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Two on-Station drainage channels traverse MCAS El Toro and two drainage channels run along the Station boundary (Figure 1-4). These drainage channels are Borrego Canyon Wash, Agua Chinon Wash, Marshburn Channel, and Bee Canyon Wash. Borrego Canyon Wash, which flows through Site 2, is concrete lined downstream of Irvine Boulevard along the boundary of the Station except for about 200 yards near the southern Station boundary. Borrego Canyon Wash receives runoff from the facility mainly during storm events. Agua Chinon and Bee Canyon Washes, which are contained within culverts across most of the Station, are open and unlined for about 100 yards near the southwestern boundary of the Station. Agua Chinon Wash is also open and unlined in Site 3 and the northeast portion of Site 19. The Bee Canyon Wash is open and unlined at Site 16. Agua Chinon and Bee Canyon Washes receive Station runoff mainly through storm sewers.

Marshburn Channel is a lined channel that flows along the northwestern boundary of the Station. Runoff from the western part of the Station augments off-Station flow to the Marshburn Channel. Water flow in the washes and channel is mostly limited to storm events. Both Bee Canyon and Agua Chinon Washes are dredged at the southwestern border of the Station (along the unlined portion) following storm events to prevent sediment buildup.

Current Off-Station Populations

Current land use around MCAS El Toro includes commercial, light industrial, and residential land to the south, southeast, and southwest. Additional residential areas are located to the northwest and west of the Station. Land adjacent to the facility on the north and east is used for agricultural purposes. Growth projections for the area include continued urbanization (City of Irvine, 1991).

Since access is restricted to the Station, current off-Station populations will not be directly exposed to on-Station COPC in soils. On-Station soil particulates could be blown off-Station; however, this is not expected to be a major route of exposure. There are four sites (5, 8, 12, and 21) located within a few hundred yards of the Station boundary. Buildings are located between sites 8 and 21 and

the Station boundary limiting off-Station migration to the adjacent commercial areas. Site 5 is covered with additional soil, and Site 12 is currently covered with grass, gravel, matting, and soil, limiting potential exposures to windblown particulates. Current off-Station populations could potentially be exposed to COPC that migrate from the site in surface water runoff and sediment.

Runoff from Borrego Canyon Wash joins Agua Chinon Wash about 1/4 mile southwest of the Station. About 1 mile downstream from its confluence with Borrego Canyon Wash, Agua Chinon Wash flows into the San Diego Creek. About 1,500 feet north of Agua Chinon Wash, Bee Canyon Wash flows into the San Diego Creek. The Marshburn Channel flows into the San Diego Creek about 3/4 mile northwest of the Bee Canyon Wash. Just southwest of the Station, the San Diego Creek runs through mainly commercial and agricultural areas. Due to the limited water flow in the creek during most of the year, there is not expected to be any swimming or fishing in the creek at this location. However, children from nearby residential areas could come in contact with surface water and sediment while playing in or near the creek (recreational exposure).

Approximately 5 miles downstream from the Station, the creek runs through a recreational area which includes hiking and bicycle paths. The creek flows into the Upper Newport Bay approximately 7 miles from the Station. Recreational uses of Newport Bay include swimming and fishing.

Groundwater in the area surrounding MCAS El Toro (off-Station) is used largely for agricultural purposes. Currently active agricultural production wells in the vicinity of MCAS El Toro include TIC-107, TIC-108, TIC-111, and TIC-113, which are located northwest of the Station, and Wells TIC-47, TIC-106, and ET-1, which are located west of the Station (See Plate 1-1).

Drinking water for the area surrounding MCAS El Toro is supplied by the MWD. The nearest drinking water production well is City of Tustin-Walnut Well, which is located west of the Station (near the intersection of Red Hill Avenue and Walnut). Other drinking water production wells located in the vicinity of the Station include a Tustin well (Pankey) and a Santa Ana well (number 26).

Future On-Station and Off-Station Populations

MCAS El Toro is currently on the list of military bases being considered for closure. Based on current and potential future land uses for areas surrounding the Station, it is assumed that future on-Station use could include commercial, recreational, and/or residential use when the Station closes.

The OCWD has future plans to use groundwater in the area as a source of potable water. These plans include pumping and treating the VOC-contaminated water and delivering the treated water to the IRWD for distribution as potable water (OCWD, 1992).

7.1.4.2 Exposure Pathway Analysis

An exposure pathway is the means by which a person (receptor) may come in contact with one or more COPC. A complete exposure pathway has five elements:

- Contaminant source (e.g., chemical residues)
- Mechanism for contaminant release (e.g., volatilization)
- Environmental transport medium (e.g., air)
- Exposure point (e.g., backyard)
- Feasible route of exposure (e.g., inhalation)

Exposure may occur when chemicals migrate or are physically moved from the site to an exposure point (i.e., a location where receptors contact chemicals) or when a receptor directly contacts materials containing the COPC. An exposure pathway is complete (i.e., there is an exposure) only if all five elements of the exposure pathway are present.

7.1.4.3 Chemical, Sources, Release, and Transport

Potential exposure sources at MCAS El Toro include groundwater, surface and near-surface soil, soil borings, sediment, and surface water runoff that contain COPC.

The fate and transport of two COPC in the environment are determined by the physical characteristics of the site as well as by the chemical and physical properties of the COPC. The site characteristics of MCAS El Toro have been described earlier; this section discusses the processes that control the distribution and migration of the COPC in the environment. Important transformation and transport processes are discussed, along with the factors that influence them.

Chemical transport is related to the distribution of chemicals between media. After a chemical is introduced to the environment, it will partition between the various environmental phases. Partition coefficients (also called distribution coefficients) quantify the ratio of a chemical between two phases at equilibrium. Examples of partition coefficients are the Henry's Law constant (H) and the organic carbon adsorption coefficient (K_{OC}). Although equilibrium conditions are often not present in the dynamic environment, they provide an indication of how a chemical will migrate to establish, or to reestablish, equilibrium conditions.

Chemical transport may also take place when a chemical is transported with the medium in which it resides. Examples of this type are the transport of chemicals sorbed to soil particles entrained by the wind and dissolved chemicals moving with the groundwater.

Volatilization. Volatilization is an important process in which chemicals partition to the gas phase. In the case of chemicals volatilizing from surface soil or surface water runoff to air, they are dispersed and potentially carried away from the source by wind. Volatilization rates from surface water bodies are a function of the chemical and physical properties of the chemical, the presence of other chemicals, and the physical characteristics of the water body. Volatilization rates increase as the exposed surface area increases and as the degree of mixing in the water increases. Mixing replenishes the supply of chemical to the surface; chemical supply to the surface may limit the amount of volatilization for highly volatile chemicals.

The primary properties that are relevant to volatilization rates from surface water are the chemical's water solubility and vapor pressure. These two properties are

incorporated into one partition coefficient that indicates the relative volatility of various contaminants; the Henry's Law constant (H) is equal to a chemical's vapor pressure divided by its water solubility (Lyman, 1990).

$$H = P_{vp} / S$$

where

$$\begin{aligned} P_{vp} &= \text{vapor pressure in atm} \\ S &= \text{solubility in mol/m}^3 \end{aligned}$$

The Henry's Law constant is more appropriate than vapor pressure alone for estimating relative volatilization rates. With a conversion of units, H is equal to the ratio of the concentration of a chemical in the gas phase to its concentration in the water phase.

The Henry's Law constants and water solubility for chemicals detected at the MCAS El Toro sites appear in Table 7-9. Compounds with a Henry's Law constant greater than 10^{-3} atmosphere-cubic meters per mole ($\text{atm}\cdot\text{m}^3/\text{mol}$) can be expected to volatilize rapidly from water to air. Those with H between 10^{-5} and 10^{-3} $\text{atm}\cdot\text{m}^3/\text{mol}$ have volatilization rates that are not as rapid, but still significant, and compounds with a Henry's constant between 10^{-7} and 10^{-5} $\text{atm}\cdot\text{m}^3/\text{mol}$ may volatilize slowly. These chemicals are often classified as semi-volatile. A contaminant with H lower than 10^{-7} $\text{atm}\cdot\text{m}^3/\text{mol}$ may be considered nonvolatile (Lyman, 1990).

When considering volatilization from surface soils, the Henry's Law constant is still a primary indicator of relative rates for various compounds; however, soil properties may also influence the potential for volatilization. The presence of soil adds a third phase to which the chemical may partition. The primary effect of soil on volatilization is through sorption of the chemicals to the soil particles. Chemicals that sorb strongly to soil have less chemical in the water phase and less tendency for volatilization. To qualitatively compare the effect of sorption on volatilization, a second partitioning parameter -- the soil adsorption coefficient (K_d)

-- is used. K_d is equal to the ratio of the concentration of chemical sorbed to the soil particles to the concentration of chemical in the water phase at equilibrium:

$$K_d = \frac{c_{\text{soil}}}{c_{\text{water}}}$$

where

c_{water} is mg/ml water
 c_{soil} is mg adsorbed/g soil

The soil adsorption coefficient and sorption are discussed more fully below.

Volatile chemicals in the context of assessing risk from inhalation of volatiles from water and soil are defined as having a Henry's Law constant of greater than 10^{-5} atm-m³/mol and a molecular weight of less than 200 g/mol (EPA, 1991a). Table 7-2 designates each chemical as volatile (yes) or nonvolatile (no). Except for some forms of mercury, inorganic chemicals are not susceptible to volatilization under typical environmental conditions, so values of H have not been included in the table.

In the case of volatilization from the soil surface, the volatilization rate may be limited by how quickly contaminants can diffuse through the soil to replace what is lost to the atmosphere. A parameter that is used in estimates of volatilization rates from soil is the effective diffusion coefficient for a contaminant in soil (D_e). D_e is estimated from soil properties, such as porosity, and from the molecular diffusion coefficient in air, also called the molecular diffusivity (D_i) (Lyman, 1990). Values for D_i appear in Table 7-9. Molecular diffusivity is provided only for compounds that are classified as volatiles.

