

**Human Health and Ecological
Risk Assessment for the
Operation of the Explosives
Waste Treatment Facility at
Site 300 of the Lawrence
Livermore National Laboratory**

Volume 1: Report of Results

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Background Information about Types of Explosives

(adapted from Mitchell, 1999)

High Explosive. An energetic material in which the decomposition process (detonation wave) proceeds through the entire material at supersonic speed. The rate at which the detonation wave passes through the energetic material depends on a large number of parameters, including the density of the energetic material, the heat released by the detonation, the geometric shape or dimensions of the energetic material, the degree of confinement, and the purity of the energetic material(s). High explosives can be divided into two subcategories: primary high explosives that detonate easily when exposed to an ignition source, and secondary high explosives that require the detonation of a primary high explosive before they detonate. Fuses and boosting charges are examples of primary high explosives. Trinitrotoluene (TNT), Research Department Explosive (RDX), tetryl, and nitroglycerin are examples of secondary explosives.

Low Explosive. An energetic material in which the decomposition process (deflagration) occurs at subsonic speed. The decomposition occurs only on the surface of the energetic material; and, unlike the high explosive, there is no shock wave. The rate determining factors for decomposition of a low explosive are the rate of heat transfer into the energetic material from the decomposition occurring on its surface and the rate of decomposition of the energetic material itself. The pressure that the decomposition products exert on the energetic material also affects the rate of heat transfer. Low explosives are usually divided into three largely unrelated categories: black powder (a mixture of sulfur, charcoal and potassium nitrate), pyrotechnics (materials used to produce light, smoke, heat or sound effects), and propellants (materials used for the propulsion of projectiles or rockets).

Propellant. A low-explosive energetic material. Some of the most commonly used propellant ingredients are nitrocellulose, nitroglycerin, and ammonium perchlorate. Propellants are placed into five subcategories based on their energetic composition: (1) single base, which contains only nitrocellulose; (2) double-base, which contains nitrocellulose and nitroglycerin; (3) triple-base, which contains nitrocellulose, nitroglycerin, and nitroguanidine; (4) ammonium perchlorate; and (5) composite, which contains an oxidizer, such as ammonium perchlorate, and a metal additive (e.g., powdered aluminum) held together by a polymeric substance, such as polybutadiene.

Human Health and Ecological Risk Assessment for the Operation of the Explosives Waste Treatment Facility at Site 300 of the Lawrence Livermore National Laboratory

Executive Summary

Human health and ecological risk assessments are required as part of the Resource Recovery and Conservation Act (RCRA) permit renewal process for waste treatment units. This risk assessment is prepared in support of the RCRA permit renewal for the Explosives Waste Treatment Facility (EWTF) at Site 300 of the Lawrence Livermore National Laboratory (LLNL).

The human health risk assessment is based on U.S. Environmental Protection Agency (U.S. EPA) approved emissions factors and on California Environmental Protection Agency (CalEPA), California Air Resources Board (CARB) and U.S. EPA assessment and air dispersion models. This risk assessment identifies the receptors of concern and evaluates theoretical carcinogenic risk, and theoretical acute and chronic non-carcinogenic hazard, following those guidelines. The carcinogenic risk to a 30-year resident at the maximum off-site receptor location is 0.0000006 or 0.6 in 1 million. The carcinogenic risk to a 25-year worker at the maximum bystander on-site receptor location is also 0.0000006 or 0.6 in 1 million. Any risk of less than 1 in a million is below the level of regulatory concern. The acute non-carcinogenic hazard for the 30-year resident is 0.01, and the chronic non-carcinogenic hazard is 0.01. The acute non-carcinogenic hazard for the 25-year worker is 0.3, and the chronic non-carcinogenic hazard is 0.2. The point of comparison for acute and chronic non-carcinogenic hazard is 1.0; an estimate less than 1.0 is below the level of regulatory concern. The estimates of health effects are based on health conservative assumptions and represent an upper bound of the possible exposures to the receptors. Based on these results, emissions from the operations of the EWTF should not be of concern for human health.

For the ecological risk assessment (ERA), 10 receptor species (including plants), representing members of the trophic levels in the habitat of Site 300, were evaluated for the possibility of potential detrimental effects from EWTF emissions. The ecological hazard quotients (EHQs) at a location closest to the EWTF suggest a potential for adverse consequences. However, the conservatisms incorporated into the analysis may overestimate potential consequences and may explain the potential for impacts. Using less conservative values suggests that there is a possibility for limited to no additional impact to occur from the continuing operation of the EWTF.

Human Health and Ecological Risk Assessment for the Operation of the Explosives Waste Treatment Facility at Site 300 of the Lawrence Livermore National Laboratory

1. Introduction

This document contains the human health and ecological risk assessment for the Resource Recovery and Conservation Act (RCRA) permit renewal for the Explosives Waste Treatment Facility (EWTF). Volume 1 is the text of the risk assessment, and Volume 2 (provided on a compact disc) is the supporting modeling data. The EWTF is operated by the Lawrence Livermore National Laboratory (LLNL) at Site 300, which is located in the foothills between the cities of Livermore and Tracy, approximately 17 miles east of Livermore and 8 miles southwest of Tracy. Figure 1 is a map of the San Francisco Bay Area, showing the location of Site 300 and other points of reference.

One of the principal activities of Site 300 is to test what are known as “high explosives” for nuclear weapons. These are the highly energetic materials that provide the force to drive fissionable material to criticality. LLNL scientists develop and test the explosives and the integrated non-nuclear components in support of the United States nuclear stockpile stewardship program as well as in support of conventional weapons and the aircraft, mining, oil exploration, and construction industries.

Many Site 300 facilities are used in support of high explosives research. Some facilities are used in the chemical formulation of explosives; others are locations where explosive charges are mechanically pressed; others are locations where the materials are inspected radiographically for such defects as cracks and voids. Finally, some facilities are locations where the machined charges are assembled before they are sent to the on-site test firing facilities, and additional facilities are locations where materials are stored.

Wastes generated from high-explosives research are treated by open burning (OB) and open detonation (OD). OB and OD treatments are necessary because they are the safest methods for treating explosives wastes generated at these facilities, and they eliminate the requirement for further handling and transportation that would be required if the wastes were treated off site.



Figure 1. Location of Site 300.

2. OB/OD Operations at Site 300

OB/OD operations are conducted at the EWTF located at the Building 845 Complex at Site 300. The EWTF consists of three units: the detonation pad, the burn pan, and the burn cage.

The detonation pad, shown in Figure 2, is used for the treatment of those waste explosives whose configuration requires treatment by open detonation, i.e., those wastes in a form that cannot be safely treated by open burning. The materials treated are 90 to 100 percent explosive materials. The detonation pad consists of a level, 30-foot x 30-foot (9-m x 9-m) gravel pad with minimum gravel pack about 8 feet (2.4 m) thick. Detonation of explosives waste is accomplished with the use of detonators or other initiating devices, and the process is controlled remotely from the Building 845 control bunker under observation by surveillance cameras. No more than 350 pounds (159 kg) of explosives waste (net explosive weight) may be detonated at one time. The detonation process is virtually instantaneous.



Figure 2. EWTF detonation pad.

The burn pan is used for the treatment of small pieces and powders of explosives wastes. These materials are 80 to 100 percent explosive materials that will not detonate during the thermal treatment process. The burn pan is a 4-foot x 8-foot x 0.5-foot-deep, rectangular, welded steel, watertight pan mounted on steel legs. The pan is equipped

with a remotely controlled, removable cover. Pieces of explosives waste are placed in the pan, and cellulose material or other combustible materials are used to initiate treatment by burning. No more than 100 pounds (45 kg) of explosives waste (net explosive weight) may be treated at one time. The duration of the combustion treatment is 10 minutes or less. Figure 3 is a photograph of the burn pan.



Figure 3. EWTF burn pan, covered. (UCRL-Photo-213179, July 16, 2005)

The burn cage is used for the treatment of explosives-containing process waste sludge, explosives-contaminated packaging, and explosives-contaminated laboratory waste. The explosive content of the material treated in the burn cage ranges from 1 to 80 percent. The burn cage is an 8-foot-diameter, ventilated, metal enclosure with a refractory lining and an elevated metal base. Propane fuel from a protected supply tank is supplied to the burn cage to assist the combustion process. No more than 260 pounds (118 kg) of total waste and 50 pounds (23 kg) net explosive waste may be treated in the burn cage at one time. Combustion treatments at the burn cage are completed in 35 minutes. Figure 4 is a photograph of the burn cage.

EWTF operations and controls are handled from a concrete and steel control bunker at Building 845 (see Figure 5).



Figure 4. EWTF burn cage. (UCRL-Photo-213179, July 16, 2005)



Figure 5. EWTF control bunker (Building 845A). Detonation pad is in the background.

Figure 6 is a site map for Site 300, showing the central location of the EWTF; this location maximizes the distance to off-site receptors. The inset in Figure 6 shows the relative locations of the detonation pad, the burn pan, and the burn cage.

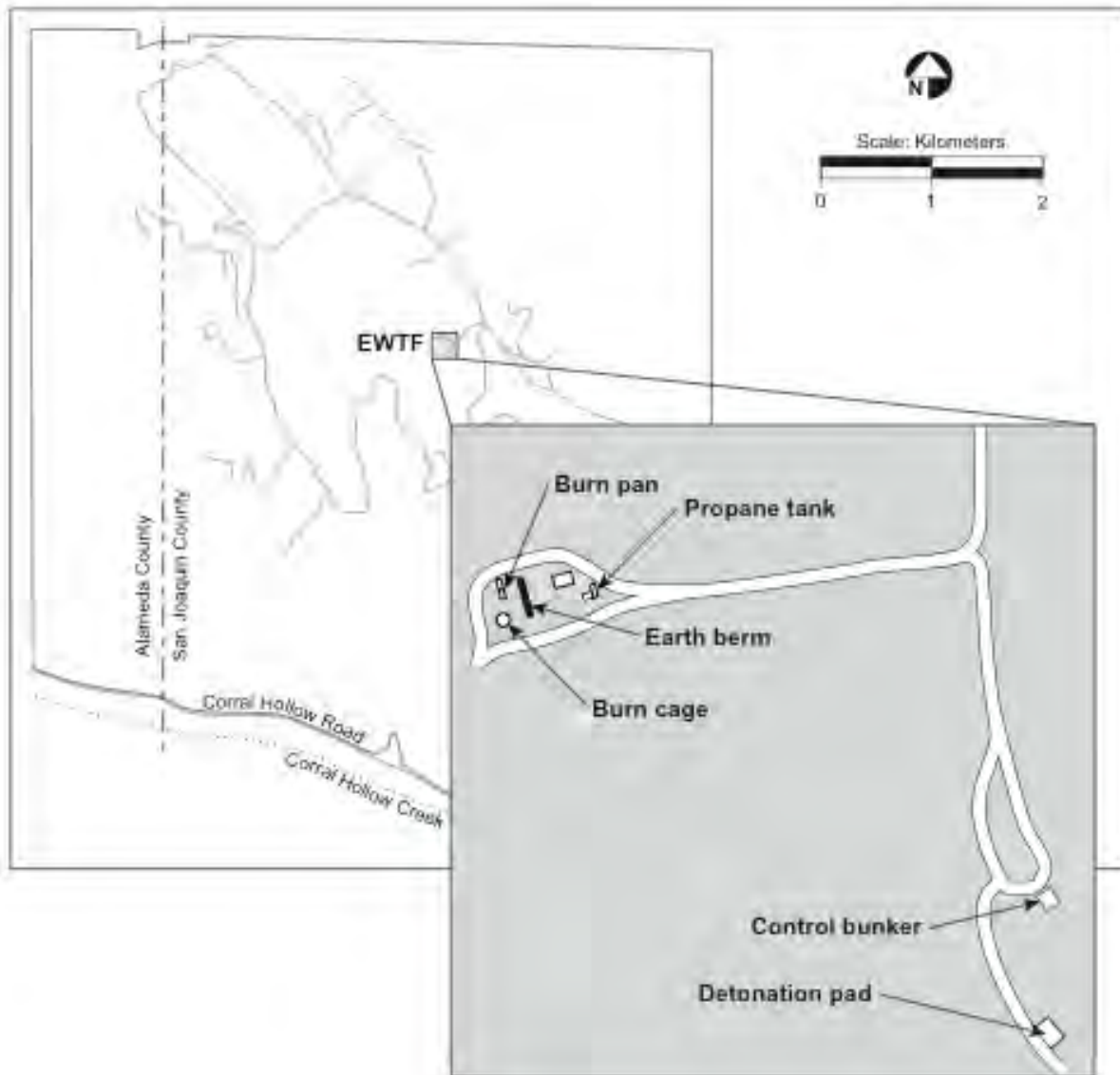


Figure 6. Location of the EWTF at Site 300.

3. Approach

The standard approach for a human health risk assessment is a four-step process stated by the National Academy of Sciences in *Risk Assessment in the Federal Government: Managing the Process* (NAS, 1983) and reiterated in *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments* (Office of Environmental Health Hazard Assessment [OEHHA], 2003). The four steps in the process are (1) hazard identification, (2) exposure assessment, (3) dose-response assessment, and (4) risk characterization.

For the operations at the EWTF, the first step, hazard identification, involves identifying emissions from the operations, i.e., the source term of specific pollutants of concern. Exposure assessment, the second step, involves emission quantification, modeling of environmental transport and fate, identification of exposure routes, identification of maximally exposed individuals, and estimation of short- and long-term exposures. The third step, dose-response assessment, characterizes the relationship between the exposure to a pollutant and any potential resulting health effect. For quantitative theoretical carcinogenic risk assessment, the dose-response relationship is estimated using cancer potency factors (CPFs) compiled by OEHHA and the U.S. Environmental Protection Agency (U.S. EPA) to calculate the theoretical risk of cancer associated with the estimated exposure. For non-carcinogenic acute and chronic effects, the dose-response relationship is quantified by comparison of modeled air concentrations with OEHHA- and U.S. EPA-defined acute and chronic reference exposure levels (RELs) for the inhalation pathway; and for the ingestion pathway, modeled dose is compared with a reference dose (RfD). The fourth and final step, risk characterization, combines the modeled exposures of the specific pollutants of concern with the dose-response relationship defined by a regulatory authority to estimate the potential health risks associated with the exposures. Each of these steps is discussed in this risk assessment.

3.1 Hazard Identification

The EWTF is a support facility at LLNL's Site 300 where wastes resulting from research activities involving explosives are treated. Most of the explosive wastes treated at Site 300 involve high explosives, such as the compounds Research Department Explosive (RDX), high melting explosive (HMX), and pentaerythritol tetranitrate (PETN), in a variety of formulations. Explosives other than high explosives are treated more rarely. The wastes treated at the EWTF are categorized into four forms described below:

Form 1 Waste. Waste explosives that, because of configuration or composition, are best treated by open detonation. Examples are explosive assemblies or devices that may detonate during open burning.

Form 2 Waste. Waste explosives that, because of configuration or composition, are best treated by open burning in the open burn pan. Examples are explosive parts and pieces generated during explosives formulation, processing, testing, or by removal from inventory.

Form 3 Waste. Waste explosives that, because of configuration or composition, are best treated by open burning in the thermal treatment unit (burn cage). Examples are wet machine fines generated during explosives processing, wet explosives-contaminated sludge from weirs and settling basins, and wet expendable filters from recycle systems.

Form 4 Waste. Waste material contaminated with energetic materials that are best treated by open burning in the thermal treatment unit (burn cage). Examples are paper, rags, plastic tubing, dry expendable filters from vacuum systems, and personal protective equipment used in explosives operations. The waste is judged to retain explosives hazards and is, therefore, considered to be a reactive waste.

Current permit limits allow 100 open detonations (Form 1 waste) and 100 open burn treatments (Forms 2, 3, or 4) annually. Table 1 presents the maximum mass amounts of treated material by treatment unit and waste form.

Table 1. Mass amounts of treated material by treatment unit and waste form.

Treatment unit/Waste form	Annual number of treatments	Maximum single treatment (lb)	Annual treatment (lb)
Detonation Pad/Form 1	100	350	35,000
Burn Pan/Form 2		100	10,000 ^a
Burn Cage/Form 3	100	50	5,000 ^a
Burn Cage/Form 4		260	26,000 ^a

^a Assuming 100 treatments at each unit; no accounting is made for the allocation of 100 permitted burn treatments among the three burn treatment options.

The estimation of potential emissions for explosives wastes is a subject of interest to both the EPA and the U.S. Department of Defense (DoD). The DoD has been seriously studying emissions from OB/OD operations since 1984. In the first comprehensive test, helicopters equipped with air sampling equipment were flown through plumes from OB and OD tests. The results were inconclusive. In 1988, the DoD began a series of studies that were contained in a large chamber called a “BangBox” at Sandia National Laboratories, Albuquerque, NM. After the first two studies, “the DoD concluded that the emission factors derived from the BangBox tests were: (1) more reliable and reproducible than those from the field tests; (2) were [*sic*] statistically equivalent to these determined from the field tests; and (3) supported the original assumption that the detonations and burns were producing emission products consistent with detonation theory” (Mitchell and Suggs, 1998, p. 9). The DoD also determined that the materials emitted from field tests and BangBox studies were similar for all materials tested and were primarily N₂, CO₂, H₂O, particles, metals, and small quantities of CO, NO, NO₂, low molecular weight volatile organic compounds (VOCs) and semi-volatile organic compounds (SVOCs) often found in ambient air.

In 1992, the EPA agreed to accept emission factors for OB/OD based on BangBox studies. The DoD built a BangBox at Dugway Proving Grounds in Dugway, UT, and conducted an additional series of studies that encompassed the open burning of 16 energetic materials and open detonation of 23 energetic materials. In 1998, EPA released a report summarizing the results and presenting emissions factors for OB/OD

operations (Mitchell and Suggs, 1998). These emissions factors were incorporated into the Open Burn/Open Detonation Dispersion Model (OBODM) developed expressly for modeling OB/OD operations (Bjorklund et al., 1998). The emission factors in the OBODM were used to characterize air emissions due to the EWTF treatment activities.

Table 2 lists all 39 energetic materials that are contained in the OBODM. Although some of the 39 energetic materials are not treated at the EWTF, they are listed for completeness so that the method for source term identification would be totally transparent. Table 2 also lists the EWTF waste form in which the materials could be found, the methods by which the materials can be treated at the EWTF, and the frequency that the materials are treated at the EWTF. As seen in Table 2, three materials are routinely treated, 15 materials are treated with less than 5 percent frequency, and six materials are treated with less than 1 percent frequency. Two other materials could be treated after additional internal review, but they are not expected to be treated. Thirteen other materials are not treated at the EWTF.

This risk assessment used a reasonable¹ yet conservative approach to characterize air emissions due to EWTF treatment activities (i.e., emissions from Form 1 waste treatment at the detonation pad, Form 2 waste treatment at the burn pan, Form 3 waste treatment at the burn cage, and Form 4 waste treatment at the burn cage). First, a subset of the energetic materials contained in the OBODM, with similar compositions to those treated at the EWTF, was identified. Second, the identified materials were mapped to the EWTF waste form in which they could be present. Third, the energetic materials (and their emission factors) were grouped by type of treatment and waste form. For example, the energetic materials (and their emission factors) for Form 1 waste treatment at the detonation pad include TNT, RDX, Explosive D, Composition B, Tritanol, Amatol, HBX, etc. (see Table 2). Finally, the maximum chemical-specific emission factor was selected for each type of treatment and waste form.

¹ This is similar to the approach taken by the U.S. Navy and affirmed by the Agency for Toxic Substances Disease Registry (ATSDR) in evaluating emissions from Isla de Vieques, Puerto Rico, bombing range (http://www.atsdr.cdc.gov/HAC/PHA/vieques4/vbr_p5.html): "ATSDR further believes the Navy contractor's approach used to select emission factors from the available Bangbox studies was appropriate. For instance, to characterize emissions from air-to-ground exercises, the Navy contractor first identified the subset of Bangbox studies that tested explosives with similar compositions to those used at Vieques, and then selected the highest emission factor for every chemical from the various tests. As a result, the emission factors used are the highest measured releases of chemical by-products from the available Bangbox studies."

Table 2. Materials tested in the BangBox experiments, the treatment frequency at the EWTF, type of treatment at the EWTF, and associated EWTF waste form.

Tested material	Frequency of material ^a treatment at the EWTF	Type of treatment at the EWTF	EWTF waste form
TNT (2,4,6-Trinitrotoluene)	Routinely treated	Detonation Pad (Form 1), Burn Pan (Form 2)	1 and 2
RDX (cyclotrimethylenetrinitramine)	Routinely treated	Detonation Pad (Form 1), Burn Pan (Form 2)	1 and 2
Manufacturer's Waste (65% propell.)	Routinely treated	Burn Cage	3 and 4
Triple Base (M30-28% Nitrocellulose)	<5%	Burn Pan	2
M1 (85% Nitrocellulose)	<5%	Burn Pan	2
Double Base (50% nitrocellulose)	<5%	Burn Pan	2
Propellant, ammonium perc., alum.	<5%	Burn Pan	2
Propellant, ammonium perc., nonal.	<5%	Burn Pan	2
Propellant, M-43	<5%	Burn Pan	2
Propellant, M-9	<5%	Burn Pan	2
Propellant, MK-23	<5%	Burn Pan	2
Propellant, M31A1E1	<5%	Burn Pan	2
Propellant, PBXN-110	<5%	Burn Pan	2
Smokeless Powder	<5%	Burn Pan	2
Propellant, Composite (MK-6)	<5%	Burn Pan	2
Propellant, M-3	<5%	Burn Pan	2
M6 (87.7% Nitrocellulose)	<5%	Burn Pan	2
Explosive D (ammonium picrate)	<5%	Detonation Pad (Form 1), Burn Pan (Form 2)	1 and 2
Composition B (56/38/6 RDX-TNT-WAX)	<1%	Detonation Pad	1
Tritonal (79% TNT, 21% Aluminum)	<1%	Detonation Pad	1
Tritonal with 2.5% Calcium Stearate	<1%	Detonation Pad	1
Amatol (50% TNT, 50% Ammn. Nitrate)	<1%	Detonation Pad	1
HBX (48/31/17/4 RDX-TNT-AI-WAX)	<1%	Detonation Pad	1
Propellant, Smokey Sam	<1%	Burn Pan	2
Detonating train	Only with additional internal review	Detonation Pad	1
40 mm HEI Cartridge	Only with additional internal review	Detonation Pad	1
Ground Illum. Signal, Red Star, M158	Not treated	Not treated	Not applicable
Signal, Illum, Arcrft, Rd Str, AN-M43A2	Not treated	Not treated	Not applicable
20 mm HEI Cartridge	Not treated	Not treated	Not applicable

Tested material	Frequency of material ^a treatment at the EWTF	Type of treatment at the EWTF	EWTF waste form
Impluse Cartridge, ARD 446-1	Not treated	Not treated	Not applicable
Impluse BBU-368 Cartridge	Not treated	Not treated	Not applicable
GGU-2/A Gas prss Prop. Act. Gen.	Not treated	Not treated	Not applicable
Impulse Cartridge, MK107 MOD01	Not treated	Not treated	Not applicable
Fuze, Inertia Tail, Bomb, FMU 54A/B	Not treated	Not treated	Not applicable
Flare, Cntermeas., Aircraft, M206	Not treated	Not treated	Not applicable
Fuze, Bomb, Tail, FMU 139A/B	Not treated	Not treated	Not applicable
Mine, Claymore, M18A1	Not treated	Not treated	Not applicable
T45E7 Adapter Booster	Not treated	Not treated	Not applicable
Diesel and Dunnage	Not treated	Not treated	Not applicable

^a Material representative of materials treated at the EWTF.

The resulting emissions factors by type of treatment are presented in Table 3. As previously mentioned, the detonation pad only treats Form 1 wastes, the burn pan treats only Form 2 wastes and the burn cage treats only Form 3 and Form 4 wastes.

The emissions factors were used to calculate maximum hourly and annual average emissions from the EWTF. Maximum hourly emissions were calculated as follows: The maximum treatment amount for a single treatment was multiplied times the emission factor for each emitted chemical for each waste form. Annual average emissions were calculated in a similar manner: The annual treatment amount was multiplied by the emission factor for each emitted chemical for each waste form.

Table 3. Emissions factors for the burn pan, burn cage, and detonation pad at the EWTF.

Analyte ID	Analyte name	Burn pan emission factor (lb/lb)	Burn cage emission factor (lb/lb)	Detonation pad emission factor (lb/lb)
67562-39-4	1,2,3,4,6,7,8-Heptachlorodibenzofuran		3.40E-08	
55673-89-7	1,2,3,4,7,8,9-Heptachlorodibenzofuran		7.90E-09	
70648-26-9	1,2,3,4,7,8-Hexachlorodibenzofuran		2.10E-08	
57117-44-9	1,2,3,6,7,8-Hexachlorodibenzofuran		9.50E-09	
39001-02-0	Octachlorinated dibenzofuran		4.00E-08	
106-99-0	1,3-Butadiene	1.70E-06		9.00E-06
121-14-2	2,4-Dinitrotoluene	1.20E-09		
606-20-2	2,6-Dinitrotoluene	1.00E-10		
95-57-8	2-Chlorophenol	1.00E-05		
7429-90-5	Aluminum	1.10E-02	3.60E-02	2.50E-02
7440-36-0	Antimony	6.70E-07		6.70E-07
7440-39-3	Barium	8.20E-03	8.60E-05	8.20E-03
71-43-2	Benzene	1.20E-04	4.50E-04	1.10E-04

Analyte ID	Analyte name	Burn pan emission factor (lb/lb)	Burn cage emission factor (lb/lb)	Detonation pad emission factor (lb/lb)
7440-43-9	Cadmium	4.00E-05		4.00E-05
56-23-5	Carbon tetrachloride	1.10E-06	5.60E-06	4.50E-06
67-66-3	Chloroform	4.20E-07	2.30E-06	3.80E-07
7440-47-3	Chromium ^a	4.80E-05		8.80E-05
7782-50-5	Cl ₂	9.20E-03	2.00E-04	
630-08-0	CO	7.20E-02	2.00E-02	5.30E-02
7440-50-8	Copper	3.70E-02	1.50E-05	8.90E-03
110-82-7	Cyclohexane	1.60E-06	2.00E-06	7.50E-06
122-39-4	Diphenylamine	2.60E-10		
75-00-3	Ethyl chloride			6.90E-07
100-41-4	Ethylbenzene	1.20E-06	2.40E-06	2.50E-06
206-44-0	Fluoranthene		2.00E-04	
7647-01-0	HCL	2.15E-01	8.30E-02	
98-82-8	i-Propylbenzene			7.30E-07
7439-92-1	Lead	1.20E-02	2.80E-04	1.10E-03
74-87-3	Methyl chloride	5.70E-06	2.00E-05	7.50E-07
71-55-6	Methyl chloroform			3.80E-07
108-87-2	Methylcyclohexane	5.10E-06	8.00E-06	7.00E-06
75-09-2	Methylenechloride	1.80E-04	1.20E-05	8.70E-04
91-20-3	Naphthalene	7.50E-08		
110-54-3	n-Hexane	1.90E-05	4.80E-06	1.90E-05
10102-44-0	Nitrogen dioxide (peroxide)	5.20E-03	6.60E-06	4.40E-03
78-11-5	Pentaerythritol tetranitrate (PETN)			5.60E-04
108-95-2	Phenol	3.43E-09		
115-07-1	Propene	7.20E-06	2.60E-05	7.30E-05
121-82-4	RDX	9.60E-06		7.40E-03
100-42-5	Styrene	1.50E-06		4.20E-05
7446-09-5	Sulfur dioxide	3.20E-03	8.60E-04	1.10E-03
127-18-4	Tetrachloroethylene		1.70E-06	1.80E-05
108-88-3	Toluene	8.60E-06	2.80E-05	2.60E-05
75-01-4	Vinyl chloride	1.50E-06		1.30E-06
7440-66-6	Zinc	4.00E-05	5.70E-04	1.10E-03
208-96-8	Acenaphthylene		1.60E-04	
86-57-7	n-Nitronaphthalene	1.40E-10		
620-14-4	m-Ethyltoluene	2.00E-06	2.60E-06	4.80E-07
622-96-8	p-Ethyltoluene	7.10E-06	5.00E-06	7.60E-06
106-98-9	1-Butene	1.60E-06	8.30E-06	3.10E-05

Analyte ID	Analyte name	Burn pan emission factor (lb/lb)	Burn cage emission factor (lb/lb)	Detonation pad emission factor (lb/lb)
592-41-6	1-Hexene			2.40E-05
109-67-1	1-Pentene	1.40E-06	5.10E-06	1.40E-05
74-86-2	Acetylene	8.30E-04	1.60E-03	1.30E-04
627-20-3	cis-2-Pentene	4.60E-07	5.60E-07	8.30E-07
287-92-3	Cyclopentane	4.70E-07	2.50E-07	1.70E-06
142-29-0	Cyclopentene	4.60E-07	9.40E-07	3.70E-06
74-84-0	Ethane	1.30E-06	9.50E-06	3.00E-05
74-85-1	Ethylene	7.20E-05	2.30E-04	3.90E-04
75-28-5	i-Butane	4.60E-07	1.40E-06	1.60E-06
115-11-7	i-Butene	1.00E-05	5.80E-06	2.40E-05
78-78-4	i-Pentane	2.60E-06	2.30E-05	9.10E-06
74-82-8	Methane	8.00E-03		2.40E-03
96-37-7	Methylcyclopentane	2.50E-06	1.10E-06	9.10E-06
106-97-8	n-Butane	4.80E-07	9.30E-06	3.10E-06
124-18-5	n-Decane	5.90E-06	1.40E-05	5.20E-06
142-82-5	n-Heptane	2.00E-06	4.70E-06	5.00E-06
111-84-2	n-Nonane	1.20E-06	1.30E-05	1.90E-06
111-65-9	n-Octane	2.90E-06	7.60E-06	3.60E-06
109-66-0	n-Pentane	3.30E-06	4.30E-06	1.30E-05
74-98-6	Propane	1.60E-06	4.50E-06	4.70E-06
624-64-6	trans-2-Butene	2.40E-06	2.10E-05	4.50E-06
646-04-8	trans-2-Pentene	4.60E-07	9.60E-07	5.00E-06

^a Total Chromium

Also worthy of comment is the selection of emissions factors to represent Form 4 waste. The treatment of Form 4 waste in the burn cage was represented by the Bjorklund et al. (1998) emissions factors for ammonium perchlorate (AP) manufacturing waste surrogate. The AP manufacturing waste surrogate included plastic gloves, cotton rags, paper, wood, and similar material, and was burned using diesel fuel (Mitchell and Suggs, 1998). The burn cage at the EWTF does not use diesel fuel, but rather propane. It is expected that the combustion temperatures of propane minimize dioxin and furan formation; nevertheless, furan species were included for purposes of conservatism. Among the possible materials that could be used to represent Form 4 waste, the AP manufacturing waste surrogate is the most reasonable choice.

The resulting maximum hourly and annual average emissions for each waste form are shown in Tables 4 and 5. Although only a total of 100 burn treatments are permitted, all burn operations were calculated at 100 burns per year at this point in the assessment to enable comparison of effects later in the analysis.

Table 4. Maximum hourly (pound/hour) estimated emissions for the burn pan, burn cage (Forms 3 and 4), and detonation pad at the EWTF.

Analyte ID	Analyte name	Burn pan	Burn cage Form 3	Burn cage Form 4	Detonation pad
67562-39-4	1,2,3,4,6,7,8-HpCDF	0.00E+00	1.70E-06	8.84E-06	0.00E+00
55673-89-7	1,2,3,4,7,8,9-HpCDF	0.00E+00	3.95E-07	2.05E-06	0.00E+00
70648-26-9	1,2,3,4,7,8-HxCDF	0.00E+00	1.05E-06	5.46E-06	0.00E+00
57117-44-9	1,2,3,6,7,8-HxCDF	0.00E+00	4.75E-07	2.47E-06	0.00E+00
39001-02-0	OCDF	0.00E+00	2.00E-06	1.04E-05	0.00E+00
106-99-0	1,3-Butadiene	1.70E-04	0.00E+00	0.00E+00	3.15E-03
121-14-2	2,4-Dinitrotoluene	1.20E-07	0.00E+00	0.00E+00	0.00E+00
606-20-2	2,6-Dinitrotoluene	1.00E-08	0.00E+00	0.00E+00	0.00E+00
95-57-8	2-Chlorophenol	1.00E-03	0.00E+00	0.00E+00	0.00E+00
7429-90-5	Aluminum	1.10E+00	1.80E+00	9.36E+00	8.75E+00
7440-36-0	Antimony	6.70E-05	0.00E+00	0.00E+00	2.35E-04
7440-39-3	Barium	8.20E-01	4.30E-03	2.24E-02	2.87E+00
71-43-2	Benzene	1.20E-02	2.25E-02	1.17E-01	3.85E-02
7440-43-9	Cadmium	4.00E-03	0.00E+00	0.00E+00	1.40E-02
56-23-5	Carbon tetrachloride	1.10E-04	2.80E-04	1.46E-03	1.58E-03
67-66-3	Chloroform	4.20E-05	1.15E-04	5.98E-04	1.33E-04
7440-47-3	Chromium	4.80E-03	0.00E+00	0.00E+00	3.08E-02
7782-50-5	Cl ₂	9.20E-01	1.00E-02	5.20E-02	0.00E+00
630-08-0	CO	7.20E+00	1.00E+00	5.20E+00	1.86E+01
7440-50-8	Copper	3.70E+00	7.50E-04	3.90E-03	3.12E+00
110-82-7	Cyclohexane	1.60E-04	1.00E-04	5.20E-04	2.63E-03
122-39-4	Diphenylamine	2.60E-08	0.00E+00	0.00E+00	0.00E+00
75-00-3	Ethyl chloride	0.00E+00	0.00E+00	0.00E+00	2.42E-04
100-41-4	Ethylbenzene	1.20E-04	1.20E-04	6.24E-04	8.75E-04
206-44-0	Fluoranthene	0.00E+00	1.00E-02	5.20E-02	0.00E+00
7647-01-0	HCL	2.15E+01	4.15E+00	2.16E+01	0.00E+00
98-82-8	i-Propylbenzene	0.00E+00	0.00E+00	0.00E+00	2.56E-04
7439-92-1	Lead	1.20E+00	1.40E-02	7.28E-02	3.85E-01
74-87-3	Methyl chloride	5.70E-04	1.00E-03	5.20E-03	2.63E-04
71-55-6	Methyl chloroform	0.00E+00	0.00E+00	0.00E+00	1.33E-04
108-87-2	Methylcyclohexane	5.10E-04	4.00E-04	2.08E-03	2.45E-03
75-09-2	Methylenechloride	1.80E-02	6.00E-04	3.12E-03	3.05E-01
91-20-3	Naphthalene	7.50E-06	0.00E+00	0.00E+00	0.00E+00
110-54-3	n-Hexane	1.90E-03	2.40E-04	1.25E-03	6.65E-03
10102-44-0	Nitrogen dioxide (peroxide)	5.20E-01	3.30E-04	1.72E-03	1.54E+00
78-11-5	Pentaerythritol	0.00E+00	0.00E+00	0.00E+00	1.96E-01

Analyte ID	Analyte name	Burn pan	Burn cage Form 3	Burn cage Form 4	Detonation pad
	tetranitrate (PETN)				
108-95-2	Phenol	3.43E-07	0.00E+00	0.00E+00	0.00E+00
115-07-1	Propene	7.20E-04	1.30E-03	6.76E-03	2.56E-02
121-82-4	RDX	9.60E-04	0.00E+00	0.00E+00	2.59E+00
100-42-5	Styrene	1.50E-04	0.00E+00	0.00E+00	1.47E-02
7446-09-5	Sulfur dioxide	3.20E-01	4.30E-02	2.24E-01	3.85E-01
127-18-4	Tetrachloroethylene	0.00E+00	8.50E-05	4.42E-04	6.30E-03
108-88-3	Toluene	8.60E-04	1.40E-03	7.28E-03	9.10E-03
75-01-4	Vinyl chloride	1.50E-04	0.00E+00	0.00E+00	4.55E-04
7440-66-6	Zinc	4.00E-03	2.85E-02	1.48E-01	3.85E-01
208-96-8	Acenaphthylene	0.00E+00	8.00E-03	4.16E-02	0.00E+00
86-57-7	n-Nitronaphthalene	1.40E-08	0.00E+00	0.00E+00	0.00E+00
620-14-4	m-Ethyltoluene	2.00E-04	1.30E-04	6.76E-04	1.68E-04
622-96-8	p-Ethyltoluene	7.10E-04	2.50E-04	1.30E-03	2.66E-03
106-98-9	1-Butene	1.60E-04	4.15E-04	2.16E-03	1.09E-02
592-41-6	1-Hexene	0.00E+00	0.00E+00	0.00E+00	8.40E-03
109-67-1	1-Pentene	1.40E-04	2.55E-04	1.33E-03	4.90E-03
74-86-2	Acetylene	8.30E-02	8.00E-02	4.16E-01	4.55E-02
627-20-3	cis-2-Pentene	4.60E-05	2.80E-05	1.46E-04	2.91E-04
287-92-3	Cyclopentane	4.70E-05	1.25E-05	6.50E-05	5.95E-04
142-29-0	Cyclopentene	4.60E-05	4.70E-05	2.44E-04	1.30E-03
74-84-0	Ethane	1.30E-04	4.75E-04	2.47E-03	1.05E-02
74-85-1	Ethylene	7.20E-03	1.15E-02	5.98E-02	1.37E-01
75-28-5	i-Butane	4.60E-05	7.00E-05	3.64E-04	5.60E-04
115-11-7	i-Butene	1.00E-03	2.90E-04	1.51E-03	8.40E-03
78-78-4	i-Pentane	2.60E-04	1.15E-03	5.98E-03	3.19E-03
74-82-8	Methane	8.00E-01	0.00E+00	0.00E+00	8.40E-01
96-37-7	Methylcyclopentane	2.50E-04	5.50E-05	2.86E-04	3.19E-03
106-97-8	n-Butane	4.80E-05	4.65E-04	2.42E-03	1.09E-03
124-18-5	n-Decane	5.90E-04	7.00E-04	3.64E-03	1.82E-03
142-82-5	n-Heptane	2.00E-04	2.35E-04	1.22E-03	1.75E-03
111-84-2	n-Nonane	1.20E-04	6.50E-04	3.38E-03	6.65E-04
111-65-9	n-Octane	2.90E-04	3.80E-04	1.98E-03	1.26E-03
109-66-0	n-Pentane	3.30E-04	2.15E-04	1.12E-03	4.55E-03
74-98-6	Propane	1.60E-04	2.25E-04	1.17E-03	1.65E-03
624-64-6	trans-2-Butene	2.40E-04	1.05E-03	5.46E-03	1.58E-03
646-04-8	trans-2-Pentene	4.60E-05	4.80E-05	2.50E-04	1.75E-03

Table 5. Maximum annual (pound/year) estimated emissions for the burn pan, burn cage (Forms 3 and 4), and detonation pad at the EWTF

Analyte ID	Analyte name	Burn pan	Burn cage Form 3	Burn cage Form 4	Detonation pad
67562-39-4	1234678-HpCDF	0.00E+00	1.70E-04	8.84E-04	0.00E+00
55673-89-7	1234789-HpCDF	0.00E+00	3.95E-05	2.05E-04	0.00E+00
70648-26-9	123478-HxCDF	0.00E+00	1.05E-04	5.46E-04	0.00E+00
57117-44-9	123678-HxCDF	0.00E+00	4.75E-05	2.47E-04	0.00E+00
39001-02-0	OCDF	0.00E+00	2.00E-04	1.04E-03	0.00E+00
106-99-0	1,3-Butadiene	1.70E-02	0.00E+00	0.00E+00	3.15E-01
121-14-2	2,4-Dinitrotoluene	1.20E-05	0.00E+00	0.00E+00	0.00E+00
606-20-2	2,6-Dinitrotoluene	1.00E-06	0.00E+00	0.00E+00	0.00E+00
95-57-8	2-Chlorophenol	1.00E-01	0.00E+00	0.00E+00	0.00E+00
7429-90-5	Aluminum	1.10E+02	1.80E+02	9.36E+02	8.75E+02
7440-36-0	Antimony	6.70E-03	0.00E+00	0.00E+00	2.35E-02
7440-39-3	Barium	8.20E+01	4.30E-01	2.24E+00	2.87E+02
71-43-2	Benzene	1.20E+00	2.25E+00	1.17E+01	3.85E+00
7440-43-9	Cadmium	4.00E-01	0.00E+00	0.00E+00	1.40E+00
56-23-5	Carbon tetrachloride	1.10E-02	2.80E-02	1.46E-01	1.58E-01
67-66-3	Chloroform	4.20E-03	1.15E-02	5.98E-02	1.33E-02
7440-47-3	Chromium	4.80E-01	0.00E+00	0.00E+00	3.08E+00
7782-50-5	Cl ₂	9.20E+01	1.00E+00	5.20E+00	0.00E+00
630-08-0	CO	7.20E+02	1.00E+02	5.20E+02	1.86E+03
7440-50-8	Copper	3.70E+02	7.50E-02	3.90E-01	3.12E+02
110-82-7	Cyclohexane	1.60E-02	1.00E-02	5.20E-02	2.63E-01
122-39-4	Diphenylamine	2.60E-06	0.00E+00	0.00E+00	0.00E+00
75-00-3	Ethyl chloride	0.00E+00	0.00E+00	0.00E+00	2.42E-02
100-41-4	Ethylbenzene	1.20E-02	1.20E-02	6.24E-02	8.75E-02
206-44-0	Fluoranthene	0.00E+00	1.00E+00	5.20E+00	0.00E+00
7647-01-0	HCL	2.15E+03	4.15E+02	2.16E+03	0.00E+00
98-82-8	i-Propylbenzene	0.00E+00	0.00E+00	0.00E+00	2.56E-02
7439-92-1	Lead	1.20E+02	1.40E+00	7.28E+00	3.85E+01
74-87-3	Methyl chloride	5.70E-02	1.00E-01	5.20E-01	2.63E-02
71-55-6	Methyl chloroform	0.00E+00	0.00E+00	0.00E+00	1.33E-02
108-87-2	Methylcyclohexane	5.10E-02	4.00E-02	2.08E-01	2.45E-01
75-09-2	Methylenechloride	1.80E+00	6.00E-02	3.12E-01	3.05E+01
91-20-3	Naphthalene	7.50E-04	0.00E+00	0.00E+00	0.00E+00
110-54-3	n-Hexane	1.90E-01	2.40E-02	1.25E-01	6.65E-01
10102-44-0	Nitrogen dioxide (peroxide)	5.20E+01	3.30E-02	1.72E-01	1.54E+02

Analyte ID	Analyte name	Burn pan	Burn cage Form 3	Burn cage Form 4	Detonation pad
78-11-5	Pentaerythritol tetranitrate (PETN)	0.00E+00	0.00E+00	0.00E+00	1.96E+01
108-95-2	Phenol	3.43E-05	0.00E+00	0.00E+00	0.00E+00
115-07-1	Propene	7.20E-02	1.30E-01	6.76E-01	2.56E+00
121-82-4	RDX	9.60E-02	0.00E+00	0.00E+00	2.59E+02
100-42-5	Styrene	1.50E-02	0.00E+00	0.00E+00	1.47E+00
7446-09-5	Sulfur dioxide	3.20E+01	4.30E+00	2.24E+01	3.85E+01
127-18-4	Tetrachloroethylene	0.00E+00	8.50E-03	4.42E-02	6.30E-01
108-88-3	Toluene	8.60E-02	1.40E-01	7.28E-01	9.10E-01
75-01-4	Vinyl chloride	1.50E-02	0.00E+00	0.00E+00	4.55E-02
7440-66-6	Zinc	4.00E-01	2.85E+00	1.48E+01	3.85E+01
208-96-8	Acenaphthylene	0.00E+00	8.00E-01	4.16E+00	0.00E+00
86-57-7	n-Nitronaphthalene	1.40E-06	0.00E+00	0.00E+00	0.00E+00
620-14-4	m-Ethyltoluene	2.00E-02	1.30E-02	6.76E-02	1.68E-02
622-96-8	p-Ethyltoluene	7.10E-02	2.50E-02	1.30E-01	2.66E-01
106-98-9	1-Butene	1.60E-02	4.15E-02	2.16E-01	1.09E+00
592-41-6	1-Hexene	0.00E+00	0.00E+00	0.00E+00	8.40E-01
109-67-1	1-Pentene	1.40E-02	2.55E-02	1.33E-01	4.90E-01
74-86-2	Acetylene	8.30E+00	8.00E+00	4.16E+01	4.55E+00
627-20-3	cis-2-Pentene	4.60E-03	2.80E-03	1.46E-02	2.91E-02
287-92-3	Cyclopentane	4.70E-03	1.25E-03	6.50E-03	5.95E-02
142-29-0	Cyclopentene	4.60E-03	4.70E-03	2.44E-02	1.30E-01
74-84-0	Ethane	1.30E-02	4.75E-02	2.47E-01	1.05E+00
74-85-1	Ethylene	7.20E-01	1.15E+00	5.98E+00	1.37E+01
75-28-5	i-Butane	4.60E-03	7.00E-03	3.64E-02	5.60E-02
115-11-7	i-Butene	1.00E-01	2.90E-02	1.51E-01	8.40E-01
78-78-4	i-Pentane	2.60E-02	1.15E-01	5.98E-01	3.19E-01
74-82-8	Methane	8.00E+01	0.00E+00	0.00E+00	8.40E+01
96-37-7	Methylcyclopentane	2.50E-02	5.50E-03	2.86E-02	3.19E-01
106-97-8	n-Butane	4.80E-03	4.65E-02	2.42E-01	1.09E-01
124-18-5	n-Decane	5.90E-02	7.00E-02	3.64E-01	1.82E-01
142-82-5	n-Heptane	2.00E-02	2.35E-02	1.22E-01	1.75E-01
111-84-2	n-Nonane	1.20E-02	6.50E-02	3.38E-01	6.65E-02
111-65-9	n-Octane	2.90E-02	3.80E-02	1.98E-01	1.26E-01
109-66-0	n-Pentane	3.30E-02	2.15E-02	1.12E-01	4.55E-01
74-98-6	Propane	1.60E-02	2.25E-02	1.17E-01	1.65E-01
624-64-6	trans-2-Butene	2.40E-02	1.05E-01	5.46E-01	1.58E-01
646-04-8	trans-2-Pentene	4.60E-03	4.80E-03	2.50E-02	1.75E-01

Source term estimation is a difficult process for any waste treatment facility because the exact identity of the particular wastes that will be treated cannot be predicted with absolute certainty. The use of emissions factors, such as those presented in Bjorklund et al. (1998), enabled health conservative factors to be identified and used to set an upper bound on the possible future conditions. Further benefits of using the Bjorklund et al. (1998) data are that the data are approved by the U.S. EPA and available to the public, making calculations easily reproducible and transparent.

