{U}/^{238}\text{U}$  mass ratios.

Ground water samples were collected from 21 wells in the Building 865 study area and analyzed for tritium. Tritium activities in ground water samples are shown in Table A-22. While tritium was detected in ground water in excess of the 100 picocuries per liter (pCi/L) background activity, these samples were collected from Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU monitor wells located upgradient from the Building 865 Complex (W-865-1802, W-865-1803, W-865-1804) and cross-gradient from Building 865 (K1-02B, K1-03, W-PIT1-01 and W-PIT1-02). The tritium detected in these upgradient and cross-gradient wells is likely the result of the migration of the tritium plume from the Building 850 source area. Historically, tritium has not been measured above the 100 pCi/L analytical detection limit in any ground water samples from wells that are downgradient of Building 865.

Ground water samples were collected from 26 wells in the Building 865 study area and analyzed for uranium isotopes and  $^{235}\text{U}/^{238}\text{U}$  atom ratios.  $^{235}\text{U}/^{238}\text{U}$  atom ratios are used to differentiate anthropogenic, depleted uranium from natural uranium. Uranium isotope activity data and  $^{235}\text{U}/^{238}\text{U}$  atom ratios in ground water samples are shown in Table A-23. All  $^{235}\text{U}/^{238}\text{U}$  atom ratios in ground water samples from wells located downgradient of the Building 865 Complex are indicative of natural uranium (0.0072). The maximum historic total uranium activity was 9.43 pCi/L in a ground water sample collected from well W-PIT1-01 on March 13, 2001.  $^{235}\text{U}/^{238}\text{U}$  atom ratios indicate that the uranium detected in this well was comprised entirely of natural uranium, and the total uranium activity is within natural background levels.

### 7.3.8. Evaluation of COCs in Ground Water

In the Site-Wide Feasibility Study (Ferry et al., 1999), background concentration ranges were developed for naturally occurring constituents in ground water, such as metals and nitrate, using analytical data collected from wells upgradient and outside areas of known or suspected contamination. COCs were defined based on exceedence of MCLs, PHGs, and/or background concentrations, persistence, and occurrence in ground water downgradient of Building 865. Because PHGs are based on a  $10^{-6}$  incremental cancer risk, site-specific risk numbers were not estimated. Table 7 contains a comparison of maximum concentrations of analytes detected in ground water and relevant water quality parameters. Based on the comparison of the ground water data collected and evaluated as part of this characterization effort against regulatory standards and background levels, Freon 113, Freon 11, and PCE are COCs in ground water in the Building 865 study area.

Although Freon 113 and Freon 11 have not been detected above drinking water MCLs or State PHGs in study area ground water, they are considered COCs because they have impacted waters of the state above background concentrations ( $<0.5 \mu\text{g/L}$ ). It appears that Freon sources in the Building 865 study area are not significant and appear to be diminishing over time. Freon 113 has not been detected above drinking water MCLs or State PHGs in study area ground

water. Freon 11 concentrations in Building 865 ground water continue to be well below both the California MCL and PHG. The general trends in maximum Freon 113 and Freon 11 concentrations in ground water are stable or declining. Fate and transport modeling indicates that Freon 113 and Freon 11 concentrations will be reduced to below the 0.5  $\mu\text{g/L}$  method detection limit in 60 to 70 years, and 10 to 15 years, respectively without migrating offsite.

Although identified as a COC because of its persistence in recent ground water samples from wells downgradient of Building 865, the extent of PCE in ground water is limited, maximum concentrations are just above the MCL, and concentrations are stable to declining over time.

Because TCE has not been detected in ground water downgradient of Building 865 since 1990, it is not considered a ground water COC.

The absence of aromatic VOCs in ground water beneath and downgradient of the Building 865 Complex indicates that these substances have not impacted ground water. Therefore, aromatic VOCs are not considered to be ground water COCs in the study area.

Although nitrate has been detected at concentrations exceeding the MCL in the Building 865 study area, it is not considered a ground water COC at this time because of: (1) the historical presence of nitrate in ground water above MCLs both upgradient and cross-gradient of Building 865, and (2) the lack of any known potential sources of nitrate in the Building 865 Complex, other than possibly the septic system.

Although perchlorate has been detected in ground water at concentrations in excess of drinking water PHGs, with the exception of one well, these samples have been collected from wells cross-gradient of Building 865. Perchlorate was only detected once in a recent sample from one downgradient well. A duplicate sample collected from the well the same day did not contain perchlorate above method detection limits. Additional samples will be collected to confirm the result. Presently, perchlorate is not considered as a COC in ground water at the Building 865 study area.