Sorption. Chemicals in soil are adsorbed primarily to the soil particles. Soil properties that can affect the degree of adsorption include porosity, percent organic carbon, moisture content, pH, particle size, and mineralogy. The soil-

**Table 7-9
 El Toro Chemicals of Potential Concern
 Fate and Transport
 MCAS El Toro Phase I RI Technical Memorandum**

Chemical	Molecular Weight	Henry's Law (atm-m ³ /mol)	HL Source	Volatile (per Risk Guidance)	Molecular Diffusivity (cm ² /s)	MD Source	Koc	Koc Source	Water Solubility (mg/L)	WS Source	Log Kow	KOW Source
ORGANICS:												
1,1,1-Trichloroethane	133.42	8.00E-03	a	yes	7.94E-02	f	152	e	347	a	2.49	a
1,1,2-Trichloroethane	133.4	1.17E-03	e	yes	7.92E-02	f	56	e	4420	a	2.07	a
1,1-Dichloroethene	97	3.40E-02	e	yes	9.19E-02	f	65	e	2250	e	1.84	e
1,2-Dichloroethane	99	9.78E-04	e	yes	9.07E-02	f	14	e	8524	a		
1,2-Dichloroethene (total)	96.95	6.56E-03	e	yes	9.39E-02	g	59	e	6300	e	1.86 (cis)/ 2.06 (trans)	a/a
2,2,4,5-Trichlorophenoxy propionic acid	269.51	5.2E-06	d	no	x							
2,4-Dimethylphenol	122.18	6.3E-07	c	no	x							
2,4-DB (4-(2,4-dichlorophenoxy) butyric acid)	249.1			no	x				46	n		
2,4-D (2,4-Dichlorophenoxy acetic acid)	221.04	1.37E-10	d	no	x		20	e	620	n	2.81	e
2,4,5-T												
2-Butanone	72.1	1.05E-05	a	yes	9.03E-02	f	4.5	e	239000	a	0.29	a
2-Hexanone	100.2	3.39E-05	k	yes	7.51E-02	g	134	k	35000	300		
2-Methylnaphthalene	142.21	2.60E-04	k	yes	6.57E-02	g	8500	k	25.4	?	4.11	?
4',4'-DDD	320	7.96E-06	e	no	x		770000	e	0.09	i	6.2	e
4',4'-DDE	318	6.80E-05	e	no	x		4400000	e	0.12	i	7	e
4',4'-DDT	355	5.13E-04	e	no	x		243000	e	0.025	i	6.19	e

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**Table 7-9
EI Toro Chemicals of Potential Concern
Fate and Transport
MCAS EI Toro Phase I RI Technical Memorandum**

Chemical	Molecular Weight	Henry's Law (atm-m ³ /mol)	HL Source	Volatile (per Risk Guidance)	Molecular Diffusivity (cm ² /s)	MD Source	Koc	Koc Source	Water Solubility (mg/L)	WS Source	Log Kow	KOW Source
4-Methy-2-pentanone	100.16	9.4E-05	a	yes	7.51E-02	g	19	ddd	20400	a		
4-Methylphenol	108.13	9.60E-07	c	no	x		360	ccc	22600	c	1.94	c
4-Nitrophenol	139.12	3.31E-08	c	no	x							
Acenaphthene	154.2	9.20E-05	e	yes	6.25E-02	g	4600	e	390	i	4	e
Acenaphthylene	152.2	1.48E-03	e	yes	6.32E-02	g	2500	e	3.88-16.1	p	3.72-4.08	p
Acetone	58.09	3.67E-05	a	yes	1.05E-01	f	2.2	e	1000000	a	0.24	a
Aldrin	364.93	1.60E-05	e	no	x		96000	e	0.02	d	6.5	d
Alpha chlordane	409.8	8.60E-04	d	no	x		3090-43650	v	0.056	v	5.54	v
Alpha-BHC	290.85	1.06E-05	d	no	x		3800	e	1.63	e	3.9	e
Anthracene	178	1.02E-03	e	yes	6.00E-02	g	14000	e	0.03-0.399	p	4.45	e
Benzene	78.11	5.43E-03	a	yes	9.32E-02	f	83	e	1791	a	2.13	a
Benzo(a)anthracene	228	1.16E-06	e	no	x		1380000	e	0.0142	n	5.6	e
Benzo(a)pyrene	252	1.55E-06	e	no	x		5500000	e	0.000172-0.0078	p	4.05-8.5	p
Benzo(b)fluoranthene	252	1.19E-05	e	no	x		550000	e	0.0015-0.014	p	5.78-6.57	p
Benzo(g,h,i)perylene	276	5.34E-08	e	no	x		1600000	e	0.00022-0.00083	p	6.51	e
Benzo(k)fluoranthene	252	3.94E-05	e	no	x		550000	e	0.0007-0.00081	p	6.06-7.20	p
Benzyl butyl phthalate	312.39	1.30E-06	c	no	--		17000	ddd	2.69	c	4.91	c
Beta-BHC												
Delta-BHC	291	2.07E-07	e	no	--		6600	e	31.4	c	4.1	e

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**Table 7-9
 El Toro Chemicals of Potential Concern
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Chemical	Molecular Weight	Henry's Law (atm-m ³ /mol)	HL Source	Volatile (per Risk Guidance)	Molecular Diffusivity (cm ² /s)	MD Source	Koc	Koc Source	Water Solubility (mg/L)	WS Source	Log Kow	KOW Source
Beta chlordane	409.8			no	--				0.056	v	5.54	v
Bis(2-ethylhexyl)phthalate	390.54	1.10E-05	c	no	--		1.2	e	0.3	c	5.11	c
Bromodichloromethane	163.83	1.60E-03	a	yes	8.71E-02	g	152	k	4700	a	2.1	a
Bromoform	252.73	6.60E-04	k	no	--	f	98	k				
Carbazole	167.2	N/A			--	g	175	?	1.03	?	3.72	?
Carbon Disulfide	76.13	1.40E-03	a	yes	1.05E-01	f	54	e	2100	a	1.7	a
Carbon tetrachloride	153.84	3.04E-02	a	yes	8.28E-02	f	110	e	805	a	2.83	a
Chlorobenzene	112.6	372E-02	e	yes	7.47E-02	f	330	e	471.7	c		
Chlorodibromomethane	208.28	8.50E-04	a	no	--		84	aaa	4400	a	2.24	a
Chloroform	119.39	4.35E-03	a	yes	8.88E-02	f	31	e	7950	a	1.97	a
Chrysene	228.30	1.05E-06	e	no	--		200000	e	0.002	e	5.61	e
Dalapon	142.97	6.43E-08	d	no	--				502000	d	0.78	g
Dibenzo(a,h)anthracene	278	7.33E-08	e	no	--		3300000	e	2490000	i	6.8	e
Dibenzofuran	168.19	9.73E-05	j	yes	6.19E-02	g	5475	j	1.0-10.3	p	3.91-4.33	p
Dicamba	221.04	9.00E-07	d	no	x		470	ccc	6500	n	2.21	d
Dichloroprop	235.07			no	x				250	n		
Dieldrin	380.93	5.80E-05	d	no	x		1700	e	0.17	d	4.32	d
Dimethyl phthalate	194.20	1.10E-07	c	no	--	g	160	c	4000	c	1.56	c
DI-n-butyl phtalate	278.38	5.3E-05	k	no	4.21E-02	f	3280	k	11.2	c		
Endosulfan I	406.95	1.12E-05	d	no	x		2042	ddd	0.45	r		
Endosulfan II	406.95	1.12E-05	d	no	x				0.10-0.33	r	3.52	r
Endosulfan sulfate	422.91	2.60E-05	dd	no	--		2344	ddd	0.117-0.22	r	3.66	r

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**Table 7-9
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Chemical	Molecular Weight	Henry's Law (atm-m ³ /mol)	HL Source	Volatile (per Risk Guidance)	Molecular Diffusivity (cm ² /s)	MD Source	Koc	Koc Source	Water Solubility (mg/L)	WS Source	Log Kow	KOW Source
Endrin	380.9	7.52E-06	d	no	--		34000	d	0.25	d	4.56	d
Endrin aldehyde	>423			no	--							
Endrin ketone	>423			no	--							
Ethylbenzene	106.16	8.44E-03	c	yes	7.55E-02	f	1100	e	161	c	3.15	c
Fluoranthene	202	6.46E-06	e	no	--		38000	e	0.21	e	4.9	e
Fluorene	166.23	6.42E-05	e	yes	5.97E-02	g	7300	e	1.69	e	4.2	e
Gamma chlordane	409.76	9.63E-06	e	no	--		140000	e				
Heptachlor	374.00	8.19E-04	e	no	--		12000	e	0.18	d	5.27	d
Heptachlor epoxide	389.4	3.2E-05	d	no	x		220	e	0.2	d		
Hexachloroethane	236.03	249E-03	e	no	x		20000	e	50	c		
Indeno(1,2,3-cd)pyrene	276.34	6.86E-08	e	no	x		1600000	e	0.00053	e	6.5	e
Isophorone	138	5.8E-06	a	no	x		31	ddd	12000	n		
Lindane	290.85	2.92E-06	d	no	--		1080	e	7	n	3.9	e
MCPA	200.63	N/A		no	--	g			825	n		
MCPP	214.66			no	--							
Methane	16	6.57E-01	k	yes	2.11E-01	g	753	k				
Methoxychlor	345.65	1.58E-05	d	no	x		80000	ddd	0.045	d		
Methylene chloride	84.94	2.68E-03	a	yes	1.05E-01	g	8.8	e	1300	a	1.25	a
Methyl chloride	50.49	4.4E-02	e	yes	1.3E-01	g	35		6500	c		
Naphthalene	128.16	4.83E-04	c	yes	7.04E-02	g	940	?	31.7	c	3.3	c
Octachlorodibenzo-p-dioxin	N/A	N/A		no	N/A		N/A		N/A		N/A	

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Petroleum hydrocarbons (total recoverable)	N/A	N/A		no	N/A		N/A		N/A		N/A	
Phenanthrene	178	1.59E-04	e	yes	6.00E-02	g	14000	e	1	e	4.46	e
Phenol	94.11	3.97E-07	c	no	--		14.2	e	87000	c	1.46	c
Pyrene	202	5.04E-06	e	no	--		38000	e	0.13	e	4.88	e
Tetrachloroethene	165.82	1.49E-01	a	yes	7.97E-02	f	364	e	1503	a	3.4	a
Toluene	92.13	5.94E-03	a	yes	8.49E-02	f	300	e	534.8	a	2.73	a
TFH-diesel	N/A	N/A		no	N/A		N/A		N/A		N/A	
TFH-gasoline	N/A	N/A		no	N/A		N/A		N/A		N/A	
Trichloroethylene	131.4	1.03E-02	a	yes	8.75E-02	f	126	e	1100	a	2.42	a
Xylenes (total)	106.17	7.04E-03	e	yes	6.95E-02	f	240	e	198	e	3.36	e

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**Table 7-9
 El Toro Chemicals of Potential Concern
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Chemical	Molecular Weight	Henry's Law (atm-m ³ /mol)	HL Source	Volatile (per Risk Guidance)	Molecular Diffusivity (cm ² /s)	MD Source	Koc	Koc Source	Water Solubility (mg/L)	WS Source	Log Kow	KOW Source
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Notes:

- Molecular diffusivity was not calculated for chemicals which were not volatile.
- N/A Not Available.

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water adsorption coefficient K_d provides an estimate of how strongly a chemical is sorbed to the soil particles. Since K_d is a function of the soil characteristics as well as the chemical's parameters, values of K_d can be compared only if they were experimentally determined using similar soils. Except for soils with significant clay content, the chemical adsorbs to the organic carbon portion of the soil; the degree of sorption increases with increasing organic carbon content. For clays, surface areas are very large relative to particle size, which may have a greater influence on sorption than organic carbon content. The adsorption coefficient can be normalized to a common basis when K_d is divided by the fraction of organic carbon in the soil. This normalized coefficient is called the organic carbon adsorption coefficient (K_{OC}).

$$K_{OC} = K_d/f_{OC}$$

where

f_{OC} is the fraction of organic carbon in the soil

Values for K_{OC} appear in Table 7-9. K_{OC} may range from 1 to 1×10^7 milliliters per gram (ml/g). Chemicals with low K_{OC} (less than 100 ml/g) are found mainly in the water phase, (that is, they partition almost entirely from soil to water); those with high K_{OC} values will tend to adsorb to soil. When values of K_{OC} are not available in the literature, they may be estimated using the octanol-water partition coefficient (K_{OW}) defined below.

Values for inorganic chemicals are not presented in the Table 7-9. Sorption of inorganics is more complex and much more dependent on the speciation of the metals and the geochemistry of the soils. Metals are typically adsorbed to inorganic carbon in the soil matrix and to metal oxide coatings on sand grains. Site-specific adsorption coefficients for inorganics may be obtained experimentally (Hillel, 1980).

When sorbed to soil or sediment particles, chemicals may be transported with the solid phase. This can occur in the case of particle entrainment, when soil is

carried with the wind, and in surface water runoff, when soils or sediments are swept with the water (e.g., after rainfall).