3.2 Exposure Assessment

3.2.1 Air Dispersion

The release of constituents of concern from OB/OD operations is to air. Generally, air dispersion modeling begins with (1) a stack height and (2) a plume rise associated with any momentum or temperature-induced flux that are added together and called the “effective release height.” However, because open burns and open detonations do not occur in buildings with stacks, the air dispersion models that are commonly used in risk assessment, such as Industrial Source Complex Short-Term (ISCST) model, are not applicable, unless appropriate adjustments are made. Moreover, most air dispersion models assume continuous releases, not short-term releases such as those associated with OB/OD treatments. The Open Burn Open Detonation Dispersion Model (OBODM, Bjorklund et al., 1998) was developed specifically for OB/OD operations. The OBODM takes into account the short-term nature of OB/OD treatments (i. e., quasi-continuous and instantaneous releases) and incorporates unique equations specifically developed to model the effective release height for burns and detonations. This analysis used the OBODM to simulate the atmospheric release and dispersion of the constituents of concern from OB/OD operations at the EWTF.

The OBODM allows the user to input various treatment-specific data, including the mass of the material treated, duration of treatment, and whether the treatment is a burn or detonation. The OBODM allows the user to create a grid of receptors as well as up to 100 individual receptors not on the grid. It can be run in a mode that allows only one meteorological condition, or in a mode that allows many years of meteorological data to be taken into account. There are many output options available to the user; specific options used in this analysis are discussed below.

The OBODM was used to model the four different waste forms/treatments at the EWTF. Waste Form 1 was modeled as an instantaneous open detonation. Waste Forms 2, 3, and 4 were modeled as quasi-continuous open burns. The source material modeled was TNT. TNT was chosen because it had the lowest heat release of the commonly treated munitions, which, in turn, lowers the plume rise and the dispersion and increases the estimated concentrations to the downwind receptors.

The OBODM models one source material and chemical of concern per model run. However, because resulting air concentrations scale linearly with input emission rates, the OBODM output can be scaled to estimate the concentrations of all chemicals of concern for all waste forms. This type of scaling is consistent with the HotSpots Analysis and Reporting Program (HARP) model (described below), which was used to calculate theoretical cancer risks, chronic hazards and acute hazards. Barium was

chosen as the scaling chemical. It was modeled at two different emission factor levels: 0.0082 for Forms 1 and 2 treatments, and at 0.000086 for Forms 3 and 4 treatments. The OBODM outputs were then input to the HARP model for scaling (see Appendix A for a description of the scaling approach). The OBODM and HARP input and output files are contained in Volume 2 (provided on the attached compact disc).

Four individual receptor locations were modeled (see Section 3.2.3) as well as locations necessary to complete the exposure pathways other than inhalation. Because the modeling region is located in complex terrain, the complex terrain option was employed, and the receptor elevations were input to the OBODM. The hours modeled were limited so that no operations would occur prior to 7:00 a.m. or after 6:00 p.m. PST. No limitations on wind speed were incorporated into the modeling because the OBODM warns that if such limitations were attempted the results may be invalidated. (The warning in the OBODM meteorological data limits menu states: "If any value in this menu is changed, program results may be invalid and cannot be supported by the authors of the OBODM program" [Bjorklund et al., 1998].)

Five years (2000-2004) of on-site hourly meteorological data were used in the modeling analysis. The Site 300 meteorological monitoring tower sensors record 15-minute average wind speed (from which average hourly wind speed is calculated), wind direction, sigma theta (standard deviation of the horizontal wind direction), temperature, delta temperature (delta-T is the difference in temperature between 2 and 10 meters), solar radiation and other parameters. The sensors meet or exceed the performance requirements found in the U.S. EPA document, *Meteorological Monitoring Guidance for Regulatory Modeling Applications* (U.S. EPA, 2000). The tower's equipment undergoes annual audits and calibrations. Data completeness for each of the 5 years far exceeds 90 percent. Prior to December 2003, the atmospheric stability class was calculated using the sigma theta and mean wind speed method. After December 2003, the atmospheric stability class was calculated using the solar radiation/delta-T method.

Hourly, site-specific mixing height data are not available for Site 300. Therefore, a reasonable, yet conservative mixing height value of 600 meters was assumed for the entire 5-year dataset. A 600-meter mixing height is reasonable yet conservative choice because 600 meters is lower than the mixing height that would be applied in common practice,² thus resulting in a lower vertical mixing layer, less vertical dispersion and higher air concentrations. For the open burns, maximum plume height is less than 100 meters and, for the open detonations, less than 264 meters; therefore, the use of a 600-meter mixing height ensured that the plume would neither be above the mixing layer where the plume would remain trapped nor mix downward to contribute to ground-level concentrations.

² For mixing heights in rural areas, the common practice is to apply the mean afternoon mixing height given by Holzworth (1972) to stability classes B, C and D, and 1.5 times the mean afternoon mixing height to stability class A (U. S. EPA, 1995). Holzworth (1972) indicates that the annual average afternoon mixing height, for the Site 300 area, is approximately 1200 meters. Following common practice would result in mixing height values of 1600 meters for stability class A and 1200 meters for stability classes B, C and D. Furthermore, the Industrial Source Complex Long-Term model assumes unlimited mixing for stability classes E and F for both rural and urban conditions, and a large value such as 10,000 meters may be input for those classes (U. S. EPA, 1995).

The meteorological data was entered into the OBODM (and ISCST) model-ready format. The meteorological data file (Sit3y5.vec) is on the compact disk provided with this risk assessment.

3.2.2 Receptors

Site 300 is located in a scarcely populated area, and only about 5 percent of the area is developed (see Figure 7). However, two residences are located very near the southern boundary of the site. One is located to the southeast of the Site 300 boundary; the other, the residence of the park rangers for the Carnegie Vehicle Recreation Park, is located near the middle of Site 300's southern boundary. Both locations were evaluated to determine the location of maximum impact. Similarly, two other locations on site at Site 300 were evaluated. These locations were the Building 812 Complex and Building 895 where bystander workers—i.e., workers who are not conducting EWTF operations—are present (see Figure 8).

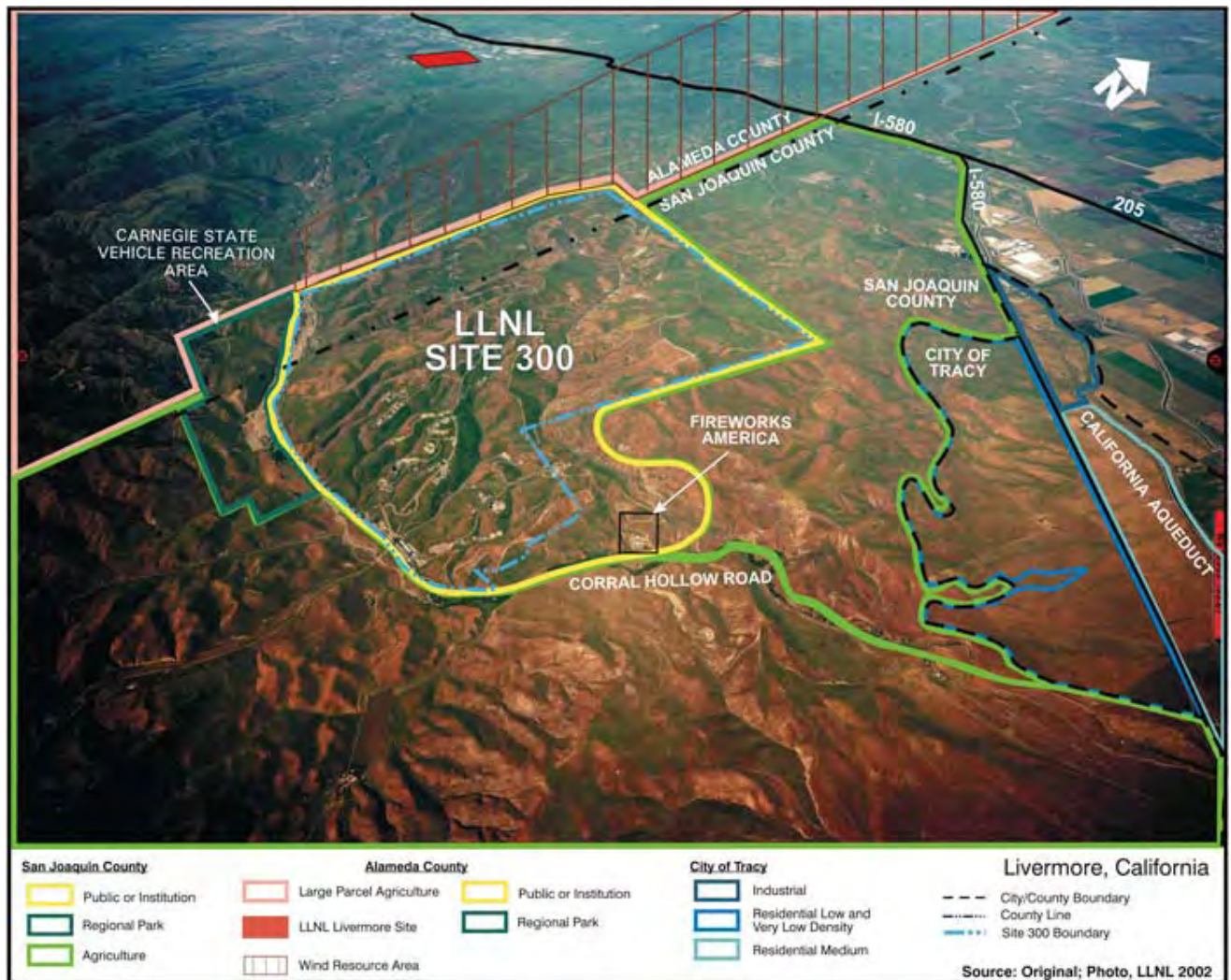


Figure 7. Site 300 environs.

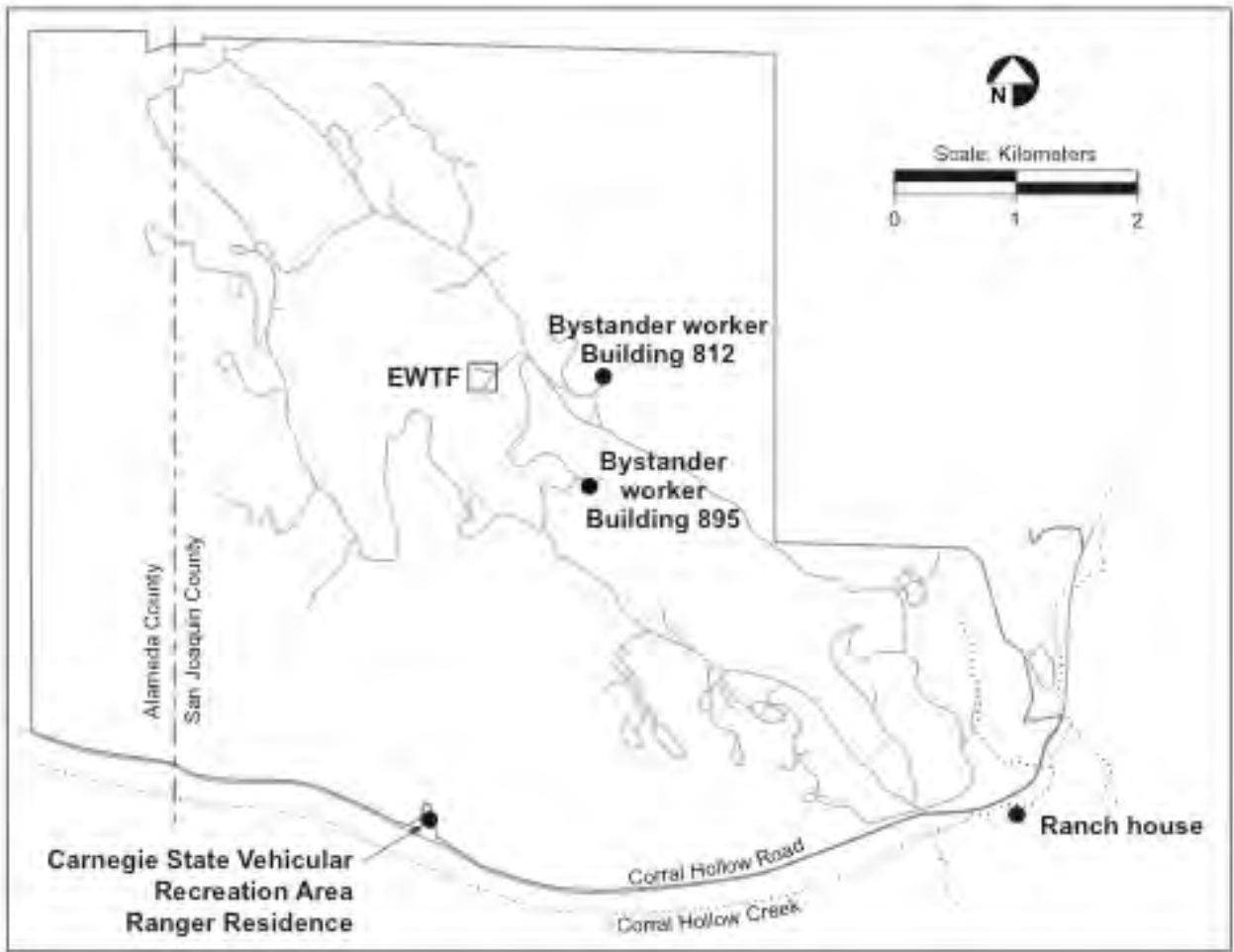


Figure 8. Locations of potentially maximally exposed receptors.

Two types of off-site receptors were evaluated for theoretical carcinogenic risk: a child for the first 9 years of life and a child/adult for a 30-year residence period. A 30-year residency is the 95th-percentile estimate of population mobility stated in the *Exposure Factors Handbook* (U.S. EPA, 1997). The on-site bystander worker was evaluated for a 25-year work duration for theoretical carcinogenic risk—a tenure that is well above the U.S. EPA-recommended occupational tenure value of 6.6 years (U.S. EPA, 1997). For non-carcinogenic hazard, because of the limitations of the risk assessment tool (California Air Resources Board [CARB], 2003), only the adult 70-year exposure was considered.

3.2.3 Exposure Pathways

Inhalation was the primary exposure pathway of concern for all receptors. The residential receptors also have the possibility of dermal exposure, ingestion of homegrown produce and meats, and incidental soil ingestion. Because furans have been included as constituents of concern, this assessment followed OEHHA guidance and evaluated the mother's milk exposure pathway (OEHHA, 2003, p. 5-3).

OEHHA guidance on worker exposure is that those individuals have potential exposure due to incidental soil ingestion and dermal exposure. However, dermal exposure is an exposure pathway for which exposure factors have been developed for outside workers, such as construction workers, gardeners, and utility workers (U.S. EPA, 2004b, p. 3–15). Bystander worker areas identified for the EWTF are for inside workers. In view of the lack of exposure factor data available for indoor workers and the low probability that indoor workers have dermal exposure to soil, this risk assessment did not calculate the dermal exposure pathway for bystander worker. The HARP model (CARB, 2003) was used to calculate theoretical carcinogenic risk and acute and chronic non-carcinogenic hazard. The HARP model, a multi-pathway model, includes calculations for inhalation, ingestion, dermal and mother’s milk pathways. The model contains default CARB/OEHHA-recommended exposure parameters, which, in some cases, can be adjusted to better fit the factual situation. The exposure parameters used in this risk assessment along with their regulatory sources are listed in Table 6. In addition, the HARP model offers a choice of analysis methods for theoretical carcinogenic risk, including average and high-end point estimates and stochastic estimates. For this risk assessment, the high-end point estimate was used, and the high-end exposure parameters are listed in Table 6.

Table 6. Exposure parameters used in the EWTF risk assessment^a.

Exposure parameter	Child (9-year exposure)	Adult resident (30-year exposure)	Adult worker (25-year exposure)
Body weight (kg)	18	63	70
Exposure frequency (d/y)	350	350	245
Inhalation rate [L/(kg•d); 95th percentile]	581 (10.46 m ³ /day)	393 (24.76 m ³ /day)	149 (10.4 m ³ /day)
Soil Loading [mg/(cm ² •d); 95th percentile]	1.0	1.0	1.0
Exposed skin surface area (cm ² ; 95th percentile)	3044	5500	Not applicable
Soil Ingestion Rate [mg/(kg•d)]	8.7	1.7 ^b	0.7 ^c

^a Unless otherwise noted, all parameters are implemented in the HARP (CARB, 2003) as described in OEHHA (2003) and represent high endpoints.

^b Corresponds to 100 mg/day.

^c U.S. EPA, 1997; corresponds to 50 mg/day.

The HARP (CARB, 2003) contains detailed calculations for the ingestion pathway, including the portions of the various types of foods ingested and the uptake of contaminants by agricultural animals. The home-produced fractions of the diet were adjusted to reflect local conditions. Table 7 shows the fractions that were changed for this risk assessment and their default values. (Although some of the default factors were set at 1, a common screening model representation of a hypothetical exposure, it is unlikely that any individual in California obtains all of his beef, pork, chicken, dairy, and eggs from one location.) The fractions used in the assessment were all obtained from the U.S. EPA’s *Exposure Factors Handbook*, Table 13-71 (U.S. EPA, 1997), using the values stated for non-metropolitan areas.

Table 7. Food consumption fraction estimated to be affected by the EWTF.

Food type	Value used in risk assessment ^a	HARP default value ^b
Exposed produce	0.207	0.15
Leafy produce	0.082 (cabbage)	0.15
Protected produce	0.134	0.15
Root produce	0.088	0.15
Beef	0.107	1.0
Chicken	0.026	1.0
Pork	0.04	1.0
Dairy	0 (Not applicable)	1.0
Eggs	0.029	1.0

^a U.S. EPA, 1997, Table 13-71, non-metropolitan.

^b CARB, 2003.

The concentrations of contaminants of concern in the non-inhalation pathways were calculated in the HARP, based on a single deposition velocity for all contaminants of concern, and did not take into account particle size or mass. The default deposition velocity in the HARP is 0.05 m/s for uncontrolled sources—an extremely conservative value. An authoritative review article by Sehmel (1980) on particle dry deposition indicates that only the largest particles would have such a deposition velocity. Moreover, particles with a deposition velocity of 0.05 m/s would, in reality, deposit very close to the source and would not deposit at the distances to residences of interest in this risk assessment. To be conservative, but realistic, a deposition velocity measured for dioxin was chosen to represent all contaminants of concern; this deposition velocity is 0.0072 m/s (Wevers et al., 2004).

3.3 Dose-Response Assessment

The dose-response effects of chemicals in the environment are the subject of state and federal regulatory guidance. The cancer potency factors (CPFs), the acute and chronic inhalation reference exposure levels (REs), and the chronic oral reference doses (RfDs) used in this assessment were compiled, first, from the OEHHA guidance as incorporated into the HARP model in the file called the health.mdb file, with a secondary source of such data obtained from a table in the U.S. EPA Region 9 Preliminary Remediation Goal (PRG; U.S. EPA, 2004a). The U.S. EPA (2004a) table lists the CPFs and REs used in deriving the preliminary remediation goals. Table 8 presents the CPFs, REs, and RfDs used in this risk assessment.

Table 8. Cancer potency factors, relative exposure levels, and reference doses for chemicals of concern for the EWTF.

Material CAS Number	Material name	Inhalation cancer slope factor ^a [1/(mg/kg-d)]	Oral cancer slope factor ^a [1/(mg/kg-d)]	Inhalation chronic REL ^a (µg/m ³)	Oral chronic RfD ^a (mg/kg-d)	Acute REL (µg/m ³)
106-99-0	1,3-Butadiene	6.00E-01		2.00E+01		
67562-39-4	1234678-HpCDF	1.30E+03	1.30E+03	4.00E-03	1.00E-06	
55673-89-7	1234789-HpCDF	1.30E+03	1.30E+03	4.00E-03	1.00E-06	
70648-26-9	123478-HxCDF	1.30E+04	1.30E+04	4.00E-04	1.00E-07	
57117-44-9	123678-HxCDF	1.30E+04	1.30E+04	4.00E-04	1.00E-07	
121-14-2	2,4-Dinitrotoluene	3.10E-01	6.10E-01	7.30E+00	2.00E-03	
606-20-2	2,6-Dinitrotoluene	6.80E-01	6.80E-01	3.70E+00	1.00E-03	
95-57-8	2-Chlorophenol			1.80E+01	5.00E-03	
7429-90-5	Aluminum			5.10E+00	1.00E+00	
7440-36-0	Antimony			2.00E-01		
7440-39-3	Barium			5.20E-01	7.00E-02	
71-43-2	Benzene	1.00E-01		6.00E+01		1.30E+03
7440-43-9	Cadmium	1.50E+01		2.00E-02	5.00E-04	
56-23-5	Carbon Tetrachloride	1.50E-01		4.00E+01		1.90E+03
67-66-3	Chloroform	1.90E-02		3.00E+02		1.50E+02
7440-47-3	Chromium				1.50E+00	
7782-50-5	Cl ₂			2.00E-01		2.10E+02
630-08-0	CO					2.30E+04
7440-50-8	Copper			2.40E+00	4.00E-02	1.00E+02
110-82-7	Cyclohexane			6.20E+03	1.70E+00	
122-39-4	Diphenylamine			9.10E+01	2.50E-02	
75-00-3	Ethyl chloride	2.90E-03		3.00E+04		
100-41-4	Ethylbenzene			2.00E+03		
206-44-0	Fluoranthene			1.50E+02	4.00E-02	
7647-01-0	HCL			9.00E+00		2.10E+03
98-82-8	i-Propylbenzene (cumene)			4.00E+02	1.00E-01	
7439-92-1	Lead	4.20E-02	8.50E-03			
74-87-3	Methyl chloride (Chloromethane)			4.50E+01		
71-55-6	Methyl chloroform (1,1,1-TCA)			1.00E+03		6.80E+04
108-87-2	Methylcyclohexane			3.10E+03		
75-09-2	Methylenechloride	3.50E-03		4.00E+02		1.40E+04
91-20-3	Naphthalene	1.20E-01		9.00E+00		

Material CAS Number	Material name	Inhalation cancer slope factor ^a [1/(mg/kg-d)]	Oral cancer slope factor ^a [1/(mg/kg-d)]	Inhalation chronic REL ^a (µg/m ³)	Oral chronic RfD ^a (mg/kg-d)	Acute REL (µg/m ³)
110-54-3	n-Hexane			7.00E+03		
10102-44-0	Nitrogen dioxide (peroxide)			4.70E+02		4.70E+02
39001-02-0	OCDF	1.30E+01	1.30E+01	4.00E-01	1.00E-04	
108-95-2	Phenol			2.00E+02	<i>3.00E-01</i>	5.80E+03
115-07-1	Propene			3.00E+03		
121-82-4	RDX	<i>1.10E-01</i>	<i>1.10E-01</i>	<i>6.10E-02</i>	<i>3.00E-03</i>	
100-42-5	Styrene			9.00E+02		2.10E+04
7446-09-5	Sulfur dioxide			6.60E+02		6.60E+02
127-18-4	Tetrachloroethylene	2.10E-02		3.50E+01		2.00E+04
108-88-3	Toluene			3.00E+02		3.70E+04
75-01-4	Vinyl chloride	2.70E-01		2.60E+01		1.80E+05
7440-66-6	Zinc			3.50E+01	<i>5.00E-02</i>	

^a Toxicity factors in italics are from U.S. EPA (2004a) all others are from CARB (2003).

Neither the HARP model nor the U.S. EPA PRG table had toxicity data available for 27 constituents of concern. Because of the uncertainty in the source term, it seemed reasonable to choose surrogates from the other constituents based on the fundamental structure of the molecule for which toxicity data were unavailable. On that basis, RDX was chosen as a surrogate for PETN; naphthalene was chosen as a surrogate for acenaphthalene and 1-nitronaphthalene; ethylbenzene was chosen as a surrogate for m- and p-ethyltoluene; and hexane was chosen as a surrogate for short-chain and cyclic aliphatic hydrocarbons. A petroleum-industry toxicological review undertaken by the Total Petroleum Hydrocarbon Criteria Working Group (TPHCWG, 1997, p. 8) to develop reference doses and reference concentrations evaluates materials by number of carbons in the compound and whether or not the material is aromatic or aliphatic. Consequently, hexane is a reasonable surrogate for these compounds.

3.4 Risk Characterization

3.4.1 OBODM/HARP Interface

As previously mentioned, the OBODM is limited to the evaluation of one constituent of concern at a time; and it has no capability for assessing risk or hazard. On the other hand, the HARP is capable of handling many chemicals simultaneously; and it incorporates the OEHHA methodology for assessing theoretical carcinogenic risk and non-carcinogenic hazard for the inhalation, food and incidental soil ingestion, and dermal and mother's milk exposure pathways. (In this risk assessment, HARPEXpress, a commercial user interface to the HARP model was actually used.)

The HARP model is, in fact, three separate computer programs linked together. The first program is a database program in which the user enters site-specific data, such as building locations, emissions locations, emissions characteristics (usually stack height,

diameter and release rate) and annual and maximum emissions. The second program is the ISCST model, a U.S. EPA continuous emission model for dispersion of air pollutants based on the Gaussian plume dispersion equations. The third program is the OEHHA-approved risk assessment equations combined with a database of OEHHA-approved toxicity factors, by which theoretical carcinogenic risk and acute and chronic non-carcinogenic hazard are calculated.

Because, for reasons previously discussed, the ISCST model is not the most reasonable model to use for OB/OD operations, the OBODM model is the preferred model for these operations. However, because the HARP model is functionally three separate models linked together, it was possible to run both the HARP model and the OBODM model with the same emissions scenarios and replace the ISCST output with the OBODM output. The details of the HARP/OBODM interface are presented in Appendix A.

3.4.2 Identification of Maximally Exposed Receptors

Theoretical carcinogenic risk and acute and chronic non-carcinogenic hazard were calculated within the HARP (with the OBODM dispersion results), using OEHHA-approved equations. The calculations were conducted for the two possible off-site residential receptors and for the two closest on-site locations of bystander workers. When the HARP provides the results for more than one receptor, the HARP output cannot be interrogated by source contribution. Because the contribution of each waste form was not known before the HARP model was run, all waste forms were modeled as if 100 events occurred annually in order to screen the waste forms and identify the maximally exposed receptors. Therefore, the screening level health effects for identifying the maximally exposed receptors were for a total of 100 detonations and 300 burns (100 from each form of waste). These screening results yielded greater health effects than would occur under the permit condition limits of no more than 100 detonations and 100 burns. (Historically, annual treatments are much less, both in frequency and mass, than the permitted limits.) The results of the HARP model screening runs are shown in Table 9. Output from the runs is in Volume 2 of this risk assessment (provided on a compact disc.)

Table 9. Screening results for identification of maximally exposed receptors.

Receptor	Carcinogenic risk	Chronic hazard index	Acute hazard index
Carnegie Ranger Station (SW)	0.0000007	0.02	0.02
Ranch Residence (SE)	0.0000004	0.01	0.01
Bystander Worker Building 812 (E)	0.0000006	0.3	0.2
Bystander Worker Building 895 (SE)	0.0000007	0.3	0.3

3.4.3 Effects on Maximally Exposed Receptors

After the maximally exposed receptors were identified, the HARP model was run again for the two individual receptors—the resident at the Carnegie State Vehicular Park ranger residence and the bystander worker at Building 895—to determine the contribution of each of the EWTF sources to the risk, and the risk outcome for the permitted level of treatments of 100 open detonations and 100 open burns. The

100 burns were represented by the greatest value among the three waste forms that are treated by burning. Because the acute hazard index is a measure of the greatest possible 1-hour exposure, the result of interest is the highest 1-hour hazard index for a single waste form, not the total of all waste forms. These results are presented in Table 10. The HARP output is contained in Volume 2 (provided on a compact disc).

In contrast to the 30-year exposure duration for the assessment of theoretical carcinogenic risk, chronic hazard values were calculated for a 70-year exposure because the HARP model uses chronic RELs based on ambient air concentrations, rather than RfDs based on exposures, receptor body weight, and exposure duration. When an REL is developed, an exposure duration is assumed. In the case of the RELs used in the HARP model, the exposure duration is 70 years. This also means that a chronic hazard specific to childhood exposure cannot be calculated. In addition, the acute hazard calculation, while fundamentally the same for both the bystander worker and residential receptors, uses a greater inhalation rate for the worker than for the resident (1.3 m³/h for the worker and 1.0 m³/h for the resident). The result for the chronic hazard index reported by the HARP model is the maximum value among the target organs or systems evaluated. In all cases in this EWTF health evaluation, the maximally affected organ/system was the respiratory system.

Table 10. Theoretical health effects for maximally exposed receptors.

Receptor	Treatment unit (waste form)	Risk adult (30-year exposure)	Risk child (9-year exposure)	Chronic hazard index	Acute hazard index
Carnegie ranger residence (SW)	Open Detonation (Form 1)	0.0000004	0.0000003	0.002	0.02
	Burn Pan (Form 2)	0.00000004	0.00000002	0.01	0.01
	Burn Cage (Form 3)	0.00000004	0.00000002	0.0008	0.0004
	Burn Cage (Form 4)	0.00000002	0.00000001	0.004	0.002
	Total (100 OD + 300 OB)	0.0000007	0.0000004	0.02	Max: 0.02
	Current permit limits (100 OD + 100 OB)	0.0000006	0.0000004	0.01	Max: 0.01
Bystander worker (Building 895)	Open Detonation (Form 1)	0.0000004	Not applicable	0.02	0.1
	Burn Pan (Form 2)	0.0000001	Not applicable	0.2	0.2
	Burn Cage (Form 3)	0.00000003	Not applicable	0.01	0.006
	Burn Cage (Form 4)	0.0000001	Not applicable	0.05	0.03
	Total (100 OD + 300 OB)	0.0000007		0.3	Max: 0.3
	Current permit limits (100 OD + 100 OB)	0.0000006		0.2	Max: 0.3

The carcinogenic risk to a 30-year resident at the maximum off-site receptor location is 0.0000006 or 0.6 in 1 million. The carcinogenic risk to a 25-year worker at the maximum bystander on-site receptor location is also 0.0000006 or 0.6 in 1 million. Any risk of less than 1 in a million is below the level of regulatory concern. The acute non-carcinogenic hazard for the 30-year resident is 0.01, and the chronic non-carcinogenic hazard is 0.01. The acute non-carcinogenic hazard for the 25-year worker is 0.3, and the chronic non-carcinogenic hazard is 0.2. The point of comparison for acute and chronic

non-carcinogenic hazard is 1.0; an estimate less than 1.0 is below the level of regulatory concern. The estimates of health effects are based on health conservative assumptions and represent an upper bound of the possible exposures to the receptors.

3.5 Lead

Possible emissions from OB/OD operations at the EWTF of Site 300 include elemental lead (Pb). The chronic non-cancer effects of lead exposure are related to blood-lead levels (as opposed to ambient air concentrations). The health risk from exposure to lead in this risk assessment was determined using the lead risk assessment spreadsheet obtained from the California Department of Toxic Substances Control (DTSC, 2000).

The DTSC Lead Risk Assessment Spreadsheet—LeadSpread 7 (DTSC, 2000)—is a model for estimating blood-lead concentrations resulting from exposure to lead via dietary intake, soil and dust ingestion, inhalation, and dermal contact. The modeled concentrations of lead in air and soil 1 cm deep at the Carnegie State Vehicular Park ranger residence and at the bystander worker location (Building 895) were used in the LeadSpread 7 calculations.

LeadSpread 7 contains equations that relate incremental blood-lead increase to a concentration in an environmental medium, using currently accepted contact rates and empirically determined ratios. Exposure-pathway contributions to blood-lead levels were summed to arrive at an estimate of the median blood-lead concentration for multiple exposure pathways. The 99th-percentile concentration was then estimated from the median value by assuming a lognormal distribution for blood-lead concentration with a geometric standard deviation (GSD) of 1.6. The blood-lead concentration of concern for children and adults is 10 µg Pb/dL, and risk management is considered applicable if there is a 0.01 risk of exceeding this value (DTSC, 1996).

Table 11 contains the values for the input factors required for performing the necessary calculations using LeadSpread 7. The air and soil/dust were obtained from the OBODM/HARP atmospheric dispersion and deposition modeling (Bjorklund et al., 1998; CARB, 2003), and the percentage of homegrown produce consumed for the residence is the average of the data presented in Table 7. The default value for respirable dust already incorporated into LeadSpread 7 was not changed.

Table 11. Values for input factors required for the lead risk assessment spreadsheet model, LeadSpread 7.

Environmental medium	Carnegie ranger residence	Bystander worker (Bldg. 895)
Air	0.00182 µg Pb/m ³	0.0286 µg Pb/m ³
Soil/dust	1.09 µg Pb/g	17.0 µg Pb/g
Home-grown produce	13% of diet	0% of diet
Respirable dust	1.5 µg Pb/m ³	1.5 µg Pb/m ³

Table 12 contains the 99th-percentile blood-lead levels predicted from lead emissions for adult and child exposures at the ranger residence location and for adult-worker exposures at Building 895. None of the receptors, even the pica-child, is expected to achieve a blood-lead level that equals the 10 µg Pb/dL level at the 99th-percentile upper

confidence limit. Consequently, no receptor is considered to attain a concentration of lead in blood that would be considered to be of concern.

Table 12. Predicted blood-lead levels for adult and child exposures at the ranger residence location and for adult-worker exposures at the Building 895 location using the lead risk assessment spreadsheet model, LeadSpread 7.

Percentile estimate of blood lead concentration	Adult exposure at Carnegie ranger residence ($\mu\text{g}/\text{dL}$)	Child exposure at Carnegie ranger residence ($\mu\text{g}/\text{dL}$)	Pica-child exposure at Carnegie ranger residence ($\mu\text{g}/\text{dL}$)	Bystander worker exposure at Building 895 ($\mu\text{g}/\text{dL}$)
99th	0.6	1.5	1.5	0.8

4. Ecological Risk Assessment

The Ecological Risk Assessment (ERA) for the EWTF was conducted following currently accepted practice. This practice involves seven steps.

1. Each CPEC emission from the OB/OD operations at the Site 300 EWTF was identified, and its soil concentration over a 6-inch (15-cm) depth ($\text{mg}/\text{kg}_{\text{soil}}$) was predicted for a receptor location of interest based on atmospheric dispersion and deposition modeling.
2. Representative receptors of ecological interest (RREIs) were selected in the habitat of interest for each trophic level of the applicable wildlife food web. A reasonable approximation of total dietary intake was obtained from the literature for each vertebrate RREI and quantified per unit body weight (i.e., avian, reptile, and mammal [$\text{mg}/[\text{kg}_{\text{bw}} \text{d}]$]; whereas, a no observed adverse effect concentration (NOEC; $\text{mg}/\text{kg}_{\text{soil}}$), obtained for the earthworm from data in the literature, was applied to invertebrates. Plants were also evaluated as a separate vegetation category of RREI, and a NOEC ($\text{mg}/\text{kg}_{\text{soil}}$) generalizable to all plants was obtained from the literature for this purpose.
3. A CPEC-specific ecological soil screening level (ESSL; $\text{mg}/\text{kg}_{\text{soil}}$) is derived from a low toxicity reference value (TRV_{Low}) for each vertebrate RREI evaluated (i.e., avian, reptile, and mammal). Each applicable TRV_{Low} corresponds to a no observed adverse effect level (NOAEL) for the respective vertebrate. This was not done for invertebrates and plants because a no observed adverse effect concentration (NOEC) is interpreted to represent the ESSL for the invertebrate and vegetation category of RREI. Each of these respective ESSLs corresponds to a CPEC-specific concentration in soil that is considered protective of a particular wildlife (wlf) receptor (e.g., mammal, bird, reptile, invertebrate, or plant) that might have contact with such soil, directly or indirectly.
4. The animal “ ESSL_{min} ” is selected from a comparison among all of the animal ESSLs—reptile (wlf = rep), avian (wlf = brd), invertebrate (wlf = inv) and mammal (wlf = mam) RREI. The ESSL_{min} for the vegetation category is addressed separately,

where that NOEC is generalized to be applicable to all plants and so is considered to represent the $ESSL_{min}$ for plants.

5. The animal $ESSL_{min}$ and the plant $ESSL_{min}$ are then compared to the respective CPEC-specific soil concentrations predicted from atmospheric dispersion and deposition modeling at specific receptor locations near and around the EWTF over a depth of 6 inches (15 cm). This comparison was made by dividing each modeled CPEC-specific soil concentration value at a specific location by the applicable animal and plant $ESSL_{min}$ value, where the result equates to a maximum ecological hazard quotient (EHQ_{max}) for each animal and plant RREIs with respect to the CPEC at the selected location. Thus, a CPEC-specific EHQ_{max} greater than unity or the sum of the animal or the plant RREI, CPEC-specific EHQ_{max} values exceeding one suggest further examination for the possibility for adverse ecological impact. CPEC-specific EHQ_{max} values also were computed at the receptor location nearest the EWTF for two CPECs of particular concern at Site 300—the San Joaquin Kit Fox and the Burrowing Owl—and these sensitive-organism specific EHQ_{max} values were based on $ESSL$ values derived specifically for these particular organisms (which may or may not equate to the animal $ESSL_{min}$).
6. For those CPECs for which an EHQ_{max} value for animals exceeds unity and/or for which an EHQ_{max} value for plants exceed unity, an additional evaluation is performed that derives an $ESSL$ value for these substances for either or both animals and plants (i.e., mg/kg_{soil}) that can equate to a lowest observed adverse effect level (LOAEL). Thus, the resulting EHQ derived using these higher $ESSL$ values will be lower than the EHQ_{max} values. This is because the $ESSL$ used to derive them are not the most protective and so are not the lowest possible. Nevertheless, the smallest animal $ESSL$ is still used to compute the new EHQ that will be less than the EHQ_{max} . Again, this $ESSL$ will be the lowest from among all those calculated for avian, reptile, and mammal RREIs now using the TRV_{High} or a comparable value (i.e., a 10-fold increase in the TRV_{Low} where a TRV_{High} is not available in the literature) and the lowest observed effect concentration (LOEC) or a comparable value (e.g., a 10-fold increase in the NOEC, where one is not provided in the literature) for the invertebrate. For those CPECs with EHQ_{max} values for plants exceeding one, a new $ESSL$ that is greater than the $ESSL_{min}$ is computed using a lowest observed effect concentration (LOEC) or comparable value (i.e., because none are available in the literature, a 10-fold increase in the NOEC is considered applicable) for each CPEC. CPEC-specific EHQ values for those CPECs with EHQ_{max} values exceeding one are also determined at the receptor location nearest the EWTF specifically for the two species of particular concern at Site 300—the San Joaquin Kit Fox and the Burrowing Owl.
7. For purposes of comparison to the results obtained in Steps 5 and 6, $ESSL$ s and EHQ s are similarly calculated for those CPECs for which Site-300 background measurement data is available. Currently, background concentrations are reported only for seven heavy metals—antimony, barium, cadmium, chromium, copper, lead, and zinc (see Peterson et al., 2006). For these CPECs and their measured values an $ESSL_{min}$ and EHQ_{max} are derived first for animals, and then for plants, as well as for the Kit Fox and Burrowing Owl. For those background concentrations of CPEC-metals with EHQ_{max} values greater than one, the $ESSL$ and EHQ are derived using

the TRV_{High} (or comparable value) described in Step 6. This analysis is also performed for the two sensitive species of interest (i.e., Kit Fox and Burrowing Owl), and also for plants.