HE compounds are not considered COCs in ground water at the Building 865 study area because: (1) HE compounds have not been detected in recent ground water samples collected from wells throughout the study area, and (2) there are no indications that HE compounds were ever used at the Building 865 Complex.

Metals concentrations in Building 865 study area water ground samples did not exceed any regulatory criterion, and are well within background ranges or below detection limits. Therefore metals are not considered COCs in ground water in the study area.

Because there is no evidence of anthropogenic tritium in ground water that emanates from the Building 865 Complex, tritium is not a COC in ground water at the Building 865 study area.

Uranium is not considered a ground water COC because data indicate that only natural uranium is present at background levels in Building 865 study area ground water.

Because there is no exposure pathway for ground water to ecological receptors, there is no ecological risk from COCs in ground water in the Building 865 study area.

The extents of all COCs (Freon 113, Freon 11, and PCE) in ground water have been defined and are bounded by wells that exhibit background concentrations of COCs in ground water. All COCs are confined to Tnbs<sub>1</sub>/Tnbs<sub>0</sub> HSU ground water. Because tritium, uranium, HE compounds, metals, and aromatic hydrocarbons have not historically and/or currently been detected at concentrations exceeding regulatory standards in ground water downgradient of Building 865 Complex, these constituents are not considered COCs in ground water and except for some discretionary or verification samples, will not be monitored for in the future.

## 8. Summary

Environmental investigation activities were conducted in the Building 865 study area to determine if contamination had been released to environmental media and if so, the extent of the contamination. As part of this investigation, the geology and hydrogeology of the study area were characterized to facilitate the evaluation of potential contaminant migration pathways in the subsurface. In addition, a screening-level risk assessment was conducted to identify contaminants of concern in environmental media.

Samples of surface soil, subsurface soil/rock, surface water, and ground water were collected and analyzed for chemical and radiological constituents that have been used in programmatic work at Building 865 and may have been released to the environment. Surface soil data were compared to EPA industrial soil PRGs and ground water and ecological SSLs and California CHSSLs to determine which constituents detected in this media could pose a risk to human health, ecological receptors, or ground water. A minimal impact to ground water was possible from cadmium in two surface soil samples. Impact to ecological receptors from arsenic, cadmium, copper, and lead in several samples was also identified. The evaluation of subsurface soil and rock data and comparison to PRGs, SSLs, SALs, and CHSSLs indicate no impact to ground water and no impact to human health or ecological receptors. Freon 113, Freon 11, and PCE, were identified as contaminants of concern in ground water because concentrations of these constituents arise from sources at Building 865 and either are persistent or have degraded waters of the state (Freon 113 and Freon 11) or occur at concentrations exceeding drinking water MCLs. There is no pathway for contaminated ground water to impact ecological receptors and thus there is no risk.

## 9. Recommendations

While metal concentrations in surface soil exceeded background concentrations, PRGs, CHSSLs, and SSLs in a few samples, their extent is limited and localized to only a few sampling locations. Because some surface soil with concentrations exceeding background, PRGs, CHSSLs, and SSLs concentrations may have been removed during soil excavation in these areas, additional surface soil samples will be collected following D&D of the Building 865 Complex to evaluate whether metals are still present in surface soil at Building 865 at concentrations exceeding regulatory standards or background levels.

Because there are no ground water contaminants above their respective regulatory standards that appear to arise from Building 865 facilities, with the exception of PCE being slightly above the MCL, and no soil contaminants that represent a threat to ground water, DOE recommends folding the Building 865 area into Operable Unit 8 for monitoring-only for VOCs in ground water until PCE is below the MCL and then for another five years after to ensure that concentration trends continue to decrease. In addition, although modeling indicates that the Freon plume will not migrate offsite, guard wells located at the boundary of the Freon 113 plume will be monitored to detect any migration of Freon 11 or Freon 113 toward the site boundary.

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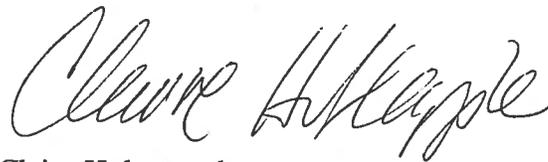
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Should you have any questions or concerning this report, please contact Leslie Ferry at (925) 422-0060 or Claire Holtzapple at (925) 422-0670.

Sincerely,



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Attachments (Figures, Tables, Attachments A and B)

cc: K. Angleberger (DOE/HQ)  
M. Brown (DOE/LSO)  
W. Bookless (w/o att)  
S. Goodwin (w/o att)  
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