Factors Related to Subsurface Contaminant Movement

Transport into, through, and out of subsurface soil occurs via several processes:

- Volatilization and subsequent bulk gas-phase flow downward due to the increased density of contaminated soil gas versus uncontaminated soil gas
- Gas-phase diffusion in any direction due to a concentration difference
- Dissolution in water and subsequent bulk flow downward with water that is infiltrating through the soil (leaching)
- Downward flow as a separate organic phase

The first two bullets address chemical transport in the vapor phase. Volatilization is governed by the same principles described above. The first bullet describes advective flow, where the contaminated soil gas flows downward as a bulk phase through the pore spaces. In the case of diffusion, the contaminant vapors migrate through the bulk soil gas from areas of high chemical concentration to areas of low chemical concentration. The most significant mechanism for gas-phase transport depends on chemical and soil characteristics, such as the soil porosity, contaminant vapor density, and distance to be traveled.

Leaching is often the most significant form of transport (moving the greatest mass of contaminant). As precipitation infiltrates soil, chemical partition from the soil to the water as a function of K_d . When the water contacts previously uncontaminated soil, the contaminant redistributes to soil particles; this redistribution via contaminant sorption/desorption expands the contaminant plume, and the contaminant downward migration rate lags behind the rate of water migration. This phenomenon is termed retardation. The retardation factor (R_f) is the ratio of the average bulk velocity of the infiltrating water to the average velocity of the contaminant (Freeze and Cherry, 1979). Retardation is a function

of a chemical's adsorption coefficient and of soil porosity and bulk density per the relationship:

$$R_f = 1 + (K_d * \rho) / \Phi$$

where:

ρ = soil bulk density (mass/ volume)

Φ = porosity (unitless)

Transformation Processes. While sorbed to soil or being transported as a gas or as dissolved components in water, contaminants are subject to transformation processes such as chemical and biological degradation. For some organic chemicals, these reactions are significant removal mechanisms. Abiotic reactions in soil include photolysis at the surface and hydrolysis. Near the surface, oxygen is available and degradation will be aerobic. As depth increases, oxygen availability decreases and anaerobic transformations predominate. Degradation of organic contaminants shows VOCs typically being more biodegradable than SVOCs (Gibson, 1984). Even if a compound is biodegradable, it will be degraded only if enough nutrients, sources of carbon and energy, water, and acclimated microbes are present to support a viable organism population. Because the potential for biodegradation is extremely site specific, values of half-lives or degradation rates have not been included in the table of physicochemical properties (Table 7-9).

The mobility of metals in soil may be affected by organic contamination if biodegradation of organic contaminants changes the soil pH and redox conditions. As conditions change from oxygenated to anaerobic with depth, metals may precipitate out of solution. Lowering of the soil pH may dissolve metals.

Factors Related to Groundwater Contaminant Movement

Migration of chemicals to groundwater is affected by several factors, including the infiltration rate of water through the soil, degree of retardation, and quantity of chemical in the soil. The presence of impermeable layers in the subsurface can impede transport, while improperly installed wells can act as conduits for contaminants.

Once chemicals have reached the groundwater, their behavior depends on whether they are relatively soluble in water. The water solubility of a chemical is the maximum concentration of that chemical that will dissolve in pure water at a given temperature. Highly soluble compounds can be rapidly leached from contaminated soil and are relatively mobile in groundwater. In general, VOCs have higher solubilities than do SVOCs or nonvolatile organic compounds. Inorganic solubilities depend on the species present and physical properties, such as redox and pH. Solubilities for organic constituents are tabulated in Table 7-9.

Dissolved chemicals can be transported with the bulk groundwater flow both horizontally and vertically. Chemical concentrations can decrease in groundwater via dilution with upgradient uncontaminated groundwater and general dispersion from the source. Adsorption will continue to retard contaminant movement, although the magnitude of retardation that is a function of organic material is often decreased due to a lower organic carbon content in groundwater zones, typically sands and gravels. Chemical losses by volatilization may be limited by the rate at which the chemicals in the groundwater can be transported to the water's surface.

7.1.4.4 Potential Exposure Pathways and Routes

Potential pathways and routes of exposure (i.e., ingestion, dermal contact, inhalation) to COPCs detected on and off-Station are summarized in Table 7-10 for all 22 sites and described in detail below. These pathways were evaluated to determine if they are or have the potential to be complete exposure pathways.

**Table 7-10
Potential Current and Future Exposure Pathways and Routes
MCAS El Toro Phase I RI Technical Memorandum**

Source	Release	Exposure Route	Receptor	On-Station Sites																					
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	21	22	
Surface Soil	Direct Contact	Ingestion or Dermal	Current On-Station Worker	*			*	*	*	*	*	*			*	*	*		*	*	*	*	*		
			Current On-Station Trespasser																	*					
			Future On-Station Worker	potential exposure across all sites																					
			Future On-Station Resident	potential exposure across all sites																					
	Wind and Mechanical Erosion	Inhalation	Current On-Station Worker	*			*	*	*	*	*	*			*	*	*		*	*	*	*	*	*	
			Current On-Station Trespasser																	*					
			Future On-Station Worker	potential exposure across all sites																					
			Future On-Station Resident	potential exposure across all sites																					
	Volatilization	Inhalation	Current On-Station Worker	*			*	*	*	*	*	*			*	*	*		*	*	*	*	*	*	
			Current On-Station Trespasser																	*					
			Future On-Station Worker	potential exposure across all sites																					
			Future On-Station Resident	potential exposure across all sites																					

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**Table 7-10
Potential Current and Future Exposure Pathways and Routes
MCAS El Toro Phase I RI Technical Memorandum**

Source	Release	Exposure Route	Receptor	On-Station Sites																				
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	21	22
Surface Soil (continue)	Storm Runoff to Surface Water	Ingestion, Dermal, or Inhalation	Current On-Station Worker				*		*	*					*		*		*		*	*		
			Current Off-Station Resident		*	*	*		*	*			*	*		*		*				*	*	
			Future On-Station Worker		*	*	*		*	*			*	*		*		*				*	*	
			Future On-Station Resident		*	*	*		*	*			*	*		*		*				*	*	
			Future Off-Station Resident		*	*	*		*	*			*	*		*		*				*	*	
	Leaching to Ground Water	Ingestion, Dermal, or Inhalation	Current On-Station Worker																					
			Current Off-Station Resident																					
			Future On-Station Worker	potential exposure across all sites																				
			Future On-Station Resident	potential exposure across all sites																				
			Future Off-Station Resident	potential exposure across all sites																				

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**Table 7-10
Potential Current and Future Exposure Pathways and Routes
MCAS El Toro Phase I RI Technical Memorandum**

Source	Release	Exposure Route	Receptor	On-Station Sites																					
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	21	22	
Subsurface Soil	Direct Contact	Ingestion or Dermal	Current On-Station Worker																						
			Future On-Station Worker	potential exposure across all sites																					
			Future On-Station Resident	potential exposure across all sites																					
	Volatilization	Inhalation	Current On-Station Worker																						
			Future On-Station Worker	potential exposure across all sites																					
			Future On-Station Resident	potential exposure across all sites																					
	Leaching to Ground Water	Ingestion, Dermal, or Inhalation	Current On-Station Worker																						
			Current Off-Station Resident																						
			Future On-Station Worker	potential exposure across all sites																					
			Future On-Station Resident	potential exposure across all sites																					
			Future Off-Station Resident	potential exposure across all sites																					

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**Table 7-10
Potential Current and Future Exposure Pathways and Routes
MCAS El Toro Phase I RI Technical Memorandum**

Source	Release	Exposure Route	Receptor	On-Station Sites																					
				1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	21	22	
Sediment	Direct Contact	Ingestion or Dermal	Current On-Station Worker				*		*	*					*		*		*		*	*			
			Future On-Station Worker		*	*	*		*	*			*	*		*		*		*		*	*		
			Future On-Station Resident		*	*	*		*	*			*	*		*		*		*		*	*		
	Wind and Mechanical Erosion	Inhalation	Current On-Station Worker				*		*	*					*		*		*		*	*			
			Future On-Station Worker		*	*	*		*	*			*	*		*		*		*		*	*		
			Future On-Station Resident		*	*	*		*	*			*	*		*		*		*		*	*		
	Volatilization	Inhalation	Current On-Station Worker				*		*	*					*		*		*		*	*			
			Future On-Station Worker		*	*	*		*	*			*	*		*		*		*		*	*		
			Future On-Station Resident		*	*	*		*	*			*	*		*		*		*		*	*		
	Sorption or Solubilization to Surface Water	Ingestion, Dermal, or Inhalation	Current On-Station Worker				*		*	*					*		*		*		*	*			
			Current Off-Station Resident		*	*	*		*	*			*	*		*		*		*		*	*		
			Future On-Station Worker		*	*	*		*	*			*	*		*		*		*		*	*		
Future On-Station Resident				*	*	*		*	*			*	*		*		*		*		*	*			
Future Off-Station Resident				*	*	*		*	*			*	*		*		*		*		*	*			

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Site 1: Explosive Ordnance Disposal Range

The Explosive Ordnance Disposal (EOD) Range is located in a small canyon in the extreme northeast portion of the Station. The site is completely fenced and has a guard gate. COPC detected in surface soils at the site include metals, solvents, and fuels.

A potential route of chemical transport at the site is through infiltration of rain through the soil to groundwater. The soil cover is unconsolidated and may not be very thick. COPC detected in site groundwater were largely restricted to metals and low level radioactivity.

Surface water runoff is not expected to be a major migration pathway. The canyon has a restricted watershed and runoff after rainstorms is captured by an earthen dam located immediately upstream. Disking operations at the site have obliterated the natural drainage pathway.

Current workers at the site include staff, personnel attending daily classes, and maintenance workers doing occasional mowing. Current workers and future workers or residents could come in contact with COPC in site soils. Exposure to soils could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, and inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of volatilized chemicals from groundwater.

Site 2: Magazine Road Landfill

Magazine Road Landfill occupies 22 acres between Borrego Canyon Wash and one of its tributaries. A manmade drainage channel bisects the site. The site is covered with grass with washout along the channel. A variety of waste types were disposed of at this site, including solvents and municipal wastes. COPC found in site surface/shallow soils include solvents, pesticides, fuels, and metals. Landfill

gas samples from the site detected benzene, chloroform, methane, methylene chloride, tetrachloroethylene, and trichloroethylene.

A potential route of chemical migration is infiltration of leachate through the subsurface soils to groundwater. COPC detected in site soil borings were limited to metals. COPC detected in groundwater at the site include volatile organics (e.g., tetrachloroethylene, chloroform, and trichloroethylene), metals, and low level radioactivity.

Migration of chemicals could also include surface water runoff and landfill leachate entering the manmade channel that bisects the site or the two tributaries of the Borrego Canyon Wash. Although leachate is normally not visible, it could develop after a rainstorm. Chemicals may be carried downstream from the site, or infiltrate into the floor of the washes. COPC detected in surface water runoff and sediments from the site include pesticides, solvents, fuels, metals and low level radioactivity.

Currently there is no receptor activity at the site; however, future workers and residents could be exposed to COPC in soil, groundwater, surface water runoff, and sediment. Future workers or residents coming into contact with soils or sediments may become exposed through incidental ingestion, dermal contact, inhalation of volatilized chemicals, and inhalation of airborne particulates. Potential future exposure to COPC in groundwater could occur through ingestion, dermal contact, or inhalation of volatilized chemicals from groundwater used for industrial/domestic purposes. Individuals coming in contact with COPC in surface water may be exposed through incidental ingestion and dermal contact.