The details of the calculations for the ecological risk assessment are provided in Appendix B. A summary of the various ecological site investigations that have been conducted at Site 300 is presented in Appendix E of the *Final Site-side Environmental Impact Statement for Continued Operation of Lawrence Livermore National Laboratory and Supplemental Stockpile Stewardship and Management Programmatic Environmental Impact Statement* (DOE/NNSA 2005). The 21 CPECs emitted from the EWTF that are to be evaluated are categorized in Table 13.

Table 13. The 21 contaminants of potential ecological concern (CPECs) at the EWTF.

Five PCDFs	Three energetics and other thermally labile compounds	Eight metals	Five SVOCs
1-4, 6-8 HpCDF	2,4-Dinitrotoluene	Aluminum	2-Chlorophenol
1-4, 7-9 HpCDF	2,6-Dinitrotoluene	Antimony	Diphenylamine
1-4, 7, 8 HxCDF	RDX	Barium	Fluoranthene
1-3, 6-8 HxCDF		Cadmium	Naphthalene
1-9 OCDF		Chromium	Phenol
		Copper	
		Lead	
		Zinc	

The ten RREIs addressed are the mammals, the reptile, the birds, the soil invertebrate, and vegetation, which are listed in Table 14 (see Figure B-1 in Appendix B). The individual exposure pathways considered relevant for each animal RREI were incidental ingestion of contaminated soil particles and ingestion of forage or prey for which uptake of a CPEC from soil or forage or prey was estimated using a calculated bioaccumulation factor (BAF). For purposes of conservatism, all the living, foraging, and prey capturing by the RREIs were considered to occur in the habitat nearest OB/OD operations, where concentrations of each CPEC are predicted to be deposited at levels requiring evaluation, and the absorption fraction of each CPEC for each RREI was considered to be 100 percent.

Table 15 (where invertebrate data does not appear because the ESSL for the invertebrate was taken directly from the literature; see footnote to Table 15) shows the eight vertebrate organisms of interest and their body weight and dietary behavior. This information was used to derive a chemical-specific ESSL for each organism (see Appendix B). Regulatory agencies have not developed ESSLs for amphibians that may be present near the EWTF, such as the California Red-legged Frog (*Rana aurora draytonii*) and the California Tiger Salamander (*Ambystoma californiense*). However, as discussed in Appendix B, serious impacts to amphibians in the area of the EWTF would be unlikely.

Table 14. Ten representative receptors of ecological interest (RREIs) at the EWTF.

Mammals	Reptile	Birds	Soil Invertebrate	Vegetation
Omnivorous small mammal (Deer Mouse [<i>Peromyscus maniculatus</i>])	Insectivorous reptile (Side-Blotched Lizard Lizard [<i>Uta stansburiana</i>])	Omnivorous bird (Savannah Sparrow [<i>Passerculus sandwichensis</i>])	Earthworm	Plants
Granivorous small mammal (Ground Squirrel [<i>Spermophilus beecheyi</i>])		Carnivorous bird (Burrowing Owl [<i>Athene cunicularia</i>])		
Herbivorous small mammal (Pocket Gopher [<i>Thomomys bottae</i>])				
Herbivorous large mammal (Black-Tailed [Mule] Deer [<i>Odocoileus hemionus columbianus</i>])				
Carnivorous mammal (San Joaquin Kit Fox [<i>Vulpes macrotis mutica</i>])				

The technical basis for this ecological risk assessment was an analysis that included the overwhelmingly dominant exposure pathway (ingestion) for each CPEC with respect to its EHQ for a particular vertebrate receptor. Any EHQ with a value greater than or equal to 1.0 suggests a potential for producing an adverse effect in each individual or population of receptor species; however, the assumptions made are conservative at this time. Appendix B contains a detailed description of the ERA analysis and the input data required for it to be performed.

Table 15. Representative vertebrate receptors of ecological interest (RREI) and respective physiological characteristics, including body weight (BW) and dietary dry-matter intake (DMI)^a.

Organism	BW (kg)	Daily DMI intake (kg _{DMI} /d)	Daily DMI intake per unit BW (kg _{DMI} /d per kg _{BW})	Fraction of total dietary dry-matter intake (DMI)				
				Vegetation	Invertebrate	Reptile	Mammal	Soil
Mammals								
Omnivorous small mammal (Deer Mouse)	0.0179	0.00381	0.2128	0.7	0.3	0	0	0.1
Granivorous small mammal (Ground Squirrel)	0.56	0.0383	0.0683	1	0	0	0	0.077
Herbivorous small mammal (Pocket Gopher)	0.104	0.013	0.1250	1	0	0	0	0.1
Herbivorous large mammal (Black-Tailed [Mule] Deer)	39.1	1.565	0.0004	1	0	0	0	0.02
Carnivorous mammal (San Joaquin Kit Fox)	1.48	0.0702	0.0474	0	0	0.5	0.5	0.028
Reptile								
Insectivorous reptile (Side-Blotched Lizard)	0.0032	0.000037	0.011563	0	1	0	0	0.1
Birds								
Omnivorous bird (Savannah Sparrow)	0.0187	0.00574	0.3070	0.39	0.61	0	0	0.04
Carnivorous bird (Burrowing Owl)	0.157	0.24	0.0495	0	0.333	0.333	0.333	0.05

^a The soil invertebrate (earthworm) does not appear in Table 15 because an ESSL for it was taken directly from literature values (see Tables B-6a and B-6b in Appendix B).

A summary of the results of the ERA analysis discussed in Appendix B appear in Tables 16a, 16b, 17, 18, and 19 of this section. These tables contain the pertinent information upon which to base recommendations as to whether further evaluation of potential impact may be required and the vehicle most appropriate to execute such an evaluation.

In Table 16a the EHQs appear for animals that correspond to model predicted soil concentrations. These are CPEC-specific maximum ecological hazard quotient (EHQ_{max}) values (i.e., ratio of soil concentration, which is a model predicted value in this case, to the minimum ecological soil screening level, ESSL_{min}) for the location. The ESSL_{min} represents the location-specific minimum ecological soil screening level (ESSL_{min}) for each CPEC that was selected from among all the animal ESSLS, each of which was derived using a low toxicity reference value (TRV_{Low}) or comparable toxicity factor equating to a no observed adverse effect level (NOAEL). Thus, the results appearing for animal EHQs at the EWTF location in Table 16a suggest that further evaluation is needed for three PCDFs (1-4, 6-8 HpCDF; 1-4, 7, 8 HxCDF; and 1-3, 6-8 HxCDF), and five heavy metals (Al, Cd, Cu, Pb, and Zn). Additionally, the cumulative EHQs are greater than one at each of the six locations identified in Table 16a. Nevertheless, aluminum can be dismissed from further discussion because it is unlikely that the pH will be low enough to render aluminum a problem in soil, as the site is geologically basic chemically and only acidic soil pH will yield Al in a form that is mobile and soluble for uptake by organisms. Therefore, additional analysis was performed for only the remaining seven substances with respect to animals.

Table 16b shows similar information for animals to that appearing in Table 16a, with the following exceptions. First, the CPECs evaluated for EHQs exceeding one in Table 16b are *only* for those CPECs for which a location-specific EHQ_{max} exceeded unity in Table 16a at any location (e.g., see EWTF). Second, the CPEC-specific EHQs appearing in Table 16b are now associated with the location-specific smallest ESSL value for animals that was derived using a TRV_{High} or comparable toxicity factor, which corresponds to a lowest observed adverse effect level (LOAEL). When these EHQs (which are computed as the ratio of model predicted soil concentrations to ESSLS that are derived from TRV_{High} values) do not exceed unity, then this result (in combination with an EHQ_{max} that exceeds one) indicates that further site specific information needs to be collected to reduce uncertainty and obtain a more site-specific estimate of the potential ecological impact that may be caused by the CPEC. The information in Table 16b suggests this to be the case for all eight CPECs (at no location does any one exceed unity), and particularly for the EWTF location, where only that cumulative EHQ is greater than one.

Table 16a. Ecological hazard quotients (EHQs) for chemicals of potential concern for animals at different receptor locations. Each EHQ is maximum because it is derived from the lowest ESSL for all organisms evaluated, where a TRV_{Low} serves as the basis for each minimum ESSL derivation.

Chemical	Receptor Location					
	EHQ _{max} (EWTF/ ESSL _{min})	EHQ _{max} (Bldg 812/ ESSL _{min})	EHQ _{max} (Bldg 895/ ESSL _{min})	EHQ _{max} (EstPst/ ESSL _{min})	EHQ _{max} (Crnge/ ESSL _{min})	EHQ _{max} (Ranch/ ESSL _{min})
Polychlorinated dibenzofurans (PCDFs)						
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	<i>1.16E+00</i>	1.42E-01	1.31E-01	7.19E-03	7.94E-03	3.78E-03
1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	2.30E-01	3.03E-02	2.83E-02	1.67E-03	1.84E-03	8.79E-04
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	<i>6.80E+00</i>	8.33E-01	7.72E-01	4.44E-02	4.90E-02	2.34E-02
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	<i>2.82E+00</i>	3.65E-01	3.40E-01	2.01E-02	2.22E-02	1.06E-02
1-9 OCDF (OCDF)	1.40E-02	1.70E-03	1.57E-03	8.46E-05	9.34E-05	4.45E-05
Energetics & other thermally labile compounds						
2,4-Dinitrotoluene	1.22E-08	1.57E-09	1.47E-09	9.20E-11	8.85E-11	4.28E-11
2,6-Dinitrotoluene	5.10E-10	6.55E-11	6.14E-11	3.83E-12	3.69E-12	1.78E-12
RDX	1.12E-01	1.55E-02	2.20E-02	1.90E-03	1.98E-03	1.14E-03
Metals						
Aluminum	<i>3.83E+00</i>	5.61E-01	5.69E-01	3.73E-02	4.01E-02	2.03E-02
Antimony	1.23E-03	1.64E-04	1.93E-04	1.48E-05	1.51E-05	8.27E-06
Barium	1.09E-01	1.46E-02	1.71E-02	1.31E-03	1.33E-03	7.30E-04
Cadmium	<i>4.27E+00</i>	<i>1.40E+00</i>	<i>1.54E+00</i>	3.73E-01	3.77E-01	2.71E-01
Chromium	5.21E-06	7.04E-07	8.79E-07	7.01E-08	7.21E-08	4.03E-08
Copper	<i>1.60E+00</i>	8.11E-01	8.19E-01	3.70E-01	3.69E-01	3.06E-01
Lead	<i>7.85E+02</i>	<i>1.57E+01</i>	<i>1.53E+01</i>	<i>1.92E+00</i>	<i>1.90E+00</i>	<i>1.27E+00</i>
Zinc	<i>1.16E+00</i>	6.05E-01	6.27E-01	2.67E-01	2.69E-01	2.47E-01
Semi-volatile organic compounds (SVOCs)						
2-Chlorophenol	3.03E-04	3.90E-05	3.65E-05	2.28E-06	2.19E-06	1.06E-06
Diphenylamine	1.06E-08	1.36E-09	1.27E-09	7.95E-11	7.65E-11	3.70E-11
Fluoranthene	5.86E-04	8.80E-05	8.22E-05	4.85E-06	5.36E-06	2.55E-06
Naphthalene	8.35E-05	1.25E-05	1.17E-05	6.91E-07	7.63E-07	3.63E-07
Phenol	6.28E-07	8.06E-08	7.56E-08	4.72E-09	4.54E-09	2.20E-09
Cumulative EHQ_{max}	1.01E+02	2.04E+01	2.02E+01	3.05E+00	3.04E+00	2.15E+00

Note: EHQ values greater than 1 appear in italics (e.g. see EHQ values for Pb).

Table 16b. Ecological hazard quotients (EHQs) for chemicals of potential concern (CPECs) for animals at different receptor locations, where the EHQ_{max} exceeded unity (see Table 16a). Each EHQ in this table is derived from the lowest ESSL (i.e., $ESSL_{small}$) for all organisms evaluated, where a TRV_{High} serves as the basis for each ESSL derivation.

Chemicals of potential ecological concern	EWTF	Bldg. 812	Bldg. 895	East Pasture	Carnegie	Ranch
	EHQ_{max}	EHQ_{max}	EHQ_{max}	EHQ_{max}	EHQ_{max}	EHQ_{max}
PCDDs/PCDFs						
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	1.2E-01	1.4E-02	1.3E-02	7.2E-04	7.9E-04	3.78E-04
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	6.8E-01	8.3E-02	7.7E-02	4.4E-03	4.9E-03	2.34E-03
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	2.8E-01	3.6E-02	3.4E-02	2.0E-03	2.2E-03	1.06E-03
Heavy Metals						
Aluminum	3.8E-01	5.6E-02	5.7E-02	3.7E-03	4.0E-03	2.03E-03
Cadmium	9.7E-02	3.2E-02	3.5E-02	8.5E-03	8.6E-03	6.16E-03
Copper	9.2E-02	1.2E-01	1.2E-01	1.6E-02	1.6E-02	1.34E-02
Lead	1.3E-01	2.5E-02	2.5E-02	3.1E-03	3.0E-03	2.03E-03
Zinc	1.2E-01	6.1E-02	6.3E-02	2.7E-02	2.7E-02	2.47E-02
Cumulative EHQ_{small}	1.9E+00	4.3E-01	4.3E-01	6.5E-02	6.7E-02	5.2E-02

Table 17 contains the evaluation of EHQs for vegetation for the seven metals—antimony (Sb), barium (Ba), cadmium (Cd), hexavalent chromium (considered 17% of total chromium; Cr), copper (Cu), lead (pb), and zinc (Zn)—for which soil measurement data exist for Site 300. However, in this table the EHQs ratios were determined for both model predicted and Site 300 measured soil concentrations relative to terrestrial plant $ESSL_{min}$ values taken from the literature. Further, the measured soil concentrations are considered to be the background levels for these substances at Site 300, and so the contribution to the cumulative EHQ relative to measured data is determined with respect to the cumulative EHQ obtained for the model predicted data for each location. For example, EHQ data in Table 17 applicable to measured soil concentrations at Site 300 would suggest background levels of total chromium and zinc could be contributing to ecological impacts. However, no model predicted soil concentrations at any location appear to contribute to ecological impacts with respect to vegetation, and constitute only a small contribution to the cumulative EHQ related to background levels.

Table 17. Ecological hazard quotients (EHQs) for plants based on measured (considered background) and model predicted soil concentrations for Site 300 and six receptor locations at or near the EWTF, where ESSLs are minimum values.

Chemicals of potential ecological concern	Terrestrial Plant ESSL (mg/kgdw)	Measured soil concentration for Site 300 (mg/kg _{soil})	Ratio of measured soil concentration to ESSL (EHQ _{measured})	EWTF modeled 15-cm soil concentration (mg/kg)	Ratio of EWTF modeled soil concentration to ESSL (EHQ _{modeled})	Bldg. 812 modeled 15-cm soil concentration (mg/kg)	Ratio of Bldg. 812 modeled soil concentration to ESSL (EHQ _{modeled})	Bldg. 895 modeled 15-cm soil concentration (mg/kg)	Ratio of Bldg. 895 modeled soil concentration to ESSL (EHQ _{modeled})
Heavy Metals									
Antimony	5b	1.0	2.0E-01	8.36E-04	1.7E-04	1.12E-04	2.2E-05	1.31E-04	2.6E-05
Barium	500b	331.0	6.6E-01	1.04E+01	2.1E-02	1.39E+00	2.8E-03	1.63E+00	3.3E-03
Cadmium	32a	2.6	8.1E-02	4.99E-02	1.6E-03	6.66E-03	2.1E-04	7.84E-03	2.5E-04
Chromium	1b,c	45.6	4.6E+01	8.39E-02	8.4E-02	1.13E-02	1.1E-02	1.41E-02	1.4E-02
Copper	100b	34.0	3.4E-01	2.93E+01	2.9E-01	3.82E+00	3.8E-02	3.94E+00	3.9E-02
Lead	120a	70.3	5.9E-01	8.93E+00	7.4E-02	1.17E+00	9.7E-03	1.14E+00	9.5E-03
Zinc	50b	78.0	1.6E+00	1.70E+00	3.4E-02	2.48E-01	5.0E-03	2.76E-01	5.5E-03
Cumulative EHQ			4.9E+01		5.1E-01		6.7E-02		7.2E-02
Contribution of EHQ_{modeled} to EHQ_{measured}					1.04E-02		1.37E-03		1.47E-03

(continued)

Table 17. (continued)

Chemicals of potential ecological concern	East Pasture modeled 15-cm soil concentration (mg/kg)	Ratio of East Pasture modeled soil concentration to ESSL (EHQ_{modeled})	Carnegie modeled 15-cm soil concentration (mg/kg)	Ratio of Carnegie modeled soil concentration to ESSL (EHQ_{modeled})	Ranch modeled 15-cm soil conc. (mg/kg)	Ratio of Ranch modeled soil concentration to ESSL (EHQ_{modeled})
Heavy Metals						
Antimony	1.01E-05	2.0E-06	<i>1.03E-05</i>	2.1E-06	<i>5.63E-06</i>	1.1E-06
Barium	1.25E-01	2.5E-04	<i>1.27E-01</i>	2.5E-04	<i>6.96E-02</i>	1.4E-04
Cadmium	6.01E-04	1.9E-05	<i>6.13E-04</i>	1.9E-05	<i>3.36E-04</i>	1.1E-05
Chromium ^b	1.13E-03	1.1E-03	<i>1.16E-03</i>	1.2E-03	<i>6.49E-04</i>	6.5E-04
Copper	2.71E-01	2.7E-03	<i>2.68E-01</i>	2.7E-03	<i>1.39E-01</i>	1.4E-03
Lead	7.37E-02	6.1E-04	<i>7.25E-02</i>	6.0E-04	<i>3.61E-02</i>	3.0E-04
Zinc	1.98E-02	4.0E-04	<i>2.12E-02</i>	4.2E-04	<i>1.13E-02</i>	2.3E-04
Cumulative EHQ		5.1E-03		5.1E-03		2.7E-03
Contribution of EHQ_{modeled} to EHQ_{measured}		1.04E-04		1.05E-04		5.53E-05

a USEPA (2005c, 2005d)

b Efroymsen et al. (1997 Table 1 and Appendix A).

c Reported chromium is for potassium chromate (chromium IV) and chromium VI is considered to be 17% of total chrome measurements (U. S. EPA, 2004a).

A similar analysis to that performed for plants in Table 17 was also performed with respect to measured data for animals in Table 18 and 19. Table 18 contains two sets of EHQs, one representing the ratios of the measurement data available for the seven metals at Site 300 already mentioned to the $ESSL_{min}$ values derived for animals from applicable TRV_{Low} values and the other representing the ratio of the measurement data to the smallest $ESSL$ derived for animals from applicable TRV_{High} values. The former results indicate that potential ecological impacts may be occurring from background levels, but the latter results suggest only barium and copper may represent a substance of potential ecological concern with respect to background levels. Also in both cases the cumulative EHQs do exceed one.

Table 18. Comparison of animal EHQs for measured (considered background) soil concentrations for Site 300 based on smallest $ESSL$ values determined either from TRV_{Low} or TRV_{High} toxicity factors.

Chemicals of potential ecological concern	Back-ground soil concentration at Site 300 (mg/kg)	TRV_{Low} based $ESSL_{min}$ (mg/kg _{soil})	Organism	$EHQ_{measured}$	TRV_{High} based $ESSL_{small}$ (mg/kg _{soil})	Organism	$EHQ_{measured}$
Heavy Metals							
Antimony	1.00E+00	6.81E-01	OSM ^a	1.47E+00	6.81E+00	OSM ^a	1.47E-01
Barium	3.31E+02	9.53E+01	OA ^b	3.47E+00	1.91E+02	OA ^b	1.73E+00
Cadmium	2.60E+00	5.99E-02	OA ^b	4.34E+01	2.93E+00	HLM ^c	8.89E-01
Chromium	4.56E+01	1.61E+04	OSM ^a	2.83E-03	1.61E+05	OSM ^a	2.83E-04
Copper	3.40E+01	2.02E+01	OA ^b	1.69E+00	3.20E+01	INV ^d	1.06E+00
Lead	7.03E+01	1.68E-01	OA ^b	4.19E+02	1.05E+02	OA ^b	6.70E-01
Zinc	7.80E+01	1.80E+01	OA ^b	4.33E+00	1.80E+02	OA ^b	4.33E-01
Cumulative EHQ				4.73E+02			4.93E+00

^a OSM = Omnivorous small mammal

^b OA = Omnivorous avian

^c HLM = Herbivorous large mammal

^d INV = Invertebrate

Table 19. Comparison of Kit Fox and Burrowing Owl EHQs for measured (considered background) soil concentrations for Site 300 based on smallest applicable ESSL values determined for each animal either from applicable TRV_{Low} or TRV_{High} toxicity factors.

Chemicals of potential ecological concern	Background soil concentration at Site 300 (mg/kg)	Kit Fox		Burrowing Owl	
		TRV-Low based EHQ _{measured}	TRV-High based EHQ _{measured}	TRV-Low based EHQ _{measured}	TRV-High based EHQ _{measured}
Heavy Metals					
Antimony	1.00E+00	8.26E-01	8.26E-02		
Barium	3.31E+02	1.69E-01	1.69E-02	1.81E+00	9.01E-01
Cadmium	2.60E+00	1.49E+00	3.40E-02	1.40E+01	1.07E-01
Chromium	4.56E+01	8.40E-04	8.40E-05		
Copper	3.40E+01	4.33E-01	1.83E-03	1.46E+00	6.44E-02
Lead	7.03E+01	1.93E+00	8.00E-03	4.15E+02	6.63E-01
Zinc	7.80E+01	5.02E-01	1.17E-02	1.70E+00	1.70E-01
Cumulative EHQ_{measured}		5.35E+00	1.55E-01	4.33E+02	1.91E+00

Nevertheless, additional analysis shown in Appendix B (Table B-19) reveals that even though for animals all seven metals may be problematic with respect to background levels (i.e., measurement data), and even though model predicted concentrations at the EWTF for Cd, Cu, Pb, and Zn have EHQ_{max} values exceeding one, with lead having an EHQ_{max} value greater than one as far away as the Ranch location, the contributions to the cumulative EHQ_{max} values associated with background levels from those calculated using model predicted concentrations is a relatively small fraction (ranging from about 17% at the ETWF to only about 0.4% at the Ranch). Further, additional data appearing in Appendix B (Table B-20) illustrate that when ESSLs for animals are used that are derived from TRV_{High} toxicity factors, only Ba, total Cr, and Cu remain problematic for Site 300; whereas, the resulting EHQs corresponding to the model predicted values are all now less than unity, and no cumulative EHQ for any of these metals exceeds one. Additionally, Appendix B (Table B-20) contains data that clearly illustrate that the contribution to both the individual and the cumulative EHQs that were derived for measured background soil concentrations from those derived for the model predicted concentrations remains quite small.

Finally, Table 19 further investigates the impact of measured values on the two sensitive animal species—the San Joaquin Kit Fox, and the Burrowing Owl. Thus, Table 19 is analogous to Table 18, except that it focuses specifically on ESSL data derived for the Kit Fox and the Burrowing Owl using TRV_{Low} and TRV_{High} toxicity factors.

Accordingly, with respect to the Kit Fox, the EHQ_{Kit Fox (max)} values (those developed with ESSL_{min} values calculated from TRV_{Low} toxicity factors) for background (measurement) concentrations at Site 300 exceed one for Cd and Pb; whereas, none of the EHQs for the

Kit Fox that were determined for background concentrations using ESSLs derived from TRV_{High} values exceeds one, and neither does the corresponding cumulative EHQ. Table 19 also illustrates that with respect to the Burrowing Owl, the $EHQ_{Burrowing\ Owl\ (max)}$ values (those developed with $ESSL_{min}$ values calculated from TRV_{Low} toxicity factors) for background measurement concentrations at Site 300 exceed one for all of the metals for which TRV data exist in the literature; whereas, none of the EHQs for the Burrowing Owl that were determined for background concentrations using ESSLs derived from available TRV_{High} values exceed one, although the cumulative EHQ in this case is greater than one.

An additional analysis was performed where EHQs were also determined for the Burrowing Owl using avian toxic reference values (TRVs) for cadmium and lead taken from U. S. EPA documents (2005a,b). The value for the avian TRV for cadmium is a geometric mean; and the value for lead is the highest bounded no-observed adverse effect level (NOAEL) that is below the lowest bounded Lowest Observed Adverse Effect Level (LOAEL). Using these values (1.47 mg/[kg d] for cadmium and 1.63 mg/[kg d] for lead) as the TRVs for cadmium and lead for the Burrowing Owl yielded ESSLs that were then used along with Site 300 measured soil concentrations to produce EHQs for these chemicals. In both cases, the values at the EWTF were significantly lower than those appearing in Table 19 for the TRV_{Low} based EHQ (0.8 for cadmium and about 4 for lead). Accordingly, the more conservative choices for TRVs may indicate a potential for impact (see Table 19), but the more recent and potentially more applicable values for TRVs for cadmium and lead considered suitable for avian species strongly suggest no ecological impact is likely from Cd, even from background levels, and a smaller, if any, impact would be predicted from background levels for Pb.

In summary, for this ERA, ten receptor species, including vegetation, were identified as representative members of trophic levels in the habitat of Site 300, and were evaluated for the possibility of potential detrimental effects from EWTF emissions, using TRVs and both model predicted and measured exposure concentrations, as applicable. Overall, the data tabulated in Tables 16a, 16b, and 17 through 19 suggest that further site specific information should be developed. Because the calculated screening results in this analysis can generally be considered conservative, potential impacts suggested by this analysis may be overestimates. Accordingly, additional data collection and further analysis would either help to reveal the degree, if any, that EWTF contributions to soil contamination would contribute to ecological impact, or dismiss from further consideration the EWTF as a source for such ecological impacts.

5. Uncertainties and Conservatism

Quantification of health risk from the operation of the EWTF involved

- Estimating the magnitude of emissions.
- The concentrations of the constituents of concern in various environmental media.
- The magnitude of exposure as well as the exposure frequency and duration for exposure pathways of concern for specific receptors.

This risk assessment implemented 95th-percentile estimates, when possible, and health-conservative estimates, when the distribution of the parameter was unknown, for the

parameters that could be controlled within the models used.

Quantification of the source term for the EWTF is uncertain because it is difficult to predict the exact nature of the explosives that will be treated. This risk assessment addressed this uncertainty by using the most conservative emissions factors that can be reasonably justified. The continued research conducted by the DoD in this area will improve emission factors for future permitting efforts and reduce the uncertainty from the emission factors, but the inherent uncertainty in exactly predicting releases from waste treatment operations at a research institution will remain.

Quantification of the air concentrations is uncertain. This uncertainty has been addressed by using the most health conservative munition, TNT, in the OBODM model. TNT is the most health conservative because it has the lowest heat of combustion, leading to the least plume rise, and, therefore, the greatest downwind concentrations. The uncertainty in the prediction of air concentrations was reduced by using 5 years of site-specific meteorological data in the air dispersion modeling.

Quantification of the soil concentrations is uncertain. This risk assessment addressed this uncertainty by using a deposition velocity for the constituents of greatest health concern, polychlorinated dibenzodioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs).

There are uncertainties as to the magnitude of exposure. These uncertainties were addressed through the use of 95th-percentile inhalation rates for residential receptors and bystander workers, for the incidental soil ingestion rate for residential receptors, for the skin surface area and dermal adhesion factor for the dermal exposure route for residential receptors. The dermal exposure route is uncertain for the indoor receptors because there are no recommended exposure factors for this route/receptor combination; however, it is unlikely that any indoor worker would have a significant dermal exposure to resuspended soil.

The 30-year residency exposure assumption is the 95th-percentile estimate of population mobility stated in the U.S. EPA's *Exposure Factors Handbook* (U.S. EPA, 1997). The average residence in one place is estimated to be significantly less, at 11.4 years for homeowners and 2.4 years for renters (Israeli and Nelson, 1992). The on-site bystander worker was evaluated for a 25-year work duration, well above the U.S. EPA-recommended occupational tenure value of 6.6 years (U.S. EPA, 1997). It should also be noted that the HARP model does not have distinct point estimates and data distributions for the 30-year and 70-year exposure scenarios. The documentation states:

However, in the interest of simplicity, the 30-year exposure duration scenario uses the same exposure point-estimates and data distributions as the 70-year exposure duration scenario. This assumption to use the 70-year exposure point-estimate for both 30 and 70-year exposures probably results in a small underestimation of dose for the 30-year exposure scenario, since the exposure parameters for earlier years are higher than years spent as an adult (OEHHA, 2003).

Quantification of toxic effects involves applying appropriate toxicity data to the constituents of potential concern. However, not all constituents of concern for the EWTF have toxicity data. This uncertainty was addressed by identifying surrogate materials and using the toxicity data for the surrogate material to estimate risk and hazard.

Cancer potency factors were estimated from long-term animal studies where the dose is typically held constant and the exposure is conducted continuously over a major portion of the life span of the animals (i.e., lifetime exposure). Human cancer risk assessments, on the other hand, typically involve estimating exposures over less than a lifetime (e. g., 9 years, 25 years, or 30 years) and multiplying the lifetime average daily dose (less than lifetime exposure total dose averaged over a 70-year lifetime) times the cancer potency factor. Although the U. S. EPA and OEHHA support the use of cancer potency factors for estimating cancer risk for these exposure durations, uncertainties are associated with applying the cancer potency factors to less than lifetime exposures or to exposures that are not continuous but intermittent (i.e., like OB/OD operations). Some chemicals are more potent carcinogens when exposures occur early in life but have little or no effect later in life; other chemicals are more potent carcinogens when exposures occur late in life but have little or no effect earlier in life. Thus, depending on when the actual less than lifetime (or intermittent) exposure occurs during one's lifetime, using lifetime average daily dose and cancer potency factors can lead to under- or overestimating theoretical cancer risks. Halmes et al. (2000) indicate that although typical linear adjustments for less-than-lifetime exposure in cancer risk assessment can theoretically result in under- or overestimation of risks, underestimation of risks from short-term exposures is more likely.

Studies of the compounding of conservatism in probabilistic risk assessments show that setting as few as two factors at high-end levels (e.g., near the 90th percentile), and setting the remaining variables at less conservative, or expected values, result in a product of all input variables that approximate a maximum exposure value (e.g., 99th-percentile value) (Cullen, 1994). This risk assessment used 95th-percentile estimates for inhalation rates, residential ingestion rates, and skin surface exposure. As a result, it provides a very conservative estimate of health effects that are, nonetheless, below any level of concern.

Quantification of the ecological risk posed by release of a particular contaminant to a specific habitat is complicated by additional uncertainties related to limited data concerning the physiological and behavioral characteristics of those wildlife species that were considered to be present. To overcome such difficulties, ecological risk assessments, as currently practiced, focus on modeling potential total dose and developing an EHQ for an individual organism of one or more species (and most often only for adults due to data limitations) in the affected habitat. This approach allows any impact to an individual of a particular species to be translated to an impact to the population, and, by inference, to a potential impact on the entire local ecosystem.

This ERA followed a similar approach, examining the potential for impact from a contaminant of potential ecological concern for an individual receptor from more than one species, and each species was considered to be at a different trophic level in the local ecosystem near the EWTF. Additional conservatism was added to these calculations by:

- Maximizing the amount of material deposited (by considering a habitat location at Site 300 quite close to the OB/OD operations—the source of emissions).
- Optimizing the receptor behavior to maximize exposures (i.e., living, foraging, and capturing prey exclusively in that immediate habitat).
- Using concentrations of CPECs that represented a depth of 6 inches (15 cm). Although 2 feet (60 cm) is a common depth for evaluating the effects on fossorial animals, soil at that depth would not be expected to have the same level of air-deposited contamination as would be present at the surface.
- Fixing the absorption fraction of each contaminant of each receptor at 100 percent.

Furthermore, this ERA employed very conservative values for wildlife TRVs generally, especially for the avian RREI with respect to cadmium and lead (i.e., 0.08 mg/kg d for cadmium and 0.014 mg/kg d for lead) (see avian BTAG values presented in DTSC [2000]). In fact, the U.S. EPA TRVs for cadmium and lead, (1.47 mg/kg d and 1.63 mg/kg d, respectively) as derived in Ecological Soils Screening Level documents (U.S. EPA, 2005a,b), still represent NOAEL levels but are not as conservative as those presented by DTSC (2000). These U.S. EPA documents identify the avian wildlife TRV for cadmium as a geometric mean value, and the highest bounded NOAEL that is below the lowest bounded LOAEL as the avian TRV for lead. Accordingly, the EHQs at the EWTF for cadmium and lead that are derived using these TRVs from U.S. EPA (2005a,b), respectively, would indicate far less, if any, ecological risk from these substances, even from background levels.

6. Summary of Risks and Hazards

Source term estimation is a difficult process for any waste treatment facility because the exact identity of the particular wastes that will be treated cannot be predicted with absolute certainty. The use of publicly available emissions factors, such as those presented here, enables health conservative factors to be identified and used to set an upper bound on the possible future conditions, and makes calculations easily reproducible and transparent.

The calculations evaluating human health risk in this assessment are based on health conservative assumptions for nearly every parameter. The use of conservative assumptions yields a very conservative upper bound estimate of potential health effects. The calculations demonstrate that the operations at the EWTF do not constitute a human health risk: the carcinogenic risk is less than 1 in 1 million, and the acute and chronic hazard indices are less than 1. In addition, the modeled 99th percentile blood-lead levels used to assess non-carcinogenic hazard are all well below the 99th percentile upper confidence limit for a blood-lead level of 10 µg Pb/dL, which represents the threshold that would be considered of concern.

The EHQs calculated based on DTSC guidance exceed 1 in some cases. However, it is likely that the conservatisms used in the modeling overestimate the consequences significantly. In fact, using more realistic avian TRVs for both cadmium and lead produces ESSLs that yield EHQs for cadmium and lead that would produce no impact

or little if any. Thus, this analysis cannot determine unequivocally whether or not the EWTF will actually contribute to any future ecological impacts at Site 300, although calculations using background measurement data for selected metals would suggest any impact to be minimum relative to background levels. Based on these results, emissions from the operations of the EWTF should not be of concern for human health and may also be of *de minimis* concern with regard to ecological impacts for the majority of emissions.

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List of Acronyms and Abbreviations

AP	Ammonium perchlorate
ATSDR	Agency for Toxic Substances Disease Registry
B	Building
BAF	Bioaccumulation factors
BJC	Bechtel Jacobs Company, LLC
brd	bird
BTAG	Biological Technical Assistance Group
BW	Body weight
CalEPA	California Environmental Protection Agency
CARB	California Air Resources Board
CAS	Chemical Abstract Service
CAS	Chemical Abstract Service
Cd	Cadmium
Cl ₂	Chlorine
CO	Carbon monoxide
CO ₂	Carbon dioxide
CPEC	Contaminant of potential ecological concern
CPF	Cancer Potency Factor
CPF	Cancer potency factor
Cu	Copper
DF	Dietary fraction
DMI	Dietary dry-matter intake
DMI	Dry-matter intake
DOD	U.S. Department of Defense
DTSC	Department of Toxic Substances Control
EHQ	Ecological hazard quotient
EPA	U.S. Environmental Protection Agency
ERA	Ecological risk assessment
ESSL	Ecological soil screening level
ETS	Experimental Test Species
EWTF	Explosives Waste Treatment Facility
GSD	Geometric standard deviation
H ₂ O	water
HARP	HotSpots Analysis and Reporting Program
HCL	Hydrogen chloride
HERD	Human and Ecological Risk Division
HMX	High melting explosive

ID	Identification
inv	invertebrate
IRIS	Integrated Risk Information System
ISCST	Industrial Source Code/Complex Short-Term
LLNL	Lawrence Livermore National Laboratory
mam	mammalian
N ₂	Nitrogen
NAS	National Academy of Sciences
NM	New Mexico
NO	Nitrogen oxide
NO ₂	Nitrogen dioxide
NOEC	No-observed effect concentrations
OB	Open Burn
OBODM	Open Burn/Open Detonation Dispersion Model
OD	Open Detonation
OEHHA	Office of Environmental Health Hazard Assessment
Pb	Lead
PCDF	Polychlorinated dibenzofuran
PCDP	Polychlorinated dibenzopdioxin
PETN	Pentaerythritol tetranitrate
PRG	Preliminary Remediation Goal
PST	Pacific Standard Time
RCRA	Resource Conservation and Recovery Act
RDX	Research Department explosive (cyclotrimethylenetrinitramine)
REL	Reference Exposure Levels
rep	reptile
RfD	Reference dose
RREI	Representative receptor of ecological interest
RWBB	Red-Winged Black Bird
SF	Scaling factor
SO ₂	Sulfur dioxide
SVOC	Semi-volatile organic compound
TCDD	2,3,7,8-Tetrachlorodibenzo-p-dioxin
TCDF	2,3,7,8-Tetrachlorodibenzofuran
TEF	Toxicity equivalency factor
TNT	Trinitrotoluene
TPHCWG	Total Petroleum Hydrocarbon Criteria Working Group
TRV	Toxic reference value
U.S.	United States

UF	Uncertainty factor
UT	Utah
veg	vegetation
VOC	Volatile organic compound
wlf	wildlife
Zn	Zinc

Appendix A. Integration of OBODM into the HARP

As stated in the main body of this risk assessment, the standard approach for human health risk assessment is a four-step process stated by the National Academy of Sciences in *Risk Assessment in the Federal Government: Managing the Process* (NAS, 1983) and reiterated in *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments* (OEHHA, 2003). The four steps in the process are (1) hazard identification, (2) exposure assessment, (3) dose-response assessment, and (4) risk characterization.

For this risk assessment for the EWTF, the DTSC recommended the use of the Open Burn Open Detonation Dispersion Model (OBODM; Bjorklund et al., 1998). Region III of the U.S. EPA (2002) also recommends its use. The OBODM has components that allow completion of steps 1 and 2 (i.e., it contains emissions factors for many chemicals based on tests of 39 types of munitions [see also Mitchell and Suggs, 1998]); and it contains a Gaussian-plume air dispersion model developed specifically for short-term episodic releases, such as open burns and open detonations. The OBODM emission factors have been widely used to estimate the hazards from OB/OD and similar operations.³ It is more common for a risk assessor to identify the hazards through developing source-specific information and/or through the use of approved emissions factors not specifically included in the air dispersion model. Unfortunately, the OBODM only allows the estimation of one released chemical for each treated material for each model run. If, for example, an OB/OD treatment involved the release of ten materials, the OBODM would have to be run ten times. Because the model is linear with respect to the initial released chemical, the OBODM could also be run once, and a scaling factor could then be used to scale the result up or down, depending on the ratio of the initial chemical to the chemical in question. (For example, if chemical A has an emission factor of 1, and chemical B has an emission factor of 2, the OBODM could be run for chemical A, and the air concentrations would then be used without adjustment for chemical A and would be multiplied by 2 for chemical B.)

To complete this risk assessment, the Hotspot Analysis Reporting Program (HARP) (CARB, 2003) was used. The OEHHA and the California Air Resources Board (CARB) developed this model for compliance with the AB2588 Hotspots reporting requirements. The HARP provides assistance with steps 2, 3 and 4 of risk assessment: (2) exposure assessment, (3) dose-response assessment, and (4) risk characterization.

³ For example, OBODM emission factors have been used by the U.S. Navy and affirmed by the Agency for Toxic Substances Disease Registry (ATSDR) in evaluating emissions from Isla de Vieques, Puerto Rico, bombing range (http://www.atsdr.cdc.gov/HAC/PHA/vieques4/vbr_p5.html): "The Navy contractor used emission factors derived from Bangbox studies to estimate emissions of chemical by-products of bombing activities. These emission factors have been widely used to assess environmental impacts from open burning and open detonation activities. For instance, the Open Burn/Open Detonation Model (OBODM), available from EPA's clearinghouse of dispersion models on the agency's technology transfer network, also estimates air emissions from the Bangbox emission factors. ATSDR acknowledges that the representativeness of static detonation tests to live bombing exercises has not been established. However, source testing (or emissions measurements) during live bombing exercises is an extremely complicated endeavor, given the potential safety hazards associated with placing field surveying equipment in the proximity of bombing targets. In the absence of such source testing results, ATSDR believes the Bangbox emission factors are reasonable indicators of chemical releases from explosions."

The HARP model is available in two formats: a free, self-contained version and a commercial version (called HARPEXpress) that relies on Microsoft Excel to provide a user-friendly interface for entering information into the program. This risk assessment used HARPEXpress; however, this risk assessment refers to the model as "HARP."

To accomplish the exposure assessment portion of the risk assessment, the HARP incorporates the Industrial Source Code, Short Term (ISCST) model. ISCST is the U.S. EPA regulatory model most commonly used in permitting actions. It includes the common assumptions that emissions are continuous and that they are vented through a stack. Consequently, the air dispersion modeling output of the HARP could not be used (at least not without some manipulation). However, the HARP is quite robust in its treatment of dose-response assessment and risk characterization. It allows modeling of many chemicals at the same time (in this case, 51) and is limited only by the availability of toxicological information.