Site 3: Original Landfill

The Original Landfill is a 20-acre site used to dispose of solvents, incinerator ash, and municipal wastes. A fence surrounds most of the site. Chemical transport through soils is limited because a portion of the site west of Agua Chinon Wash has been graded, compacted, and paved with aggregate material, and a concrete pad has been constructed between the drainage channel and the entrance road

from Gate 2. The remainder of the site is covered with gravel. COPC detected in the soils at the site include petroleum hydrocarbons, solvents, pesticides, fuels, dioxins and metals. Landfill gases detected at the site include chloroform, methylene chloride and trichlorethylene.

A potential route of chemical transport is infiltration of landfill leachate through unconsolidated alluvium beneath the landfill to groundwater. COPC detected in the groundwater below the site consisted primarily of pesticides, solvents, metals, and low level radioactivity.

Surface water transport may also be a route of chemical transport. Leachate has not been visible at the site, but may occur after prolonged precipitation. This leachate may potentially enter Agua Chinon Wash, which is incised about 10 feet below the ground surface. Surface water could then either infiltrate through sediments in the bottom of the wash, or flow downstream and eventually reach San Diego Creek. Agua Chinon Wash enters a culvert immediately downstream from the site and does not emerge again until it reaches the southwest facility boundary. COPC detected in surface water runoff and sediments on the site included pesticides, fuels, petroleum hydrocarbons, and metals.

The only receptor activity at the site is occasional mowing of the grass. Much of the site is being used to house the Phase I RI site facilities (e.g., trailers, storage containers, and decontamination pad), and the Waste Staging Area. Current workers and future workers or residents could be exposed to site soils, groundwater, sediment, or surface water. Workers or residents coming into contact with soils or sediments may become exposed through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates. Exposure to COPC in groundwater could occur through ingestion, dermal contact, or inhalation of volatilized chemicals from groundwater used for industrial/domestic purposes. Individuals coming in contact with COPC in surface water may be exposed through incidental ingestion or dermal contact.

Site 4: Ferrocene Spill Area

The Ferrocene Spill Area is in the northeast section of the Station near the engine testing facilities and adjacent to the Original Landfill. Historically, ferrocene and hydrocarbon carrier solutions were spilled onto the ground and rinse water carrying the ferrocene and hydrocarbon carrier solutions may have drained into a nearby drainage ditch. COPC detected in surface/shallow soils at the site included solvents, polynuclear aromatic hydrocarbons (PAHs) fuels, and metals.

Migration of chemicals from the site could include surface water runoff during storm events. Surface water could flow along the drainage ditch into the storm drain, which discharges into the Agua Chion Wash. COPC detected in sediments near the site consisted primarily of metals.

Infiltration of chemicals to groundwater may be a route of chemical migration. Water may have infiltrated downward through contaminated soil to groundwater over a long period of time. COPC detected in groundwater below the site include solvents, fuels, benzene, and metals. Some low level gross beta particle was detected in the upgradient well. Gross alpha and beta particle activity was not measured in downgradient wells.

Current workers at or near the site include maintenance workers for occasional mowing of the grass and workers in the nearby engine testing facility. Current workers and future workers or residents could come in contact with COPC in site soils/sediments. Exposure to soils/sediments could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from groundwater.

Site 5: Perimeter Road Landfill

The Perimeter Road Landfill is located in the southeast section of the Station, just north of Gate 3 near the Station boundary. The site is currently fenced. Recurring settling in the landfill has necessitated periodic applications of additional cover soil to prevent ponding. COPC detected in surface/shallow soils on the site include pesticides, petroleum hydrocarbons, fuels, and metals. Landfill gas sampled at the site consisted of methylene chloride, tetrachloroethylene, and trichloroethylene.

A potential route of chemical transport at the site is migration of contaminants to groundwater. Landfill leachate may migrate from the base of the landfill to the groundwater. COPC detected in the groundwater below the site consisted primarily of solvents, trichloroethylene, metals and low level radioactivity.

Surface water runoff is not expected to be a major pathway due to the flat topography and the distance from Borrego Canyon Wash.

Current receptor activity on the site consists of occasional mowing of the grass. Current workers and future workers or residents could come in contact with COPC in site soils. Exposure to soils could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from groundwater.

Site 6: Drop Tank Drainage Area No. 1

Drop Tank Drainage Area No. 1 is a fenced grassy area in the southwest quadrant of the Station. From 1969 to 1983, aircraft drop tanks were routinely transported to the site where the remaining fuel would be drained and the tanks rinsed. COPC found in soils at the site consisted of solvents, petroleum hydrocarbons, fuels, and metals.

The main routes for chemical transport at the site would be through groundwater and surface water runoff. COPC may have accumulated near the base of the swale and infiltrated through the soil potentially affecting the groundwater. COPC in groundwater below the site include solvents and metals.

Surface runoff may flow during storm events to the catch basin and reach the Agua Chinon Wash. COPC may then infiltrate through the sediments or be carried to San Diego Creek. COPC found in the sediments from the site include solvents, petroleum hydrocarbons, fuels, and metals.

Current receptor activity at the site includes maintenance personnel who are on site daily and occasional grass mowing. Current workers and future workers or residents could come in contact with COPC in site soils/sediments. Exposure to soils/sediments can occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from water.

Site 7: Drop Tank Drainage Area No. 2

Drop Tank Drainage Area No. 2 is located in the southwest quadrant of the Station near the hangar buildings. Approximately 80% of the site is covered with concrete. The remainder of the site is covered with grass. COPC detected in surface/shallow soils at the site include pesticides, PAHs, petroleum hydrocarbons, fuel, and metals.

Both groundwater and surface runoff are potential transport pathways at the site. Brown and Caldwell (1986) estimated that as much as 3,680 gallons of JP-5 jet fuel, 11,400 gallons of lubrication oil, and 6,720 gallons of waste oil have been disposed on the site causing widespread soil contamination (B&C, 1986). Water infiltrating through the soil may have carried contaminants to groundwater. Groundwater near the site is about 100 feet below the ground surface and flows in

a westerly direction. COPC detected in the groundwater below the site include carbon tetrachloride, chloroform, tetrachloroethylene, trichloroethylene, fuel, metals and low level radioactivity.

Surface water runoff could have collected in a catch basin located adjacent to the site. Chemicals carried into the catch basin could be discharged to the Agua Chinon Wash and either migrate downward through sediments or be carried to San Diego Creek. No surface water runoff or sediment samples were taken at this site.

Maintenance personnel and pilots are on the site daily. Grass areas of the site are also mowed occasionally. Current workers and future workers or residents could come in contact with COPC in site soils. Exposure to soils could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from groundwater.

Site 8: DRMO Storage Area

The DRMO Storage area is located on the southwest corner of the intersection of Marine Way and "R" Street at the southwestern Station boundary. The site is covered with gravel and fenced. It is currently used as a storage area and a parking lot.

In 1984, polychlorinated biphenyl (PCB) oil from a leaking electrical console was spilled onto a small area in the yard. Several gallons of PCB oils were estimated to have leaked (Brown and Caldwell, 1986) and soils in the vicinity were excavated. Mechanical and electrical components and containerized liquids of unknown composition are also stored at the site, and spills of materials may have occurred. COPC detected in soil include PAHs, PCBs, pesticides, petroleum

hydrocarbons, solvents, fuels, and metals. Volatilization can be an important migration pathway route for PCBs.

A potential route of chemical transport at the site would be through migration of contaminants from soils down to groundwater. Since the site is flat and unpaved, the potential for groundwater infiltration is present. COPC detected in groundwater below the site include volatile organic chemicals (e.g., benzene carbon tetrachloride, chloroform, tetrachloroethylene, and trichloroethylene), solvents, and metals.

There are no obvious surface water pathways at the site. However, contaminants may move in sheet flow during large rain events, and eventually reach the storm sewer system and migrate to Agua Chinon Wash.

Current receptor activity at the site consists primarily of occasional weeding and personnel who come on-site to park vehicles. Current workers and future workers or residents could come in contact with COPC in site soils. Exposure to soils could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater can occur through ingestion, dermal contact, or inhalation of chemicals volatilized from groundwater.

Site 9: Crash Crew Pit No. 1

The Crash Crew Pit area is in the west quadrant of the Station. The pits were used for fire fighting training during the late 1960s. COPC detected in soils around the suspected area of the pit include petroleum hydrocarbons, fuels, solvents, and metals.

Historical information on construction of the pit suggests that the fuel, gasoline, and other liquid wastes burned there would primarily be expected to migrate through subsurface soils along with contaminated water that collected in the pit.

Groundwater in the area is assumed to flow in a westerly direction. The groundwater below the site contains volatile organic chemicals (e.g., dichloroethene, carbon tetrachloride, chloroform, tetrachloroethylene, and trichloroethylene) fuels, metals and low level radioactivity.

Because of the flat topography at the site, and because fuels were collected in the pit, surface water runoff is not expected to be a major chemical transport pathway.

Current receptor activity at the site is limited to occasional grass mowing. Current workers and future workers or residents could come in contact with COPC in site soils. Exposure to soils could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from groundwater.

Site 10: Petroleum Disposal Area

The Petroleum Disposal Area is located near the southwest corner of the Station. It is currently fenced and covered with aircraft matting and a concrete apron. COPC detected in soils at the site include petroleum hydrocarbons, PAHs, solvents, fuels, and metals.

Historically waste oils were applied to a large area consisting of gravel and dirt for the purposes of dust control. During that time, chemicals may have migrated downward to groundwater, or overland through surface water transport. Surface soils are essentially covered, however depending on the permeability of the concrete and matting to air and water, some chemical transport may still occur. COPC detected in the groundwater below the site volatile organic chemicals (e.g., dichloroethene, carbon tetrachloride, chloroform, tetrachloroethylene and trichloroethylene) and metals.

Since the site is essentially covered, exposure to contaminated soils is minimal. Future workers or residents could come in contact with COPC in site soils. Exposure to soils could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from groundwater.

Site 11: Transformer Storage Site

The Transformer Storage Area is a 30-foot by 30-foot concrete pad located in the southeast quadrant of the Station. The site is currently fenced. A 3-foot-wide asphalt lined drainage ditch runs adjacent to the pad. The ditch drains to the northwest and into a catch basin that discharges into the Bee Canyon Wash.

Transformers were stored on site from 1968 to 1983, during which time, some leaked or spilled. It is estimated that 60 gallons of PCB transformer oil may have leaked onto the concrete pad (Brown and Caldwell, 1986). The PCB oil would probably run off the concrete pad into the adjacent drainage ditch and surrounding soils.

Because of the amount of PCB oil that was spilled at the site and the low mobility of PCBs in soil, contamination at the site most probably has only affected the uppermost soils in the immediate vicinity of the storage area and the drainage ditch. COPC detected in surface/shallow soils at the site consist primarily of PCBs and pesticides. Volatilization can be an important migration pathway for PCBs.

During storm events, other routes of chemical transport could include surface water runoff to Bee Canyon Wash via the catch basin. No surface water runoff or sediment samples were taken at this site.

Currently, the site is used for storage and personnel are on the site only periodically. Since the site is covered with concrete, there are no current onsite

exposures. Current workers and future workers or residents could come in contact with COPC in site soils. Exposure to soils could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Site 12: Sludge Drying Beds

The Sludge Drying Beds are located in the southwest corner of the facility. The site was used from 1943 through 1972 to dewater sludge from the secondary wastewater treatment plant operated on Station. When the waste water treatment facility was closed, the sludge may have been abandoned and the drying beds eventually plowed under. The site is currently covered with grass in Area 1 and gravel, soil, and matting in Area 2.

A potential pathway of transport is infiltration of rainfall through soils to groundwater. COPC detected in soils at the site include pesticides, PAHs, petroleum hydrocarbons, PCBs, fuels, and metals. COPC detected in the groundwater below the site included pesticides, volatiles organic chemicals (carbon tetrachloride, chloroform, trichloroethylene, tetrachloroethylene), and metals.

Chemicals may have also been transported through surface drainage during storm events. Surface drainage may flow to a swale located in the center of the site and on to a catch basin on the west side of the site which flows into Bee Canyon Wash. COPC detected in sediment samples from the catch basin include pesticides, PAHs, petroleum hydrocarbons, fuels, and metals.

The drying beds are no longer in use and the site is currently used for offices and storage for contractors. Grass at the site is mowed occasionally. Current workers and future workers or residents could come in contact with COPC in site soils/sediments. Exposure to soils/sediments could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from water.

Site 13: Oil Change Area

The Oil Change Area is located in the southwest corner of the Station. Waste crankcase oil from maintenance vehicles and heavy equipment was drained directly onto the ground at the site. COPC detected in the soils included petroleum hydrocarbons, PAHs, pesticides, fuels, and metals.

Migration of COPC at the site may occur by downward movement of water through contaminated soils through the vadose zone to the groundwater. After reaching groundwater, chemicals could move in a westerly direction toward the main groundwater basin. COPC detected in groundwater included benzene, xylene, fuel, and metals.

Surface water transport would be of lesser importance at the site; because of the flat topography and lack of discrete drainage ways. However, during storm events chemicals may be transported in sheet flow to the storm sewer system, and eventually be discharged to Bee Canyon Wash. No surface water runoff samples were taken at this site.

Currently there is no receptor activity at the site, however, the nearby museum does use the area for storage. Future workers or residents could come in contact with COPC in site soils. Exposure to soils could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from water.

Site 14: Battery Acid Disposal Area

The Battery Acid Disposal Area is located near the former heavy equipment maintenance shop in the southwest corner of the Station. Batteries from facility vehicles were drained onto the soil of the site. The site is currently covered with grass. A drainage ditch runs parallel to the site and empties into a catch basin which discharges into Bee Canyon Wash. COPC detected in both soils and sediments included solvents, petroleum hydrocarbons, PAHs, fuels and metals.

Migration of chemicals at the site may occur by downward movement through unconsolidated sediments of the vadose zone to the groundwater. After reaching groundwater, chemicals could move in a westerly direction toward the main groundwater basin. COPC detected in groundwater below the site include carbon tetrachloride, chloroform, trichloroethylene, and metals.

Surface water transport may also be of importance at the site, because of the discrete drainage way running through the site. COPC may have migrated into soils in the drainage way, or may have been transported in surface water runoff during storm events to Bee Canyon Wash.

The only receptor activity at the site currently is occasional grass mowing. Current workers and future workers or residents could come in contact with COPC in site soils/sediments. Exposure to soils/sediments could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from water.

Site 15: Suspended Fuel Tanks

The Suspended Fuel Tank site is located in the southern corner of the northwest quadrant of the Station. The site was formerly a diesel fuel tank storage area.

Two elevated tanks were located at the site from 1979 through mid-1984. Reportedly, the tanks leaked fuel from the fueling hoses and nozzles onto the ground. The site is currently covered with gravel or grass and is fenced. COPC detected in soil included of solvents, petroleum hydrocarbons, fuel volatiles, and metals.

A potential migration pathway at the site involves chemical transport vertically down through soil to groundwater. COPC detected in groundwater include benzene, xylene, fuel, and metals.

Chemical migration through surface water runoff would only occur during heavy storm events. No surface water runoff pathways, drainage ditches, or catch basins are within the immediate vicinity of the site.

Personnel engaged in the maintenance and operations of equipment work adjacent to the site on a daily basis. Personnel are also on the site occasionally to mow the grass. Current workers and future workers or residents could come in contact with COPC in site soils. Exposure to soils could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from groundwater.

Site 16: Crash Crew Pit No. 2

The Crash Crew Pit No. 2 is located in the central runway area of the Station near the current fire training area. As with Crash Crew Pit No. 1, fuel, gasoline, and other liquid wastes were burned during fire fighting training activities. COPC detected in soil include solvents, petroleum hydrocarbons, fuels, and metals.

A potential pathway for migration of chemicals at the site is expected to be through groundwater, as ponded fluids infiltrated into the soil beneath the pits.

COPC would migrate vertically to groundwater, then northwesterly along the regional groundwater gradient. COPC in groundwater below the consisted of chloroform and metals.

Chemical migration may also have occurred through surface water runoff. A drainage ditch runs along the northwest side of the site that could potentially transport chemicals by surface water runoff during storm events to Bee Canyon Wash. No surface water runoff or sediment samples were taken at this site.

The pits are not currently in use; however, the grass on the site is mowed occasionally and training events are held monthly at the adjacent new training facility. Current workers and future workers or residents could come in contact with COPC in site soils. Exposure to soils could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from water.

Site 17: Communication Station Landfill

The Communication Station Landfill is a 26-acre site located in a small canyon to the east of the Station. The landfill was used from 1981 through 1983 as a Station-wide disposal facility. The site is currently covered with soil, grass, and scrub brush. COPC detected in soils include pesticides, PAHs, petroleum hydrocarbons, solvents, fuels and metals. The only chemical detected in landfill gas at the site was methylene chloride.

The potential chemical transport pathway at the site is migration to groundwater. Leachate from the landfill, as well as chemicals deposited at the landfill, may have infiltrated through the soil and migrated vertically down to groundwater. COPC detected in groundwater included carbon tetrachloride, chloroform and metals.

Originally, surface water drainage in the small canyon probably flowed west to join Agua Chinon Wash. However, the natural drainage has been obliterated in the canyon by the landfill and by soil from the hill being dismantled above the landfill. Below the landfill the soil appears to be disked, possibly to support agricultural activities. The disruption of the drainage, together with the permeable soils and small watershed area, greatly reduce the importance of surface water as a potential chemical transport mechanism.

The site is no longer active; however, future workers or residents could come in contact with COPC in site soils. Exposure to soils could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from groundwater.

Site 18: Regional Groundwater Contamination

The regional groundwater VOC investigation is being conducted to map the extent of groundwater contamination originating at the station (predominantly VOCs) and to assess the potential sources of the contamination.

Potentially, both point and nonpoint sources of contamination exist at the Station. The main potential transport media include air, surface water, and groundwater. Surface water is conveyed from the facility along four major drainages. Two of the drainages, Bee Canyon Wash and Agua Chinon Wash, are enclosed culverts through most of the distance across the Station. The other two washes, Borrego Canyon Wash and Marshburn Channel, are lined along the Station boundaries although there are cracks in the concrete. Surface water from the four washes may either flow to San Diego Creek and finally to Upper Newport Bay during storm events, infiltrate through the bottoms of the washes or cracks in the culverts or channels to groundwater, or evaporate.

Chemicals released from buried wastes, contaminated sediments, or surface soils may infiltrate downward through the vadose zone to the groundwater. Chemicals in groundwater may then migrate along regional flowpaths to the northwest beneath the Tustin Plain. Horizontal flow may occur along more permeable buried stream channels that may roughly parallel the major surface washes running through the Station.

Downward vertical hydraulic gradients exist that can convey groundwater from shallow zones beneath the facility to deeper zones west of the facility. Downward gradients are expected because the Station serves as a groundwater recharge zone for the basin, and because the main groundwater discharge from the basin is to deep wells located west of the facility.

Numerous COPC were detected in subsurface soils, sediments, surface waters, and groundwater collected from areas thought to be potential sources of the groundwater VOC contamination. COPC detected in both sediments and subsurface soils included pesticides, solvents, petroleum hydrocarbons, fuels, and metals. COPC detected in surface water runoff include pesticides, volatile organic chemicals, solvents, and metals. COPC detected in groundwater include volatile organic chemicals (e.g., dichloroethane, carbon tetrachloride, chloroform, tetrachloroethylene, and trichloroethylene), pesticides, solvents, fuels, and metals.

The regional groundwater contamination includes areas both on- and off-Station. Currently, most wells located in the suspected contaminant area are used for monitoring and agricultural purposes. Three wells located to the west and northwest of the site are currently being used for municipal purposes. These wells are Tustin well 77, Santa Ana well 26, and The Irvine Company (TIC) Well 25.

Future on-Station and off-Station workers or residents could potentially be exposed to COPC in groundwater. Exposures to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from groundwater.

Individuals from nearby residential areas could be exposed to surface water runoff or sediments from the Station. Exposure to sediments could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates. Exposure to surface water could occur through incidental ingestion or dermal contact.

Site 19: Aircraft Expeditionary Refueling (ACER) Site

The ACER site is located in the southeast quadrant of the Station and was used to store six 20,000-gallon aboveground jet fuel bladder tanks. Bladder ruptures resulted in spillage throughout the operational period of the facility. The site is currently fenced and covered with grass. COPC detected in soil included PAHs, petroleum hydrocarbons, fuels, pesticides, solvents, and metals.

A potential route of chemical transport at the site is infiltration of water through contaminated soils to groundwater. COPC detected in groundwater below the site include tetrachloroethylene, trichloroethylene, metals, and low level radioactivity.

Surface water transport is not considered a major pathway because spills were contained within a berm surrounding the tanks. The topography is also flat with no discrete drainage channels.

The leaking fuel bladders were removed from the site in 1987; however, the site is still used for fueling. Personnel work on the site daily and grass is occasionally mowed. Current workers and future workers or residents could come in contact with COPC in site soils. Exposure to soils could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from groundwater.

Site 20: Hobby Shop

The Hobby Shop is located in the northwest quadrant of the Station and has been used by personnel to service privately owned vehicles. The site is currently paved within the shop area. The site has an underground waste oil tank, oil/water separators from which water drains into a ditch which runs along the site, and a solvent parts tanks from which sludge is dispersed to the oil/water separators. COPC detected in soils include solvents, petroleum hydrocarbons, PAHs, fuels, pesticides, and metals.

A potential pathway of chemical transport is through surface water runoff. COPC could potentially migrate from the site in surface water runoff through ditches to Marshburn Channel. From Marshburn Channel, the chemicals could be transported in storm runoff to San Diego Creek. COPC found in sediments consisted of solvents, petroleum hydrocarbons, fuels, and metals.

Another pathway of migration is through infiltration of chemicals to groundwater. Chemicals could infiltrate through the unlined ditch or ground surface near the tanks or separators and eventually reach the groundwater. The depth to groundwater is approximately 190 feet. Groundwater samples taken below the site contained trichloroethylene, methylchloride, and metals.

The site is currently in use. Grass at the site is also mowed occasionally. Current workers and future workers or residents could come in contact with COPC in site soils/sediments. Exposure to soils/sediments could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from groundwater.

Site 21: Materials Management Group, Building 320

The Materials Management Group site is located near the southwest Station boundary. The site, which is currently fenced, is used for distribution of supplies

and temporary storage of contaminated liquids. COPC detected in soils from the site include petroleum hydrocarbons, PAHs, fuels, solvents, pesticides, and metals.

A potential route of chemical transport is surface water runoff during storm events. A drainage ditch is located on the southwest corner of the site. Surface water runoff entering the ditch would eventually be transported to Bee Canyon Wash. COPC detected in sediment consist of PAHs, petroleum hydrocarbons, fuels, solvents, pesticides, and metals.

A second potential route of transport is through infiltration of chemicals downward through the soil to groundwater. COPC detected in groundwater include chloroform, trichloroethylene, solvents, and metals.

The site is currently in use and supply personnel are present daily. Exposure to contaminated soil is decreased by the gravel ground cover. Current workers and future workers or residents could come in contact with COPC in site soils/sediments. Exposure to soils/sediments could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from groundwater.