The problem that arose in this risk assessment was how to integrate the source term and the atmospheric modeling capabilities of the OBODM together with the exposure assessment, dose response and risk characterization attributes of the HARP.

The integration of the emissions factors information was straightforward. The emissions factors from the OBODM were read into a Microsoft Access database file. The database file was queried for the munitions that were identified as those representative of waste Forms 1 through 4, and the highest emission factor for each emitted chemical was selected. These emissions factors were multiplied by the amount of material treated, and the emissions estimates for each chemical for each waste form were copied into the HARP.

The integration of the air dispersion modeling was somewhat more complex. First, it is important to remember that the HARP is written in a modular form and that the modules operate independently. The HARP modules are the source term calculations, the air dispersion calculations (which is the ISCST model), and the risk and hazard calculations. However, only the air dispersion modeling of the HARP needed to be changed from ISCST output to the OBODM output.

Fortunately (from the point of view of inserting the OBODM results into the HARP), ISCST (within the HARP) begins all of its air dispersion calculations from the assumption that 1 gram per second (1 g/s) is being released from a facility. It does not use the actual emissions until later in the modeling code. From the starting point of a 1-g/s release (also called a unit-source release), ISCST then calculates the concentrations at all the receptor locations identified in the input file, in micrograms per cubic meter of air ($\mu\text{g}/\text{m}^3$) for that 1-g/s release. The result is called the unit source "X/Q," where "X" (the Greek letter "chi") is the concentration at the receptor location, and "Q" is the emission rate for the material of interest. The X/Q data are located in an ISCST file named "filename.XOQ" where "filename" represents the file name of the particular model run.

Therefore, to incorporate the OBODM results into the HARP, the modeler needs to acquire a unit source "X/Q" from the OBODM for all receptor locations and substitute

that data into the filename.XOQ file. After the substitution is made, the risk and the hazard assessments modules of the HARP can be run based on OBODM X/Q data. The OBODM does not have an intermediate "X/Q" file that is obviously accessible. However, the OBODM primary output, ground-level concentrations, can be used with the input emissions concentrations to calculate the X/Q for each location. This was the approach that was taken. It was used for both maximum hourly X/Q and annual average X/Q.

The chemical barium was selected for the calculation because it had an emission factor for all four waste forms. The emission factor for barium for Forms 1 and 2 was 0.0082, and the emission factor for Forms 3 and 4 was 0.000086. The OBODM model was run for each of these emission factors for all four forms. Because a "unit" X/Q was being calculated, the results should be the same without regard to the initial emission factor. The use of actual emission factors enabled checking the concentration of barium for each of the waste forms in the HARP after the substitution was made.

To reiterate, the concentration output of the OBODM model must be divided by the emission rate for each of the waste forms to yield a unit source X/Q. However, this step requires the availability of the source emission rates. These emission rates were calculated from the estimated masses of the quantities emitted per second. The calculations and the resulting emission rates are shown in Table A-1. Table A-2 shows the unit source X/Q calculations based on the 0.0082 barium emission factor, and Table A-3 shows the unit source X/Q calculations based on the 0.000086 barium emission factor. A comparison of Tables A-2 and A-3 shows that the unit source X/Qs are calculated to be the same to five significant digits. Exact agreement to more significant digits was not expected because only three significant digits are presented in the OBODM output. It should be noted that the source order in Tables A-2 and A-3 are as follows: source 1 is the burn pan, source 2 is the burn cage (Form 3), source 3 is the burn cage (Form 4), and source 4 is the detonation pad. The same source order was implemented in the HARP.

Table A-4 shows the modified .XOQ file after the annual average and maximum hourly values were updated with OBODM X/Q values. The validity of the approach was checked by comparing the concentrations calculated by the HARP for barium with those calculated by the OBODM. The results were equal, confirming that the .XOQ file had been modified appropriately. This confirmatory calculation was carried out independently by two of the authors of this report; both of whom obtained the same results. The calculations are shown in Table A-5, where the appropriate ground-level concentrations for each of the sources are summed for the total annual average concentration and the maximum 1-hour concentration for each modeled receptor location. Figure A-1 is a screen shot of the annual average and maximum hourly ground-level concentrations calculated by the HARP.

Table A-1. Calculation of unit source values for two barium emission factors.

	Burn pan	Burn cage (form 3)	Burn cage (form 4)	Detonation pad
Barium factor 0.0082	Annual average emission rate			
Pounds per event	100	50	260	350
Events per year	100	100	100	100
Total pounds per year	10000	5000	26000	35000
Total grams per year	4535923	2267962	11793400	15875731
Total seconds per year	31536000	31536000	31536000	31536000
Annual average g/s	0.144	0.072	0.374	0.503
Barium emission factor	0.0082	0.0082	0.0082	0.0082
Barium annual average emission rate (g/s)	0.00118	0.00059	0.00307	0.00413
	Maximum hourly emission rate			
Pounds per event	100	50	260	350
Events per hour	1	1	1	1
Total pounds per hour	100	50	260	350
Total grams per hour	45359	22680	117934	158757
Total seconds per hour	3600	3600	3600	3600
Hourly g/s	12.6	6.3	32.8	44.1
Barium emission factor	0.0082	0.0082	0.0082	0.0082
Barium maximum hourly emission rate (g/s)	0.103	0.052	0.269	0.362
Barium factor 0.000086	Annual average emission rate			
Pounds per event	100	50	260	350
Events per year	100	100	100	100
Total pounds per year	10000	5000	26000	35000
Total grams per year	4535923	2267962	11793400	15875731
Total seconds per year	31536000	31536000	31536000	31536000
Annual average g/s	0.144	0.072	0.374	0.503
Barium emission factor	0.000086	0.000086	0.000086	0.000086
Barium annual average emission rate (g/s)	0.0000124	0.0000062	0.0000322	0.0000433
	Maximum hourly emission rate			
Pounds per event	100	50	260	350
Events per hour	1	1	1	1
Total pounds per hour	100	50	260	350
Total grams per hour	45359	22680	117934	158757
Total seconds per hour	3600	3600	3600	3600

	Burn pan	Burn cage (form 3)	Burn cage (form 4)	Detonation pad
Hourly g/s	12.6	6.3	32.8	44.1
Barium emission factor	0.000086	0.000086	0.000086	0.000086
Barium maximum hourly emission rate (g/s)	0.00108	0.00054	0.00282	0.00379

Table A-2. Calculations of X/Q based on barium emission factor of 0.0082.

Emission factor 0.0082 (form12out)		OB Pan	OB Cage 3	OB Cage 4	OD	factors by which to divide Ba emissions to derive unit chi/Q
		annual ave mxhrly	1.18E-03 1.03E-01	5.90E-04 5.17E-02	3.07E-03 2.69E-01	4.13E-03 3.62E-01

Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter) (Due to source group 1, sources: 1) Burn Pan (Maximum = .13365E+00 at X,Y,Z = 629500.00,4168500.00,383.90)						
X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	
633000	4170500	273.9	1.00E-03	8.52E-01	.8515709E+00	Pasture
628681.5	4165968	201	9.67E-04	8.19E-01	.8194978E+00	Carnegie
632976.6	4166183	158.4	4.68E-04	3.97E-01	.3965510E+00	Ranch
629950	4168674	309.4	1.72E-02	1.46E+01	.1455489E+02	B812
630020	4168179	379.3	1.61E-02	1.36E+01	.1364920E+02	B895
633000	4170500	273.9	1.00E-03	8.52E-01	.8515709E+00	Pasture repeat
629500	4168500	383.9	1.34E-01	1.13E+02	.1133045E+03	Ecological

Table 3

Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter) (Due to source group 2, sources: 2) Burn Cage (form 3) (Maximum = .66794E-01 at X,Y,Z = 629500.00,4168500.00,383.90)						
X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	
633000	4170500	273.9	4.99E-04	8.47E-01	.8469687E+00	Pasture
628681.5	4165968	201	5.69E-04	9.65E-01	.9646185E+00	Carnegie
632976.6	4166183	158.4	2.67E-04	4.52E-01	.4524008E+00	Ranch
629950	4168674	309.4	1.05E-02	1.78E+01	.1782248E+02	B812
630020	4168179	379.3	8.92E-03	1.51E+01	.1511857E+02	B895
633000	4170500	273.9	4.99E-04	8.47E-01	.8469687E+00	Pasture repeat
629500	4168500	383.9	6.68E-02	1.13E+02	.1132647E+03	Ecological

Table 4

Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter) (Due to source group 3, sources: 3) Burn Cage (form 4) (Maximum = .30209E+00 at X,Y,Z = 629500.00,4168500.00,383.90)						
X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	
633000	4170500	273.9	2.55E-03	8.33E-01	.8327705E+00	Pasture
628681.5	4165968	201	2.80E-03	9.14E-01	.9135818E+00	Carnegie
632976.6	4166183	158.4	1.34E-03	4.37E-01	.4366443E+00	Ranch
629950	4168674	309.4	4.49E-02	1.46E+01	.1463560E+02	B812
630020	4168179	379.3	4.28E-02	1.39E+01	.1394625E+02	B895
633000	4170500	273.9	2.55E-03	8.33E-01	.8327705E+00	Pasture repeat
629500	4168500	383.9	3.02E-01	9.85E+01	.9851385E+02	Ecological

Table A-2. Calculations of X/Q based on barium emission factor of 0.0082 (continued).

Table 5
Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 4, sources: 4) Detonation Pad
(Maximum = .12371E+00 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	
633000	4170500	273.9	2.10E-03	5.08E-01	.5081017E+00	Pasture
628681.5	4165968	201	2.19E-03	5.31E-01	.5313550E+00	Carnegie
632976.6	4166183	158.4	1.27E-03	3.07E-01	.3067384E+00	Ranch
629950	4168674	309.4	1.72E-02	4.17E+00	.4165249E+01	B812
630020	4168179	379.3	2.44E-02	5.90E+00	.5900564E+01	B895
633000	4170500	273.9	2.10E-03	5.08E-01	.5081017E+00	Pasture repeat
629500	4168500	383.9	1.24E-01	3.00E+01	.2996745E+02	Ecological

Table 6
Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 1, sources: 1) Burn Pan
(Maximum = 11.877 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	0.12558	1.22E+00	.1215468E+01	3	26	0	68	800
628681.5	4165968	201	0.223714	2.17E+00	.2165290E+01	9	13	1	86	800
632976.6	4166183	158.4	0.114005	1.10E+00	.1103435E+01	3	6	3	65	800
629950	4168674	309.4	2.8726	2.78E+01	.2780341E+02	11	6	2	310	800
630020	4168179	379.3	2.95159	2.86E+01	.2856795E+02	12	20	4	355	800
633000	4170500	273.9	0.12558	1.22E+00	.1215468E+01	3	26	0	86	800
629500	4168500	383.9	11.877	1.15E+02	.1149555E+03	9	11	2	254	800

Table 8
Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 2, sources: 2) Burn Cage (form 3)
(Maximum = 5.0540 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	0.050014	9.68E-01	.9681504E+00	12	6	2	340	800
628681.5	4165968	201	8.33E-02	1.61E+00	.1612033E+01	9	13	1	256	800
632976.6	4166183	158.4	0.040661	7.87E-01	.7870981E+00	3	6	3	65	800
629950	4168674	309.4	1.3717	2.66E+01	.2655291E+02	1	19	4	19	900
630020	4168179	379.3	1.17555	2.28E+01	.2275590E+02	11	25	0	330	800
633000	4170500	273.9	0.050014	9.68E-01	.9681504E+00	12	6	2	340	800
629500	4168500	383.9	5.05396	9.78E+01	.9783286E+02	9	11	2	254	800

Table A-2. Calculations of X/Q based on barium emission factor of 0.0082 (continued).

Table 10
 Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
 (Due to source group 3, sources: 3) Burn Cage (form 4)
 (Maximum = 21.001 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	0.246753	9.19E-01	.9185696E+00	12	6	2	340	800
628681.5	4165968	201	0.391287	1.46E+00	.1456616E+01	9	13	1	256	800
632976.6	4166183	158.4	0.198177	7.38E-01	.7377392E+00	3	6	3	65	800
629950	4168674	309.4	4.95688	1.85E+01	.1845262E+02	1	19	4	19	900
630020	4168179	379.3	5.4473	2.03E+01	.2027827E+02	11	25	0	330	900
633000	4170500	273.9	0.246753	9.19E-01	.9185696E+00	12	6	2	340	800
629500	4168500	383.9	21.0008	7.82E+01	.7817816E+02	9	11	2	254	800

Table 12
 Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
 (Due to source group 4, sources: 4) Detonation Pad
 (Maximum = 18.767 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	0.591244	1.64E+00	.1635015E+01	12	8	0	343	900
628681.5	4165968	201	0.435929	1.21E+00	.1205510E+01	9	13	1	256	800
632976.6	4166183	158.4	0.373553	1.03E+00	.1033016E+01	10	16	1	289	800
629950	4168674	309.4	1.92837	5.33E+00	.5332677E+01	1	1	0	1	900
630020	4168179	379.3	8.25488	2.28E+01	.2282789E+02	3	6	3	65	800
633000	4170500	273.9	0.591244	1.64E+00	.1635015E+01	12	8	0	343	900
629500	4168500	383.9	18.767	5.19E+01	.5189790E+02	2	18	0	49	800

Table A-3. Calculations of X/Q based on barium emission factor of 0.000086.

Emission factor 0.000086 (form34out)		OB Pan	OB Cage 3	OB Cage 4	OD	factors by which to divide Ba emissions to derive unit chi/Q
		annual ave	1.24E-05	6.18E-06	3.22E-05	4.33E-05
		mxhrly	1.08E-03	5.42E-04	2.82E-03	3.79E-03

Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)						
(Due to source group 1, sources: 1)						
(Maximum = .14015E-02 at X,Y,Z = 629500.00,4168500.00,383.90)						
X	Y	Z	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Burn Pan
(Meters)	(Meters)	(Meters)				
633000	4170500	273.9	1.05E-05	8.52E-01	.8515679E+00	Pasture
628681.5	4165968	201	1.01E-05	8.19E-01	.8194975E+00	Carnegie
632976.6	4166183	158.4	4.91E-06	3.97E-01	.3965511E+00	Ranch
629950	4168674	309.4	1.80E-04	1.46E+01	.1455489E+02	B812
630020	4168179	379.3	1.69E-04	1.36E+01	.1364921E+02	B895
633000	4170500	273.9	1.05E-05	8.52E-01	.8515679E+00	Pasture repeat
629500	4168500	383.9	1.40E-03	1.13E+02	.1133047E+03	Ecological

Table 3

Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)						
(Due to source group 2, sources: 2)						
(Maximum = .70052E-03 at X,Y,Z = 629500.00,4168500.00,383.90)						
X	Y	Z	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Burn Cage (form 3)
(Meters)	(Meters)	(Meters)				
633000	4170500	273.9	5.24E-06	8.47E-01	.8469696E+00	Pasture
628681.5	4165968	201	5.97E-06	9.65E-01	.9646204E+00	Carnegie
632976.6	4166183	158.4	2.80E-06	4.52E-01	.4524023E+00	Ranch
629950	4168674	309.4	1.10E-04	1.78E+01	.1782249E+02	B812
630020	4168179	379.3	9.35E-05	1.51E+01	.1511861E+02	B895
633000	4170500	273.9	5.24E-06	8.47E-01	.8469696E+00	Pasture repeat
629500	4168500	383.9	7.01E-04	1.13E+02	.1132646E+03	Ecological

Table 4

Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)						
(Due to source group 3, sources: 3)						
(Maximum = .31683E-02 at X,Y,Z = 629500.00,4168500.00,383.90)						
X	Y	Z	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Burn Cage (form 4)
(Meters)	(Meters)	(Meters)				
633000	4170500	273.9	2.68E-05	8.33E-01	.8327701E+00	Pasture
628681.5	4165968	201	2.94E-05	9.14E-01	.9135820E+00	Carnegie
632976.6	4166183	158.4	1.40E-05	4.37E-01	.4366424E+00	Ranch
629950	4168674	309.4	4.71E-04	1.46E+01	.1463560E+02	B812
630020	4168179	379.3	4.49E-04	1.39E+01	.1394629E+02	B895
633000	4170500	273.9	2.68E-05	8.33E-01	.8327701E+00	Pasture repeat
629500	4168500	383.9	3.17E-03	9.85E+01	.9851374E+02	Ecological

Table A-3. Calculations of X/Q based on barium emission factor of 0.000086 (continued).

Table 5
Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 4, sources: 4)
(Maximum = .12974E-02 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Detonation Pad
633000	4170500	273.9	2.20E-05	5.08E-01	.5081029E+00	Pasture
628681.5	4165968	201	2.30E-05	5.31E-01	.5313557E+00	Carnegie
632976.6	4166183	158.4	1.33E-05	3.07E-01	.3067369E+00	Ranch
629950	4168674	309.4	1.80E-04	4.17E+00	.4165263E+01	B812
630020	4168179	379.3	2.55E-04	5.90E+00	.5900570E+01	B895
633000	4170500	273.9	2.20E-05	5.08E-01	.5081029E+00	Pasture repeat
629500	4168500	383.9	1.30E-03	3.00E+01	.2996758E+02	Ecological

Table 6
Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 1, sources: 1)
(Maximum = .12456E+00 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr	Burn Pan
633000	4170500	273.9	1.32E-03	1.22E+00	.1215469E+01	3	26	0	86	800	
628681.5	4165968	201	2.35E-03	2.17E+00	.2165291E+01	9	13	1	256	800	
632976.6	4166183	158.4	1.20E-03	1.10E+00	.1103433E+01	3	6	3	65	800	
629950	4168674	309.4	3.01E-02	2.78E+01	.2780344E+02	11	6	2	310	800	
630020	4168179	379.3	3.10E-02	2.86E+01	.2856795E+02	12	20	4	355	800	
633000	4170500	273.9	1.32E-03	1.22E+00	.1215469E+01	3	26	0	86	800	
629500	4168500	383.9	1.25E-01	1.15E+02	.1149549E+03	9	11	2	254	800	

Table 8
Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 2, sources: 2)
(Maximum = .53005E-01 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr	Burn Cage (form 3)
633000	4170500	273.9	5.25E-04	9.68E-01	.9681504E+00	12	6	2	340	800	
628681.5	4165968	201	8.73E-04	1.61E+00	.1612032E+01	9	13	1	256	800	
632976.6	4166183	158.4	4.26E-04	7.87E-01	.7870972E+00	3	6	3	65	800	
629950	4168674	309.4	1.44E-02	2.66E+01	.2655287E+02	1	19	4	19	900	
630020	4168179	379.3	1.23E-02	2.28E+01	.2275583E+02	11	25	0	330	800	
633000	4170500	273.9	5.25E-04	9.68E-01	.9681504E+00	12	6	2	340	800	
629500	4168500	383.9	5.30E-02	9.78E+01	.9783278E+02	9	11	2	254	800	

Table A-3. Calculations of X/Q based on barium emission factor of 0.000086 (continued).

Table 10
 Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
 (Due to source group 3, sources: 3)
 (Maximum = .22025E+00 at X,Y,Z = 629500.00,4168500.00,383.90)

Burn Cage (form 4)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	2.59E-03	9.19E-01	.9185706E+00	12	6	2	340	800
628681.5	4165968	201	4.10E-03	1.46E+00	.1456615E+01	9	13	1	256	800
632976.6	4166183	158.4	2.08E-03	7.38E-01	.7377422E+00	3	6	3	65	800
629950	4168674	309.4	5.20E-02	1.85E+01	.1845262E+02	1	19	4	19	900
630020	4168179	379.3	5.71E-02	2.03E+01	.2027826E+02	11	25	0	330	800
633000	4170500	273.9	2.59E-03	9.19E-01	.9185706E+00	12	6	2	340	800
629500	4168500	383.9	2.20E-01	7.82E+01	.7817806E+02	9	11	2	254	800

Table 12
 Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
 (Due to source group 4, sources: 4)
 (Maximum = .19682E+00 at X,Y,Z = 629500.00,4168500.00,383.90)

Detonation Pad

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	6.20E-03	1.64E+00	.1635014E+01	12	8	0	343	900
628681.5	4165968	201	4.57E-03	1.21E+00	.1205510E+01	9	13	1	256	800
632976.6	4166183	158.4	3.92E-03	1.03E+00	.1033016E+01	10	16	1	289	800
629950	4168674	309.4	2.02E-02	5.33E+00	.5332686E+01	1	1	0	1	900
630020	4168179	379.3	8.66E-02	2.28E+01	.2282787E+02	3	6	3	65	800
633000	4170500	273.9	6.20E-03	1.64E+00	.1635014E+01	12	8	0	343	900
629500	4168500	383.9	1.97E-01	5.19E+01	.5189800E+02	2	18	0	49	800

Table A-4. Modified .XOQ file after the annual average and maximum hourly values were updated with OBODM X/Q values. (Other values in .XOQ files were not used in this risk assessment).

SRC	REC	UNUSED	AVERAGE	1HR_MAX	... (additional columns, not used in this assessment)
1	1	0.3961217E+00	0.8515709E+00	0.1215468E+01	...
1	2	0.2721988E-02	0.8194978E+00	0.2165290E+01	...
1	3	0.2719286E-02	0.3965510E+00	0.1103435E+01	...
1	4	0.2839895E-02	0.1455489E+02	0.2780341E+02	...
1	5	0.3750449E-01	0.1364920E+02	0.2856795E+02	...
1	6	0.2341939E-01	0.8515709E+00	0.1215468E+01	...
1	7	0.2341939E-01	0.1133045E+03	0.1149555E+03	...
2	1	0.4261317E+00	0.8469687E+00	0.9681504E+00	...
2	2	0.3105313E-02	0.9646185E+00	0.1612033E+01	...
2	3	0.4173856E-01	0.4524008E+00	0.7870981E+00	...
2	4	0.2657336E-01	0.1782248E+02	0.2655291E+02	...
2	5	0.8583720E+00	0.1511857E+02	0.2275590E+02	...
2	6	0.1174408E+01	0.8469687E+00	0.9681504E+00	...
2	7	0.2341939E-01	0.1132647E+03	0.9783286E+02	...
3	1	0.4261317E+00	0.8327705E+00	0.9185696E+00	...
3	2	0.3105313E-02	0.9135818E+00	0.1456616E+01	...
3	3	0.4173856E-01	0.4366443E+00	0.7377392E+00	...
3	4	0.2657336E-01	0.1463560E+02	0.1845262E+02	...
3	5	0.8583720E+00	0.1394625E+02	0.2027827E+02	...
3	6	0.1174408E+01	0.8327705E+00	0.9185696E+00	...
3	7	0.2341939E-01	0.9851385E+02	0.7817816E+02	...
4	1	0.2331261E+00	0.5051017E+00	0.1635015E+01	...
4	2	0.2328404E-02	0.5313550E+00	0.1205510E+01	...
4	3	0.3221262E-01	0.3067384E+00	0.1033016E+01	...
4	4	0.1822067E-01	0.4165249E+01	0.5332677E+01	...
4	5	0.7229874E+00	0.5900564E+01	0.2282789E+02	...
4	6	0.9328276E+00	0.5081017E+00	0.1635015E+01	...
4	7	0.2341939E-01	0.2996745E+02	0.5189790E+02	...

Table A-5. Total ground level concentration of barium for all four sources by receptor location^a.

Annual average				
Location	X (UTM East) (Meters)	Y (UTM North) (Meters)	Z (Elevation) (Meters)	Ground Level Concentration $\mu\text{g}/\text{m}^3$
Pasture	633000	4170500	273.9	3.13E-03
Carnegie	628681.5	4165968	201	3.20E-03
Ranch	632976.6	4166183	158.4	1.75E-03
B812	629950	4168674	309.4	3.49E-02
B895	630020	4168179	379.3	4.10E-02
Pasture repeat	633000	4170500	273.9	3.13E-03
Ecological	629500	4168500	383.9	2.61E-01
Maximum 1 hour				
Location	X (UTM East) (Meters)	Y (UTM North) (Meters)	Z (Elevation) (Meters)	Ground Level Concentration $\mu\text{g}/\text{m}^3$
Pasture	633000	4170500	273.9	7.20E-01
Carnegie	628681.5	4165968	201	6.65E-01
Ranch	632976.6	4166183	158.4	4.90E-01
B812	629950	4168674	309.4	4.87E+00
B895	630020	4168179	379.3	1.13E+01
Pasture repeat	633000	4170500	273.9	7.20E-01
Ecological	629500	4168500	383.9	3.09E+01

^a the burn pan (source 1) and detonation pad (source 4) values are obtained from Table A-2, and the burn cage/Form 3 (source 2) and burn cage/Form 4 (source 3) values are obtained from Table A-3.

Figure A-1. Screen captures of total ground level concentrations for the HARP for barium (CAS number 7440393).

Rec	Type	CAS 7440393 $\mu\text{g}/\text{m}^3$
1	PATHWAY	3.13E-03
2	SENSITIVE	3.20E-03
3	SENSITIVE	1.75E-03
4	SENSITIVE	3.49E-02
5	SENSITIVE	4.10E-02
6	SENSITIVE	3.13E-03
7	SENSITIVE	2.61E-01

Rec	Type	CAS 7440393 $\mu\text{g}/\text{m}^3$
1	PATHWAY	7.20E-01
2	SENSITIVE	6.65E-01
3	SENSITIVE	4.90E-01
4	SENSITIVE	4.87E+00
5	SENSITIVE	1.13E+01
6	SENSITIVE	7.20E-01
7	SENSITIVE	3.09E+01

Note: The pathway location (for the beef ingestion pathway) was repeated as the number 6 “sensitive” location (for a person) in the HARP to assure that the final result was a risk value for a person at that location, and not some other type of receptor, e.g., a cow. The pathway location was necessary for the HARP to calculate a human ingestion dose from the beef pathway.

Appendix A. Integration of OBODM into the HARP

As stated in the main body of this risk assessment, the standard approach for human health risk assessment is a four-step process stated by the National Academy of Sciences in *Risk Assessment in the Federal Government: Managing the Process* (NAS, 1983) and reiterated in *The Air Toxics Hot Spots Program Guidance Manual for Preparation of Health Risk Assessments* (OEHHA, 2003). The four steps in the process are (1) hazard identification, (2) exposure assessment, (3) dose-response assessment, and (4) risk characterization.

For this risk assessment for the EWTF, the DTSC recommended the use of the Open Burn Open Detonation Dispersion Model (OBODM; Bjorklund et al., 1998). Region III of the U.S. EPA (2002) also recommends its use. The OBODM has components that allow completion of steps 1 and 2 (i.e., it contains emissions factors for many chemicals based on tests of 39 types of munitions [see also Mitchell and Suggs, 1998]); and it contains a Gaussian-plume air dispersion model developed specifically for short-term episodic releases, such as open burns and open detonations. The OBODM emission factors have been widely used to estimate the hazards from OB/OD and similar operations.³ It is more common for a risk assessor to identify the hazards through developing source-specific information and/or through the use of approved emissions factors not specifically included in the air dispersion model. Unfortunately, the OBODM only allows the estimation of one released chemical for each treated material for each model run. If, for example, an OB/OD treatment involved the release of ten materials, the OBODM would have to be run ten times. Because the model is linear with respect to the initial released chemical, the OBODM could also be run once, and a scaling factor could then be used to scale the result up or down, depending on the ratio of the initial chemical to the chemical in question. (For example, if chemical A has an emission factor of 1, and chemical B has an emission factor of 2, the OBODM could be run for chemical A, and the air concentrations would then be used without adjustment for chemical A and would be multiplied by 2 for chemical B.)

To complete this risk assessment, the Hotspot Analysis Reporting Program (HARP) (CARB, 2003) was used. The OEHHA and the California Air Resources Board (CARB) developed this model for compliance with the AB2588 Hotspots reporting requirements. The HARP provides assistance with steps 2, 3 and 4 of risk assessment: (2) exposure assessment, (3) dose-response assessment, and (4) risk characterization.

³ For example, OBODM emission factors have been used by the U.S. Navy and affirmed by the Agency for Toxic Substances Disease Registry (ATSDR) in evaluating emissions from Isla de Vieques, Puerto Rico, bombing range (http://www.atsdr.cdc.gov/HAC/PHA/vieques4/vbr_p5.html): "The Navy contractor used emission factors derived from Bangbox studies to estimate emissions of chemical by-products of bombing activities. These emission factors have been widely used to assess environmental impacts from open burning and open detonation activities. For instance, the Open Burn/Open Detonation Model (OBODM), available from EPA's clearinghouse of dispersion models on the agency's technology transfer network, also estimates air emissions from the Bangbox emission factors. ATSDR acknowledges that the representativeness of static detonation tests to live bombing exercises has not been established. However, source testing (or emissions measurements) during live bombing exercises is an extremely complicated endeavor, given the potential safety hazards associated with placing field surveying equipment in the proximity of bombing targets. In the absence of such source testing results, ATSDR believes the Bangbox emission factors are reasonable indicators of chemical releases from explosions."

The HARP model is available in two formats: a free, self-contained version and a commercial version (called HARPEXpress) that relies on Microsoft Excel to provide a user-friendly interface for entering information into the program. This risk assessment used HARPEXpress; however, this risk assessment refers to the model as "HARP."

To accomplish the exposure assessment portion of the risk assessment, the HARP incorporates the Industrial Source Code, Short Term (ISCST) model. ISCST is the U.S. EPA regulatory model most commonly used in permitting actions. It includes the common assumptions that emissions are continuous and that they are vented through a stack. Consequently, the air dispersion modeling output of the HARP could not be used (at least not without some manipulation). However, the HARP is quite robust in its treatment of dose-response assessment and risk characterization. It allows modeling of many chemicals at the same time (in this case, 51) and is limited only by the availability of toxicological information.

The problem that arose in this risk assessment was how to integrate the source term and the atmospheric modeling capabilities of the OBODM together with the exposure assessment, dose response and risk characterization attributes of the HARP.

The integration of the emissions factors information was straightforward. The emissions factors from the OBODM were read into a Microsoft Access database file. The database file was queried for the munitions that were identified as those representative of waste Forms 1 through 4, and the highest emission factor for each emitted chemical was selected. These emissions factors were multiplied by the amount of material treated, and the emissions estimates for each chemical for each waste form were copied into the HARP.

The integration of the air dispersion modeling was somewhat more complex. First, it is important to remember that the HARP is written in a modular form and that the modules operate independently. The HARP modules are the source term calculations, the air dispersion calculations (which is the ISCST model), and the risk and hazard calculations. However, only the air dispersion modeling of the HARP needed to be changed from ISCST output to the OBODM output.

Fortunately (from the point of view of inserting the OBODM results into the HARP), ISCST (within the HARP) begins all of its air dispersion calculations from the assumption that 1 gram per second (1 g/s) is being released from a facility. It does not use the actual emissions until later in the modeling code. From the starting point of a 1-g/s release (also called a unit-source release), ISCST then calculates the concentrations at all the receptor locations identified in the input file, in micrograms per cubic meter of air ($\mu\text{g}/\text{m}^3$) for that 1-g/s release. The result is called the unit source "X/Q," where "X" (the Greek letter "chi") is the concentration at the receptor location, and "Q" is the emission rate for the material of interest. The X/Q data are located in an ISCST file named "filename.XOQ" where "filename" represents the file name of the particular model run.

Therefore, to incorporate the OBODM results into the HARP, the modeler needs to acquire a unit source "X/Q" from the OBODM for all receptor locations and substitute

that data into the filename.XOQ file. After the substitution is made, the risk and the hazard assessments modules of the HARP can be run based on OBODM X/Q data. The OBODM does not have an intermediate "X/Q" file that is obviously accessible. However, the OBODM primary output, ground-level concentrations, can be used with the input emissions concentrations to calculate the X/Q for each location. This was the approach that was taken. It was used for both maximum hourly X/Q and annual average X/Q.

The chemical barium was selected for the calculation because it had an emission factor for all four waste forms. The emission factor for barium for Forms 1 and 2 was 0.0082, and the emission factor for Forms 3 and 4 was 0.000086. The OBODM model was run for each of these emission factors for all four forms. Because a "unit" X/Q was being calculated, the results should be the same without regard to the initial emission factor. The use of actual emission factors enabled checking the concentration of barium for each of the waste forms in the HARP after the substitution was made.

To reiterate, the concentration output of the OBODM model must be divided by the emission rate for each of the waste forms to yield a unit source X/Q. However, this step requires the availability of the source emission rates. These emission rates were calculated from the estimated masses of the quantities emitted per second. The calculations and the resulting emission rates are shown in Table A-1. Table A-2 shows the unit source X/Q calculations based on the 0.0082 barium emission factor, and Table A-3 shows the unit source X/Q calculations based on the 0.000086 barium emission factor. A comparison of Tables A-2 and A-3 shows that the unit source X/Qs are calculated to be the same to five significant digits. Exact agreement to more significant digits was not expected because only three significant digits are presented in the OBODM output. It should be noted that the source order in Tables A-2 and A-3 are as follows: source 1 is the burn pan, source 2 is the burn cage (Form 3), source 3 is the burn cage (Form 4), and source 4 is the detonation pad. The same source order was implemented in the HARP.

Table A-4 shows the modified .XOQ file after the annual average and maximum hourly values were updated with OBODM X/Q values. The validity of the approach was checked by comparing the concentrations calculated by the HARP for barium with those calculated by the OBODM. The results were equal, confirming that the .XOQ file had been modified appropriately. This confirmatory calculation was carried out independently by two of the authors of this report; both of whom obtained the same results. The calculations are shown in Table A-5, where the appropriate ground-level concentrations for each of the sources are summed for the total annual average concentration and the maximum 1-hour concentration for each modeled receptor location. Figure A-1 is a screen shot of the annual average and maximum hourly ground-level concentrations calculated by the HARP.

Table A-1. Calculation of unit source values for two barium emission factors.

	Burn pan	Burn cage (form 3)	Burn cage (form 4)	Detonation pad
Barium factor 0.0082	Annual average emission rate			
Pounds per event	100	50	260	350
Events per year	100	100	100	100
Total pounds per year	10000	5000	26000	35000
Total grams per year	4535923	2267962	11793400	15875731
Total seconds per year	31536000	31536000	31536000	31536000
Annual average g/s	0.144	0.072	0.374	0.503
Barium emission factor	0.0082	0.0082	0.0082	0.0082
Barium annual average emission rate (g/s)	0.00118	0.00059	0.00307	0.00413
	Maximum hourly emission rate			
Pounds per event	100	50	260	350
Events per hour	1	1	1	1
Total pounds per hour	100	50	260	350
Total grams per hour	45359	22680	117934	158757
Total seconds per hour	3600	3600	3600	3600
Hourly g/s	12.6	6.3	32.8	44.1
Barium emission factor	0.0082	0.0082	0.0082	0.0082
Barium maximum hourly emission rate (g/s)	0.103	0.052	0.269	0.362
Barium factor 0.000086	Annual average emission rate			
Pounds per event	100	50	260	350
Events per year	100	100	100	100
Total pounds per year	10000	5000	26000	35000
Total grams per year	4535923	2267962	11793400	15875731
Total seconds per year	31536000	31536000	31536000	31536000
Annual average g/s	0.144	0.072	0.374	0.503
Barium emission factor	0.000086	0.000086	0.000086	0.000086
Barium annual average emission rate (g/s)	0.0000124	0.0000062	0.0000322	0.0000433
	Maximum hourly emission rate			
Pounds per event	100	50	260	350
Events per hour	1	1	1	1
Total pounds per hour	100	50	260	350
Total grams per hour	45359	22680	117934	158757
Total seconds per hour	3600	3600	3600	3600

	Burn pan	Burn cage (form 3)	Burn cage (form 4)	Detonation pad
Hourly g/s	12.6	6.3	32.8	44.1
Barium emission factor	0.000086	0.000086	0.000086	0.000086
Barium maximum hourly emission rate (g/s)	0.00108	0.00054	0.00282	0.00379

Table A-2. Calculations of X/Q based on barium emission factor of 0.0082.

Emission factor 0.0082 (form12out)		OB Pan	OB Cage 3	OB Cage 4	OD	factors by which to divide Ba emissions to derive unit chi/Q
		annual ave mxhrly	1.18E-03 1.03E-01	5.90E-04 5.17E-02	3.07E-03 2.69E-01	4.13E-03 3.62E-01

Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter) (Due to source group 1, sources: 1) Burn Pan (Maximum = .13365E+00 at X,Y,Z = 629500.00,4168500.00,383.90)						
X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	
633000	4170500	273.9	1.00E-03	8.52E-01	.8515709E+00	Pasture
628681.5	4165968	201	9.67E-04	8.19E-01	.8194978E+00	Carnegie
632976.6	4166183	158.4	4.68E-04	3.97E-01	.3965510E+00	Ranch
629950	4168674	309.4	1.72E-02	1.46E+01	.1455489E+02	B812
630020	4168179	379.3	1.61E-02	1.36E+01	.1364920E+02	B895
633000	4170500	273.9	1.00E-03	8.52E-01	.8515709E+00	Pasture repeat
629500	4168500	383.9	1.34E-01	1.13E+02	.1133045E+03	Ecological

Table 3

Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter) (Due to source group 2, sources: 2) Burn Cage (form 3) (Maximum = .66794E-01 at X,Y,Z = 629500.00,4168500.00,383.90)						
X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	
633000	4170500	273.9	4.99E-04	8.47E-01	.8469687E+00	Pasture
628681.5	4165968	201	5.69E-04	9.65E-01	.9646185E+00	Carnegie
632976.6	4166183	158.4	2.67E-04	4.52E-01	.4524008E+00	Ranch
629950	4168674	309.4	1.05E-02	1.78E+01	.1782248E+02	B812
630020	4168179	379.3	8.92E-03	1.51E+01	.1511857E+02	B895
633000	4170500	273.9	4.99E-04	8.47E-01	.8469687E+00	Pasture repeat
629500	4168500	383.9	6.68E-02	1.13E+02	.1132647E+03	Ecological

Table 4

Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter) (Due to source group 3, sources: 3) Burn Cage (form 4) (Maximum = .30209E+00 at X,Y,Z = 629500.00,4168500.00,383.90)						
X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	
633000	4170500	273.9	2.55E-03	8.33E-01	.8327705E+00	Pasture
628681.5	4165968	201	2.80E-03	9.14E-01	.9135818E+00	Carnegie
632976.6	4166183	158.4	1.34E-03	4.37E-01	.4366443E+00	Ranch
629950	4168674	309.4	4.49E-02	1.46E+01	.1463560E+02	B812
630020	4168179	379.3	4.28E-02	1.39E+01	.1394625E+02	B895
633000	4170500	273.9	2.55E-03	8.33E-01	.8327705E+00	Pasture repeat
629500	4168500	383.9	3.02E-01	9.85E+01	.9851385E+02	Ecological

Table A-2. Calculations of X/Q based on barium emission factor of 0.0082 (continued).

Table 5
Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 4, sources: 4) Detonation Pad
(Maximum = .12371E+00 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	
633000	4170500	273.9	2.10E-03	5.08E-01	.5081017E+00	Pasture
628681.5	4165968	201	2.19E-03	5.31E-01	.5313550E+00	Carnegie
632976.6	4166183	158.4	1.27E-03	3.07E-01	.3067384E+00	Ranch
629950	4168674	309.4	1.72E-02	4.17E+00	.4165249E+01	B812
630020	4168179	379.3	2.44E-02	5.90E+00	.5900564E+01	B895
633000	4170500	273.9	2.10E-03	5.08E-01	.5081017E+00	Pasture repeat
629500	4168500	383.9	1.24E-01	3.00E+01	.2996745E+02	Ecological

Table 6
Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 1, sources: 1) Burn Pan
(Maximum = 11.877 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	0.12558	1.22E+00	.1215468E+01	3	26	0	68	800
628681.5	4165968	201	0.223714	2.17E+00	.2165290E+01	9	13	1	86	800
632976.6	4166183	158.4	0.114005	1.10E+00	.1103435E+01	3	6	3	65	800
629950	4168674	309.4	2.8726	2.78E+01	.2780341E+02	11	6	2	310	800
630020	4168179	379.3	2.95159	2.86E+01	.2856795E+02	12	20	4	355	800
633000	4170500	273.9	0.12558	1.22E+00	.1215468E+01	3	26	0	68	800
629500	4168500	383.9	11.877	1.15E+02	.1149555E+03	9	11	2	254	800

Table 8
Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 2, sources: 2) Burn Cage (form 3)
(Maximum = 5.0540 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	0.050014	9.68E-01	.9681504E+00	12	6	2	340	800
628681.5	4165968	201	8.33E-02	1.61E+00	.1612033E+01	9	13	1	256	800
632976.6	4166183	158.4	0.040661	7.87E-01	.7870981E+00	3	6	3	65	800
629950	4168674	309.4	1.3717	2.66E+01	.2655291E+02	1	19	4	19	900
630020	4168179	379.3	1.17555	2.28E+01	.2275590E+02	11	25	0	330	800
633000	4170500	273.9	0.050014	9.68E-01	.9681504E+00	12	6	2	340	800
629500	4168500	383.9	5.05396	9.78E+01	.9783286E+02	9	11	2	254	800

Table A-2. Calculations of X/Q based on barium emission factor of 0.0082 (continued).

Table 10
 Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
 (Due to source group 3, sources: 3) Burn Cage (form 4)
 (Maximum = 21.001 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	0.246753	9.19E-01	.9185696E+00	12	6	2	340	800
628681.5	4165968	201	0.391287	1.46E+00	.1456616E+01	9	13	1	256	800
632976.6	4166183	158.4	0.198177	7.38E-01	.7377392E+00	3	6	3	65	800
629950	4168674	309.4	4.95688	1.85E+01	.1845262E+02	1	19	4	19	900
630020	4168179	379.3	5.4473	2.03E+01	.2027827E+02	11	25	0	330	900
633000	4170500	273.9	0.246753	9.19E-01	.9185696E+00	12	6	2	340	800
629500	4168500	383.9	21.0008	7.82E+01	.7817816E+02	9	11	2	254	800

Table 12
 Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
 (Due to source group 4, sources: 4) Detonation Pad
 (Maximum = 18.767 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	0.591244	1.64E+00	.1635015E+01	12	8	0	343	900
628681.5	4165968	201	0.435929	1.21E+00	.1205510E+01	9	13	1	256	800
632976.6	4166183	158.4	0.373553	1.03E+00	.1033016E+01	10	16	1	289	800
629950	4168674	309.4	1.92837	5.33E+00	.5332677E+01	1	1	0	1	900
630020	4168179	379.3	8.25488	2.28E+01	.2282789E+02	3	6	3	65	800
633000	4170500	273.9	0.591244	1.64E+00	.1635015E+01	12	8	0	343	900
629500	4168500	383.9	18.767	5.19E+01	.5189790E+02	2	18	0	49	800

Table A-3. Calculations of X/Q based on barium emission factor of 0.000086.