Site 22: Tactical Air Fuel Dispensing System

The Tactical Air Fuel Dispensing System (TAFDS) site is adjacent to Site 10 in the southwest quadrant of the Station. The site consists of two separate areas used for storage of fuel bladders and has an undocumented history of spills and leaks. The site is covered with concrete and aircraft matting and surrounded by grass. COPC detected in soil include PAHs, fuels, petroleum hydrocarbons, solvents, pesticides, and metals.

A potential pathway for chemical migration at the site is through infiltration to groundwater. COPC detected in groundwater below the site include carbon tetrachloride, tetrachloroethylene, trichloroethylene, fuels, metals and low level radioactivity.

Because of the volatile nature of many of the COPC and the lack of nearby drainage facilities to convey water, surface water runoff is probably not a pathway of concern.

The site is currently being used and personnel rotate through on duty. Current workers and future workers or residents could come in contact with COPC in site soils. Exposure to soils could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates.

Future workers or residents could also come in contact with COPC in groundwater. Exposure to chemicals in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from groundwater.

7.1.4.5 Quantification of Exposure

Exposure is defined as the contact of an organism with a chemical or physical agent. Exposure (or intake) is normalized for time and body weight and is expressed as milligrams of chemical per kilogram of body weight per day (mg/kg-day). Six basic factors are used to estimate intake: chemical concentration, contact rate, exposure frequency, exposure duration, body weight, and averaging time.

Exposure can be described by the following general equation:

$$\text{Exposure} = \frac{\text{Concentration} \times \text{Contact Rate} \times \text{Exposure Frequency} \times \text{Exposure Duration}}{\text{Body Weight} \times \text{Averaging Time}}$$

Exposure Estimation for Cancer Effects. The intake of a chemical evaluated for cancer health effects (i.e., lifetime average chemical intake) is calculated by

prorating the total cumulative dose of the chemical over an averaging time of an entire life span (assumed to be 70 years). The selection of an averaging time that spans a lifetime is based on U.S. EPA guidance: "The approach for carcinogens is based on the assumption that a high dose received over a short period of time is equivalent to a corresponding low dose spread over a lifetime" (U.S. EPA, 1989a).

Exposure Estimation for Noncancer Effects. The intake of chemicals evaluated for noncancer health effects is estimated over an averaging time dependent on the actual duration of exposure being evaluated. This assessment evaluates the effects of chronic exposure to chemicals on the basis of systemic toxic effects. The averaging time used is based on the estimated period of exposure.

Reasonable Maximum Exposure. U.S. EPA guidance states that remedial actions at Superfund sites should be based on an estimate of the "reasonable maximum exposure" expected to occur under both current and future land use conditions. The reasonable maximum exposure is defined as the "highest exposure that is reasonably expected to occur at a site" (U.S. EPA, 1989a). The intent of the reasonable maximum exposure is to estimate a conservative exposure case (i.e., well above the average case) that is still within the range of possibilities. Each exposure factor has a range of possible values. To the extent possible, this assessment has selected values for the exposure factors that result in an estimate of the reasonable maximum exposure.

7.1.4.6 Exposure Assumptions

Potentially exposed populations to site-related contamination in surface and near-surface soil and soil borings include current on-Station workers, future on-Station workers, and future on-Station residents. Potentially exposed populations to site related contamination in groundwater include current agricultural workers and future on-Station and off-Station workers and residents. In addition, future on-Station and current off-Station residents could potentially be exposed to COPC present in on-Station sediment and surface water runoff, and in off-Station

sediment and surface water runoff, in the washes and San Diego Creek, respectively.

Based on potential exposure frequency, duration, and estimated contact rates, future residents exposed to contaminated soils, sediments, groundwater, surface water, and soil-gas are expected to be the maximally exposed population. Risk-based concentrations are derived in this preliminary risk assessment for the residential exposure scenarios. Residential exposure to the COPC is assumed for the following exposure routes:

- Oral ingestion of soil, sediment, surface water, and groundwater
- Inhalation of organics that volatilize from soil, sediment, and groundwater
- Inhalation of airborne particulates from soil and sediment
- Dermal absorption of soils, sediments, and surface water

Future on-Station residents could be exposed to COPC in surface soil through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates. In addition, it is likely that the on-Station sites would need to be excavated and graded to build housing. To evaluate exposure to potential future on-Station residents, it was assumed that the top 10 feet could be excavated or graded. This is the maximum depth to which soil is likely to be excavated on residential property in California (Reynolds et al., 1990).

Exposure to COPC in groundwater could occur through ingestion, dermal contact, or inhalation of chemicals volatilized from groundwater used for domestic use. People can be directly exposed to contaminants in groundwater through the ingestion of tap water. Individuals can also be exposed to chemicals volatilized from tap water to the air from showers, baths, toilets, dishwashers, washing machines, and cooking. Dermal absorption could occur during bathing, showering, food preparation, and washing dishes.

Children could potentially be exposed to sediment or surface water while playing in the washes or creek (recreational exposure). Exposures to sediment could occur through incidental ingestion, dermal contact, inhalation of volatilized chemicals, or inhalation of airborne particulates. Individuals coming in contact

with COPC in surface water in the washes during storm events or in the San Diego Creek may be exposed through incidental ingestion or dermal contact. For this preliminary risk assessment, it is assumed that a child (ages 9 through 16) may come in contact with surface water and sediment 26 days/year for 2 hours/day. This is likely a conservative estimate due to the limited amount of surface water in the washes and creek, the limited access to onsite washes, and the land use in areas surrounding the creek southwest of the Station (i.e., commercial and agricultural).

Summaries of the exposure assumptions (i.e., contact rate, exposure frequency, exposure duration, body weight, and averaging time) used to estimate risk-based concentrations are presented in Tables 7-11 through 7-14 for the soil, groundwater, surface water, sediment, and air pathways.

In spite of the uncertainties inherent in estimating exposure by dermal absorption, this exposure pathway has been evaluated for the soil/sediment and surface water pathways using conservative assumptions. This approach is intended to provide an upper bound estimate of exposure by dermal absorption. The dermal absorption efficiency for soils and sediment was assumed to be 10 percent for organic chemicals and 1 percent for inorganic chemicals (SCAQMD, 1988). For dermal contact with surface water, the estimated chemical-specific skin permeability constants obtained from EPA guidance on dermal exposure (1992a). A default permeability constant for water (1.5×10^{-3} cm/hr) was used for organic COPC in surface water runoff with no estimated values. A default value of 1×10^{-3} cm/hr was used for inorganic COPC (EPA, 1992a).

This preliminary risk assessment does not quantitatively estimate dermal absorption from household water use. Cothorn et al. (1985) suggest that intake through dermal absorption would normally be much less (by several orders of magnitude) than either the ingestion or inhalation routes in a household setting where exposure comes from the water supply. Estimation of household exposures by Foster and Chrostowski (1986) yields similar results. In this assessment, dermal absorption in the residential groundwater use setting is considered not likely to be a significant route of exposure.

Table 7-11 Exposure Assumptions for Soil Pathways MCAS El Toro Phase I RI Technical Memorandum	
Exposure Parameter	Reasonable Maximum Exposure^a
Exposed Individual	Resident
Body Weight (kg)	15 (0-6 year) 70 (>6 year)
Soil Ingestion Rate (mg/day)	200 (0-6 year) 100 (>6 year)
Inhalation Rate (m ³ /day)	20 ^b
Soil-to-Volatilization Factor (m ³ /kg)	Chemical specific ^c
Particulate Emission Factor (m ³ /kg)	4.63 x 10 ⁹
Skin Surface Area (cm ²)	5800 ^d
Absorption Factor (fraction)	0.10 (organics) ^e 0.01 (inorganics)
Soil-to-Skin Adherence Factor (mg/cm ²)	0.5 ^e
Exposure Frequency (days/year)	350
Exposure Duration (years)	30
<p>Notes:</p> <p>^aSource is EPA, 1991a, unless otherwise noted.</p> <p>^bEPA, 1991b.</p> <p>^cInhalation of volatilized chemicals from groundwater was evaluated for all COPC with a Henry's Law Constant (HLC) greater than or equal to 1 x 10⁻⁵ atm-m³/mole and a molecular weight (MW) less than or equal to 200 g/mole. (See Table 7-9 for chemical-specific HCLs and MWs).</p> <p>^dEPA, 1989a. Exposed adult surface area is assumed to include arms, hands, and lower legs.</p> <p>^eSCAQMD, 1988.</p>	

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Table 7-12 Exposure Assumptions for Groundwater Pathways MCAS El Toro Phase I RI Technical Memorandum	
Exposure Parameter	Reasonable Maximum Exposure^a
Exposed Individual	Resident
Body Weight (kg)	70
Ingestion Rate(l/day)	2
Inhalation Rate (m ³ /days)	15
Volatilization factor from groundwater (m ³ /day)	0.5 ^b
Exposure Frequency (days/year)	350
Exposure Duration (years)	30
Notes: ^a EPA, 1991a. ^b Inhalation of volatilized chemicals from groundwater was evaluated for all COPC with a Henry's Law Constant (HLC) greater than or equal to 1×10^{-5} atm-m ³ /mole and a molecular weight (MW) less than or equal to 200 g/mole. (See Table 7-9 for chemical-specific HLCs and MWs.)	

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Table 7-13 Exposure Assumptions for Sediment and Surface Water Pathways MCAS El Toro Phase I RI Technical Memorandum	
Exposure Parameter	Reasonable Maximum Exposure^a
Exposed individual	Recreational User (Age 9 - 16)
Body weight (kg)	46 ^b
Water ingestion rate (mL/hour)	5 ^c
Soil ingestion rate (mg/day)	100
Inhalation rate (m ³ /hour)	0.7 ^d
Soil-to-air volatilization factor (m ³ /kg)	chemical specific ^e
Particulate emission factor (m ³ /kg)	4.63 x 10 ⁹
Surface area (cm ²)	5600 ^b
Absorption factor (fraction)	0.10 (organics) ^f 0.01 (inorganics)
Soil-to-skin adherence factor (mg/cm ²)	0.5 ^f
Exposure time (hours/day)	2 ^c
Exposure frequency (days/year)	26 ^c
Exposure duration (years)	7
<p>Notes:</p> <p>^aSource is EPA, 1991a, unless otherwise noted.</p> <p>^bEPA, 1985. Exposed surface area is assumed to include arms, hands, lower legs, and feet.</p> <p>^cBased on professional judgment.</p> <p>^dEPA, 1989c.</p> <p>^eInhalation of volatilized chemicals from sediments was evaluated for all COPC with a Henry's Law Constant (HLC) greater than or equal to 1 x 10⁻⁵ atm-m³/mole and a molecular weight (MW) less than or equal to 200 g/mole. (See Table 7-9 for chemical-specific HLCs and MWs.)</p> <p>^fSCAQMD, 1988.</p>	

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Table 7-14	
Exposure Assumptions for Landfill Gas Pathways	
MCAS El Toro Phase I RI Technical Memorandum	
Exposure Parameter	Reasonable Maximum Exposure^a
Exposed individual	Resident
Body weight (kg)	70
Inhalation rate (m ³ /day)	20 ^b
Exposure frequency (days/year)	350
Exposure duration (years)	30
Notes: ^a Source is EPA, 1991a, unless otherwise noted. ^b EPA, 1991b.	

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7.1.5 Toxicity Assessment

The toxicity assessment involves identifying the COPC to cause adverse health effects in exposed individuals. The toxicity assessment also seeks to develop a reasonable appraisal of the associations between the degree of exposure to a contaminant and the possibility of adverse health effects. A chemical agent may not cause adverse toxic effects in biological systems unless the agent, or its metabolic byproducts, reach critical receptor sites in the body at specific levels and for a period of time sufficient to illicit a particular effect. Whether or not a toxic response occurs depends on the chemical and physical properties of the toxic agent, the degree of exposure to the agent, and the susceptibility of an individual to the particular effect. To characterize the toxicity of a particular chemical, the type of effect it can produce and how much is needed to produce that effect must be known.

The toxicity assessment consists of two components:

- **Hazard Identification:** the process of evaluating what types of adverse human health effects may result from exposure to the COPC.
- **Dose-Response Evaluation:** a quantitative examination of the relationship between the level of exposure and the occurrence of adverse health effects in the potentially exposed population.

7.1.5.1 Hazard Identification

In this preliminary risk assessment, human health risks are evaluated in terms of cancer and noncancer risks. Chemicals posing cancer risks frequently have noncancer effects, also.

Cancer Effects

Cancer effects result in, or are suspected to result in, the development of cancer. Based on available data, EPA assumes a nonthreshold mechanism for carcinogens. Therefore, any amount of exposure to a carcinogenic chemical is

assumed to pose a potential for generating a carcinogenic response in the exposed organism.

EPA has developed a carcinogen classification scheme (EPA, 1986a) using a weight-of-evidence approach to determine the likelihood of a chemical's carcinogenic potential in humans. Information considered in developing the classification system includes epidemiological evidence (human studies) of the association between cancer incidence and exposure; long-term animal studies conducted under controlled laboratory settings; short-term tests for genotoxicity, metabolic, and pharmacokinetic properties; toxicological effects other than cancer; structure-activity relationships; and physical/chemical properties of the chemical. Chemicals are classified by EPA as:

- A - Known human carcinogen
- B1 - Probable human carcinogen; limited human data are available
- B2 - Probable human carcinogen; sufficient evidence in animals and inadequate or no evidence in humans
- C - Possible human carcinogen
- D - Not classifiable as to human carcinogenicity
- E - Evidence of noncarcinogenicity for humans

Noncancer Effects

Noncancer or systemic effects are assumed to exhibit a level of exposure from above zero to some finite value that can be tolerated by the organism without causing an observed health effect. Noncancer health effects include a variety of toxicological end points and may include effects on specific organs or systems, such as the kidney (nephrotoxicants), the liver (hepatotoxicants), the nervous system (neurotoxicants), the lungs (pulmonary toxicants), and reproductive toxicants. Organisms may have adaptive mechanisms that must be overcome before a toxic effect can be detected. The systemic toxicity of a chemical is assessed through a review of toxic effects noted in short-term (acute) animal

studies, long-term (chronic) animal studies, and epidemiological investigations describing effects on humans.

7.1.5.2 Dose-Response Evaluation

The magnitude of chemical toxicity depends upon the degree of exposure to a substance (i.e., the dose-response relationship). Critical toxicity values are a quantitative expression of the dose-response relationship for a chemical. Toxicity values are expressed as slope factors and reference doses, both of which are specific to routes of exposure.

Several sources of toxicity values are used in the preliminary risk assessment. The primary source is EPA's Integrated Risk Information System (IRIS) data base (EPA, 1992b). This data base is EPA's repository of verified toxicity values. If a toxicity value is not available through IRIS, then the most current update of the Health Effects Assessment Summary Table (HEAST) (EPA, 1992c) is consulted. HEAST summarizes interim toxicity values.

Toxicity Values for Cancer Effects

Current EPA guidelines recommend using a linearized multistage model for carcinogenicity, when appropriate, for extrapolating from the high exposure levels used in animal experiments to low exposure levels typical of environmental exposures (EPA, 1989a). The model assumes that there is no threshold for carcinogens and that any exposure leads to some risk.

The toxicity value used to describe the dose-response relationship for carcinogenic chemicals is called the cancer slope factor (SF). Generally, the SF is a plausible upperbound estimate of the probability of a carcinogenic response per unit intake of a chemical over a lifetime. The SF factor is the upper 95 percent confidence limit on the slope of the dose-response (response per unit intake) curve which is obtained from the linearized multistage model of animal data. SFs are expressed as the inverse of milligrams of chemical per kilogram of body weight per day $(\text{mg}/\text{kg}\cdot\text{day})^{-1}$. The SFs used in this risk assessment are

presented in Table 7-15. In the absence of chemical-specific inhalation and dermal SFs, oral SFs have been used.

Data used for estimating the dose-response relationship are derived from lifetime animal studies and human occupational or epidemiological studies where excessive cancer incidence has been positively associated with exposure to a particular chemical. In animal studies, the assumption is that if a carcinogenic response occurs at the dose levels used in the study, then a response will occur at all lower dose levels. For practical reasons, low levels of risk cannot be measured directly, either by animal experiments or by epidemiological studies (EPA, 1984a). Some adjustments are made to account for interspecies differences. This is a conservative approach, however, and may overestimate the actual risk. The use of carcinogenic SFs assumes that cancer is probabilistic and that any degree of exposure leads to some degree of risk.

Toxicity Values for Noncancer Health Effects

The critical toxicity value used to describe the dose-response relationship for noncancer health effects is the reference dose (RfD). The EPA (1989a) defines the RfD as:

"...an estimate (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive subgroups) that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfD is generally expressed in units of milligrams per kilogram of body weight per day (mg/kg/day)."

Reference doses for effects associated with inhalation of a particular chemical are given as a reference concentration (RfC) (mg/m^3) which can be converted to an intake in terms of mg/kg/day.

Uncertainty factors and modifying factors are used to derive RfDs from the No Observed Adverse Effect Level (NOAEL) or the Lowest Observed Adverse Effect

Table 7-15
Dose-Response Variables for Chemicals of Concern-Cancer Health Effects
MCAS El Toro Phase I RI Technical Memorandum

Chemical	Carcinogenic Potency (mg/kg/day) ⁻¹						
	Tumor Site	Oral Slope Factor	Weight of Evidence ^a	Source	Inhalation Slope Factor	Weight of Evidence ^a	Source
ORGANICS:							
1,1,1-Trichloroethane	--	--	D	IRIS	--	D	IRIS
1,1-Dichloroethane	--	--	C	IRIS	--	C	IRIS
1,1-Dichloroethene	Lung, Mammary gland	0.6	C	IRIS	0.185	C	IRIS
1,1,2-Trichloroethane	Liver, Spleen	0.057	C	IRIS	0.058	C	IRIS
1,2-Dichloroethane	Liver	0.091	B2	IRIS	0.091	B2	IRIS
1,2-Dichloroethene (total)	--	--	D	IRIS	--	D	IRIS
2,4,5-Trichlorophenoxy propionic acid	--	--	D	IRIS	--	D	IRIS
2,4,5-T	--	--	--	--	--	--	--
2,4-D	--	--	--	--	--	--	--
2,4-DB	--	--	--	--	--	--	--
2,4-Dimethylphenol	--	--	--	--	--	--	--
2-Butanone	--	--	D	IRIS	--	D	IRIS
2-Hexanone	--	--	--	--	--	--	--
2-Methylnaphthalene	--	--	--	--	--	--	--
4',4'-DDD	Lung, Liver	0.24	B2	IRIS	--	--	--
4',4'-DDE	Liver	0.34	B2	IRIS	--	--	--
4',4'-DDT	Lung, Liver	0.34	B2	IRIS	0.34	B2	IRIS
4-Methyl-2-pentanone	--	--	--	--	--	--	--
4-Methylphenol	--	--	C	IRIS	--	C	IRIS
4-Nitrophenol	--	--	--	--	--	--	--
Acenaphthene	--	--	--	--	--	--	--
Acenaphthylene	--	--	D	IRIS	--	D	IRIS
Acetone	--	--	D	IRIS	--	D	IRIS
Aldrin	Liver	17.0	B2	IRIS	17	B2	IRIS
Alpha chlordane	Liver	1.3 ^b	B2	IRIS	1.3 ^b	B2	IRIS
Alpha-BHC	Liver	6.3	B2	IRIS	6.3	B2	IRIS
Anthracene	--	--	D	IRIS	--	D	IRIS
Benzene	Nonlymphocytic leukemia	0.029	A	IRIS	0.029	A	IRIS
Benzo(a)anthracene	Liver, Lung	7.3 ^c	B2	EPA 7/10/92	--	B2	IRIS

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Table 7-15
Dose-Response Variables for Chemicals of Concern-Cancer Health Effects
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Chemical	Carcinogenic Potency (mg/kg/day) ⁻¹						
	Tumor Site	Oral Slope Factor	Weight of Evidence ^a	Source	Inhalation Slope Factor	Weight of Evidence ^a	Source
Benzo(a)pyrene	Gut, Respiratory tract	7.3	B2	IRIS	--	B2	IRIS
Benzo(b)fluoranthene	Liver, Lung, Thorax	7.3 ^c	B2	EPA 7/10/92	--	B2	IRIS
Benzo(g,h,i)perylene	--	--	D	IRIS	--	D	IRIS
Benzo(k)fluoranthene	Liver, Lung, Thorax	7.3 ^c	B2	EPA 7/10/92	--	B2	IRIS
Benzyl butyl phthalate	Leukemia	--	C	IRIS	--	C	IRIS
Beta chlordane	Liver	1.3 ^b	B2	IRIS	1.3 ^b	B2	IRIS
Beta-BHC	Liver	1.8	C	IRIS	1.9	C	IRIS
bis(2-Ethylhexyl)phthalate	Liver	0.014	B2	IRIS	--	B2	IRIS
Bromodichloromethane	Large intestine, Liver, Kidney	0.062	B2	IRIS	--	--	--
Bromoform	Large intestine	0.0079	B2	IRIS	0.0038	B2	IRIS
Carbazole	Liver	0.02	B2	HEAST	--	--	--
Carbon disulfide	--	--	--	--	--	--	--
Carbon tetrachloride	Liver	0.13	B2	IRIS	0.053	B2	IRIS
Chlorobenzene	--	--	D	IRIS	--	D	IRIS
Chlorodibromomethane	Liver	0.084	C	IRIS	--	C	IRIS
Chloroform	Liver, Kidney	0.0061	B2	IRIS	0.081	B2	IRIS
Chrysene	Liver	7.3	B2	EPA 7/10/92	--	B2	EPA 7/10/92
Dalapon	--	--	--	--	--	--	--
Delta-BHC	--	--	D	IRIS	--	D	IRIS
Dibenzo(a,h)anthracene	Mammary gland	7.3	B2	EPA 7/10/92	--	B2	EPA 7/10/92
Dibenzofuran	--	--	D	IRIS	--	D	IRIS
Dicamba	--	--	--	--	--	--	--
Dichloroprop	--	--	--	--	--	--	--
Dieldrin	Liver, Lungs	16	B2	IRIS	16	B2	IRIS
Diethyl phthalate	--	--	D	IRIS	--	D	--
Dimethyl phthalate	--	--	D	IRIS	--	--	--
Di-n-butyl phthalate	--	--	D	IRIS	--	D	IRIS
Endosuffan I	--	--	--	--	--	--	--
Endosuffan II	--	--	--	--	--	--	--
Endosuffan sulfate	--	--	--	--	--	--	--