Emission factor 0.000086 (form34out)		OB Pan	OB Cage 3	OB Cage 4	OD	factors by which to divide Ba emissions to derive unit chi/Q
		annual ave	1.24E-05	6.18E-06	3.22E-05	4.33E-05
		mxhrly	1.08E-03	5.42E-04	2.82E-03	3.79E-03

Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)						
(Due to source group 1, sources: 1)						
(Maximum = .14015E-02 at X,Y,Z = 629500.00,4168500.00,383.90)						
X	Y	Z	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Burn Pan
(Meters)	(Meters)	(Meters)				
633000	4170500	273.9	1.05E-05	8.52E-01	.8515679E+00	Pasture
628681.5	4165968	201	1.01E-05	8.19E-01	.8194975E+00	Carnegie
632976.6	4166183	158.4	4.91E-06	3.97E-01	.3965511E+00	Ranch
629950	4168674	309.4	1.80E-04	1.46E+01	.1455489E+02	B812
630020	4168179	379.3	1.69E-04	1.36E+01	.1364921E+02	B895
633000	4170500	273.9	1.05E-05	8.52E-01	.8515679E+00	Pasture repeat
629500	4168500	383.9	1.40E-03	1.13E+02	.1133047E+03	Ecological

Table 3

Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)						
(Due to source group 2, sources: 2)						
(Maximum = .70052E-03 at X,Y,Z = 629500.00,4168500.00,383.90)						
X	Y	Z	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Burn Cage (form 3)
(Meters)	(Meters)	(Meters)				
633000	4170500	273.9	5.24E-06	8.47E-01	.8469696E+00	Pasture
628681.5	4165968	201	5.97E-06	9.65E-01	.9646204E+00	Carnegie
632976.6	4166183	158.4	2.80E-06	4.52E-01	.4524023E+00	Ranch
629950	4168674	309.4	1.10E-04	1.78E+01	.1782249E+02	B812
630020	4168179	379.3	9.35E-05	1.51E+01	.1511861E+02	B895
633000	4170500	273.9	5.24E-06	8.47E-01	.8469696E+00	Pasture repeat
629500	4168500	383.9	7.01E-04	1.13E+02	.1132646E+03	Ecological

Table 4

Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)						
(Due to source group 3, sources: 3)						
(Maximum = .31683E-02 at X,Y,Z = 629500.00,4168500.00,383.90)						
X	Y	Z	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Burn Cage (form 4)
(Meters)	(Meters)	(Meters)				
633000	4170500	273.9	2.68E-05	8.33E-01	.8327701E+00	Pasture
628681.5	4165968	201	2.94E-05	9.14E-01	.9135820E+00	Carnegie
632976.6	4166183	158.4	1.40E-05	4.37E-01	.4366424E+00	Ranch
629950	4168674	309.4	4.71E-04	1.46E+01	.1463560E+02	B812
630020	4168179	379.3	4.49E-04	1.39E+01	.1394629E+02	B895
633000	4170500	273.9	2.68E-05	8.33E-01	.8327701E+00	Pasture repeat
629500	4168500	383.9	3.17E-03	9.85E+01	.9851374E+02	Ecological

Table A-3. Calculations of X/Q based on barium emission factor of 0.000086 (continued).

Table 5
Annual Average Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 4, sources: 4)
(Maximum = .12974E-02 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Detonation Pad
633000	4170500	273.9	2.20E-05	5.08E-01	.5081029E+00	Pasture
628681.5	4165968	201	2.30E-05	5.31E-01	.5313557E+00	Carnegie
632976.6	4166183	158.4	1.33E-05	3.07E-01	.3067369E+00	Ranch
629950	4168674	309.4	1.80E-04	4.17E+00	.4165263E+01	B812
630020	4168179	379.3	2.55E-04	5.90E+00	.5900570E+01	B895
633000	4170500	273.9	2.20E-05	5.08E-01	.5081029E+00	Pasture repeat
629500	4168500	383.9	1.30E-03	3.00E+01	.2996758E+02	Ecological

Table 6
Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 1, sources: 1)
(Maximum = .12456E+00 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr	Burn Pan
633000	4170500	273.9	1.32E-03	1.22E+00	.1215469E+01	3	26	0	86	800	
628681.5	4165968	201	2.35E-03	2.17E+00	.2165291E+01	9	13	1	256	800	
632976.6	4166183	158.4	1.20E-03	1.10E+00	.1103433E+01	3	6	3	65	800	
629950	4168674	309.4	3.01E-02	2.78E+01	.2780344E+02	11	6	2	310	800	
630020	4168179	379.3	3.10E-02	2.86E+01	.2856795E+02	12	20	4	355	800	
633000	4170500	273.9	1.32E-03	1.22E+00	.1215469E+01	3	26	0	86	800	
629500	4168500	383.9	1.25E-01	1.15E+02	.1149549E+03	9	11	2	254	800	

Table 8
Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
(Due to source group 2, sources: 2)
(Maximum = .53005E-01 at X,Y,Z = 629500.00,4168500.00,383.90)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr	Burn Cage (form 3)
633000	4170500	273.9	5.25E-04	9.68E-01	.9681504E+00	12	6	2	340	800	
628681.5	4165968	201	8.73E-04	1.61E+00	.1612032E+01	9	13	1	256	800	
632976.6	4166183	158.4	4.26E-04	7.87E-01	.7870972E+00	3	6	3	65	800	
629950	4168674	309.4	1.44E-02	2.66E+01	.2655287E+02	1	19	4	19	900	
630020	4168179	379.3	1.23E-02	2.28E+01	.2275583E+02	11	25	0	330	800	
633000	4170500	273.9	5.25E-04	9.68E-01	.9681504E+00	12	6	2	340	800	
629500	4168500	383.9	5.30E-02	9.78E+01	.9783278E+02	9	11	2	254	800	

Table A-3. Calculations of X/Q based on barium emission factor of 0.000086 (continued).

Table 10
 Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
 (Due to source group 3, sources: 3)
 (Maximum = .22025E+00 at X,Y,Z = 629500.00,4168500.00,383.90)

Burn Cage (form 4)

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	2.59E-03	9.19E-01	.9185706E+00	12	6	2	340	800
628681.5	4165968	201	4.10E-03	1.46E+00	.1456615E+01	9	13	1	256	800
632976.6	4166183	158.4	2.08E-03	7.38E-01	.7377422E+00	3	6	3	65	800
629950	4168674	309.4	5.20E-02	1.85E+01	.1845262E+02	1	19	4	19	900
630020	4168179	379.3	5.71E-02	2.03E+01	.2027826E+02	11	25	0	330	800
633000	4170500	273.9	2.59E-03	9.19E-01	.9185706E+00	12	6	2	340	800
629500	4168500	383.9	2.20E-01	7.82E+01	.7817806E+02	9	11	2	254	800

Table 12
 Highest Barium Time-Average {1-hr} Concentration (Micrograms/Cubic Meter)
 (Due to source group 4, sources: 4)
 (Maximum = .19682E+00 at X,Y,Z = 629500.00,4168500.00,383.90)

Detonation Pad

X (Meters)	Y (Meters)	Z (Meters)	Time-Avg. Con.	chi/Q	chi/Q for .XOQ file	Mo/	Dy/	Yr	Jdy	Hr
633000	4170500	273.9	6.20E-03	1.64E+00	.1635014E+01	12	8	0	343	900
628681.5	4165968	201	4.57E-03	1.21E+00	.1205510E+01	9	13	1	256	800
632976.6	4166183	158.4	3.92E-03	1.03E+00	.1033016E+01	10	16	1	289	800
629950	4168674	309.4	2.02E-02	5.33E+00	.5332686E+01	1	1	0	1	900
630020	4168179	379.3	8.66E-02	2.28E+01	.2282787E+02	3	6	3	65	800
633000	4170500	273.9	6.20E-03	1.64E+00	.1635014E+01	12	8	0	343	900
629500	4168500	383.9	1.97E-01	5.19E+01	.5189800E+02	2	18	0	49	800

Table A-4. Modified .XOQ file after the annual average and maximum hourly values were updated with OBODM X/Q values. (Other values in .XOQ files were not used in this risk assessment).

SRC	REC	UNUSED	AVERAGE	1HR_MAX	... (additional columns, not used in this assessment)
1	1	0.3961217E+00	0.8515709E+00	0.1215468E+01	...
1	2	0.2721988E-02	0.8194978E+00	0.2165290E+01	...
1	3	0.2719286E-02	0.3965510E+00	0.1103435E+01	...
1	4	0.2839895E-02	0.1455489E+02	0.2780341E+02	...
1	5	0.3750449E-01	0.1364920E+02	0.2856795E+02	...
1	6	0.2341939E-01	0.8515709E+00	0.1215468E+01	...
1	7	0.2341939E-01	0.1133045E+03	0.1149555E+03	...
2	1	0.4261317E+00	0.8469687E+00	0.9681504E+00	...
2	2	0.3105313E-02	0.9646185E+00	0.1612033E+01	...
2	3	0.4173856E-01	0.4524008E+00	0.7870981E+00	...
2	4	0.2657336E-01	0.1782248E+02	0.2655291E+02	...
2	5	0.8583720E+00	0.1511857E+02	0.2275590E+02	...
2	6	0.1174408E+01	0.8469687E+00	0.9681504E+00	...
2	7	0.2341939E-01	0.1132647E+03	0.9783286E+02	...
3	1	0.4261317E+00	0.8327705E+00	0.9185696E+00	...
3	2	0.3105313E-02	0.9135818E+00	0.1456616E+01	...
3	3	0.4173856E-01	0.4366443E+00	0.7377392E+00	...
3	4	0.2657336E-01	0.1463560E+02	0.1845262E+02	...
3	5	0.8583720E+00	0.1394625E+02	0.2027827E+02	...
3	6	0.1174408E+01	0.8327705E+00	0.9185696E+00	...
3	7	0.2341939E-01	0.9851385E+02	0.7817816E+02	...
4	1	0.2331261E+00	0.5051017E+00	0.1635015E+01	...
4	2	0.2328404E-02	0.5313550E+00	0.1205510E+01	...
4	3	0.3221262E-01	0.3067384E+00	0.1033016E+01	...
4	4	0.1822067E-01	0.4165249E+01	0.5332677E+01	...
4	5	0.7229874E+00	0.5900564E+01	0.2282789E+02	...
4	6	0.9328276E+00	0.5081017E+00	0.1635015E+01	...
4	7	0.2341939E-01	0.2996745E+02	0.5189790E+02	...

Table A-5. Total ground level concentration of barium for all four sources by receptor location^a.

Annual average				
Location	X (UTM East) (Meters)	Y (UTM North) (Meters)	Z (Elevation) (Meters)	Ground Level Concentration $\mu\text{g}/\text{m}^3$
Pasture	633000	4170500	273.9	3.13E-03
Carnegie	628681.5	4165968	201	3.20E-03
Ranch	632976.6	4166183	158.4	1.75E-03
B812	629950	4168674	309.4	3.49E-02
B895	630020	4168179	379.3	4.10E-02
Pasture repeat	633000	4170500	273.9	3.13E-03
Ecological	629500	4168500	383.9	2.61E-01
Maximum 1 hour				
Location	X (UTM East) (Meters)	Y (UTM North) (Meters)	Z (Elevation) (Meters)	Ground Level Concentration $\mu\text{g}/\text{m}^3$
Pasture	633000	4170500	273.9	7.20E-01
Carnegie	628681.5	4165968	201	6.65E-01
Ranch	632976.6	4166183	158.4	4.90E-01
B812	629950	4168674	309.4	4.87E+00
B895	630020	4168179	379.3	1.13E+01
Pasture repeat	633000	4170500	273.9	7.20E-01
Ecological	629500	4168500	383.9	3.09E+01

^a the burn pan (source 1) and detonation pad (source 4) values are obtained from Table A-2, and the burn cage/Form 3 (source 2) and burn cage/Form 4 (source 3) values are obtained from Table A-3.

Figure A-1. Screen captures of total ground level concentrations for the HARP for barium (CAS number 7440393).

Rec	Type	CAS 7440393 ug/m^3
1	PATHWAY	3.13E-03
2	SENSITIVE	3.20E-03
3	SENSITIVE	1.75E-03
4	SENSITIVE	3.49E-02
5	SENSITIVE	4.10E-02
6	SENSITIVE	3.13E-03
7	SENSITIVE	2.61E-01

Rec	Type	CAS 7440393 ug/m^3
1	PATHWAY	7.20E-01
2	SENSITIVE	6.65E-01
3	SENSITIVE	4.90E-01
4	SENSITIVE	4.87E+00
5	SENSITIVE	1.13E+01
6	SENSITIVE	7.20E-01
7	SENSITIVE	3.09E+01

Note: The pathway location (for the beef ingestion pathway) was repeated as the number 6 “sensitive” location (for a person) in the HARP to assure that the final result was a risk value for a person at that location, and not some other type of receptor, e.g., a cow. The pathway location was necessary for the HARP to calculate a human ingestion dose from the beef pathway.

Appendix B. Ecological Risk Assessment in Support of Renewal of Permit for the Explosive Waste Treatment Facility (EWTF) at Site 300 of Lawrence Livermore National Laboratory

B.1 Introduction

This ecological risk assessment (ERA) is a supplement to the human health risk assessment (HRA) for the Explosive Waste Treatment Facility (EWTF). The EWTF is located near the center of Site 300 in a small, isolated canyon (see Figures 2 through 6 in the text). The ERA described in detail in this Appendix was prepared in accordance with guidance on currently accepted practice provided by the Human and Ecological Risk Division (HERD) at the Department of Toxic Substances Control (DSTC) of the State of California Environmental Protection Agency (CalEPA) in Sacramento, California.

The technical basis for this ERA was an analysis that screened each contaminant of potential ecological concern (CPEC) for its potential to produce an adverse ecological impact in a particular wildlife species at a specific location based on the relationship between its predicted soil concentration and the ecological soil screening levels (ESSLs) determined for each of the nine different wildlife representative receptors of ecological interest (RREI) that are members of the food network and also vegetation. There were seven steps in the ERA analysis:

- 1) Each CPEC in emissions from the Open Burn/Open Detonation (OB/OD) operations at the Site 300 EWTF was identified, and its soil concentration over a 6-inch (15-cm) depth ($\text{mg}/\text{kg}_{\text{soil}}$) was predicted for a receptor location of interest based on atmospheric dispersion and deposition modeling.
- 2) RREIs were selected in the habitat of interest for each trophic level of the applicable wildlife food web. A reasonable approximation of total dietary intake was obtained from the literature for each vertebrate RREI and quantified per unit body weight (i.e., avian, reptile, and mammal [$\text{mg}/\{\text{kg}_{\text{bw}} \text{d}\}$]); whereas, a no observed adverse effect concentration (NOEC; $\text{mg}/\text{kg}_{\text{soil}}$), obtained for the earthworm from data in the literature, was applied to invertebrates. Plants were also evaluated as a separate vegetation category of RREI, and a NOEC ($\text{mg}/\text{kg}_{\text{soil}}$) generalizable to all plants was obtained from the literature for this purpose.
- 3) A CPEC-specific ecological soil screening level (ESSL; $\text{mg}/\text{kg}_{\text{soil}}$) is derived from a low toxicity reference value (TRV_{Low}) for each vertebrate RREI evaluated (i.e., avian, reptile, and mammal). Each applicable TRV_{Low} corresponds to a no observed adverse effect level (NOAEL) for the respective vertebrate. This was not done for invertebrates and plants because a NOEC is interpreted to represent the ESSL for the invertebrate and vegetation category of RREI. Each of these respective ESSLs corresponds to a CPEC-specific concentration in soil that is considered protective of a particular wildlife (wlf) receptor (e.g., mammal, bird, reptile, invertebrate, or plant) that might have contact with such soil, directly or indirectly.
- 4) The animal ESSL_{min} is selected from a comparison among all of the animal ESSLs—reptile (wlf = rep), avian (wlf = brd), invertebrate (wlf = inv) and mammal (wlf = mam) RREI. The ESSL_{min} for the vegetation category is addressed separately, where

that NOEC is generalized to be applicable to all plants and so is considered to represent the $ESSL_{min}$ for plants.

- 5) The animal $ESSL_{min}$ and the plant $ESSL_{min}$ are then compared to the respective CPEC-specific soil concentrations predicted from atmospheric dispersion and deposition modeling at specific receptor locations near and around the EWTF over a depth of 6 inches (15 cm). This comparison is made by dividing each modeled CPEC-specific soil concentration value at a specific location by the applicable animal and plant $ESSL_{min}$ value, where the result equates to a maximum ecological hazard quotient (EHQ_{max}) for each animal and plant RREI with respect to the CPEC at the selected location. Thus, a CPEC-specific EHQ_{max} greater than unity or the sum of animal or plant RREI, CPEC-specific EHQ_{max} values that exceed one suggest further examination for the possibility for adverse ecological impact. CPEC-specific EHQ_{max} values also were computed at the receptor location nearest the EWTF for two species of particular concern at Site 300—the San Joaquin Kit Fox and the Burrowing Owl—and these sensitive-organism specific EHQ_{max} values were based on $ESSL$ values derived specifically for these particular organisms (which may or may not equate to the animal $ESSL_{min}$).
- 6) For those CPECs for which an EHQ_{max} value for animals exceeds unity and/or for which an EHQ_{max} value for plants exceed unity, an additional evaluation is performed that derives an $ESSL$ value for these substances for either or both animals and plants (i.e., mg/kg_{soil}) that can equate to a lowest observed adverse effect level (LOAEL). Thus, the resulting EHQ derived using these higher $ESSL$ values will be lower than the EHQ_{max} values. This is because the $ESSL$ used to derive them are not the most protective and so are not the lowest possible. Nevertheless, the smallest animal $ESSL$ is still used to compute the new EHQ that will be less than the EHQ_{max} . Again, this $ESSL$ will be the lowest from among all those calculated for avian, reptile, and mammal RREIs now using the TRV_{High} or a comparable value (i.e., a 10-fold increase in the TRV_{Low} , where a TRV_{High} is not available in the literature) and the lowest observed effect concentration (LOEC) or a comparable value (e.g., a 10-fold increase in the NOEC, where one is not provided in the literature) for the invertebrate. For those CPECs with EHQ_{max} values for plants exceeding one, a new $ESSL$ that is greater than the $ESSL_{min}$ is computed using an LOEC or comparable value (i.e., because none are available in the literature, a 10-fold increase in the NOEC is considered applicable) for each CPEC. CPEC-specific EHQ values for those CPECs with EHQ_{max} values exceeding one are also determined at the receptor location nearest the EWTF specifically for the two species of particular concern at Site 300—the San Joaquin Kit Fox and the Burrowing Owl.
- 7) For purposes of comparison to the results obtained in Steps 5 and 6, $ESSL$ s and EHQ s are similarly calculated for those CPECs for which Site-300 background measurement data is available. Currently, background concentrations are reported only for seven heavy metals—antimony, barium, cadmium, chromium, copper, lead, and zinc (see Peterson et al., 2006). For these CPECs and their measured values, an $ESSL_{min}$ and EHQ_{max} are derived first for animals, and then for plants, as well as for the Kit Fox and Burrowing Owl. For those background concentrations of CPEC-metals with EHQ_{max} values greater than one, the $ESSL$ and EHQ are derived using the TRV_{High} (or comparable value) described in Step 6. This analysis is also

performed for the two sensitive species of interest (i.e., Kit Fox and Burrowing Owl), and also for plants.

Forty-five potential contaminants (including surrogates, such as Research Department Explosive (RDX), which represents both RDX and pentaerythritol tetranitrate [PETN]) are considered to be produced from OB/OD operations at the EWTF. Among these 45 substances, 24 are not addressed in this ERA because they are gaseous or gaseous upon emission. These emissions disperse significantly into the atmosphere and do not pose a problem as potential soil contaminants. The 24 emissions falling into this “gaseous emission” category are carbon monoxide (CO), chlorine (Cl), hydrogen chloride (HCl), nitrogen dioxide (NO₂), sulfur dioxide (SO₂), and 19 additional volatile organic compounds (VOCs)—allyl chloride; benzene; 1,3-butadiene; carbon tetrachloride; chloroform; cyclohexane; ethylbenzene; ethyl chloride; isopropylbenzene; methyl chloride (or chloromethane); methyl chloroform (or 1,1,1-trichloroethane); methyl cyclohexane; methyl chloride; n-hexane; propene; styrene; tetrachloroethylene (1,1,2,2-tetrachloroethane); toluene; and vinyl chloride. The 21 remaining substances were considered CPECs and consisted of five polychlorinated dibenzofurans (PCDFs), three energetic or other thermally labile compounds, eight metals, and five semi-volatile organic compounds (SVOCs).

This ERA evaluated deposited emissions with respect to impacts on plants and the nine different animal RREIs identified below:

- Soil invertebrate (represented by the earthworm).
- Ominivorous bird (represented by the Savannah Sparrow [*Passerculus sandwichensis*]).
- Carnivorous bird (represented by the Burrowing Owl [*Athene cunicularia*]).
- Insectivorous reptile (represented by the Side-Blotched Lizard [*Uta stansubriana*]).
- Omnivorous small mammal (Deer Mouse [*Peromyscus maniculatus*]).
- Granivorous small mammal (California Ground Squirrel [*Spermophilus beecheyi*]).
- Herbivorous small mammal (Pocket Gopher [*Thomomys bottae*]).
- Herbivorous large mammal (Black-Tailed [Mule] Deer [*Odocoileus hemionus columbianus*]).
- Carnivorous mammal (San Joaquin Kit Fox [*Vulpes macrotis mutica*]).

Each animal RREI (except for the soil invertebrate) has a distinct diet at its particular level of the food web (conceptualized in Figure B-1).

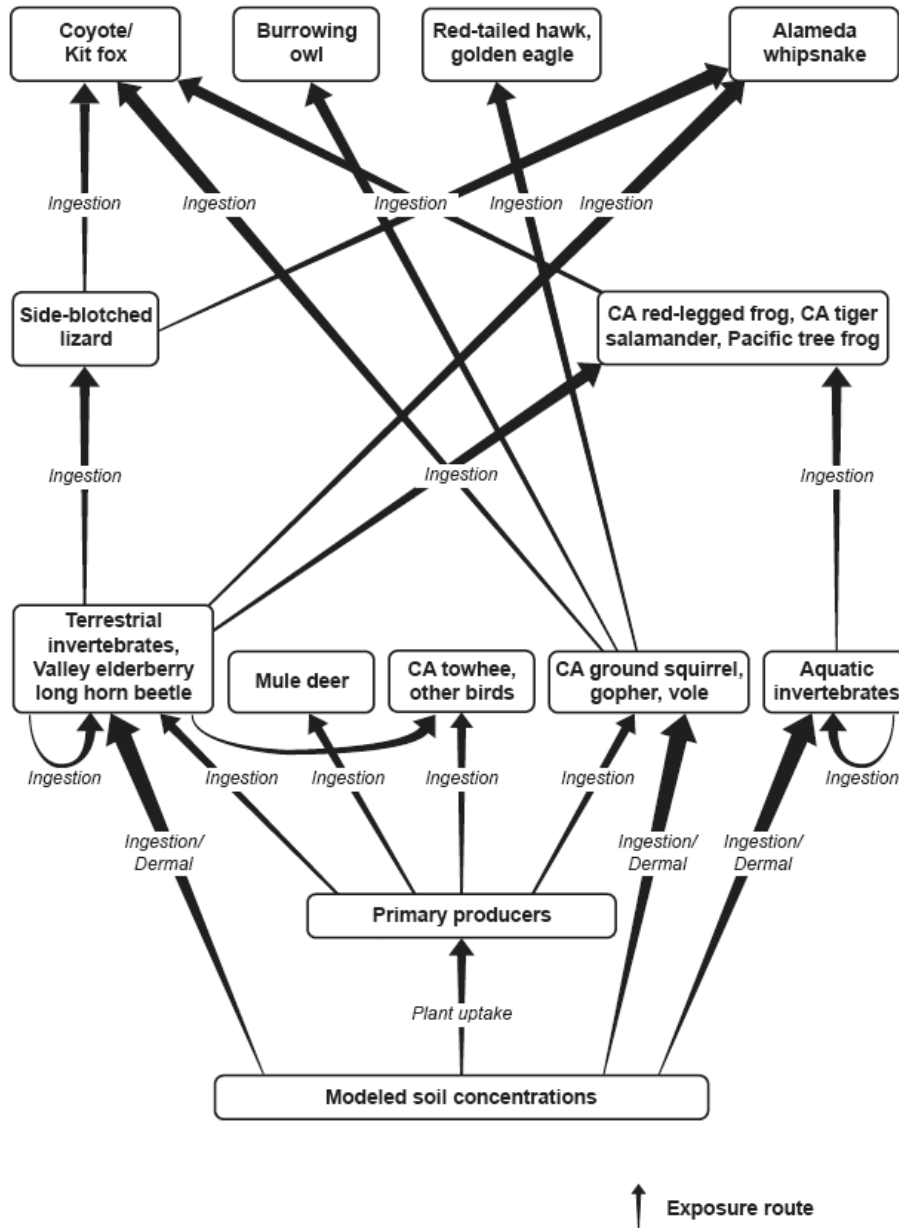


Figure B-1. RREIs of concern in relation to conceptualized food web.

B.1.1 Source Term

The EWTF OB/OD operations at Site 300 represent the source term. As described in the risk assessment text, these operations involve:

- Open detonation of Waste Form 1 (waste explosives that otherwise might detonate during open burning).
- Open burning in a burn pan of Waste Form 2 (waste explosives or explosive parts).
- Open burning in a burn cage of either Waste Form 3 (waste explosives that are wetted in processing or as a result of removal from waste water as sludge from weirs and settling basins or on wetted expendable filters) or Waste Form 4 (explosives-contaminated waste materials, including paper, rags, plastic tubing, gloves and personal protective equipment).

Emissions were estimated based on the planned quantities of materials to be treated annually (see Table 1 in the text):

- Waste Form 1 (OD treatment) is considered to involve 100 annual treatments of 350 pounds (159 kg) each.
- Waste Form 2 (OB pan) is considered to involve 100 annual treatments of 100 pounds (45 kg) each.
- Waste Form 3 (OB cage) is considered to involve 100 annual treatments of 50 pounds (23 kg) each.
- Waste Form 4 (OB cage) is considered to involve 100 annual treatments of 260 pounds (118 kg) each.

For this ERA, the Open Burn/Open Detonation Dispersion Model (OBODM) and HotSpots Analysis and Reporting Program (HARP) models (see Bjorklund et al., 1998; CARB, 2003) were linked to estimate maximum annual soil concentrations for each of the 21 CPECs over a depth of 6 inches (15 cm) at six different receptor locations in the habitat of Site 300, including one location near the OD pad, OB burn pan, and OB burn cage (all of which are in close proximity) at the EWTF site (shown in Figure 6 of the main text).

B.1.2 Relevant Exposure Pathways for Each RREI

Only the ingestion exposure pathway was considered for each animal RREI. "Ingestion" is defined as dry-matter intake (DMI) of the proportion of vegetation, invertebrate prey and/or vertebrate prey as well as incidental soil ingestion considered representative of the diet of a particular RREI. Potential inhalation and dermal absorption of CPEC-contaminated soil as a result of particulate resuspension into air or contact with soil on the ground or in burrows were considered to contribute significantly lower doses than those associated with the ingestion pathway. The intake of contaminated water by an RREI also was not addressed in this ERA as water contamination is not considered especially relevant for the locations.

For purposes of conservatism, all animal RREI living, foraging, prey capturing, and subject to incidental soil ingestion were considered to occur at the selected receptor sites, including that habitat nearest OB/OD operations, where modeling predicted that the highest concentrations of each CPEC are deposited. In addition, concentrations of CPECs were calculated over a depth of 6 inches (15 cm). Although 2 feet (60 cm) is a common depth for evaluating the effects on fossorial animals (DTSC, 1998), that depth was not used. One conservative reason for not using a depth greater than 6 inches (15 cm) is that the source of contamination is air deposition; therefore, the soil at depth is not expected to be at as high a level of contamination as that soil which is present at or near the surface. Another conservative reason for not considering contamination to a greater depth than 6 inches is that the assumption is made that the absorption fraction of each CPEC from the intestinal tract of each RREI is considered to be 100 percent. Therefore, the combination of these factors makes considering contamination to only a 6-in (15-cm) depth sufficiently conservative to be justified.

B.1.3 Habitat

Site 300 itself is hilly, natural grassland habitat. Only about 5 percent of this 11-square-mile (28-sq-km) site is even developed. Put into perspective, the vast majority of this site is undeveloped and consists mostly of undisturbed land with diverse wildlife. In fact, Site 300 is a high explosives testing area, has no public access, and is subject to controlled burns. Indeed, these factors all combine to prevent impacts from grazing and contribute to natural biodiversity (U.S. Department of Energy/National Nuclear Security Administration [DOE/NNSA], 2005).

B.1.4 Identification of CPECs and RREIs

Table B-1 contains the list of the 21 CPECs, along with their Chemical Abstract Service registry identification numbers (CAS ID), applicable toxicity equivalency factors (TEF), and the RREI specific low toxicity reference values (TRV_{Low} values) obtained experimentally for mammalian and avian test species, as well as the body weight associated with each experimental test species (ETS). The 21 CPECs are divided among four chemical categories:

- Five polychlorinated dibenzofurans (PCDFs).
- Three energetic and thermally labile compounds.
- Eight metals.
- Five SVOCs.

For each of the five PCDF congeners, the TEFs that are applicable to humans and mammals with respect to 2,3,7,8 tetrachlorodibenzo-p-dioxin (TCDD), and to birds with respect to 2,3,7,8-tetrachlorodibenzofuran (TCDF) were provided (see Van den Berg et al., 1998). Thus, a TRV that is applicable to a mammal for a particular PCDF can be divided by the TEF for that PCDF to yield the TRV for TCDD that was used to generate it. Similarly, a TRV that is applicable to birds for a particular PCDF can be divided by the TEF for that PCDF to yield the TRV for TCDF that was used to generate it. For the chemicals in the other categories, the TEF is equal to 1.0 because each TRV was derived specifically for that substance.

As a consequence of the location and the habitat of Site 300, the wildlife that were specified in this ERA as RREIs include three fossorial (i.e., burrowing) species:

- California Ground Squirrel, a small, mammalian granivore, which is generally considered to have a home range of one-quarter to one-half an acre (.1 to 0.2 ha) (CDFG, 2005a).
- San Joaquin Kit Fox, a mammalian carnivore with a general home range of 1 to 2 square miles (2.6 to 5.2 sq km)(CDFG, 2005a).
- Burrowing Owl, an avian carnivore with a general home range of (1 to 4 acres (0.4 to 1.6 ha) (CDFG, 2005b).

In addition to these organisms, wildlife also of interest in the food web of the habitat (see Figure B-1) are represented by:

- An insectivorous reptile (Side-blotched Lizard).
- An omnivorous bird (Savannah Sparrow).
- An herbivorous small mammal (Pocket Gopher).
- An herbivorous large mammal (Black-tailed [Mule] Deer with a general home range of one-third to 1 square mile (1 to 3 sq km)(CDFG, 2005a).
- An omnivorous small mammal (Deer Mouse).
- The earthworm, a terrestrial soil invertebrate.

The physiological characteristics, including body weight, total dry-matter dietary intake, and proportion of diet from other trophic levels applicable to each of these organisms, except, of course, the earthworm, appear in Table B-2.

B.1.5 Estimating CPEC-Specific Ecological Soil Screening Levels (ESSLs) for Each RREI

The procedure followed for estimating a CPEC-specific ESSL for an RREI involved two steps:

- 1) CPEC-specific toxicity reference values (i.e., either low or high in units of $\text{mg}/[\text{kg}_{\text{bw}} \text{ d}]$), where they exist for an experimental test species (TRV_{ETS}), were converted to a toxicity reference value for each wildlife RREI (TRV_{wlf}), except for the earthworm whose ESSL is specifically a no-observed effect concentration in soil (i.e., $\text{mg}/\text{kg}_{\text{soil}}$).
- 2) Next, the CPEC-specific TRV_{wlf} for each animal (except the invertebrate earthworm for which a NOEC is used) was divided by the quantity that consists of the product of the appropriate dietary factors (i.e., sum of products of dietary fraction and bioaccumulation factors [BAF]) and the total daily dry-matter intake per unit body weight, to yield a CPEC-specific ESSL for each wildlife RREI. Generally, dietary fractions are assumed values open to interpretation, but are considered to be reasonable approximations.

For situations where the body weight of the wildlife is within two orders of magnitude of the body weight of the experimental test species (i.e., when $\text{BW}_{\text{ETS}}/\text{BW}_{\text{wlf}} < 100$ or $\text{BW}_{\text{ETS}}/\text{BW}_{\text{wlf}} > 0.01$), the TRV_{wlf} is equal to the quotient of the TRV_{ETS} divided by the

TEF and any applicable uncertainty factors (e.g., for a PCDF, it would be the TRV_{ETS} for a congener of TCDD for mammals or TCDF for birds divided by the applicable TEF). For the situation where the body weight of the wildlife is at least two orders of magnitude different from that of the experimental test species (i.e., when $BW_{ETS}/BW_{wlf} \geq 100$ or $BW_{ETS}/BW_{wlf} \leq 0.01$), allometric scaling was required to derive the TRV_{wlf} , and the following equation was used:

$$TRV_{wlf} \text{ (mg/[kg}_{bw} \text{ d)])} = [TRV_{ETS} / (TEF \times UFs)] \times (BW_{ETS}/BW_{wlf})^{1-b} ,$$

where UF is the product of any applicable uncertainty factor(s) (UFs) and “b” in the exponent is the allometric scaling factor (SF) (Sample and Arenal, 1999).

Table B-3 contains the UFs and SFs for mammalian and avian species used to derive the CPEC-specific TRVs for wildlife. The TRVs for the wildlife representing each RREI are presented in Table B-4. Table B-5 contains the appropriate BAFs for plants, invertebrates, and mammals that were used to transform a TRV_{wlf} into an $ESSL_{wlf}$ at each location. This was done using the following mathematical expression:

$$ESSL_{wlf} \text{ (mg/kg}_{soil} \text{)} = (TRV_{wlf}) / \{[(DF_{veg} \times BAF_{veg}) + (DF_{inv} \times BAF_{inv}) + (DF_{rep} \times BAF_{rep}) + (DF_{mam} \times BAF_{mam}) + (DF_{soil} \times BAF_{soil})] \times (DMI)\},$$

where DF_{veg} , DF_{inv} , DF_{rep} , DF_{mam} , DF_{soil} , and DMI are the dietary fractions (DF) for each organism that are represented by vegetation (veg), invertebrates (inv), reptiles (rep), mammals (mam) and/or soil; and DMI is the total dietary dry-matter intake per unit body weight ($mg_{dmi}/[kg_{bw} \text{ d}]$). These data appear in Table B-2; BAFs appear in Table B-5.

The CPEC-specific $ESSL_{wlf}$ values (derived using no observed adverse effect data) for each RREI, including the earthworm, are assembled in Tables B-6a and 6b for the EWTF and the Ranch locations (the two locations that are the furthest distances apart). The two parts of Table B-6 serve as illustration of how these results are used to select a minimum $ESSL_{wlf}$ for each CPEC that is then used to determine the CPEC-specific $ESSL$ -equivalent EHQ for each location that is then compared to a soil concentration. Table B-7 contains the *minima* for the $ESSL$ s determined for each CPEC at each receptor location of interest. The organism to which each minimum applies is also noted in Table B-7.

The receptor locations and modeled soil concentrations predicted for them appear in Table B-8. Table B-9 contains the CPEC-specific EHQ_{max} values derived for these locations, which are obtained by dividing each CPEC-specific soil concentration at each location by the minimum $ESSL_{wlf}$ value obtained from $ESSL_{wlf}$ data appearing in Table B-7.

There are EHQ_{max} values appearing in Table B-9 that do exceed unity. For example, the EHQ_{max} values for lead suggest a potential to produce ecological impact at all receptor locations for which a soil concentration was predicted. Similarly, the EHQ_{max} values for cadmium suggest a potential for ecological impact at the location of the EWTF and also possibly at the Building 812 and Building 895 receptor locations. However, these EHQ_{max} values in excess of unity are based on the most conservative TRVs

corresponding to LOAEL. In fact, the TRVs for cadmium and lead derived by U.S. EPA for these compounds in Ecological Soil Screening Level documents (U.S. EPA, 2005c,d), still represent NOAEL levels, but they are not as conservative as those presented by DTSC (2000). These U.S. EPA documents identify the avian wildlife TRV for cadmium as a geometric mean value and the highest bounded No-Observed Adverse Effect Level (NOAEL) below the lowest bounded Lowest Observed Adverse Effect Level (LOAEL) as the avian TRV for lead. The EHQs at the EWTF for cadmium and lead are 4.27 and 78.5, respectively, following DTSC guidance. The EHQs that were derived using the TRVs from U.S. EPA (2005c,d) are actually lower than unity and less than 10, respectively (i.e., 0.03 for cadmium and 8.7 for lead). Additionally, cumulative EHQ_{max} values at all six locations (i.e., sum of location-specific EHQ_{max} values for all substances) do exceed unity based on this screening calculation, which again suggests further evaluation should be conducted.

Another comparison was made between the predicted soil concentrations at the EWTF and the ESSL_{max} values specific to two wildlife species considered to be of particular concern at Site 300—the San Joaquin Kit Fox and the Burrowing Owl (because they are identified to be endangered or sensitive species). These results appear in Table B-10. For the Kit Fox, only aluminum may represent a potential impact and only at the EWTF location (i.e., $\text{EHQ}_{\text{Kit Fox(max)}} > 1$). Interestingly, the U.S. EPA regards aluminum only as a CPEC if soil pH is less than 5.5 (U.S. EPA, 2003). The soil pH at Site 300 is greater than 5.5 (unreported measurements have ranged from 6.9 to 9); therefore, aluminum should not be of concern. However, for the Burrowing Owl, the $\text{EHQ}_{\text{Burrowing Owl(max)}}$ for lead, as well as for cadmium, exceeds 1 at the EWTF and for lead, the $\text{EHQ}_{\text{Burrowing Owl(max)}}$ exceeds 1 at all other locations. As stated previously, the U.S. EPA has less conservative TRV values for cadmium and lead, which would lead to lower EHQs than those described. Also, the assumption that all soils to which these fossorial animals are exposed have the same concentration as predicted over a depth of 6 inches (15 cm) is conservative. If the estimated concentrations were adjusted to include uncontaminated soils at deeper levels, the calculated EHQ could be reduced by a factor of 4 or more. Whereas, the cumulative EHQ for the Kit Fox exceeds unity only for the EWTF location, the cumulative EHQ for the Burrowing Owl exceeds unity at all locations. Results from the Soil Sampling Plan will provide for a comparison of the ESSLS (Table B-7) and predicted soil concentrations (Table B-8) to actual constituent concentration data. This comparison will shed light on the cumulative EHQs exceeding unity in the vicinity of EWTF.

Additionally, ESSLS have not been developed by regulatory agencies for amphibians, such as the California red-legged frog (*Rana aurora draytonii*) and the California tiger salamander (*Ambystoma californiense*) that may be present near the EWTF. However, in a technical report prepared for the Naval Facility Engineering Command in Port Hueneme, CA, by ENSR International (2004; Table 3-7, p. 3-17), a range for the no-observed effect concentrations (NOECs) in sediments that correspond to sub-lethal endpoints (e.g., growth) applicable to the leopard frog (*Rana* [likely *pipiens*]) were presented for the heavy metals Cd, Cu, Pb, and Zn. For all four of these elements, the lowest sediment NOEC value in the range provided for each element (i.e., Cd = 0.46 mg/kg; Cu = 64 mg/kg; Pb = 2000 mg/kg; and Zn = 900 mg/kg) was always less than the soil concentration predicted near the EWTF from atmospheric dispersion and deposition modeling (i.e., Cd = 0.05 mg/kg; Cu = 29 mg/kg; Pb = 8.9 mg/kg; and

Zn = 1.7 mg/kg). On the basis of these results, and assuming *Rana* (likely *pipiens*) to be a suitable surrogate for *Rana aurora draytonii* and *Ambystoma californiense* serious impacts from these elements to amphibians in the area of the EWTF (as well as a distances further away) would appear to be unlikely.

Plants were evaluated separately on the basis of $ESSL_{min}$ values based on NOECs. These values exist only for heavy metals and were obtained from USEPA (2005c,d) or presented by Efroymsen et al. (1997). Where $ESSL_{min}$ values for these CPECs are provided by both sources, the USEPA data took precedent. In Table B-11, $ESSL_{min}$ values are compared first to measured soil values applicable to Site 300, and then to predicted values from modeling. The EHQ determined from the ratio of measured values to $ESSL_{min}$ suggest only total chromium and zinc may be of potential concern for Site 300, although the cumulative EHQ for these measured values does exceed one, which suggests further evaluation be performed. Nevertheless, EHQs at each location corresponding to predicted concentrations from modeling are all less than unity, and the contribution to the fraction of the cumulative EHQ at each location that is represented by the predicted concentration is exceptionally low.

Data appearing in Tables B-12, B-13a, B-13b, and B-14 are applicable to vertebrate animals and complement the information appearing in Tables B-1, B-4, B-6a, B-6b, and B-7, with the exception that these data are now applicable only to the substances for which EHQ_{max} values exceeded unity and were constructed to obtain the smallest ESSLs from TRV_{High} values. The EHQs for the model predicted concentrations of these eight CPECs—three PCDFs and five heavy metals—appear in Table B-15 for each location. These results indicate that none of these EHQs exceed unity, and only for the EWTF location will the cumulative EHQ exceed one. Furthermore, Table B-16a indicates that these EHQs specific to the Kit Fox will not exceed unity at any location and none of the cumulative EHQs now do either. Table B-16b indicates similar results for the Burrowing Owl.

Results similar to those for animals were found for plants. As can be seen from Table B-17, none of the EHQs for CPECs exceed unity, and the contribution to the cumulative EHQ for predicted concentrations with respect to that for measured data are again quite small and even less than similar values appearing in Table B-11.

For purposes of comparison, animal EHQs were also derived for the Site 300 measured soil concentrations applicable to the seven heavy metals for which measurement data are available: antimony (Sb), barium (Ba), cadmium (Cd), total chromium (Cr; assumed to be six fold greater than hexavalent chromium), copper (Cu), lead (Pb), and zinc (Zn). To make this comparison, BAFs were determined based on soil concentration for those substances for which a median BAF was not readily available in the literature. These particular BAFs change with soil concentration according to equations specified in the footnotes of Table B-18a. However, all BAFs are provided in Table B-18a, including those constituting median values. Table B-18b provides the ESSLs that are predicted corresponding to TRV_{Low} and TRV_{High} values using such BAF data. Thus, Table B-18b contains the ESSLs that are complementary to the information presented in Tables B-6a and 6b (derived using TRV_{Low} values) and Table B-13b (derived using TRV_{High} values), with the exception that the BAFs used for the ESSLs based on TRV_{Low} values

and the ESSLs based on TRV_{High} values are applicable to measured soil concentrations for heavy metals reported for Site 300 (Peterson et al., 2006).

Table 19 applies to animals, but is constructed similar to Table 11 for plants. Thus, in Table 19 the ESSL minimum appears along with the TRV_{Low} derived EHQ values for the measured soil concentrations and these data suggest that the measured soil concentrations, considered to be background levels, may pose a problem for animals with respect to all of the metals measured, both individually and cumulatively (i.e., all EHQs exceed one). However, additional data provided in Table 19 for model predicted soil concentrations indicates that the TRV_{Low} derived cumulative EHQ_{max} at all locations may contribute no more than about 17% of the cumulative EHQ due to measured soil concentrations, and then only in the region of the EWTF (the contribution at all other locations is much less than 17%).

Table B-20 is comparable to Table B-17 for plants. But in this case the data are for animals, and the ESSL minimum and corresponding EHQ for measured data are based on TRV_{High} values. The data in Table B-20 indicates that background soil concentrations measured at Site 300 for the metals Ba, total Cr, and Cu may pose a problem for animals, as the EHQs for these measurements exceed unity. The cumulative EHQ also suggests further evaluation is necessary because it too exceeds a value of one for the measured values. However, the contribution of the EHQ_{max} to the EHQ derived for measured data is at most 5% (for the EWTF location), and even less at the locations further from the EWTF.

Tables B-21 through B-24 report the EHQ for measured data that are derived specifically for the Kit Fox and Burrowing Owl from TRV_{Low} and TRV_{High} factors. Accordingly information in Tables B-21 through B-24 corresponds to data in Tables B-10a and B-10b, and Tables B-16a and B-16b. However, in this case the data are for measured values. The results in Table B-21 suggest that the Kit Fox may be impacted by background levels of Cd, and Pb, and the cumulative EHQ for the Site 300 measurement data suggests further evaluation be performed. A similar situation is apparent for the Burrowing Owl, and for all measured heavy metals, as can be seen from data in Table B-22. However, when the TRV_{High} is employed to derive ESSLs for the measured values for the Kit Fox (Table B-23), there appears to be no impact from background concentrations or the cumulative EHQ. Although, a similar condition exists for the Burrowing Owl with respect to measurement of these metals and the TRV_{High} derived ESSL, the cumulative EHQ for the Burrowing Owl suggests further evaluation be performed.

B.2 ERA Conclusions

Quantification of the ecological risk posed by release of a particular contaminant to a specific habitat is complicated by many uncertainties related to limited data. However, this ERA employed very conservative values for wildlife TRVs, especially for avian RREI with respect to cadmium and lead (see avian BTAG values presented in DTSC [2000]).

The TRVs published by the U.S. EPA (2005 c,d) are more recent than the more conservative BTAG values and are based on extensive literature reviews with literally

hundreds of data points. The calculated EHQs that suggest potential impacts may occur are most likely overly conservative, and the Burrowing Owl and other wildlife are unlikely to be impacted organisms. Thus, the possibility exists that the EHQs for all CPECs and for each RREI at the EWTF are all actually less than unity, and that it is unlikely that adverse ecological impacts are going to occur.

This ERA focused on developing an EHQ for an individual organism in one or more species (and most often only for adults due to data limitations) in the affected habitat; any impact to an individual of a particular species may translate to an impact to the population and, by inference, to a potential impact on the entire local ecosystem. Following this approach, this ERA examined the potential for impact from a CPEC for an individual RREI from more than one species, with each species considered to be at a different trophic level in the local ecosystem near the EWTF. Additional conservatism was added to these ERA calculations by maximizing the amount of material deposited (by considering a habitat location at Site 300 quite close to the OB/OD operations—the source of emissions—and calculating exposure of animals at soil concentrations estimated over a 6-inch [15-cm] depth); optimizing the RREI behavior to maximize exposures (i.e., living, foraging, and capturing prey exclusively in that immediate habitat); and fixing the absorption fraction of each CPEC from the intestinal tract of each RREI at 100 percent. Adding these conservatisms acts to address uncertainty because they increase the likelihood that each calculated EHQ will be an overestimate.

Overall, the data tabulated in Tables B-9, B-10a, 10b; B-11, B-17, B-19, and Tables B-20 to B-24 suggests that further site specific information should be developed. Additional data collection and further analysis would either help to reveal the degree, if any, that EWTF contributions to soil contamination would contribute to ecological impact, or dismiss from further consideration the EWTF as a source for such ecological impacts.

B.3 References

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Table B-1. Chemicals of potential ecological concern (CPECs) with respect to emissions from the EWTF along with their corresponding Chemical Abstracts Service registry identification numbers (CAS IDs), toxicity equivalency factors (TEFs), and the available lowest mammalian and avian toxicity reference values (TRV-Low) for identified experimental test species (ETS) with specified body weights (BW).

Chemical	CAS ID	TEF ^a	Mammal ETS	Mammal BW ^b (kg _{bw})	Mammal TRV _{ETS} ^c [mg/(kg d)]	Avian ETS	Avian BW ^d (kg _{bw})	Avian TRV _{ETS} ^e [mg/(kg d)]
PCDFs								
1-4, 6-8 HpCDF	67562-39-4	0.01	Rat	0.35	1 × 10 ⁻⁵	Chicken	1.5	1 × 10 ⁻³
1-4, 7-9 HpCDF	55673-89-7	0.01	Rat	0.35	1 × 10 ⁻⁵	Chicken	1.5	1 × 10 ⁻³
1-4, 7, 8 HxCDF	70648-26-9	0.1	Rat	0.35	1 × 10 ⁻⁶	Chicken	1.5	1 × 10 ⁻⁴
1-3, 6-8 HxCDF	57117-44-9	0.1	Rat	0.35	1 × 10 ⁻⁶	Chicken	1.5	1 × 10 ⁻⁴
1-9 OCDF	39001-02-0	0.0001	Rat	0.35	1 × 10 ⁻³	Chicken	1.5	1 × 10 ⁻¹
Energetics and other thermally labile compounds								
2,4-Dinitrotoluene	121-14-2	1.0	Dog	14	0.2	Not Available ^f		
2,6-Dinitrotoluene	606-20-2	1.0	Dog	14	0.4	Not Available ^f		
RDX	121-82-4	1.0	Rat	0.35	10	Not Available ^f		
Metals								
Aluminum	7429-90-5	1.0	Mouse	0.03	1.93	Mallard duck	1.153	109.7
Antimony	7440-36-0	1.0	Shrew	0.044	0.059	Not Available ^f		
Barium	7440-39-3	1.0	Shrew	0.044	51.8	Chicken	1.5	20.8
Cadmium	7440-43-9	1.0	Mouse	0.0322	0.06	Mallard duck	1.153	0.08
Chromium	7440-47-3	1.0	Rat	0.35	1468	Not Available ^f		
Copper	7440-50-8	1.0	Mouse	0.03	2.67	Chicken	1.5	2.3
Lead	7439-92-1	1.0	Rat	0.35	1.0	Quail	0.014	0.014
Zinc	7440-66-6	1.0	Mouse	0.0255	9.6	Mallard duck	1.153	17.2
SVOCs								
2-Chlorophenol	95-57-8	1.0	Rat	0.35	5	Not Available ^f		
Diphenylamine	122-39-4	1.0	Dog	14	2.5	Practically Non-toxic ^e		
Fluoranthene	206-44-0	1.0	Mouse	0.03	125	Not Available ^f		

Chemical	CAS ID	TEF ^a	Mammal ETS	Mammal BW ^b (kg _{bw})	Mammal TRV _{ETS} ^c [mg/(kg d)]	Avian ETS	Avian BW ^d (kg _{bw})	Avian TRV _{ETS} ^e [mg/(kg d)]
Naphthalene	91-20-3	1.0	Rat	0.2765	50	Not Available ^f		
Phenol	108-95-2	1.0	Rat	0.35	60	RWBB ^e	0.96	113

^a Toxicity equivalency factors (TEFs) for PCDFs from Van den Berg et al. (1998; Table 5) and Denton (2003) for mammalian species; Van den Berg et al. (1998; Table 5) for avian species; experimental test species and body weight for TCDD and TCDF evaluations were taken from Sample et al. (1996) and from DTSC (2005) data submitted for Vandenberg Air Force Base, California.

^b Experimental test species and corresponding body weight data for mammals taken from ATSDR (1998) for 2,4-dinitrotoluene; and from U.S. EPA (1999) for 2,6-dinitrotoluene; from Talmage et al. (1999) for RDX; from Sample et al., (1996) for Al; from U.S. EPA (2005a,b) for Sb and Ba; from EFA West (1998) for Cd, Cu, Zn, and naphthalene; from the U.S. EPA Integrated Risk Information System (IRIS) database (U.S. EPA, 2006 accessed) for Cr, 2-chlorophenol, diphenylamine, fluoranthene, and phenol; and from DTSC (2002a) for Pb.

^c Toxicity reference values (TRVs) for mammals that are applicable to Cd, Cu, Pb, Zn, and naphthalene are TRV-lows taken from DTSC (2002a,b); those that are applicable to Sb and Ba are taken from U.S. EPA (2005a,b); and the remainder are derived from literature values.

^d Experimental test species and corresponding body weight data for avian organisms taken from DTSC (2005) for PCDF congeners, from Sample et al. (1996) for Al, Ba, and Zn; from EFA West (1998) for Cd, Cu, and Pb; and from Schafer et al. (1983) for phenol.

^e Toxicity reference values for avian organisms were obtained for Al and Ba from Sample et al. (1996); for Cd, Cu, Pb, and Zn from DTSC (2002b); diphenylamine was declared practically non-toxic for avian species by U.S. EPA (1998); and the toxicity reference value for phenol was derived from data taken from Schafer et al. (1983) applicable to the Red-winged Blackbird (RWBB).

^f Avian data for this substance is not available.

Table B-2. Representative receptors of ecological interest (RREI) and respective physiological characteristics, including body weight (BW) and dietary dry-matter intake (DMI).

Organism	BW ^a (kg)	Daily dietary dry-matter intake (kg _{dmf} /d)	Daily dietary dry-matter intake per unit body weight (kg _{dmf} /d per kg _{bw})	Fraction of total dietary dry-matter intake (DMI) ^b				
				Vegetation	Invertebrate	Reptile	Mammal	Soil ^c
Mammals								
Omnivorous small mammal (Deer Mouse)	0.0179	0.00381	0.2128	0.7	0.3	0	0	0.1
Granivorous small mammal (Ground Squirrel)	0.56	0.0383	0.0683	1	0	0	0	0.077
Herbivorous small mammal (Pocket Gopher)	0.104	0.013	0.1250	1	0	0	0	0.1
Herbivorous large mammal [Black-Tailed (Mule) Deer]	39.1	1.565	0.0004	1	0	0	0	0.02
Carnivorous mammal (San Joaquin Kit Fox)	1.48	0.0702	0.0474	0	0	0.5	0.5	0.028
Reptile								
Insectivorous reptile (Side-Blotched Lizard)	0.0032	0.000037	0.011563	0	1	0	0	0.1
Birds								
Omnivorous bird (Savannah Sparrow)	0.0187	0.00574	0.3070	0.39	0.61	0	0	0.04
Carnivorous bird (Burrowing Owl)	0.157 ^d	0.24	0.0495	0	0.333	0.333	0.333	0.05

^a Body weight (BW) and dietary dry-matter intake (DMI) for the wildlife organisms are taken directly from Nagy (2001) for the Deer Mouse, Pocket Gopher, Black-Tailed (Mule) Deer, Kit Fox, Side-Blotched Lizard, and Savannah Sparrow. The body weights of the Burrowing Owl and Ground Squirrel come from Thomsen (1971) and Carlsen (1996), and dietary dry-matter intake (DMI) for these two organisms is computed from wet weight intake for Ground Squirrel given by Carlsen (1996) to dry-matter intake using relationships described Nagy (2001; p. 2-R) and from body weight for Burrowing Owl derived from Thomsen (1971) using allometric scaling described by Nagy (2001; p. 9-R).

^b Fraction of total dietary dry-matter intake represented by vegetation (plants), invertebrates, reptiles, mammals, and soil provides reasonable conservative default estimates for the organisms being evaluated.

^c Data from Carlsen (1996) for Ground Squirrel, Mule Deer, and San Joaquin Kit Fox; and Zarn (1974) for Burrowing Owl. Default values that are considered conservative approximations are used for Deer Mouse, Pocket Gopher, Side-Blotched Lizard, and Savannah Sparrow.

^d Thomsen (1971; Table 6), average of survivors and siblings.

Note: The soil invertebrate category does not appear because an ESSL for that organism (earthworm) was taken directly from literature values (see Tables B-6a and B-6b).

Table B-3. Chemicals of potential ecological concern (CPEC) and factors used for deriving applicable mammalian and avian wildlife toxicity reference values (TRV_{wlf}) from those determined for experimental test species (i.e., TRV_{ETS}).

Chemical	CAS ID	Mammal uncertainty factor (UF_M)	Mammal Scaling factor (SF_M) ^a	Avian uncertainty factor (UF_A)	Avian scaling factor (SF_A) ^a
1-4, 6-8 HpCDF	67562-39-4	1	0.537	1	1.19
1-4, 7-9 HpCDF	55673-89-7	1	0.537	1	1.19
1-4, 7, 8 HxCDF	70648-26-9	1	0.537	1	1.19
1-3, 6-8 HxCDF	57117-44-9	1	0.537	1	1.19
1-9 OCDF	39001-02-0	1	0.537	1	1.19
2,4-Dinitrotoluene	121-14-2	1	0.940	Not Available ^b	Not Available ^b
2,6-Dinitrotoluene	606-20-2	1	0.940	Not Available ^b	Not Available ^b
RDX	121-82-4	1	0.940	1	1.19
Aluminum	7429-90-5	1	0.940	1	1.19
Antimony	7440-36-0	1	0.940	Not Available ^b	Not Available ^b
Barium	7440-39-3	1	0.746	1	1.19
Cadmium	7440-43-9	1	0.440	1	1.19
Chromium	7440-47-3	1	0.940	Not Available ^b	Not Available ^b
Copper	7440-50-8	1	0.940	1	1.19
Lead	7439-92-1	1	0.940	1	1.19
Zinc	7440-66-6	1	0.851	1	1.19
2-Chlorophenol	95-57-8	1	0.940	Not Available ^b	Not Available ^b
Diphenylamine	122-39-4	1	0.940	Not Available ^b	Not Available ^b
Fluoranthene	206-44-0	2 ^c	0.940	Not Available ^b	Not Available ^b
Naphthalene	91-20-3	1	0.940	Not Available ^b	Not Available ^b
Phenol	108-95-2	1	0.940	100 ^c	1.19

^a Allometric scaling is applied only if the difference in body weight between an experimental test species and a wildlife RREI is more than two orders of magnitude apart. If applied, it is done so according to the equation recommended by Sample and Arenal (1999), where $TRV_{wlf} = [TRV_{ETS}/(TEF \times UFs)] \times (BW_{ETS}/BW_{wlf})^{1-b}$ and the specified scaling factors for b that appear in the fourth and last columns for mammals and avian organisms, respectively.

^b Uncertainty and scaling factors applicable to avian species were not available for this substance.

^c Uncertainty factors (UFs) greater than 1 are applied as noted to convert TRV_{ETS} to a TRV for wildlife in Table B-4. Application of safety factors is described in DTSC (1996), such that a UF = 2 is used when it is necessary to extrapolate from subchronic to chronic exposure studies, and an UF = 5 is applied when extrapolating from lowest observed adverse effect to no observed adverse effect.

Table B-4. Toxicity reference values derived for wildlife (TRV-Low) for chemicals of potential ecological concern (CPEC).^a

Chemical	Toxicity reference values (TRVs) derived from experimental test species for respective wildlife species							
	Omnivorous small mammal (Deer Mouse)	Granivorous small mammal (Ground Squirrel)	Herbivorous small mammal (Pocket Gopher)	Herbivorous large mammal (Black-Tailed [Mule] Deer)	Carnivorous mammal (San Joaquin Kit Fox)	Insectivorous reptile (Side-Blotched Lizard)	Omnivorous bird (Savannah Sparrow)	Carnivorous bird (Burrowing Owl)
PCDDs/PCDFs								
1-4, 6-8 HpCDF	1.00E-05	1.00E-05	1.00E-05	1.13E-06 ^b	1.00E-05	8.79E-05 ^b	1.00E-03	1.00E-03
1-4, 7-9 HpCDF	1.00E-06	1.00E-06	1.00E-06	1.13E-07 ^b	1.00E-06	8.79E-05 ^b	1.00E-03	1.00E-03
1-4, 7, 8 HxCDF	1.00E-06	1.00E-06	1.00E-06	1.13E-07 ^b	1.00E-06	8.79E-06 ^b	1.00E-04	1.00E-04
1-3, 6-8 HxCDF	1.00E-03	1.00E-03	1.00E-03	1.13E-04 ^b	1.00E-03	8.79E-06 ^b	1.00E-04	1.00E-04
1-9 OCDF	1.00E-05	1.00E-05	1.00E-05	1.13E-06 ^b	1.00E-05	8.79E-03 ^b	1.00E-01	1.00E-01
Energetics and other thermally labile compounds								
2,4-Dinitrotoluene	2.98E-01 ^b	2.00E-01	2.68E-01 ^b	2.00E-01	2.00E-01	3.31E-01 ^b	Not Available ^c	Not Available ^c
2,6-Dinitrotoluene	5.97E-01 ^b	4.00E-01	5.37E-01 ^b	4.00E-01	4.00E-01	6.61E-01 ^b	Not Available ^c	Not Available ^c
RDX	1.00E+01	1.00E+01	1.00E+01	7.54E+00 ^b	1.00E+01	1.00E+01 ^b	Not Available ^c	Not Available ^c
Metals								
Aluminum	1.93E+00	1.93E+00	1.93E+00	1.26E+00 ^b	1.93E+00	1.93E+00	1.10E+02	1.10E+02
Antimony	5.90E-02	5.90E-02	5.90E-02	3.93E-02 ^b	5.90E-02	5.90E-02	Not Available ^c	Not Available ^c
Barium	5.18E+01	5.18E+01	5.18E+01	9.23E+00 ^b	5.18E+01	5.18E+01	2.08E+01	2.08E+01
Cadmium	6.00E-02	6.00E-02	6.00E-02	1.12E-03 ^b	6.00E-02	6.00E-02	8.00E-02	1.60E-02 ^d
Chromium	1.47E+03	1.47E+03	1.47E+03	1.11E+03	1.47E+03	1.95E+03 ^b	Not Available ^c	Not Available ^c
Copper	2.67E+00	2.67E+00	2.67E+00	1.74E+00 ^b	2.67E+00	2.67E+00	2.30E+00	2.30E+00
Lead	1.00E+00	1.00E+00	1.00E+00	7.54E-01	1.00E+00	1.33E+00 ^b	1.40E-02	2.80E-03 ^d

Chemical	Toxicity reference values (TRVs) derived from experimental test species for respective wildlife species							
	Omnivorous small mammal (Deer Mouse)	Granivorous small mammal (Ground Squirrel)	Herbivorous small mammal (Pocket Gopher)	Herbivorous large mammal (Black-Tailed [Mule] Deer)	Carnivorous mammal (San Joaquin Kit Fox)	Insectivorous reptile (Side-Blotched Lizard)	Omnivorous bird (Savannah Sparrow)	Carnivorous bird (Burrowing Owl)
Zinc	9.60E+00	9.60E+00	9.60E+00	3.22E+00 ^b	9.60E+00	9.60E+00	1.72E+01	1.72E+01
SVOCs								
2-Chlorophenol	5.00E+00	5.00E+00	5.00E+00	3.77E+00 ^b	5.00E+00	6.63E+00 ^b	Not Available ^c	Not Available ^c
Diphenylamine	3.73E+00 ^b	2.50E+00	3.35E+00	2.50E+00	2.50E+00	4.13E+00	Not toxic ^e	Not toxic ^e
Fluoranthene	6.25E+01 ^d	6.25E+01 ^d	6.25E+01 ^d	4.06E+01 ^b	6.25E+01 ^d	6.25E+01 ^d	Not Available ^c	Not Available ^c
Naphthalene	5.00E+01	5.00E+01	5.00E+01	3.71E+01 ^b	5.00E+01	5.00E+01 ^b	Not Available ^c	Not Available ^c
Phenol	5.70E+02	5.70E+02	5.70E+02	4.30E+02 ^b	5.70E+02	7.95E+01 ^b	1.13E+00 ^d	1.13E+00 ^d

^a TRV_{wlf} was derived from TRV_{ETS} using applicable uncertainty and scaling factors appearing in Table B-3.

^b Allometric scaling applied based on ratio of ETS body weight to wlf body weight exceeding two orders of magnitude (see equation in footnote "a" of Table B-3 and body weight information in Tables B-1 and B-2).

^c TRV_{wlf} applicable to avian species for this chemical could not be computed because derivation depends on data that are not available (see Table B-1).

^d See footnote "c" in Table B-3, which identifies safety factors greater than 1 for avian species and safety factor greater than 1 for mammalian species (also applied to insectivorous reptile).

^e Diphenylamine was declared practically non-toxic for avian species by the U.S. EPA (1998).

Table B-5. Bioaccumulation factors (BAFs) for the six receptor locations at which atmospheric dispersion and deposition modeling was used to determine the soil concentration over a 6-in (15-cm) soil depth.

Chemicals of potential concern	EWTF				Bldg 812 Adult				Bldg 895 ECP			
	Soil concentration (mg/kg)	BAF plant ^a	BAF soil invertebrate ^b	BAF small mammal ^c	Soil concentration (mg/kg)	BAF plant ^a	BAF soil invertebrate ^b	BAF small mammal ^c	Soil concentration (mg/kg)	BAF plant ^a	BAF soil invertebrate ^b	BAF small mammal ^c
PCDDs/PCDFs												
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.4E-05	1.0E+00	4.9E+00	1.25E-01	3.6E-06	1.0E+00	3.5E+00	1.25E-01	3.36E-06	1.00E+00	3.45E+00	1.25E-01
1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	5.6E-06	1.0E+00	3.8E+00	1.25E-01	8.4E-07	1.0E+00	2.7E+00	1.25E-01	7.80E-07	1.00E+00	2.65E+00	1.25E-01
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.5E-05	1.0E+00	4.5E+00	1.25E-01	2.2E-06	1.0E+00	3.2E+00	1.25E-01	2.07E-06	1.00E+00	3.16E+00	1.25E-01
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	6.7E-06	1.0E+00	3.9E+00	1.25E-01	1.0E-06	1.0E+00	2.8E+00	1.25E-01	9.38E-07	1.00E+00	2.74E+00	1.25E-01
1-9 OCDF (OCDF)	2.8E-05	1.0E+00	5.1E+00	1.25E-01	4.2E-06	1.0E+00	3.601E+00	1.25E-01	3.95E-06	1.00E+00	3.56E+00	1.25E-01
Energetics & other thermally labile compounds												
2,4-Dinitrotoluene	1.6E-08	1.0E+00	1.0E+00	1.0E+00	2.0E-09	1.0E+00	1.0E+00	1.0E+00	1.88E-09	1.00E+00	1.00E+00	1.00E+00
2,6-Dinitrotoluene	1.3E-09	1.0E+00	1.0E+00	1.0E+00	1.7E-10	1.0E+00	1.0E+00	1.0E+00	1.57E-10	1.00E+00	1.00E+00	1.00E+00
RDX	4.8E+00	1.0E+00	1.0E+00	1.0E+00	6.6E-01	1.0E+00	1.0E+00	1.0E+00	9.40E-01	1.00E+00	1.00E+00	1.00E+00
Metals												
Aluminum	8.6E+01	2.870E-03	1.0E+00	2.6E-02	1.3E+01	2.87E-03	1.0E+00	2.6E-02	1.28E+01	2.87E-03	1.00E+00	2.63E-02
Antimony	8.4E-04	1.020E-02	1.0E+00	1.0E+00	1.1E-04	1.02E-02	1.0E+00	1.0E+00	1.31E-04	1.02E-02	1.00E+00	1.00E+00
Barium	1.0E+01	1.560E-01	1.0E+00	5.7E-02	1.4E+00	1.56E-01	1.0E+00	5.7E-02	1.63E+00	1.56E-01	1.00E+00	5.66E-02
Cadmium	5.0E-02	2.385E+00	1.5E+01	3.0E+00	6.7E-03	5.9E+00	2.3E+01	8.5E+00	7.84E-03	5.48E+00	2.24E+01	7.84E+00
Chromium	8.4E-02	4.100E-02	1.0E+00	4.5E-01	1.1E-02	4.10E-02	1.0E+00	7.7E-01	1.41E-02	4.10E-02	1.00E+00	7.22E-01
Copper	2.9E+01	2.489E-01	4.4E-01	4.3E-01	3.8E+00	8.6E-01	2.0E+00	2.4E+00	3.94E+00	8.47E-01	1.95E+00	2.38E+00
Lead	8.9E+00	1.009E-01	5.3E-01	3.2E-01	1.2E+00	2.5E-01	7.8E-01	9.9E-01	1.14E+00	2.50E-01	7.85E-01	1.00E+00
Zinc	1.7E+00	3.840E+00	6.0E+01	5.3E+01	2.5E-01	9.0E+00	2.2E+02	3.2E+02	2.76E-01	8.56E+00	2.03E+02	2.88E+00
SVOCs												
2-Chlorophenol	6.5E-03	1.0E+00	1.0E+00	1.0E+00	8.3E-04	1.0E+00	1.0E+00	1.0E+00	7.80E-04	1.00E+00	1.00E+00	1.00E+00
Diphenylamine	1.7E-07	1.0E+00	1.0E+00	1.0E+00	2.2E-08	1.0E+00	1.0E+00	1.0E+00	2.03E-08	1.00E+00	1.00E+00	1.00E+00
Fluoranthene	2.2E-02	1.0E+00	1.0E+00	1.0E+00	3.3E-03	1.0E+00	1.0E+00	1.0E+00	3.12E-03	1.00E+00	1.00E+00	1.00E+00
Naphthalene	1.8E-02	1.0E+00	1.0E+00	1.0E+00	2.7E-03	1.0E+00	1.0E+00	1.0E+00	2.50E-03	1.00E+00	1.00E+00	1.00E+00
Phenol	2.2E-06	1.0E+00	1.0E+00	1.0E+00	2.9E-07	1.0E+00	1.0E+00	1.0E+00	2.68E-07	1.00E+00	1.00E+00	1.00E+00

Table B5. Continued

Chemicals of potential concern	East Pasture				Carnegie				Ranch			
	Soil concentration (mg/kg)	BAF plant ^a	BAF soil invertebrate ^b	BAF small mammal ^c	Soil concentration (mg/kg)	BAF plant ^a	BAF soil invertebrate ^b	BAF small mammal ^c	Soil concentration (mg/kg)	BAF plant ^a	BAF soil invertebrate ^b	BAF small mammal ^c
PCDFs												
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.0E-07	1.0E+00	2.1E+00	1.25E-01	2.2E-07	1.0E+00	2.1E+00	1.25E-01	1.0E-07	1.0E+00	1.8E+00	1.25E-01
1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	4.6E-08	1.0E+00	1.6E+00	1.25E-01	5.1E-08	1.0E+00	1.6E+00	1.25E-01	2.4E-08	1.0E+00	1.4E+00	1.25E-01
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.2E-07	1.0E+00	1.9E+00	1.25E-01	1.4E-07	1.0E+00	1.9E+00	1.25E-01	6.4E-08	1.0E+00	1.7E+00	1.25E-01
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	5.5E-08	1.0E+00	1.6E+00	1.25E-01	6.1E-08	1.0E+00	1.7E+00	1.25E-01	2.9E-08	1.0E+00	1.5E+00	1.25E-01
1-9 OCDF (OCDF)	2.3E-07	1.0E+00	2.1E+00	1.25E-01	2.6E-07	1.0E+00	2.2E+00	1.25E-01	1.2E-07	1.0E+00	1.9E+00	1.25E-01
Energetics & other thermally-labile compounds												
2,4-Dinitrotoluene	1.2E-10	1.0E+00	1.0E+00	1.0E+00	1.1E-10	1.0E+00	1.0E+00	1.0E+00	5.5E-11	1.0E+00	1.0E+00	1.0E+00
2,6-Dinitrotoluene	9.8E-12	1.0E+00	1.0E+00	1.0E+00	9.4E-12	1.0E+00	1.0E+00	1.0E+00	4.5E-12	1.0E+00	1.0E+00	1.0E+00
RDX	8.1E-02	1.0E+00	1.0E+00	1.0E+00	8.5E-02	1.0E+00	1.0E+00	1.0E+00	4.9E-02	1.0E+00	1.0E+00	1.0E+00
Heavy Metals												
Aluminum	8.4E-01	2.87E-03	1.0E+00	2.6E-02	9.1E-01	2.87E-03	1.00E+00	2.6E-02	4.6E-01	2.87E-03	1.0E+00	2.6E-02
Antimony	1.0E-05	1.02E-02	1.0E+00	1.0E+00	1.0E-05	1.02E-02	1.00E+00	1.0E+00	5.6E-06	1.02E-02	1.0E+00	1.0E+00
Barium	1.2E-01	1.56E-01	1.0E+00	5.7E-02	1.3E-01	1.56E-01	1.00E+00	5.7E-02	7.0E-02	1.56E-01	1.0E+00	5.7E-02
Cadmium	6.0E-04	1.7E+01	3.8E+01	2.9E+01	6.1E-04	1.727E+01	3.77E+01	2.9E+01	3.4E-04	2.3E+01	4.3E+01	4.0E+01
Chromium	1.1E-03	4.10E-02	1.0E+00	1.4E+00	1.2E-03	4.10E-02	1.00E+00	1.4E+00	6.5E-04	4.10E-02	1.0E+00	1.6E+00
Copper	2.7E-01	4.3E+00	1.4E+01	2.4E+01	2.7E-01	4.4E+00	1.41E+01	2.4E+01	1.4E-01	6.5E+00	2.3E+01	4.2E+01
Lead	7.4E-02	8.3E-01	1.3E+00	4.6E+00	7.2E-02	8.4E-01	1.33E+00	4.7E+00	3.6E-02	1.1E+00	1.5E+00	6.9E+00
Zinc	2.0E-02	2.7E+01	1.2E+03	3.3E+03	2.1E-02	2.6E+01	1.14E+03	3.1E+03	1.1E-02	3.5E+01	1.7E+03	5.6E+03
SVOCs												
2-Chlorophenol	4.9E-05	1.0E+00	1.0E+00	1.0E+00	4.7E-05	1.0E+00	1.0E+00	1.0E+00	2.3E-05	1.0E+00	1.0E+00	1.0E+00
Diphenylamine	1.3E-09	1.0E+00	1.0E+00	1.0E+00	1.2E-09	1.0E+00	1.0E+00	1.0E+00	5.9E-10	1.0E+00	1.0E+00	1.0E+00
Fluoranthene	1.8E-04	1.0E+00	1.0E+00	1.0E+00	2.0E-04	1.0E+00	1.0E+00	1.0E+00	9.7E-05	1.0E+00	1.0E+00	1.0E+00
Naphthalene	1.5E-04	1.0E+00	1.0E+00	1.0E+00	1.6E-04	1.0E+00	1.0E+00	1.0E+00	7.8E-05	1.0E+00	1.0E+00	1.0E+00
Phenol	1.7E-08	1.0E+00	1.0E+00	1.0E+00	1.6E-08	1.0E+00	1.0E+00	1.0E+00	7.8E-09	1.0E+00	1.0E+00	1.0E+00

Note: BAFs for reptile and soil are not included in this table because they are considered equal to one for all CPECs at all locations.

^a Bioaccumulation factors (BAFs) for plants are from either chemical-specific regression models with a significant model fit, where $BAF = \exp[B_0 + B_1(\ln C_{soil})]/C_{soil}$, or are a median value from empirical data; both of which are presented in BJC (1998), or when no chemical-specific uptake data were available, a default value of 1.0 was applied (as recommended in DTSC, 2000).

^b BAFs for soil invertebrates are from either chemical-specific regression models with a significant model fit, where $BAF = \exp[B_0 + B_1(\ln C_{soil})]/C_{soil}$, or are a median value from empirical data, both of which are presented in Sample et al. (1998a), or when no chemical-specific uptake data were available, a default value of 1.0 was applied (as recommended in DTSC, 2000).

^c BAFs for small mammals are from either chemical-specific regression models with a significant model fit, where $BAF = \exp[B_0 + B_1(\ln C_{soil})]/C_{soil}$, or are a median value from empirical data; both of which are presented in Sample et al. (1998b), or when no chemical-specific uptake data were available, a default value of 1.0 was applied (as recommended in DTSC, 2000).

Table B-6a. Derived ecological soil screening levels (ESSLs) applicable to the chemicals of potential ecological concern (CPECs) with respect to each representative receptor of ecological interest (RREI) in the habitat nearest the EWTF and used to select a minimum ESSL for generating an ecological hazard quotient (EHQ).

EWTF	Calculated as Mammal ESSL for insectivorous reptile (Side-blotched lizard) [mg/kg _{soil}] ^a	ESSL for omnivorous sm mammal (Deer mouse) [mg/kg _{soil}]	ESSL for granivorous sm mammal (Ground squirrel) [mg/kg _{soil}]	ESSL for herbivorous sm mammal (Pocket gopher) [mg/kg _{soil}]	ESSL for herbivorous lg mammal (Black-tailed [Mule] deer) [mg/kg _{soil}]	ESSL for carnivorous mammal (Kit fox) [mg/kg _{soil}]	ESSL for omnivorous avian (Savannah Sparrow) [mg/kg _{soil}]	ESSL for carnivorous avian (Burrowing Owl) [mg/kg _{soil}]	Calculated as Avian ESSL for insectivorous reptile ^a (Side-blotched lizard) [mg/kg _{soil}]	ESSL for soil invertebrate ^b (e.g., earthworm) [mg/kg _{soil}]	
PCDFs											
1	1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	1.51E-03	2.06E-05	1.36E-04	7.27E-05	2.76E-03	3.57E-04	9.5E-04	9.8E-03	5.3E-02	5
2	1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	1.96E-03	2.43E-05	1.36E-04	7.27E-05	2.76E-03	3.57E-04	1.2E-03	1.2E-02	6.9E-02	5
3	1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.64E-04	2.18E-06	1.36E-05	7.27E-06	2.76E-04	3.57E-05	1.0E-04	1.0E-03	5.8E-03	5
4	1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	1.89E-04	2.38E-06	1.36E-05	7.27E-06	2.76E-04	3.57E-05	1.2E-04	1.2E-03	6.7E-03	5
5	1-9 OCDF (OCDF)	1.47E-01	2.02E-03	1.36E-02	7.27E-03	2.76E-01	3.57E-02	9.2E-02	9.5E-01	5.2E+00	5
Explosives											
14	2,4-Dinitrotoluene	2.60E+01	1.27E+00	2.72E+00	1.95E+00	4.90E+02	4.10E+00	Not Available ^c	Not Available ^c	Not Available ^c	Not Available ^c
15	2,6-Dinitrotoluene	5.20E+01	2.55E+00	5.43E+00	3.90E+00	9.80E+02	8.20E+00	Not Available ^c	Not Available ^c	Not Available ^c	Not Available ^c
16	RDX	1.04E+03	4.27E+01	1.36E+02	7.27E+01	1.85E+04	2.05E+02	Not Available ^c	Not Available ^c	Not Available ^c	Not Available ^c
Metals											
6	Aluminum	1.52E+02	2.26E+01	3.54E+02	1.50E+02	1.37E+05	7.52E+01	5.5E+02	3.1E+03	2.8E+03	Not Available ^c
7	Antimony	4.64E+00	6.81E-01	9.90E+00	4.28E+00	3.25E+03	1.21E+00	Not Available ^c	Not Available ^c	Not Available ^c	Not Available ^c
8	Barium	4.07E+03	4.78E+02	3.25E+03	1.62E+03	1.31E+05	1.96E+03	9.5E+01	5.7E+02	5.1E+02	330
9	Cadmium	3.37E-01	4.43E-02	3.57E-01	1.93E-01	1.17E+00	6.19E-01	2.5E-02	8.0E-02	1.5E-01	140
10	Chromium	1.53E+05	1.61E+04	1.82E+05	8.33E+04	4.53E+07	4.11E+04	Not Available ^c	Not Available ^c	Not Available ^c	1.2 ^d
11	Copper	4.24E+02	3.08E+01	1.20E+02	6.12E+01	1.61E+04	7.59E+01	1.8E+01	6.9E+01	1.1E+02	32
12	Lead	1.83E+02	1.43E+01	8.22E+01	3.98E+01	1.56E+04	3.07E+01	1.1E-01	1.4E-01	1.9E+00	1700
13	Zinc	1.39E+01	2.18E+00	3.59E+01	1.95E+01	2.08E+03	7.44E+00	1.5E+00	9.1E+00	8.1E+00	199
SVOCs											
17	2-Chlorophenol	5.21E+02	2.14E+01	6.79E+01	3.64E+01	9.23E+03	1.03E+02	3.5E+00	2.2E+01	8.9E+01	Not Available ^c
18	Diphenylamine	3.25E+02	1.59E+01	3.40E+01	2.44E+01	6.12E+03	5.13E+01	Not toxic ^e	Not toxic ^e	Not Available ^c	Not Available ^c
19	Fluoranthene	4.91E+03	2.67E+02	8.49E+02	4.55E+02	9.95E+04	1.28E+03	Not Available ^c	Not Available ^c	Not Available ^c	38
20	Naphthalene	3.93E+03	2.14E+02	6.79E+02	3.64E+02	9.10E+04	1.03E+03	Not Available ^c	Not Available ^c	Not Available ^c	Not Available ^c
21	Phenol	6.25E+03	2.56E+02	8.15E+02	4.36E+02	1.11E+05	1.23E+03	3.5E+00	2.2E+01	8.9E+01	30

^a The ecological soil screening level (ESSL) for the reptile of ecological interest was computed along with both mammalian and avian RREI categories to determine the lowest value for comparison in selecting a chemical-specific minimum ESSL.

^b ESSLs for soil invertebrates are from DTSC (2005) for TCDD (assuming it is same for TCDF and its congeners); from U.S. EPA (2005a-d) for Sb, Cd, Ba, and Pb; from U.S. EPA (1999) for hexavalent Cr, Cu, and Zn; from Sverdrup et al. (2002) for fluoranthene; and from Sample et al. (1996) for phenol.

^c ESSL applicable to avian species (or for Side-blotched Lizard, as avian species) or for the soil invertebrate for this chemical could not be computed because derivation depends on data that are not available.

^d Chromium VI is considered to be 17% of this total chromium value (US EPA, 2004), which corresponds to the 0.2 mg/kg_{soil} hexavalent chromium reported applicable to invertebrates by USEPA (1999).

^e Considered to be practically non-toxic (U.S. EPA, 1998) to avian organisms.

Table B-6b. Derived ecological soil screening levels (ESSLs) applicable to the chemicals of potential ecological concern (CPECs) with respect to each representative receptor of ecological interest (RREI) in the habitat at the Ranch site, which is the receptor location furthest from the EWTF, and used to select a minimum ESSL for generating an ecological hazard quotient (EHQ).

	Ranch	Calculated as Mammal ESSL for insectivorous reptile ^a (Side-blotched lizard) [mg/kg _{soil}] ^a	ESSL for omnivorous sm mammal (Deer mouse) [mg/kg _{soil}]	ESSL for granivorous sm mammal (Ground squirrel) [mg/kg _{soil}]	ESSL for herbivorous sm mammal (Pocket gopher) [mg/kg _{soil}]	ESSL for herbivorous lg mammal (Black-tailed Mule deer) [mg/kg _{soil}]	ESSL for carnivorous mammal (Kit fox) [mg/kg _{soil}]	ESSL for omnivorous avian (Savannah Sparrow) [mg/kg _{soil}]	ESSL for carnivorous avian (Burrowing Owl) [mg/kg _{soil}]	Calculated as Avian ESSL for insectivorous reptile ^a (Side-blotched lizard) [mg/kg _{soil}]	ESSL for soil invertebrate ^b (e.g., earthworm) [mg/kg _{soil}]
PCDDs/PCDFs											
1	1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	3.93E-03	3.48E-05	1.36E-04	7.27E-05	2.76E-03	3.57E-04	2.1E-03	2.0E-02	1.4E-02	5
2	1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	5.04E-03	3.84E-05	1.36E-04	7.27E-05	2.76E-03	3.57E-04	2.5E-03	2.3E-02	1.8E-02	5
3	1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	4.27E-04	3.60E-06	1.36E-05	7.27E-06	2.76E-04	3.57E-05	2.2E-04	2.1E-03	1.5E-03	5
4	1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	4.89E-04	3.80E-06	1.36E-05	7.27E-06	2.76E-04	3.57E-05	2.5E-04	2.2E-03	1.7E-03	5
5	1-9 OCDF (OCDF)	3.82E-01	3.44E-03	1.36E-02	7.27E-03	2.76E-01	3.57E-02	2.1E-01	1.9E+00	1.4E+00	5
Metals											
6	Aluminum	1.52E+02	2.26E+01	3.54E+02	1.50E+02	1.37E+05	7.52E+01	5.5E+02	3.1E+03	2.8E+03	Not Available ^c
7	Antimony	4.64E+00	6.81E-01	9.90E+00	4.28E+00	3.25E+03	1.21E+00	Not Available ^c	Not Available ^c	Not Available ^c	Not Available ^c
8	Barium	4.07E+03	4.78E+02	3.25E+03	1.62E+03	1.31E+05	1.96E+03	9.5E+01	5.7E+02	5.1E+02	330
9	Cadmium	1.21E-01	9.81E-03	3.87E-02	2.11E-02	1.24E-01	6.24E-02	7.5E-03	1.9E-02	5.3E-02	140
10	Chromium	1.53E+05	1.61E+04	1.82E+05	8.33E+04	4.53E+07	2.30E+04	Not Available ^c	Not Available ^c	Not Available ^c	12 ^d
11	Copper	1.01E+01	1.09E+00	5.92E+00	3.22E+00	6.63E+02	2.63E+00	4.5E-01	2.1E+00	2.7E+00	32
12	Lead	7.05E+01	3.46E+00	1.20E+01	6.45E+00	1.62E+03	5.31E+00	3.2E-02	2.8E-02	7.4E-01	1700
13	Zinc	4.77E-01	8.24E-02	4.01E+00	2.19E+00	2.30E+02	7.27E-02	5.2E-02	1.4E-01	2.8E-01	199
Explosives											
14	2,4-Dinitrotoluene	2.60E+01	1.27E+00	2.72E+00	1.95E+00	4.90E+02	4.10E+00	Not Available ^c	Not Available ^c	Not Available ^c	Not Available ^c
15	2,6-Dinitrotoluene	5.20E+01	2.55E+00	5.43E+00	3.90E+00	9.80E+02	8.20E+00	Not Available ^c	Not Available ^c	Not Available ^c	Not Available ^c
16	RDX	1.04E+03	4.27E+01	1.36E+02	7.27E+01	1.85E+04	2.05E+02	Not Available ^c	Not Available ^c	Not Available ^c	Not Available ^c
SVOCs											
17	2-Chlorophenol	5.21E+02	2.14E+01	6.79E+01	3.64E+01	9.23E+03	1.03E+02	Not Available ^c	Not Available ^c	Not Available ^c	Not Available ^c
18	Diphenylamine	3.25E+02	1.59E+01	3.40E+01	2.44E+01	6.12E+03	5.13E+01	Not toxic ^e	Not toxic ^e	Not Available ^c	Not Available ^c
19	Fluoranthene	4.91E+03	2.67E+02	8.49E+02	4.55E+02	9.95E+04	1.28E+03	Not Available ^c	Not Available ^c	Not Available ^c	38
20	Naphthalene	3.93E+03	2.14E+02	6.79E+02	3.64E+02	9.10E+04	1.03E+03	Not Available ^c	Not Available ^c	Not Available ^c	Not Available ^c
21	Phenol	6.25E+03	2.56E+02	8.15E+02	4.36E+02	1.11E+05	1.23E+03	Not Available ^c	Not Available ^c	Not Available ^c	30

^a The ecological soil screening level (ESSL) for the reptile of ecological interest was computed along with both mammalian and avian RREI categories to determine the lowest value for comparison in selecting a chemical-specific minimum ESSL.

^b ESSLs for soil invertebrates are from DTSC (2005) for TCDD (assuming it is same for TCDF and its congeners); from U.S. EPA (2005a-d) for Sb, Cd, Ba, and Pb; from U.S. EPA (1999) for hexavalent Cr, Cu, and Zn; from Sverdrup et al. (2002) for fluoranthene; and from Sample et al. (1996) for phenol.

^c ESSL applicable to avian species (or for Side-blotched Lizard, as avian species) or for the soil invertebrate for this chemical could not be computed because derivation depends on data that are not available.

^d Chromium VI is considered to be 17% of this total chromium value (US EPA, 2004), which corresponds to the 0.2 mg/kg_{soil} hexavalent chromium reported applicable to invertebrates by USEPA (1999).

^e Considered to be practically non-toxic (U.S. EPA, 1998) to avian organisms.

Table B-7. Minimum ecological soil screening levels (ESSLs) based on TRV-Low values for the chemicals of potential ecological concern (CPECs), and the organism corresponding to it, for all six receptor locations at which soil concentrations over a 6-in (15-cm) depth were predicted from atmospheric dispersion and deposition modeling.

Chemicals of potential ecological concern	EWTF ^a		Bldg. 812		Bldg. 895		East Pasture		Carnegie		Ranch ^a	
	ESSL _{min} (mg/kg _{soil})	Organism	ESSL _{min} (mg/kg _{soil})	Organism	ESSL _{min} (mg/kg _{soil})	Organism	ESSL _{min} (mg/kg _{soil})	Organism	ESSL _{min} (mg/kg _{soil})	Organism	ESSL _{min} (mg/kg _{soil})	Organism
PCDDs/PCDFs												
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.06E-05	OSM ^b	2.54E-05	OSM ^b	2.56E-05	OSM ^b	2.76E-05	HLM ^c	2.76E-05	HLM ^c	2.76E-05	HLM ^c
1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	2.43E-05	OSM ^b	2.76E-05	HLM ^c	2.76E-05	HLM ^c	2.76E-05	HLM ^c	2.76E-05	HLM ^c	2.76E-05	HLM ^c
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	2.18E-06	OSM ^b	2.67E-06	OSM ^b	2.69E-06	OSM ^b	2.76E-06	HLM ^c	2.76E-06	HLM ^c	2.76E-06	HLM ^c
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	2.38E-06	OSM ^b	2.76E-06	HLM ^c	2.76E-06	HLM ^c	2.76E-06	HLM ^c	2.76E-06	HLM ^c	2.76E-06	HLM ^c
1-9 OCDF (OCDF)	2.02E-03	OSM ^b	2.50E-03	OSM ^b	2.52E-03	OSM ^b	2.76E-03	HLM ^c	2.76E-03	HLM ^c	2.76E-03	HLM ^c
Energetics & other thermally-labile compounds												
2,4-Dinitrotoluene	1.27E+00	OSM ^b	1.27E+00	OSM ^b	1.27E+00	OSM ^b	1.27E+00	OSM ^b	1.27E+00	OSM ^b	1.27E+00	OSM ^b
2,6-Dinitrotoluene	2.55E+00	OSM ^b	2.55E+00	OSM ^b	2.55E+00	OSM ^b	2.55E+00	OSM ^b	2.55E+00	OSM ^b	2.55E+00	OSM ^b
RDX	4.27E+01	OSM ^b	4.27E+01	OSM ^b	4.27E+01	OSM ^b	4.27E+01	OSM ^b	4.27E+01	OSM ^b	4.27E+01	OSM ^b
Heavy Metals												
Aluminum	2.26E+01	OSM ^b	2.26E+01	OSM ^b	2.26E+01	OSM ^b	2.26E+01	OSM ^b	2.26E+01	OSM ^b	2.26E+01	OSM ^b
Antimony	6.81E-01	OSM ^b	6.81E-01	OSM ^b	6.81E-01	OSM ^b	6.81E-01	OSM ^b	6.81E-01	OSM ^b	6.81E-01	OSM ^b
Barium	9.53E+01	OA ^d	9.53E+01	OA ^d	9.53E+01	OA ^d	9.53E+01	OA ^b	9.53E+01	OA ^d	9.53E+01	OA ^d
Cadmium	1.17E-02	HLM ^c	4.74E-03	HLM ^c	5.10E-03	HLM ^c	1.61E-03	HLM ^c	1.62E-03	HLM ^c	1.24E-03	HLM ^c
Chromium	1.61E+04	OSM ^b	1.61E+04	OSM ^b	1.61E+04	OSM ^b	1.61E+04	OSM ^b	1.61E+04	OSM ^b	1.61E+04	OSM ^b
Copper	1.84E+01	OA ^d	4.71E+00	OA ^d	4.81E+00	OA ^d	7.31E-01	OA ^d	7.26E-01	OA ^d	4.53E-01	OA ^d
Lead	1.14E-01	OA ^d	7.44E-02	OA ^d	7.40E-02	OA ^d	3.83E-02	CA ^e	3.81E-02	CA ^e	2.85E-02	CA ^e
Zinc	1.47E+00	OA ^d	4.10E-01	OA ^d	4.40E-01	OA ^d	7.43E-02	CA ^e	7.87E-02	CA ^e	4.57E-02	CA ^e
SVOCs												
2-Chlorophenol	2.14E+01	OSM ^b	2.14E+01	OSM ^b	2.14E+01	OSM ^b	2.14E+01	OSM ^b	2.14E+01	OSM ^b	2.14E+01	OSM ^b
Diphenylamine	1.59E+01	OSM ^b	1.59E+01	OSM ^b	1.59E+01	OSM ^b	1.59E+01	OSM ^b	1.59E+01	OSM ^b	1.59E+01	OSM ^b
Fluoranthene	3.80E+01	INV ^f	3.80E+01	INV ^f	3.80E+01	INV ^f	3.80E+01	INV ^f	3.80E+01	INV ^f	3.80E+01	INV ^f
Naphthalene	2.14E+02	OSM ^b	2.14E+02	OSM ^b	2.14E+02	OSM ^b	2.14E+02	OSM ^b	2.14E+02	OSM ^b	2.14E+02	OSM ^b
Phenol	3.54E+00	OA ^d	3.54E+00	OA ^d	3.54E+00	OA ^d	3.54E+00	OA ^d	3.54E+00	OA ^d	3.54E+00	OA ^d

^a Minimum ESSLs for EWTF and for the Ranch sites can be obtained from examination of Tables B-6a and B-6b.

^b OSM = Omnivorous small mammal

^c HLM = Herbivorous large mammal

^d OA = Omnivorous avian

^e CA = Carnivorous avian

^f INV = Invertebrate

Table B-8. Soil concentrations over 6-in (15-cm) soil depth predicted at six receptor locations from atmospheric dispersion and deposition modeling (mg/kg).

Chemical	Carnegie	Ranch	Bldg 812 Adult	Bldg 895 ECP	East Pasture	EWTF
PCDDs/PCDFs						
1,2,3,4,6,7,8-Heptachlorodibenzofuran	2.2E-07	1.0E-07	3.6E-06	3.4E-06	2.0E-07	2.4E-05
1,2,3,4,7,8,9-Heptachlorodibenzofuran	5.1E-08	2.4E-08	8.4E-07	7.8E-07	4.6E-08	5.6E-06
1,2,3,4,7,8-Hexachlorodibenzofuran	1.4E-07	6.4E-08	2.2E-06	2.1E-06	1.2E-07	1.5E-05
1,2,3,6,7,8-Hexachlorodibenzofuran	6.1E-08	2.9E-08	1.0E-06	9.4E-07	5.5E-08	6.7E-06
1,2,3,4,6,7,8,9-Octachlorodibenzofuran	2.6E-07	1.2E-07	4.2E-06	4.0E-06	2.3E-07	2.8E-05
Explosives						
2,4-Dinitrotoluene	1.1E-10	5.5E-11	2.0E-09	1.9E-09	1.2E-10	1.6E-08
2,6-Dinitrotoluene	9.4E-12	4.5E-12	1.7E-10	1.6E-10	9.8E-12	1.3E-09
PETN (same as RDX) ^a	6.0E-03	3.4E-03	4.7E-02	6.6E-02	5.7E-03	3.4E-01
RDX ^a	7.9E-02	4.5E-02	6.2E-01	8.7E-01	7.5E-02	4.4E+00
Metals						
Aluminum	9.1E-01	4.6E-01	1.3E+01	1.3E+01	8.4E-01	8.6E+01
Antimony	1.0E-05	5.6E-06	1.1E-04	1.3E-04	1.0E-05	8.4E-04
Barium	1.3E-01	7.0E-02	1.4E+00	1.6E+00	1.2E-01	1.0E+01
Cadmium	6.1E-04	3.4E-04	6.7E-03	7.8E-03	6.0E-04	5.0E-02
Chromium	1.2E-03	6.5E-04	1.1E-02	1.4E-02	1.1E-03	8.4E-02
Copper	2.7E-01	1.4E-01	3.8E+00	3.9E+00	2.7E-01	2.9E+01
Lead	7.2E-02	3.6E-02	1.2E+00	1.1E+00	7.4E-02	8.9E+00
Zinc	2.1E-02	1.1E-02	2.5E-01	2.8E-01	2.0E-02	1.7E+00
SVOCs						
2-Chlorophenol	4.7E-05	2.3E-05	8.3E-04	7.8E-04	4.9E-05	6.5E-03
Diphenylamine	1.2E-09	5.9E-10	2.2E-08	2.0E-08	1.3E-09	1.7E-07
Fluoranthene	2.0E-04	9.7E-05	3.3E-03	3.1E-03	1.8E-04	2.2E-02
Naphthalene ^b	2.2E-08	1.1E-08	3.9E-07	3.6E-07	2.3E-08	3.0E-06
Naphthalene surrogate ^b	1.6E-04	7.8E-05	2.7E-03	2.5E-03	1.5E-04	1.8E-02
Phenol	1.6E-08	7.8E-09	2.9E-07	2.7E-07	1.7E-08	2.2E-06

^a Soil concentrations for PETN and RDX are summed for purposes of analysis and assessment.

^b Soil concentration for naphthalene and naphthalene surrogate are summed for purposes of analysis and assessment.

Table B-9. Maximum ecological hazard quotients (EHQs) for chemicals of potential concern (CPECs) at different receptor locations. Each EHQ is derived from the lowest ESSL computed from a TRV-Low for all organisms evaluated for the receptor location.

Chemical	Receptor Location					
	EHQ _{max} (EWTF/ESSL _{min})	EHQ _{max} (Bldg 812/ESSL _{min})	EHQ _{max} (Bldg 895/ESSL _{min})	EHQ _{max} (EstPst/ESSL _{min})	EHQ _{max} (Crnge/ESSL _{min})	EHQ _{max} (Ranch/ESSL _{min})
PCDDs/PCDFs						
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	<i>1.16E+00</i>	1.42E-01	1.31E-01	7.19E-03	7.94E-03	3.78E-03
1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	2.30E-01	3.03E-02	2.83E-02	1.67E-03	1.84E-03	8.79E-04
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	<i>6.80E+00</i>	8.33E-01	7.72E-01	4.44E-02	4.90E-02	2.34E-02
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	<i>2.82E+00</i>	3.65E-01	3.40E-01	2.01E-02	2.22E-02	1.06E-02
1-9 OCDF (OCDF)	1.40E-02	1.70E-03	1.57E-03	8.46E-05	9.34E-05	4.45E-05
Energetics & other thermally-labile compounds						
2,4-Dinitrotoluene	1.22E-08	1.57E-09	1.47E-09	9.20E-11	8.85E-11	4.28E-11
2,6-Dinitrotoluene	5.10E-10	6.55E-11	6.14E-11	3.83E-12	3.69E-12	1.78E-12
RDX (+ PETN, because RDX is surrogate)	1.12E-01	1.55E-02	2.20E-02	1.90E-03	1.98E-03	1.14E-03
Metals						
Aluminum	<i>3.83E+00</i>	5.61E-01	5.69E-01	3.73E-02	4.01E-02	2.03E-02
Antimony	1.23E-03	1.64E-04	1.93E-04	1.48E-05	1.51E-05	8.27E-06
Barium	1.09E-01	1.46E-02	1.71E-02	1.31E-03	1.33E-03	7.30E-04
Cadmium	<i>4.27E+00</i>	<i>1.40E+00</i>	<i>1.54E+00</i>	3.73E-01	3.77E-01	2.71E-01
Chromium	5.21E-06	7.04E-07	8.79E-07	7.01E-08	7.21E-08	4.03E-08
Copper	<i>1.60E+00</i>	8.11E-01	8.19E-01	3.70E-01	3.69E-01	3.06E-01
Lead	<i>7.85E+01</i>	<i>1.57E+01</i>	<i>1.53E+01</i>	<i>1.92E+00</i>	<i>1.90E+00</i>	<i>1.27E+00</i>
Zinc	<i>1.16E+00</i>	6.05E-01	6.27E-01	2.67E-01	2.69E-01	2.47E-01
SVOCs						
2-Chlorophenol	3.03E-04	3.90E-05	3.65E-05	2.28E-06	2.19E-06	1.06E-06
Diphenylamine	1.06E-08	1.36E-09	1.27E-09	7.95E-11	7.65E-11	3.70E-11
Fluoranthene	5.86E-04	8.80E-05	8.22E-05	4.85E-06	5.36E-06	2.55E-06
Naphthalene (+ Naphthalene surrogate)	8.35E-05	1.25E-05	1.17E-05	6.91E-07	7.63E-07	3.63E-07
Phenol	6.28E-07	8.06E-08	7.56E-08	4.72E-09	4.54E-09	2.20E-09
Cumulative EHQ _{max} =	1.01E+02	2.04E+01	2.02E+01	3.05E+00	3.04E+00	2.15E+00

Note: EHQ values greater than 1 appear in italics (e.g., see EHQ values for Pb).

Table B-10a. Ecological hazard quotients (EHQs) derived using TRV-Low specifically for the San Joaquin Kit Fox at the six receptor locations for which soil concentrations were predicted from modeling.^a

Chemicals of potential ecological concern	EWTF for Kit Fox			Bldg. 812 for Kit Fox			Bldg. 895 for Kit Fox		
	15-cm soil _{model} (mg/kg)	ESSL _{Kit fox(min)}	EHQ _{Kit fox(max)}	15-cm soil _{model} (mg/kg)	ESSL _{Kit fox(min)}	EHQ _{Kit fox(max)}	15-cm soil _{model} (mg/kg)	ESSL _{Kit fox(min)}	EHQ _{Kit fox(max)}
PCDDs/PCDFs									
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.4E-05	3.6E-04	6.7E-02	3.6E-06	3.6E-04	1.0E-02	3.4E-06	3.6E-04	9.4E-03
1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	5.6E-06	3.6E-04	1.6E-02	8.4E-07	3.6E-04	2.3E-03	7.8E-07	3.6E-04	2.2E-03
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.5E-05	3.6E-05	4.1E-01	2.2E-06	3.6E-05	6.2E-02	2.1E-06	3.6E-05	5.8E-02
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	6.7E-06	3.6E-05	1.9E-01	1.0E-06	3.6E-05	2.8E-02	9.4E-07	3.6E-05	2.6E-02
1-9 OCDF (OCDF)	2.8E-05	3.6E-02	7.9E-04	4.2E-06	3.6E-02	1.2E-04	4.0E-06	3.6E-02	1.1E-04
Energetics & other thermally-labile compounds									
2,4-Dinitrotoluene	1.6E-08	4.1E+00	3.8E-09	2.0E-09	4.1E+00	4.9E-10	1.9E-09	4.1E+00	4.6E-10
2,6-Dinitrotoluene	1.3E-09	8.2E+00	1.6E-10	1.7E-10	8.2E+00	2.0E-11	1.6E-10	8.2E+00	1.9E-11
RDX	4.8E+00	2.1E+02	2.3E-02	6.6E-01	2.1E+02	3.2E-03	9.4E-01	2.1E+02	4.6E-03
Heavy Metals									
Aluminum	8.6E+01	7.5E+01	1.2E+00	1.3E+01	7.5E+01	1.7E-01	1.3E+01	7.5E+01	1.7E-01
Antimony	8.4E-04	1.2E+00	6.9E-04	1.1E-04	1.2E+00	9.2E-05	1.3E-04	1.2E+00	1.1E-04
Barium	1.0E+01	2.0E+03	5.3E-03	1.4E+00	2.0E+03	7.1E-04	1.6E+00	2.0E+03	8.3E-04
Cadmium	5.0E-02	6.2E-01	8.1E-02	6.7E-03	2.6E-01	2.5E-02	7.8E-03	2.8E-01	2.8E-02
Chromium	8.4E-02	4.1E+04	2.0E-06	1.1E-02	3.4E+04	3.3E-07	1.4E-02	3.5E+04	4.1E-07
Copper	2.9E+01	7.6E+01	3.9E-01	3.8E+00	3.2E+01	1.2E-01	3.9E+00	3.3E+01	1.2E-01
Lead	8.9E+00	3.1E+01	2.9E-01	1.2E+00	2.1E+01	5.7E-02	1.1E+00	2.0E+01	5.6E-02
Zinc	1.7E+00	7.4E+00	2.3E-01	2.5E-01	1.3E+00	2.0E-01	2.8E-01	1.4E+00	2.0E-01
SVOCs									
2-Chlorophenol	6.5E-03	1.0E+02	6.3E-05	8.3E-04	1.0E+02	8.1E-06	7.8E-04	1.0E+02	7.6E-06
Diphenylamine	1.7E-07	5.1E+01	3.3E-09	2.2E-08	5.1E+01	4.2E-10	2.0E-08	5.1E+01	4.0E-10
Fluoranthene	2.2E-02	1.3E+03	1.7E-05	3.3E-03	1.3E+03	2.6E-06	3.1E-03	1.3E+03	2.4E-06
Naphthalene	1.8E-02	1.0E+03	1.7E-05	2.7E-03	1.0E+03	2.6E-06	2.5E-03	1.0E+03	2.4E-06
Phenol	2.2E-06	1.2E+03	1.8E-09	2.9E-07	1.2E+03	2.3E-10	2.7E-07	1.2E+03	2.2E-10
Cumulative EHQ _{Kit Fox (max)} =			2.9E+00			6.7E-01			6.7E-01

Table B-10a. (continued)

Chemicals of potential ecological concern	East Pasture for Kti Fox			Carnegie for Kit Fox			Ranch for Kit Fox		
	15-cm soil _{model} (mg/kg)	ESSL _{Kit fox(min)}	EHQ _{Kit fox(max)}	15-cm soil _{model} (mg/kg)	ESSL _{Kit fox(min)}	EHQ _{Kit fox(max)}	15-cm soil _{model} (mg/kg)	ESSL _{Kit fox(min)}	EHQ _{Kit fox(max)}
PCDDs/PCDFs									
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.0E-07	3.6E-04	5.6E-04	2.2E-07	3.6E-04	6.1E-04	1.0E-07	3.6E-04	2.9E-04
1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	4.6E-08	3.6E-04	1.3E-04	5.1E-08	3.6E-04	1.4E-04	2.4E-08	3.6E-04	6.8E-05
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.2E-07	3.6E-05	3.4E-03	1.4E-07	3.6E-05	3.8E-03	6.4E-08	3.6E-05	1.8E-03
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	5.5E-08	3.6E-05	1.6E-03	6.1E-08	3.6E-05	1.7E-03	2.9E-08	3.6E-05	8.2E-04
1-9 OCDF (OCDF)	2.3E-07	3.6E-02	6.5E-06	2.6E-07	3.6E-02	7.2E-06	1.2E-07	3.6E-02	3.4E-06
Energetics & other thermally-labile compounds									
2,4-Dinitrotoluene	1.2E-10	4.1E+00	2.9E-11	1.1E-10	4.1E+00	2.7E-11	5.5E-11	4.1E+00	1.3E-11
2,6-Dinitrotoluene	9.8E-12	8.2E+00	1.2E-12	9.4E-12	8.2E+00	1.1E-12	4.5E-12	8.2E+00	5.5E-13
RDX	8.1E-02	2.1E+02	3.9E-04	8.5E-02	2.1E+02	4.1E-04	4.9E-02	2.1E+02	2.4E-04
Heavy Metals									
Aluminum	8.4E-01	7.5E+01	1.1E-02	9.1E-01	7.5E+01	1.2E-02	4.6E-01	7.5E+01	6.1E-03
Antimony	1.0E-05	1.2E+00	8.3E-06	1.0E-05	1.2E+00	8.5E-06	5.6E-06	1.2E+00	4.7E-06
Barium	1.2E-01	2.0E+03	6.3E-05	1.3E-01	2.0E+03	6.5E-05	7.0E-02	2.0E+03	3.5E-05
Cadmium	6.0E-04	8.3E-02	7.2E-03	6.1E-04	8.4E-02	7.3E-03	3.4E-04	6.2E-02	5.4E-03
Chromium	1.1E-03	2.5E+04	4.5E-08	1.2E-03	2.5E+04	4.6E-08	6.5E-04	2.3E+04	2.8E-08
Copper	2.7E-01	4.6E+00	5.9E-02	2.7E-01	4.5E+00	5.9E-02	1.4E-01	2.6E+00	5.3E-02
Lead	7.4E-02	7.4E+00	9.9E-03	7.2E-02	7.4E+00	9.8E-03	3.6E-02	5.3E+00	6.8E-03
Zinc	2.0E-02	1.2E-01	1.6E-01	2.1E-02	1.3E-01	1.6E-01	1.1E-02	7.3E-02	1.6E-01
SVOCs									
2-Chlorophenol	4.9E-05	1.0E+02	4.7E-07	4.7E-05	1.0E+02	4.6E-07	2.3E-05	1.0E+02	2.2E-07
Diphenylamine	1.3E-09	5.1E+01	2.5E-11	1.2E-09	5.1E+01	2.4E-11	5.9E-10	5.1E+01	1.1E-11
Fluoranthene	1.8E-04	1.3E+03	1.4E-07	2.0E-04	1.3E+03	1.6E-07	9.7E-05	1.3E+03	7.6E-08
Naphthalene	1.5E-04	1.0E+03	1.4E-07	1.6E-04	1.0E+03	1.6E-07	7.8E-05	1.0E+03	7.6E-08
Phenol	1.7E-08	1.2E+03	1.4E-11	1.6E-08	1.2E+03	1.3E-11	7.8E-09	1.2E+03	6.3E-12
Cumulative EHQ _{Kit Fox (max)} =									
			2.6E-01			2.6E-01			2.3E-01

^a The San Joaquin Kit Fox (*Vulpes macrotis mutica*) and the Burrowing Owl (*Athene cunicularia*) are of particular interest because these organisms are of particular concern in the habitat of Site 300.

Table B-10b. Ecological hazard quotients (EHQs) derived using TRV-Low specifically for the Burrowing Owl at the six receptor locations for which soil concentrations were predicted from modeling.^a

Chemicals of potential ecological concern	EWTF for Burrowing Owl			Bldg. 812 for Burrowing Owl			Bldg. 895 for Burrowing Owl		
	15-cm soil _{model} (mg/kg)	ESSL _{Burrowing Owl(min)}	EHQ _{Burrowing Owl(max)}	15-cm soil _{model} (mg/kg)	ESSL _{Burrowing Owl(min)}	EHQ _{Burrowing Owl(max)}	15-cm soil _{model} (mg/kg)	ESSL _{Burrowing Owl(min)}	EHQ _{Burrowing Owl(max)}
PCDDs/PCDFs									
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.4E-05	3.1E-03	7.7E-03	3.6E-06	4.1E-03	8.8E-04	3.4E-06	4.1E-03	8.2E-04
1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	5.6E-06	3.8E-03	1.5E-03	8.4E-07	4.9E-03	1.7E-04	7.8E-07	5.0E-03	1.6E-04
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.5E-05	3.4E-04	4.4E-02	2.2E-06	4.3E-04	5.1E-03	2.1E-06	4.4E-04	4.7E-03
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	6.7E-06	3.7E-04	1.8E-02	1.0E-06	4.8E-04	2.1E-03	9.4E-07	4.8E-04	1.9E-03
1-9 OCDF (OCDF)	2.8E-05	3.1E-01	9.2E-05	4.2E-06	4.0E-01	1.1E-05	4.0E-06	4.0E-01	9.8E-06
Energetics & other thermally-labile compounds									
2,4-Dinitrotoluene	1.6E-08	Not Available ^b		2.0E-09	Not Available ^b		1.9E-09	Not Available ^b	
2,6-Dinitrotoluene	1.3E-09	Not Available ^b		1.7E-10	Not Available ^b		1.6E-10	Not Available ^b	
RDX	4.8E+00	Not Available ^b		6.6E-01	Not Available ^b		9.4E-01	Not Available ^b	
Heavy Metals									
Aluminum	8.6E+01	9.8E+02	8.8E-02	1.3E+01	9.8E+02	1.3E-02	1.3E+01	9.8E+02	1.3E-02
Antimony	8.4E-04	Not Available ^b		1.1E-04	Not Available ^b		1.3E-04	Not Available ^b	
Barium	1.0E+01	1.8E+02	5.7E-02	1.4E+00	1.8E+02	7.6E-03	1.6E+00	1.8E+02	8.9E-03
Cadmium	5.0E-02	8.0E-02	6.3E-01	6.7E-03	4.7E-02	1.4E-01	7.8E-03	5.0E-02	1.6E-01
Chromium	8.4E-02	Not Available ^b		1.1E-02	Not Available ^b		1.4E-02	Not Available ^b	
Copper	2.9E+01	2.2E+01	1.3E+00	3.8E+00	8.0E+00	4.8E-01	3.9E+00	8.2E+00	4.8E-01
Lead	8.9E+00	1.4E-01	6.5E+01	1.2E+00	9.3E-02	1.3E+01	1.1E+00	9.3E-02	1.2E+01
Zinc	1.7E+00	2.9E+00	5.8E-01	2.5E-01	6.2E-01	4.0E-01	2.8E-01	6.8E-01	4.1E-01
SVOCs									
2-Chlorophenol	6.5E-03	Not Available ^b		8.3E-04	Not Available ^b		7.8E-04	Not Available ^b	
Diphenylamine	1.7E-07	Not Available ^b		2.2E-08	Not Available ^b		2.0E-08	Not Available ^b	
Fluoranthene	2.2E-02	Not Available ^b		3.3E-03	Not Available ^b		3.1E-03	Not Available ^b	
Naphthalene	1.8E-02	Not Available ^b		2.7E-03	Not Available ^b		2.5E-03	Not Available ^b	
Phenol	2.2E-06	6.97E+00	3.2E-07	2.9E-07	7.0E+00	4.1E-08	2.7E-07	7.0E+00	3.8E-08
Cumulative EHQ _{Kit Fox (max)} =									
			6.8E+01			1.4E+01			1.3E+01

Table B-10b. (continued)

Chemicals of potential ecological concern	East Pasture for Burrowing Owl			Carnegie for Burrowing Owl			Ranch for Burrowing Owl		
	15-cm soil _{model} (mg/kg)	ESSL _{Burrowing Owl(min)}	EHQ _{Burrowing Owl(max)}	15-cm soil _{model} (mg/kg)	ESSL _{Burrowing Owl(min)}	EHQ _{Burrowing Owl(max)}	15-cm soil _{model} (mg/kg)	ESSL _{Burrowing Owl(min)}	EHQ _{Burrowing Owl(max)}
PCDDs/PCDFs									
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.0E-07	5.8E-03	3.4E-05	2.2E-07	5.8E-03	3.8E-05	1.0E-07	6.2E-03	1.7E-05
1-4, 7-9 HpCDF (1,2,3,4,7,8,9-HpCDF)	4.6E-08	6.8E-03	6.8E-06	5.1E-08	6.7E-03	7.6E-06	2.4E-08	7.2E-03	3.3E-06
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.2E-07	6.1E-04	2.0E-04	1.4E-07	6.1E-04	2.2E-04	6.4E-08	6.6E-04	9.8E-05
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	5.5E-08	6.7E-04	8.3E-05	6.1E-08	6.6E-04	9.3E-05	2.9E-08	7.1E-04	4.1E-05
1-9 OCDF (OCDF)	2.3E-07	5.7E-01	4.1E-07	2.6E-07	5.7E-01	4.6E-07	1.2E-07	6.1E-01	2.0E-07
Energetics & other thermally-labile compounds									
2,4-Dinitrotoluene	1.2E-10	Not Available ^b		1.1E-10	Not Available ^b		5.5E-11	Not Available ^b	
2,6-Dinitrotoluene	9.8E-12	Not Available ^b		9.4E-12	Not Available ^b		4.5E-12	Not Available ^b	
RDX	8.1E-02	Not Available ^b		8.5E-02	Not Available ^b		4.9E-02	Not Available ^b	
Heavy Metals									
Aluminum	8.4E-01	9.8E+02	8.6E-04	9.1E-01	9.8E+02	9.2E-04	4.6E-01	9.8E+02	4.7E-04
Antimony	1.0E-05	Not Available ^b		1.0E-05	Not Available ^b		5.6E-06	Not Available ^b	
Barium	1.2E-01	1.8E+02	6.8E-04	1.3E-01	1.8E+02	6.9E-04	7.0E-02	1.8E+02	3.8E-04
Cadmium	6.0E-04	2.3E-02	2.6E-02	6.1E-04	2.3E-02	2.7E-02	3.4E-04	1.9E-02	1.8E-02
Chromium	1.1E-03	Not Available ^b		1.2E-03	Not Available ^b		6.5E-04	Not Available ^b	
Copper	2.7E-01	1.2E+00	2.3E-01	2.7E-01	1.1E+00	2.3E-01	1.4E-01	6.8E-01	2.0E-01
Lead	7.4E-02	3.8E-02	1.9E+00	7.2E-02	3.8E-02	1.9E+00	3.6E-02	2.8E-02	1.3E+00
Zinc	2.0E-02	7.4E-02	2.7E-01	2.1E-02	7.9E-02	2.7E-01	1.1E-02	4.6E-02	2.5E-01
SVOCs									
2-Chlorophenol	4.9E-05	Not Available ^b		4.7E-05	Not Available ^b		2.3E-05	Not Available ^b	
Diphenylamine	1.3E-09	Not Available ^b		1.2E-09	Not Available ^b		5.9E-10	Not Available ^b	
Fluoranthene	1.8E-04	Not Available ^b		2.0E-04	Not Available ^b		9.7E-05	Not Available ^b	
Naphthalene	1.5E-04	Not Available ^b		1.6E-04	Not Available ^b		7.8E-05	Not Available ^b	
Phenol	1.7E-08	7.0E+00	2.4E-09	1.6E-08	7.0E+00	2.3E-09	7.8E-09	7.0E+00	1.1E-09
Cumulative EHQ _{Kit Fox (max)} =									
			2.5E+00			2.4E+00			1.7E+00

^a The Burrowing Owl (*Athene cunicularia*) as well as the San Joaquin Kit Fox (*Vulpes macrotis mutica*) are of particular interest because these organisms are of particular concern in the habitat of Site 300.

^b ESSL applicable to avian species for this chemical could not be computed because derivation depends on data that are not available.

Table B-11. EHQs for plants calculated for measured and modeled soil concentrations at six receptor locations and their ratios based on benchmark (or low) ESSLs.

Chemicals of potential ecological concern	Measured Total Metal conc. (mg/kg) ^a	USEPA ESSL (mg/kg _{dw}) ^b	Terrestrial Plant ESSL (mg/kg _{dw})	Ratio of measured soil concentration to ESSL (EHQ _{measured})	EWTF modeled 15-cm soil concentration (mg/kg)	Ratio of EWTF modeled soil concentration to ESSL (EHQ _{modeled})	Ratio for EWTF of EHQ _{modeled} to EHQ _{measured}	Bldg. 812 modeled 15-cm soil concentration (mg/kg)	Ratio of B812 modeled soil concentration to ESSL (EHQ _{modeled})	Ratio for B812 of EHQ _{modeled} to EHQ _{measured}	Bldg. 895 modeled 15-cm soil conc. (mg/kg)	Ratio of B895 modeled soil concentration to ESSL (EHQ _{modeled})	Ratio for B895 of EHQ _{modeled} to EHQ _{measured}
Heavy Metals													
Antimony	1.0		5	2.0E-01	8.36E-04	1.7E-04	8.4E-04	1.12E-04	2.2E-05	1.1E-04	1.31E-04	2.6E-05	1.3E-04
Barium	331.0		500	6.6E-01	1.04E+01	2.1E-02	3.1E-02	1.39E+00	2.8E-03	2.1E+00	1.63E+00	3.3E-03	4.9E-03
Cadmium	2.6	32	4	8.1E-02	4.99E-02	1.6E-03	1.9E-02	6.66E-03	2.1E-04	8.2E-02	7.84E-03	2.5E-04	3.0E-03
Chromium	45.6		1.2 ^c	<i>4.6E+01</i>	8.39E-02	8.4E-02	1.8E-03	1.13E-02	1.1E-02	2.5E-04	1.41E-02	1.4E-02	3.1E-04
Copper	34.0		100	3.4E-01	2.93E+01	2.9E-01	8.6E-01	3.82E+00	3.8E-02	1.1E+01	3.94E+00	3.9E-02	1.2E-01
Lead	70.3	120	50	5.9E-01	8.93E+00	7.4E-02	1.3E-01	1.17E+00	9.7E-03	2.0E+00	1.14E+00	9.5E-03	1.6E-02
Zinc	78.0		50	<i>1.6E+00</i>	1.70E+00	3.4E-02	2.2E-02	2.48E-01	5.0E-03	1.6E-01	2.76E-01	5.5E-03	3.5E-03
Cumulative EHQ =						4.9E+01				6.7E-02			7.2E-02
Contributed of EHQ _{modeled} to EHQ _{measured} =							1.0E-02			1.4E-03			1.5E-03

Table B-11. (continued)

Chemicals of potential ecological concern	Measured Total Metal concentration (mg/kg) ^a	EAST PASTURE modeled 15-cm soil concentration (mg/kg)	Ratio of East Pasture modeled soil concentration to ESSL (EHQ _{modeled})	Ratio for East Pasture of EHQ _{modeled} to EHQ _{measured}	CARNEGIE modeled 15-cm soil concentration (mg/kg)	Ratio of Carnegie modeled soil concentration to ESSL (EHQ _{modeled})	Ratio for Carnegie of EHQ _{modeled} to EHQ _{measured}	RANCH modeled 15-cm soil concentration (mg/kg)	Ratio of Ranch modeled soil concentration to ESSL (EHQ _{modeled})	Ratio for Ranch of EHQ _{modeled} to EHQ _{measured}
Heavy Metals										
Antimony	1.0	1.01E-05	2.0E-06	1.0E-05	1.03E-05	2.1E-06	1.0E-05	5.63E-06	1.1E-06	5.6E-06
Barium	331.0	1.25E-01	2.5E-04	3.8E-04	1.27E-01	2.5E-04	3.8E-04	6.96E-02	1.4E-04	2.1E-04
Cadmium	2.6	6.01E-04	1.9E-05	2.3E-04	6.13E-04	1.9E-05	2.4E-04	3.36E-04	1.1E-05	1.3E-04
Chromium ^c	45.6	1.13E-03	1.1E-03	2.5E-05	1.16E-03	1.2E-03	2.5E-05	6.49E-04	6.5E-04	1.4E-05
Copper	34.0	2.71E-01	2.7E-03	8.0E-03	2.68E-01	2.7E-03	7.9E-03	1.39E-01	1.4E-03	4.1E-03
Lead	70.3	7.37E-02	6.1E-04	1.0E-03	7.25E-02	6.0E-04	1.0E-03	3.61E-02	3.0E-04	5.1E-04
Zinc	78.0	1.98E-02	4.0E-04	2.5E-04	2.12E-02	4.2E-04	2.7E-04	1.13E-02	2.3E-04	1.4E-04
Cumulative EHQ =				5.1E-03			5.1E-03		2.7E-03	
Contributed of EHQ _{modeled} to EHQ _{measured} =				1.0E-04			1.0E-04		5.5E-05	

Note: EHQ values greater than 1 appear in italics (e.g., see EHQ values for Pb).

^a Measured total soils concentrations for metals from Peterson et al. (2006). Measured concentrations for other chemicals of potential concern are not available (Peterson et al., 2006).

^b USEPA (2005c, 2005d).

^c Efrogmson et al. (1997, Table 1 and Appendix A), where chromium reported ESSL is for potassium chromate (chromium IV; 0.2 mg/kg), but the measured chromium is for total chromium. Because, chromium VI is considered to be 17% of total chromium measurements (US EPA, 2004), the reported chromium ESSL is multiplied by a factor of 6 to obtain the total chromium ESSL for comparison (i.e., 6 × 0.2 = 1.2 mg/kg).

Table B-12. Chemicals of potential ecological concern (CPECs) with respect to emissions from the EWTF along with their corresponding Chemical Abstracts Service registry identification numbers (CAS IDs), toxicity equivalency factors (TEFs), and the available highest mammalian and avian toxicity reference values (TRV-High) for identified experimental test species (ETS) with specified body weights (BW).

Chemicals of potential ecological concern	CAS ID	TEF	Mammal ETS	Mammal BW (kg)	Mammal TRV _{High} [mg/(kg d)]	Avian ETS	Avian BW (kg)	Avian TRV _{High} [mg/(kg d)]
PCDDs/PCDFs								
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	67562-39-4	0.01	rat	0.35	1.00E-09	Chicken	1.5	1.00E-03
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	70648-26-9	0.1	rat	0.35	1.00E-08	Chicken	1.5	1.00E-04
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	57117-44-9	0.1	rat	0.35	1.00E-08	Chicken	1.5	1.00E-04
Heavy Metals								
Antimony	7440-36-0	1.0	shrew	0.044	5.90E-01			
Cadmium	7440-43-9	1.0	mouse	0.0322	2.64E+00	Mallard duck	1.153	1.04E+01
Copper	7440-50-8	1.0	mouse	0.03	6.32E+02	Chicken	1.5	5.23E+01
Lead	7439-92-1	1.0	MOUSE	0.03	2.41E+02	Quail	0.014	8.75E+00
Zinc	7440-66-6	1.0	RAT	0.35	4.11E+02	Mallard duck	1.153	1.72E+02

Note: Aluminum is identified as a CPEC only at sites where the soil pH is less than 5.5, and average soil pH is estimated to be over 6 at Site 300 based on unpublished measurement data that is consistent with the site's geology contributing to its soil being basic geochemically.

Table B-13a. Toxicity reference values derived for wildlife (TRV-High; mg/[kg_{bw} d]) for chemicals of potential ecological concern (CPEC).

Chemicals of potential ecological concern	Omnivorous small mammal (Deer mouse)	Granivorous small mammal (Ground squirrel)	Herbivorous small mammal (Pocket gopher)	Herbivorous large mammal (Mule Deer)	Carnivorous mammal (San Joaquin Kit Fox)	Insectivorous reptile (Side-Blotched Lizard)	Omnivorous bird (Savannah Sparrow)	Carnivorous bird (Burrowing Owl)
PCDDs/PCDFs								
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	1.00E-04	1.00E-04	1.00E-04	1.13E-05	1.00E-04	3.11E-03	1.00E-02	1.00E-02
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.00E-05	1.00E-05	1.00E-05	1.13E-06	1.00E-05	3.11E-04	1.00E-03	1.00E-03
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	1.00E-05	1.00E-05	1.00E-05	1.13E-06	1.00E-05	3.11E-04	1.00E-03	1.00E-03
Heavy Metals								
Antimony	5.90E-01	5.90E-01	5.90E-01	3.93E-01	5.90E-01	Not available	Not available	Not available
Cadmium	2.64E+00	2.64E+00	2.64E+00	4.95E-02	2.64E+00	3.40E+00	1.04E+01	1.04E+01
Copper	6.32E+02	6.32E+02	6.32E+02	4.11E+02	6.32E+02	1.63E+01	5.23E+01	5.23E+01
Lead	2.41E+02	2.41E+02	2.41E+02	1.57E+02	2.41E+02	8.75E+00	8.75E+00	8.75E+00
Zinc	4.11E+02	4.11E+02	4.11E+02	2.04E+02	4.11E+02	5.62E+01	1.72E+02	1.72E+02

Table B-13b. ESSLs (mg/kg_{soil}) for EWTF and Ranch derived from TRV-High or ESSL-High.

Chemicals of potential ecological concern	Omnivorous small mammal (Deer mouse)		Granivorous small mammal (Ground squirrel)		Herbivorous small mammal (Pocket gopher)		Herbivorous large mammal (Mule Deer)		Carnivorous mammal (San Joaquin Kit Fox)	
	EWTF	Ranch	EWTF	Ranch	EWTF	Ranch	EWTF	Ranch	EWTF	Ranch
PCDDs/PCDFs										
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.06E-04	3.48E-04	1.36E-03	1.36E-03	7.27E-04	7.27E-04	2.76E-04	2.76E-04	3.57E-03	3.57E-03
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	2.18E-05	3.60E-05	1.36E-04	1.36E-04	7.27E-05	7.27E-05	2.76E-05	2.76E-05	3.57E-04	3.57E-04
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	2.38E-05	3.80E-05	1.36E-04	1.36E-04	7.27E-05	7.27E-05	2.76E-05	2.76E-05	3.57E-04	3.57E-04
Heavy Metals										
Antimony	6.81E+00	6.81E+00	9.90E+01	9.90E+01	4.28E+01	4.28E+01	3.25E+02	3.25E+02	1.21E+01	1.21E+01
Cadmium	1.95E+00	4.32E-01	1.57E+01	1.70E+00	8.50E+00	9.29E-01	5.14E-01	5.46E-02	2.72E+01	2.74E+00
Copper	7.29E+03	2.58E+02	2.84E+04	1.40E+03	1.45E+04	7.63E+02	3.82E+04	1.57E+03	1.80E+04	6.22E+02
Lead	3.44E+03	8.35E+02	1.98E+04	2.90E+03	9.60E+03	1.55E+03	3.24E+04	3.38E+03	7.40E+03	1.28E+03
Zinc	9.32E+01	3.53E+00	1.54E+03	1.72E+02	8.35E+02	9.39E+01	1.32E+03	1.46E+02	3.18E+02	3.11E+00

Table B-13b. (continued)

Chemicals of potential ecological concern	Mammal derived Insectivorous reptile (Side-Blotched Lizard) ^a		Avian derived Insectivorous reptile (Side-Blotched Lizard) ^b		Omnivorous bird (Savannah Sparrow)		Carnivorous bird (Burrowing Owl)		Invertebrate (e.g., earthworm)	
	EWTF	Ranch	EWTF	Ranch	EWTF	Ranch	EWTF	Ranch	EWTF	Ranch
PCDDs/PCDFs										
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	1.51E-02	3.93E-02	5.34E-02	1.39E-01	9.47E-03	2.10E-02	3.13E-02	6.25E-02	5.00E+01	5.00E+01
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.64E-03	4.27E-03	5.82E-03	1.51E-02	1.02E-03	2.24E-03	3.35E-03	6.57E-03	5.00E+01	5.00E+01
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	1.89E-03	4.89E-03	6.70E-03	1.73E-02	1.16E-03	2.47E-03	3.75E-03	7.12E-03	5.00E+01	5.00E+01
Heavy Metals										
Antimony	4.64E+01	4.64E+01	Not available	Not available	Not available	Not available	Not available	Not available	7.80E+02	7.80E+02
Cadmium	1.48E+01	5.34E+00	1.91E+01	6.87E+00	3.29E+00	9.71E-01	1.04E+01	2.43E+00	1.40E+03	1.40E+03
Copper	1.00E+05	2.38E+03	2.58E+03	6.12E+01	4.18E+02	1.03E+01	5.03E+02	1.54E+01	3.20E+02	3.20E+02
Lead	3.32E+04	1.28E+04	1.21E+03	4.65E+02	7.11E+01	2.01E+01	8.52E+01	1.78E+01	1.70E+04	1.70E+04
Zinc	1.19E+03	4.11E+01	8.12E+01	2.79E+00	1.47E+01	5.21E-01	2.93E+01	4.57E-01	1.99E+03	1.99E+03

^a Lowest calculated value derived from mammal data (not avian).

^b Lowest calculated value derived from avian data (not mammal).

Table B-14. Smallest ecological soil screening levels (ESSLs) based on TRV-High (or comparable) values for the chemicals of potential ecological concern (CPECs), and the organism corresponding to it, for all six receptor locations at which soil concentrations over a 6-in (15-cm) depth were predicted from atmospheric dispersion and deposition modeling.

Chemicals of potential ecological concern	EWTF		Bldg. 812		Bldg. 895		East Pasture		Carnegie		Ranch	
	TRV ^{High} based ESSL _{small} (mg/kg _{soil})	Organism	TRV ^{High} based ESSL _{small} (mg/kg _{soil})	Organism	TRV ^{High} based ESSL _{small} (mg/kg _{soil})	Organism	TRV ^{High} based ESSL _{small} (mg/kg _{soil})	Organism	TRV ^{High} based ESSL _{small} (mg/kg _{soil})	Organism	TRV ^{High} based ESSL _{small} (mg/kg _{soil})	Organism
PCDDs/PCDFs												
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.1E-04	OSM ^a	2.5E-04	OSM ^a	2.56E-04	OSM ^a	2.76E-04	HLM ^b	2.76E-04	HLM ^b	2.8E-04	HLM ^b
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	2.2E-05	OSM ^a	2.7E-05	OSM ^a	2.69E-05	OSM ^a	2.76E-05	HLM ^b	2.76E-05	HLM ^b	2.8E-05	HLM ^b
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	2.4E-05	OSM ^a	2.8E-05	HLM ^b	2.76E-05	HLM ^b	2.76E-05	HLM ^b	2.76E-05	HLM ^b	2.8E-05	HLM ^b
Heavy Metals												
Aluminum	2.3E+02	OSM ^a	2.3E+02	OSM ^a	2.26E+02	OSM ^a	2.26E+02	OSM ^a	2.26E+02	OSM ^a	2.3E+02	OSM ^a
Cadmium	5.1E-01	HLM ^b	2.1E-01	HLM ^b	2.25E-01	HLM ^b	7.09E-02	HLM ^b	7.15E-02	HLM ^b	5.5E-02	HLM ^b
Copper	3.2E+02	INV ^c	1.1E+02	OA ^d	1.1E+02	OA ^d	1.66E+01	OA ^d	1.65E+01	OA ^d	1.0E+01	OA ^d
Lead	7.1E+01	OA ^d	4.7E+01	OA ^d	4.63E+01	OA ^d	2.40E+01	CA ^e	2.38E+01	CA ^e	1.8E+01	CA ^e
Zinc	1.5E+01	OA ^d	4.1E+00	OA ^d	4.40E+00	OA ^d	7.43E-01	CA ^e	7.87E-01	CA ^e	4.6E-01	CA ^e

^a OSM =Omnivorous small mammal

^b HLM = Herbivorous large mammal

^c INV= Invertebrate

^d OA = Omnivorous avian

^e CA = carnivorous avian

Table B-15. Ecological hazard quotients (EHQs) for chemicals of potential concern (CPECs) at different receptor locations. Each EHQ is derived from the lowest ESSL computed from a TRV-High (or comparable) for all organisms evaluated for the receptor location.

Chemicals of potential ecological concern	EWTF			Bldg. 812			Bldg. 895		
	15-cm soil conc. (mg/kg _{soil})	TRV _{High} based ESSL _{small} (mg/kg _{soil})	EHQ	15-cm soil conc. (mg/kg _{soil})	TRV _{High} based ESSL _{small} (mg/kg _{soil})	EHQ	15-cm soil conc. (mg/kg _{soil})	TRV _{High} based ESSL _{small} (mg/kg _{soil})	EHQ
PCDDs/PCDFs									
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.4E-05	2.1E-04	1.2E-01	3.6E-06	2.5E-04	1.4E-02	3.4E-06	2.6E-04	1.3E-02
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.5E-05	2.2E-05	6.8E-01	2.2E-06	2.7E-05	8.3E-02	2.1E-06	2.7E-05	7.7E-02
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	6.7E-06	2.4E-05	2.8E-01	1.0E-06	2.8E-05	3.6E-02	9.4E-07	2.8E-05	3.4E-02
Heavy Metals									
Aluminum	8.6E+01	2.3E+02	3.8E-01	1.3E+01	2.3E+02	5.6E-02	1.3E+01	2.3E+02	5.7E-02
Cadmium	5.0E-02	5.1E-01	9.7E-02	6.7E-03	2.1E-01	3.2E-02	7.8E-03	2.2E-01	3.5E-02
Copper	2.9E+01	3.2E+02	9.2E-02	3.8E+00	1.1E+02	3.6E-02	3.9E+00	1.1E+02	3.6E-02
Lead	8.9E+00	7.1E+01	1.3E-01	1.2E+00	4.7E+01	2.5E-02	1.1E+00	4.6E+01	2.5E-02
Zinc	1.7E+00	1.5E+01	1.2E-01	2.5E-01	4.1E+00	6.1E-02	2.8E-01	4.4E+00	6.3E-02
Cumulative EHQ _{small} =			1.9E+00			3.4E-01			3.4E-01

Table B-15. (continued).

Chemicals of potential ecological concern	East Pasture			Carnegie			Connolly Ranch		
	15-cm soil conc. (mg/kg _{soil})	TRV _{High} based ESSL _{small} (mg/kg _{soil})	EHQ	15-cm soil conc. (mg/kg _{soil})	TRV _{High} based ESSL _{small} (mg/kg _{soil})	EHQ	15-cm soil conc. (mg/kg _{soil})	TRV _{High} based ESSL _{small} (mg/kg _{soil})	EHQ _{max}
PCDDs/PCDFs									
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.0E-07	2.8E-04	7.2E-04	2.2E-07	2.8E-04	7.9E-04	1.0E-07	2.76E-04	3.78E-04
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.2E-07	2.8E-05	4.4E-03	1.4E-07	2.8E-05	4.9E-03	6.4E-08	2.76E-05	2.34E-03
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	5.5E-08	2.8E-05	2.0E-03	6.1E-08	2.8E-05	2.2E-03	2.9E-08	2.76E-05	1.06E-03
Heavy Metals									
Aluminum	8.4E-01	2.3E+02	3.7E-03	9.1E-01	2.3E+02	4.0E-03	4.6E-01	2.26E+02	2.03E-03
Cadmium	6.0E-04	7.1E-02	8.5E-03	6.1E-04	7.1E-02	8.6E-03	3.4E-04	5.46E-02	6.16E-03
Copper	2.7E-01	1.7E+01	1.6E-02	2.7E-01	1.7E+01	1.6E-02	1.4E-01	1.03E+01	1.34E-02
Lead	7.4E-02	2.4E+01	3.1E-03	7.2E-02	2.4E+01	3.0E-03	3.6E-02	1.78E+01	2.03E-03
Zinc	2.0E-02	7.4E-01	2.7E-02	2.1E-02	7.9E-01	2.7E-02	1.1E-02	4.57E-01	2.47E-02
Cumulative EHQ _{small} =			6.5E-02			6.7E-02			5.2E-02

Table B-16a. Ecological hazard quotients (EHQs) derived using TRV-High specifically for the San Joaquin Kit Fox at the six receptor locations for which soil concentrations were predicted from modeling.^a

Chemicals of potential ecological concern	EWTF for Kit Fox			Bldg. 812 for Kit Fox			Bldg. 895 for Kit Fox		
	15-cm soil conc. (mg/kg _{soil})	TRV _{High} ESSL _{Kit fox}	EHQ _{Kit fox}	15-cm soil conc. (mg/kg _{soil})	TRV _{High} ESSL _{Kit fox}	EHQ _{Kit fox}	15-cm soil conc. (mg/kg _{soil})	TRV _{High} ESSL _{Kit fox}	EHQ _{Kit fox}
PCDDs/PCDFs									
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.4E-05	3.6E-03	6.7E-03	3.6E-06	3.6E-03	1.0E-03	3.4E-06	3.6E-03	9.4E-04
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.5E-05	3.6E-04	4.1E-02	2.2E-06	3.6E-04	6.2E-03	2.1E-06	3.6E-04	5.8E-03
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	6.7E-06	3.6E-04	1.9E-02	1.0E-06	3.6E-04	2.8E-03	9.4E-07	3.6E-04	2.6E-03
Heavy Metals									
Aluminum	8.6E+01	7.5E+02	1.2E-01	1.3E+01	7.5E+02	1.7E-02	1.3E+01	7.5E+02	1.7E-02
Cadmium	5.0E-02	2.7E+01	1.8E-03	6.7E-03	1.2E+01	5.7E-04	7.8E-03	1.3E+01	6.3E-04
Copper	2.9E+01	1.8E+04	1.6E-03	3.8E+00	7.6E+03	5.0E-04	3.9E+00	7.7E+03	5.1E-04
Lead	8.9E+00	7.4E+03	1.2E-03	1.2E+00	5.0E+03	2.3E-04	1.1E+00	4.9E+03	2.3E-04
Zinc	1.7E+00	3.2E+02	5.4E-03	2.5E-01	5.4E+01	4.6E-03	2.8E-01	6.0E+01	4.6E-03
Cumulative EHQ _{Kit Fox (small)} =			1.9E-01			3.3E-02			3.2E-02

Table B-16a. (continued)^a

Chemicals of potential ecological concern	East Pasture for Kit Fox			Carnegie for Kit Fox			Connolly Ranch for Kit Fox		
	15-cm soil conc. (mg/kg _{soil})	TRV Adjusted ESSL _{Kit fox}	EHQ _{Kit fox}	15-cm soil conc. (mg/kg _{soil})	TRV Adjusted ESSL _{Kit fox}	EHQ _{Kit fox}	15-cm soil conc. (mg/kg _{soil})	TRV _{High} ESSL _{Kit fox}	EHQ _{Kit fox}
PCDDs/PCDFs									
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.0E-07	3.6E-03	5.6E-05	2.2E-07	3.6E-03	6.1E-05	1.0E-07	3.6E-03	2.9E-05
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.2E-07	3.6E-04	3.4E-04	1.4E-07	3.6E-04	3.8E-04	6.4E-08	3.6E-04	1.8E-04
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	5.5E-08	3.6E-04	1.6E-04	6.1E-08	3.6E-04	1.7E-04	2.9E-08	3.6E-04	8.2E-05
Heavy Metals									
Aluminum	8.4E-01	7.5E+02	1.1E-03	9.1E-01	7.5E+02	1.2E-03	4.6E-01	7.5E+02	6.1E-04
Cadmium	6.0E-04	3.7E+00	1.6E-04	6.1E-04	3.7E+00	1.7E-04	3.4E-04	2.7E+00	1.2E-04
Copper	2.7E-01	1.1E+03	2.5E-04	2.7E-01	1.1E+03	2.5E-04	1.4E-01	6.2E+02	2.2E-04
Lead	7.4E-02	1.8E+03	4.1E-05	7.2E-02	1.8E+03	4.1E-05	3.6E-02	1.3E+03	2.8E-05
Zinc	2.0E-02	5.2E+00	3.8E-03	2.1E-02	5.6E+00	3.8E-03	1.1E-02	3.1E+00	3.6E-03
Cumulative EHQ _{Kit Fox (small)} =			5.9E-03			6.1E-03			4.9E-03

^a The San Joaquin Kit Fox (*Vulpes macrotis mutica*) and the Burrowing Owl (*Athene cunicularia*) are of particular interest because these organisms are of particular concern in the habitat of Site 300.

Table B-16b. Ecological hazard quotients (EHQs) derived using TRV-High specifically for the Burrowing Owl at the six receptor locations for which soil concentrations were predicted from modeling.^a

Chemicals of potential ecological concern	EWTF for Burrowing Owl			Bldg. 812 for Burrowing Owl			Bldg. 895 for Burrowing Owl		
	15-cm soil conc. (mg/kg _{soil})	TRV _{High} ESSL _{Owl}	EHQ _{Owl}	15-cm soil conc. (mg/kg _{soil})	TRV _{High} ESSL _{Owl}	EHQ _{Owl}	15-cm soil conc. (mg/kg _{soil})	TRV _{High} ESSL _{Owl}	EHQ _{Owl}
PCDDs/PCDFs									
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.4E-05	3.1E-02	7.7E-04	3.6E-06	4.1E-02	8.8E-05	3.4E-06	4.1E-02	8.2E-05
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.5E-05	3.4E-03	4.4E-03	2.2E-06	4.3E-03	5.1E-04	2.1E-06	4.4E-03	4.7E-04
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	6.7E-06	3.7E-03	1.8E-03	1.0E-06	4.8E-03	2.1E-04	9.4E-07	4.8E-03	1.9E-04
Heavy Metals									
Aluminum	8.6E+01	9.8E+03	8.8E-03	1.3E+01	9.8E+03	1.3E-03	1.3E+01	9.8E+03	1.3E-03
Cadmium	5.0E-02	1.0E+01	4.8E-03	6.7E-03	6.2E+00	1.1E-03	7.8E-03	6.4E+00	1.2E-03
Copper	2.9E+01	5.0E+02	5.8E-02	3.8E+00	1.8E+02	2.1E-02	3.9E+00	1.9E+02	2.1E-02
Lead	8.9E+00	8.5E+01	1.0E-01	1.2E+00	5.8E+01	2.0E-02	1.1E+00	5.8E+01	2.0E-02
Zinc	1.7E+00	2.9E+01	5.8E-02	2.5E-01	6.2E+00	4.0E-02	2.8E-01	6.8E+00	4.1E-02
Cumulative EHQ _{Owl(small)} =			2.4E-01			8.4E-02			8.5E-02

Table B-16b. (continued)^a

Chemicals of potential ecological concern	East Pasture for Burrowing Owl			Carnegie for Burrowing Owl			Ranch for Burrowing Owl		
	15-cm soil conc. (mg/kg _{soil})	TRV _{High} ESSL _{Owl}	EHQ _{Owl}	15-cm soil conc. (mg/kg _{soil})	TRV _{High} ESSL _{Owl}	EHQ _{Owl}	15-cm soil conc. (mg/kg _{soil})	TRV _{High} ESSL _{Owl}	EHQ _{Owl}
PCDDs/PCDFs									
1-4, 6-8 HpCDF (1,2,3,4,6,7,8-HpCDF)	2.0E-07	5.8E-02	3.4E-06	2.2E-07	5.8E-02	3.8E-06	1.0E-07	6.2E-02	1.7E-06
1-4, 7, 8 HxCDF (1,2,3,4,7,8-HxCDF)	1.2E-07	6.1E-03	2.0E-05	1.4E-07	6.1E-03	2.2E-05	6.4E-08	6.6E-03	9.8E-06
1-3, 6-8 HxCDF (1,2,3,6,7,8-HxCDF)	5.5E-08	6.7E-03	8.3E-06	6.1E-08	6.6E-03	9.3E-06	2.9E-08	7.1E-03	4.1E-06
Heavy Metals									
Aluminum	8.4E-01	9.8E+03	8.6E-05	9.1E-01	9.8E+03	9.2E-05	4.6E-01	9.8E+03	4.7E-05
Cadmium	6.0E-04	3.0E+00	2.0E-04	6.1E-04	3.0E+00	2.1E-04	3.4E-04	2.4E+00	1.4E-04
Copper	2.7E-01	2.6E+01	1.0E-02	2.7E-01	2.6E+01	1.0E-02	1.4E-01	1.5E+01	9.0E-03
Lead	7.4E-02	2.4E+01	3.1E-03	7.2E-02	2.4E+01	3.0E-03	3.6E-02	1.8E+01	2.0E-03
Zinc	2.0E-02	7.4E-01	2.7E-02	2.1E-02	7.9E-01	2.7E-02	1.1E-02	4.6E-01	2.5E-02
Cumulative EHQ _{Owl(small)} =			4.0E-02			4.1E-02			3.6E-02

^a The Burrowing Owl (*Athene cunicularia*) as well as the San Joaquin Kit Fox (*Vulpes macrotis mutica*) are of particular interest because these organisms are of particular concern in the habitat of Site 300.

Table B-17. EHQs for plants calculated for measured and modeled soil concentrations at six receptor locations and their ratios based on estimated high ESSLs.

Chemicals of potential ecological concern	Measured Total Metal conc. (mg/kg) ^b	USEPA ESSL (mg/kg _{dw}) ^c	Terrestrial Plant ESSL (mg/kg _{dw})	Ratio of measured soil concentration to ESSL (EHQ _{measured})	EWTF modeled 15-cm soil conc. (mg/kg)	Ratio of EWTF modeled soil concentration to ESSL (EHQ _{modeled})	Ratio for EWTF of EHQ _{modeled} to EHQ _{measured}	Bldg. 812 modeled 15-cm soil conc. (mg/kg)	Ratio of B812 modeled soil concentration to ESSL (EHQ _{modeled})	Ratio for B812 of EHQ _{modeled} to EHQ _{measured}	Bldg. 895 modeled 15-cm soil conc. (mg/kg)	Ratio of B895 modeled soil concentration to ESSL (EHQ _{modeled})	Ratio for B895 of EHQ _{modeled} to EHQ _{measured}
Heavy Metals													
Antimony	1.0		50 ^a	2.0E-02	8.36E-04	1.7E-05	8.4E-04	1.12E-04	2.2E-06	1.1E-04	1.31E-04	2.6E-06	1.3E-04
Barium	331.0		5000 ^a	6.6E-02	1.04E+01	2.1E-03	3.1E-02	1.39E+00	2.8E-04	2.1E+01	1.63E+00	3.3E-04	4.9E-03
Cadmium	2.6	320 ^a	40 ^a	8.1E-03	4.99E-02	1.6E-04	1.9E-02	6.66E-03	2.1E-05	8.2E-01	7.84E-03	2.5E-05	3.0E-03
Chromium	45.6		12 ^d	<i>4.6E+00</i>	8.39E-02	8.4E-03	1.8E-03	1.13E-02	1.1E-03	2.5E-03	1.41E-02	1.4E-03	3.1E-04
Copper	34.0		1000 ^a	3.4E-02	2.93E+01	2.9E-02	8.6E-01	3.82E+00	3.8E-03	1.1E+02	3.94E+00	3.9E-03	1.2E-01
Lead	70.3	1200 ^a	500 ^a	5.9E-02	8.93E+00	7.4E-03	1.3E-01	1.17E+00	9.7E-04	2.0E+01	1.14E+00	9.5E-04	1.6E-02
Zinc	78.0		500 ^a	1.6E-01	1.70E+00	3.4E-03	2.2E-02	2.48E-01	5.0E-04	1.6E+00	2.76E-01	5.5E-04	3.5E-03
Cumulative EHQ =				4.9E+00		5.1E-02			6.7E-03			7.2E-03	
Contribution of EHQ _{modeled} to EHQ _{measured} =						1.0E-02			1.4E-03			1.5E-03	

Table B-17. (continued)^a

Chemicals of potential ecological concern	Measured Total Metal conc. (mg/kg) ^b	EAST PASTURE modeled 15-cm soil conc. (mg/kg)	Ratio of East Pasture modeled soil concentration to ESSL (EHQ _{modeled})	Ratio for East Pasture of EHQ _{modeled} to EHQ _{measured}	CARNEGIE modeled 15-cm soil conc. (mg/kg)	Ratio of Carnegie modeled soil conc. to ESSL (EHQ _{modeled})	Ratio for Carnegie of EHQ _{modeled} to EHQ _{measured}	RANCH modeled 15-cm soil conc. (mg/kg)	Ratio of Ranch modeled soil conc. to ESSL (EHQ _{modeled})	Ratio for Ranch of EHQ _{modeled} to EHQ _{measured}
Heavy Metals										
Antimony	1.0	1.01E-05	2.0E-07	1.0E-05	1.03E-05	2.1E-07	1.0E-05	5.63E-06	1.1E-07	5.6E-06
Barium	331.0	1.25E-01	2.5E-05	3.8E-04	1.27E-01	2.5E-05	3.8E-04	6.96E-02	1.4E-05	2.1E-04
Cadmium	2.6	6.01E-04	1.9E-06	2.3E-04	6.13E-04	1.9E-06	2.4E-04	3.36E-04	1.1E-06	1.3E-04
Chromium	45.6	1.13E-03	1.1E-04	2.5E-05	1.16E-03	1.2E-04	2.5E-05	6.49E-04	6.5E-05	1.4E-05
Copper	34.0	2.71E-01	2.7E-04	8.0E-03	2.68E-01	2.7E-04	7.9E-03	1.39E-01	1.4E-04	4.1E-03
Lead	70.3	7.37E-02	6.1E-05	1.0E-03	7.25E-02	6.0E-05	1.0E-03	3.61E-02	3.0E-05	5.1E-04
Zinc	78.0	1.98E-02	4.0E-05	2.5E-04	2.12E-02	4.2E-05	2.7E-04	1.13E-02	2.3E-05	1.4E-04
Cumulative EHQ =			5.1E-04			5.1E-04			2.7E-04	
Contribution of EHQ _{modeled} to EHQ _{measured} =			1.0E-04			1.0E-04			5.5E-05	

Note: EHQ values greater than 1 appear in italics (e.g., see EHQ values for Pb).

^a Estimated high ESSL calculated by multiplying the benchmark (or low) ESSL by 10.

^b Measured total soils concentrations for metals from Peterson et al. (2006). Measured concentrations for other chemicals of potential concern are not available.

^c USEPA (2005c, 2005d).

^d Efrogmson et al. (1997, Table 1 and Appendix A)

^e Efrogmson et al. (1997, Table 1 and Appendix A), where chromium reported is for potassium chromate (chromium IV; 0.2 mg/kg), but the measured chromium is for total chromium. Because, chromium VI is considered to be 17% of total chromium measurements (US EPA, 2004), the benchmark ESSL for hexavalent chromium is now multiplied by a factor of 60 (10 x 6) to obtain the total chromium for comparison.

Table B-18a. Bioaccumulation Factors (BAFs) for measured concentrations of metals at Site 300.^a

Chemicals of potential ecological concern	Site 300 measured concentration (mg/kg)	BAF plant	BAF soil invertebrate	BAF small mammal
Heavy Metals				
Antimony	1.00E+00	1.02E-02	1.00E+00	1.00E+00
Barium	3.31E+02	1.56E-01	1.00E+00	5.66E-02
Cadmium	2.60E+00	4.03E-01	6.81E+00	3.98E-01
Chromium	4.56E+01	4.10E-02	1.00E+00	8.40E-02
Copper	3.40E+01	2.27E-01	3.98E-01	3.77E-01
Lead	7.03E+01	4.07E-02	3.54E-01	1.01E-01
Zinc	7.80E+01	7.14E-01	4.58E+00	1.55E+00

^a BAFs for reptile and for soil are considered equal to a default value of one, and do not appear in this table (see Appendix B discussion concerning Table 5).

Table B-18b. ESSL (mg/kg_{soil}) for Site 300 measured data for animals.

Chemicals of potential ecological concern	Omnivorous small mammal (Deer mouse)		Granivorous small mammal (Ground squirrel)		Herbivorous small mammal (Pocket gopher)		Herbivorous large mammal (Mule Deer)		Carnivorous mammal (San Joaquin Kit Fox)	
	TRV _{Low}	TRV _{High}	TRV _{Low}	TRV _{High}	TRV _{Low}	TRV _{High}	TRV _{Low}	TRV _{High}	TRV _{Low}	TRV _{High}
Heavy Metals										
Antimony	6.81E-01	6.81E+00	9.90E+00	9.90E+01	4.28E+00	4.28E+01	3.25E+01	3.25E+02	1.21E+00	1.21E+01
Barium	4.78E+02	4.78E+03	3.25E+03	3.25E+04	1.62E+03	1.62E+04	1.31E+03	1.31E+04	1.96E+03	1.96E+04
Cadmium	1.16E-01	5.12E+00	1.83E+00	8.06E+01	9.55E-01	4.20E+01	6.65E-02	2.93E+00	1.74E+00	7.66E+01
Chromium	1.61E+04	1.61E+05	1.82E+05	1.82E+06	8.33E+04	8.33E+05	4.53E+05	4.53E+06	5.43E+04	5.43E+05
Copper	3.31E+01	7.84E+03	1.28E+02	3.04E+04	6.52E+01	1.54E+04	1.75E+02	4.15E+04	7.86E+01	1.86E+04
Lead	2.00E+01	4.83E+03	1.24E+02	3.00E+04	5.69E+01	1.37E+04	3.10E+02	6.45E+04	3.65E+01	8.79E+03
Zinc	2.29E+01	9.79E+02	1.78E+02	7.60E+03	9.44E+01	4.04E+03	1.10E+02	6.93E+03	1.56E+02	6.66E+03

Table B-18b. (continued)

Chemicals of potential ecological concern	Mammal derived Insectivorous reptile (Side-Blotched Lizard) ^a		Avian derived Insectivorous reptile (Side-Blotched Lizard) ^b		Omnivorous bird (Savannah Sparrow)		Carnivorous bird (Burrowing Owl)		Invertebrate (e.g., earthworm)	
	TRV _{Low}	TRV _{High}	TRV _{Low}	TRV _{High}	TRV _{Low}	TRV _{High}	TRV _{Low}	TRV _{High}	TRV _{Low}	TRV _{High}
Heavy Metals										
Antimony	4.64E+00	4.64E+01	Not available	Not available	Not available	Not available	Not available	Not available	7.80E+01	7.80E+02
Barium	4.07E+03	4.07E+04	1.64E+03	3.28E+03	9.53E+01	1.91E+02	1.83E+02	3.67E+02	3.30E+02	3.30E+03
Cadmium	7.51E-01	3.31E+01	3.27E-01	4.25E+01	5.99E-02	7.79E+00	1.86E-01	2.42E+01	1.40E+02	1.40E+03
Chromium	1.53E+05	1.53E+06	Not available	Not available	Not available	Not available	Not available	Not available	3.20E+01	1.20E+01
Copper	4.63E+02	1.10E+05	1.24E+02	2.82E+03	2.02E+01	4.58E+02	2.32E+01	5.28E+02	1.20E+00	3.20E+02
Lead	2.53E+02	4.59E+04	2.67E+00	1.67E+03	1.68E-01	1.05E+02	1.70E-01	1.06E+02	1.70E+03	1.70E+04
Zinc	1.77E+02	1.53E+04	1.04E+02	1.04E+03	1.80E+01	1.80E+02	4.60E+01	4.60E+02	1.99E+02	1.99E+03

^a Lowest calculated value derived from mammal data (not avian).

^b Lowest calculated value derived from avian data (not mammal).

Table B-19. EHQs for animals calculated for measured and modeled soil concentrations at six receptor locations and their ratios based on estimated TRV-low SSLs.

Chemicals of potential ecological concern	Background soil concentration at Site 300 (mg/kg)	SITE 300			EWTF		Bldg. 812		Bldg. 895	
		ESSL _{min} (mg/kg _{soil})	Organism	EHQ _{measured}	EHQ _{max/model}	Ratio for EWTF of EHQ _{max/model} to EHQ _{measured}	EHQ _{max/model}	Ratio for B812 of EHQ _{max/model} to EHQ _{measured}	EHQ _{max/model}	Ratio for B895 of EHQ _{max/model} to EHQ _{measured}
Heavy Metals										
Antimony	1.00E+00	6.81E-01	OSM ^a	<i>1.47E+00</i>	1.23E-03	8.36E-04	1.64E-04	1.12E-04	1.93E-04	1.31E-04
Barium	3.31E+02	9.53E+01	OA ^b	<i>3.47E+00</i>	1.09E-01	3.14E-02	1.46E-02	4.20E-03	1.71E-02	4.92E-03
Cadmium	2.60E+00	5.99E-02	OA ^b	<i>4.34E+01</i>	<i>4.27E+00</i>	9.84E-02	<i>1.40E+00</i>	3.24E-02	<i>1.54E+00</i>	3.54E-02
Chromium	4.56E+01	1.61E+04	OSM ^a	<i>2.83E-03</i>	5.21E-06	1.84E-03	7.04E-07	2.48E-04	8.79E-07	3.10E-04
Copper	3.40E+01	2.02E+01	OA ^b	<i>1.69E+00</i>	<i>1.60E+00</i>	9.47E-01	8.11E-01	4.81E-01	8.19E-01	4.86E-01
Lead	7.03E+01	1.68E-01	OA ^b	<i>4.19E+02</i>	<i>7.85E+01</i>	1.87E-01	<i>1.57E+01</i>	3.74E-02	<i>1.53E+01</i>	3.66E-02
Zinc	7.80E+01	1.80E+01	OA ^b	<i>4.33E+00</i>	<i>1.16E+00</i>	2.67E-01	6.05E-01	1.40E-01	6.27E-01	1.45E-01
Cumulative EHQ =				4.73E+02	8.56E+01		1.85E+01		1.83E+01	
Contributed of EHQ _{modeled} to EHQ _{measured} =					1.81E-01		3.91E-02		3.88E-02	

Table B-19. (continued)

Chemicals of potential ecological concern	Background soil concentration at Site 300 (mg/kg)	East Pasture		Carnegie		Ranch	
		EHQ _{max/model}	Ratio for East Pasture of EHQ _{max/model} to EHQ _{measured}	EHQ _{max/model}	Ratio for Carnegie of EHQ _{max/model} to EHQ _{measured}	EHQ _{max/model}	Ratio for Ranch of EHQ _{max/model} to EHQ _{measured}
Heavy Metals							
Antimony	1.00E+00	1.48E-05	1.01E-05	1.51E-05	1.03E-05	8.27E-06	5.63E-06
Barium	3.31E+02	1.31E-03	3.76E-04	1.33E-03	3.84E-04	7.30E-04	2.10E-04
Cadmium	2.60E+00	3.73E-01	8.60E-03	3.77E-01	8.69E-03	2.71E-01	6.24E-03
Chromium	4.56E+01	7.01E-08	2.47E-05	7.21E-08	1.90E-09	4.03E-08	1.06E-09
Copper	3.40E+01	3.70E-01	2.20E-01	3.69E-01	2.19E-01	3.06E-01	1.81E-01
Lead	7.03E+01	<i>1.92E+00</i>	4.59E-03	<i>1.90E+00</i>	4.55E-03	<i>1.27E+00</i>	3.03E-03
Zinc	7.80E+01	2.67E-01	6.16E-02	2.69E-01	6.22E-02	2.47E-01	5.70E-02
Cumulative EHQ =		2.94E+00		2.92E+00		2.09E+00	
Contributed of EHQ _{modeled} to EHQ _{measured} =		6.20E-03		6.17E-03		4.09E-03	

Note: EHQ values greater than 1 appear in italics (e.g., see EHQ values for Pb).

Table B-20. EHQs for animals calculated for measured and modeled soil concentrations at six receptor locations and their ratios based on estimated TRV-high SSLs.

Chemicals of potential ecological concern	Background soil concentration at Site 300 (mg/kg)	SITE 300			EWTF		Bldg. 812		Bldg. 895	
		TRV _{HI} ES _{min} (mg/kg _{soil})	Organism	EHQ _{measured}	EHQ _{max/model}	Ratio for EWTF of EHQ _{max/model} to EHQ _{measured}	EHQ _{max/model}	Ratio for B812 of EHQ _{max/model} to EHQ _{measured}	TRV _{HI} EHQ _{max/model}	Ratio for B895 of EHQ _{max/model} to EHQ _{measured}
Heavy Metals										
Antimony	1.00E+00	6.81E+00	OSM ^a	<i>1.47E+00</i>	1.23E-04	8.36E-04	1.64E-05	1.12E-04	1.93E-05	1.31E-04
Barium	3.31E+02	1.91E+02	OA ^b	<i>1.73E+00</i>	5.43E-02	3.14E-02	7.27E-03	4.20E-03	8.53E-03	4.92E-03
Cadmium	2.60E+00	2.93E+00	HLM ^c	8.89E-01	9.71E-02	1.09E-01	3.19E-02	3.59E-02	3.49E-02	3.93E-02
Chromium	4.56E+01	1.61E+05	OSM ^a	2.83E-04	5.21E-07	1.84E-03	7.04E-08	2.48E-04	8.79E-08	3.10E-04
Copper	3.40E+01	3.20E+01	INV	<i>1.06E+00</i>	9.16E-02	8.63E-02	1.20E-01	1.12E-01	1.23E-01	1.16E-01
Lead	7.03E+01	1.05E+02	OA ^b	6.70E-01	1.26E-01	1.87E-01	2.50E-02	3.74E-02	2.46E-02	3.66E-02
Zinc	7.80E+01	1.80E+02	OA ^b	4.33E-01	1.16E-01	2.67E-01	6.05E-02	1.40E-01	6.27E-02	1.45E-01
Cumulative EHQ =				4.93E+00	4.84E-01		2.44E-01		2.54E-01	
Contributed of EHQmodeled to EHQmeasured =					9.82E-02		4.95E-02		5.15E-02	

Table B-20. (continued)

Chemicals of potential ecological concern	Background soil concentration at Site 300 (mg/kg)	East Pasture		Carnegie		Ranch	
		TRV _{HI} EHQ _{max/model}	Ratio for East Pasture of EHQ _{max/model} to EHQ _{measured}	TRV _{HI} EHQ _{max/model}	Ratio for Carnegie of EHQ _{max/model} to EHQ _{measured}	TRV _{HI} EHQ _{max/model}	Ratio for Ranch of EHQ _{max/model} to EHQ _{measured}
Heavy Metals							
Antimony	1.00E+00	1.48E-06	1.01E-05	1.51E-06	1.03E-05	8.27E-07	5.63E-06
Barium	3.31E+02	6.52E-04	3.76E-04	6.64E-04	3.84E-04	3.64E-04	2.10E-04
Cadmium	2.60E+00	8.48E-03	9.54E-03	8.57E-03	9.64E-03	6.16E-03	6.93E-03
Chromium	4.56E+01	7.01E-09	2.47E-05	7.21E-09	2.54E-05	5.41E-05	1.42E-05
Copper	3.40E+01	1.63E-02	1.53E-02	1.62E-02	1.53E-02	1.34E-02	1.27E-02
Lead	7.03E+01	3.08E-03	4.59E-03	3.05E-03	4.55E-03	2.03E-03	3.03E-03
Zinc	7.80E+01	2.67E-02	6.16E-02	2.69E-02	6.22E-02	2.47E-02	5.70E-02
Cumulative EHQ =		5.52E-02		5.54E-02		4.67E-02	
Contributed of EHQmodeled to EHQmeasured =		1.12E-02		1.12E-02		5.35E-03	

Note: EHQ values greater than 1 appear in italics (e.g., see EHQ values for Pb).

Table B-21. EHQs for Kit fox calculated for measured soil concentrations at Site 300 based on TRV-low derived ESSLs.

Chemicals of potential ecological concern	Background soil concentration at Site 300 (mg/kg)	KitFox ESSL _{min} (mg/kg _{soil})	EHQ _{measured}
Heavy Metals			
Antimony	1.00E+00	1.21E+00	8.26E-01
Barium	3.31E+02	1.96E+03	1.69E-01
Cadmium	2.60E+00	1.74E+00	<i>1.49E+00</i>
Chromium	4.56E+01	5.43E+04	8.40E-04
Copper	3.40E+01	7.86E+01	4.33E-01
Lead	7.03E+01	3.65E+01	<i>1.93E+00</i>
Zinc	7.80E+01	1.56E+02	5.02E-01
Cumulative EHQ _{measured} =			5.35E+00

Note: EHQ values greater than 1 appear in italics (e.g., see EHQ values for Pb).

Table B-22. EHQs for Burrowing owl calculated for measured soil concentrations at Site 300 based on TRV-low derived ESSLs.

Chemicals of potential ecological concern	Background soil concentration at Site 300 (mg/kg)	Burrowing owl ESSL _{min} (mg/kg _{soil})	EHQ _{measured}
Heavy Metals			
Antimony	1.00E+00		
Barium	3.31E+02	1.83E+02	<i>1.81E+00</i>
Cadmium	2.60E+00	1.86E-01	<i>1.40E+01</i>
Chromium	4.56E+01		
Copper	3.40E+01	2.32E+01	<i>1.46E+00</i>
Lead	7.03E+01	1.70E+01	<i>4.15E+02</i>
Zinc	7.80E+01	4.60E+01	<i>1.70E+00</i>
Cumulative EHQ _{measured} =			4.33E+02

Note: EHQ values greater than 1 appear in italics (e.g., see EHQ values for Pb).

Table B-23. EHQs for Kit fox calculated for measured soil concentrations at Site 300 based on TRV-high derived ESSLs.

Chemicals of potential ecological concern	Background soil concentration at Site 300 (mg/kg)	KitFox TRV _{HI} ESSL _{min} (mg/kg _{soil})	EHQ _{measured}
Heavy Metals			
Antimony	1.00E+00	1.21E+01	8.26E-02
Barium	3.31E+02	1.96E+04	1.69E-02
Cadmium	2.60E+00	7.66E+01	3.40E-02
Chromium	4.56E+01	5.43E+05	8.40E-05
Copper	3.40E+01	1.86E+04	1.83E-03
Lead	7.03E+01	8.79E+03	8.00E-03
Zinc	7.80E+01	6.66E+03	1.17E-02
Cumulative EHQ _{measured} =			1.55E-01

Note: EHQ values greater than 1 appear in italics (e.g., see EHQ values for Pb).

Table B-24. EHQs for Burrowing owl calculated for measured soil concentrations at Site 300 based on TRV-high derived ESSLs.

Chemicals of potential ecological concern	Background soil concentration at Site 300 (mg/kg)	Burrowing owl TRV _{HI} ESSL _{min} (mg/kg _{soil})	EHQ _{measured}
Heavy Metals			
Antimony	1.00E+00		
Barium	3.31E+02	3.67E+02	9.01E-01
Cadmium	2.60E+00	2.42E+01	1.07E-01
Chromium	4.56E+01		
Copper	3.40E+01	5.28E+02	6.44E-02
Lead	7.03E+01	1.06E+02	6.63E-01
Zinc	7.80E+01	4.60E+02	1.70E-01
Cumulative EHQ _{measured} =			1.91E+00

Note: EHQ values greater than 1 appear in italics (e.g., see EHQ values for Pb).