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Table 7-15
Dose-Response Variables for Chemicals of Concern-Cancer Health Effects
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Chemical	Carcinogenic Potency (mg/kg/day) ⁻¹						
	Tumor Site	Oral Slope Factor	Weight of Evidence ^a	Source	Inhalation Slope Factor	Weight of Evidence ^a	Source
Endrin	--	--	D	IRIS	--	D	IRIS
Endrin aldehyde	--	--	--	--	--	--	--
Endrin ketone	--	--	--	--	--	--	--
Ethylbenzene	--	--	D	IRIS	--	D	IRIS
Fluoranthene	--	--	D	IRIS	--	D	IRIS
Fluorene	--	--	D	IRIS	--	D	IRIS
Gamma chlordane	Liver	1.3 ^d	B2	IRIS	1.3 ^d	B2	IRIS
Heptachlor	Liver	4.5	B2	IRIS	4.6	B2	IRIS
Heptachlor epoxide	Liver	9.1	B2	IRIS	9.1	B2	IRIS
Hexachloroethane	Kidney	0.014	C	IRIS	49.0	C	IRIS
Indeno(1,2,3-cd)pyrene	Liver	7.3	B2	EPA 7/10/92	--	B2	EPA 7/10/92
Isophorone	Liver, Preputial gland	0.001	C	IRIS	--	--	--
Lindane	Liver	1.3	B2	HEAST	--	--	--
MCPA	--	--	--	--	--	--	--
MCPP	--	--	--	--	--	--	--
Methane	--	--	--	--	--	--	--
Methoxychlor	--	--	D	IRIS	--	D	IRIS
Methyl chloride	Kidney	0.013	C	HEAST	0.0063	C	HEAST
Methylene chloride	Liver, Lung	0.0075	B2	IRIS	0.0016	B2	IRIS
Naphthalene	--	--	D	IRIS	--	D	IRIS
Octachlorodibenzo-p-dioxin	--	--	--	--	--	--	--
PCB 1248	Liver	7.7 ^d	B2	IRIS	--	B2	IRIS
PCB 1254	Liver	7.7 ^d	B2	IRIS	--	B2	IRIS
PCB 1260	Liver	7.7 ^d	B2	IRIS	--	B2	IRIS
Petroleum hydrocarbons (total recoverable)	Kidney, Liver	0.0017	C	EPA 3/24/92	0.00000048	C	EPA 3/24/92
Phenanthrene	--	--	D	IRIS	--	D	IRIS
Phenol	--	--	D	IRIS	--	D	IRIS
Pyrene	--	--	D	IRIS	--	D	IRIS
Tetrachloroethene	Liver, Leukemia	0.051	B2	HEAST	0.0018	B2	HEAST
Toluene	--	--	D	IRIS	--	D	IRIS

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Table 7-15
Dose-Response Variables for Chemicals of Concern-Cancer Health Effects
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Chemical	Carcinogenic Potency (mg/kg/day) ⁻¹						
	Tumor Site	Oral Slope Factor	Weight of Evidence ^a	Source	Inhalation Slope Factor	Weight of Evidence ^a	Source
TFH - diesel	Skin	--	D	EPA 3/24/92	--	D	EPA 3/24/92
TFH - gasoline	Kidney, Liver	0.002	C	EPA 3/24/92	--	C	EPA 3/24/92
Trichloroethylene	Lung, Liver	0.011	B2	HEAST	0.006	B2	HEAST
Vinyl chloride	Liver, Lung	1.9	A	HEAST	0.3	A	HEAST
Xylenes (total)	--	--	D	IRIS	--	D	IRIS
INORGANICS:							
Aluminum	--	--	--	--	--	--	--
Antimony	--	--	--	--	--	--	--
Arsenic	Lung	1.75	A	IRIS	15	A	IRIS
Barium	--	--	--	--	--	--	--
Beryllium	Lung, Bone	4.3	B2	IRIS	8.4	B2	IRIS
Cadmium	Lung	--	--	--	6.3	B1	IRIS
Chromium (VI)	Lung, Injection site	--	--	--	42	A	IRIS
Cobalt	--	--	--	--	--	--	--
Copper	--	--	D	IRIS	--	D	IRIS
Cyanide	--	--	D	IRIS	--	D	IRIS
Lead	Kidney	--	B2	IRIS	--	B2	IRIS
Manganese	--	--	D	IRIS	--	D	IRIS
Mercury	--	--	D	IRIS	--	D	IRIS
Nickel	--	--	--	--	--	--	--
Nitrate	--	--	--	--	--	--	--
Nitrite	--	--	--	--	--	--	--
Selenium	--	--	D	IRIS	--	D	IRIS
Silver	--	--	D	IRIS	--	D	IRIS
Thallium	--	--	D	IRIS	--	D	IRIS
Vanadium	--	--	--	--	--	--	--
Zinc	--	--	D	IRIS	--	D	IRIS
RADIONUCLIDES:							
Gross alpha	--	--	--	--	--	--	--
Gross beta	--	--	--	--	--	--	--

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Table 7-15
Dose-Response Variables for Chemicals of Concern-Cancer Health Effects
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Chemical	Carcinogenic Potency (mg/kg/day) ⁻¹						
	Tumor Site	Oral Slope Factor	Weight of Evidence ^a	Source	Inhalation Slope Factor	Weight of Evidence ^a	Source
<p>Notes:</p> <p>HEAST = Health Effects Assessment Summary Tables (EPA, 1992c).</p> <p>IRIS = Integrated Risk Information System (EPA, 1992b).</p> <p>EPA = EPA, July 10, 1992 memo from Roseanne M. Lorenzana or March 24, 1992 memo from Joan S. Dollarhide.</p> <p>-- = Information not available.</p> <p>CNS = Central Nervous System.</p> <p>^aWeight of Evidence Groups: A is Human Carcinogen; B is Probable Human Carcinogen (B1-limited evidence of carcinogenicity in humans, B2-sufficient evidence of carcinogenicity in animals with inadequate or lack of evidence in humans); C is Possible human Carcinogen; D is Not Classifiable as to Human Carcinogenicity.</p> <p>^bToxicity value is based on Chlordane.</p> <p>^cToxicity value is based on Benzo(a)pyrene.</p> <p>^dToxicity value is based on total PCBs.</p>							

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Level (LOAEL) in animal studies. The larger these factors are, the more uncertainty is associated with the RfD.

The RfDs and the critical effects for the COPC at the El Toro site are presented in Table 7-16. In the absence of chemical-specific inhalation and dermal RfDs, oral RfDs have been used.

Dioxin Toxicity Equivalence Factors. Dioxin and furan congeners have no SFs with the exception of 2,3,7,8-tetrachlorodibenzo-p-dioxin (2,3,7,8-TCDD) and mixtures of hexachlorodibenzo-p-dioxins. Until supporting data are available, the EPA Risk Assessment Forum has devised an interim approach using Toxicity Equivalence Factors (TEFs) for estimating risk from the congeners lacking SFs (EPA, 1989d). The TEF assumes a relative potency for carcinogens equivalent to the relative potency as measured in *in vitro* tests. Thus, if 2,3,7,8-TCDD has a TEF of 1, then octachlorodibenzo-p-dioxin is considered 1/1000 as potent (TEF= 0.001). TEFs used in this risk assessment are summarized in Table 7-17.

Toxicity of Fuels. Jet and diesel fuels are complex hydrocarbon mixtures produced by the distillation of crude oil. The actual composition for any given fuel will vary depending on the source of crude oil, the refinery processes used, and the product specifications. Jet fuels (JP-4 and JP-5) and diesel fuels are essentially specially-refined types of kerosene consisting of C₉-C₁₆ paraffins, cycloparaffins, aromatics, olefins, and a small amount of polycyclic aromatic hydrocarbons. The benzene content of jet fuels is typically less than 0.02 percent.

Due to their complex nature, provisional oral toxicity values have been developed for noncancer effects of diesel and jet fuels (EPA, 1992d). An oral reference dose of 0.02 mg/kg/day for JP-5 and kerosene is based on route-to-route extrapolation from inhalation data and therefore assumes equal absorption by both inhalation and oral routes.

No conclusive evidence for carcinogenicity of diesel or jet fuels to humans has been documented. Based on the available animal data, diesel fuel and jet fuels

(JP-4 and JP-5) have been assigned an EPA weight-of-evidence of D: not classifiable as to human carcinogenicity (EPA, 1992d).

Lead Toxicity Issues. EPA has developed the Uptake Biokinetic Model (UBK) to perform site-specific assessments of total lead exposure that predict blood levels in the most sensitive population. This population consists of children zero to 6 years of age who are exposed to lead in air, dust, drinking water, soil, and paint. The UBK model is a multimedia model that is capable of addressing lead exposures in different media. EPA uses the results of the UBK model to develop site-specific soil cleanup levels in accordance with a directive issued by the Office of Solid Waste and Emergency Response (OSWER), Directive Number 9355.4-02 (EPA, 1991c).

For the purposes of this preliminary risk assessment, a soil concentration of 500 mg/kg is used as a level of concern for lead. This value is based on use of the EPA UBK Model. Using the UBK Model, assuming a benchmark of 95% of the sensitive population having blood lead levels below 10 $\mu\text{g}/\text{dl}$, EPA has stated that a value of approximately 500 mg/kg is predicted as an acceptable level (EPA, 1991c). The value of 500 mg/kg is obtained by using the default parameters in the UBK Model for a residential scenario.

In June 1991, EPA also promulgated an action level for lead in drinking water (EPA, 1991d). This action level requires all public water systems to optimize corrosion control to minimize lead contamination resulting from corrosion of plumbing materials. Any water system whose water exceeds 15 $\mu\text{g}/\text{L}$ of lead in more than 90 percent of tap water samples must monitor their source water to determine whether treatment is required to remove lead. The regulation requires water suppliers to replace all lead service lines if treatment is ineffective for meeting the 15 $\mu\text{g}/\text{L}$ action level.

This regulation responds to scientific studies indicating adverse effects on humans, primarily on children, resulting from lead exposure. According to EPA (EPA, 1991c) these effects could include:

Table 7-16
Dose-Response Variables for Chemicals of Concern-Noncancer Effects
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Chemical	Systemic Toxicity (mg/kg/day)				
	Critical Effect	Oral RfD	Source	Inhalation RfD	Source
ORGANICS:					
1,1,1-Trichloroethane	Liver	0.09	HEAST	0.29	HEAST
1,1-Dichloroethane	Kidney damage	0.1	HEAST	0.1	HEAST
1,1-Dichloroethene	Liver	0.009	IRIS	a	--
1,1,2-Trichloroethane	Serum chemistry	0.004	IRIS	a	--
1,2-Dichloroethane	--	--	--	--	--
1,2-Dichloroethene (total)	Liver	0.009	HEAST	--	--
2,4,5-Trichlorophenoxy propionic acid	--	0.008	IRIS	--	--
2,4,5-T	Increased urinary coproporphyrins	0.01	IRIS	--	--
2,4-D	Blood, Liver, Kidney	0.01	IRIS	--	--
2,4-DB	Internal hemorrhages, Mortality	0.008	IRIS	--	--
2,4-Dimethyl phenol	--	0.02	IRIS	--	--
2-Butanone	CNS, Fetotoxic	--	--	0.29	IRIS
2-Hexanone	--	--	--	--	--
2-Methylnaphthalene	--	--	--	--	--
4',4'-DDD	--	--	--	--	--
4',4'-DDE	--	--	--	--	--
4',4'-DDT	Liver lesions	0.0005	IRIS	--	--
4-Methyl-2-pentanone	Liver, Kidney	0.05	HEAST	0.02	HEAST
4-Methylphenol	CNS	0.05	HEAST	--	--
4-Nitrophenol	--	--	--	--	--
Acenaphthene	--	0.06	IRIS	--	--
Acenaphthylene	--	a	--	--	--
Acetone	Liver, Kidney, CNS	0.1	IRIS	--	--

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Table 7-16
Dose-Response Variables for Chemicals of Concern-Noncancer Effects
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Chemical	Systemic Toxicity (mg/kg/day)				
	Critical Effect	Oral RfD	Source	Inhalation RfD	Source
Aldrin	Liver, Kidney	0.00003	IRIS	--	--
Alpha chlordane	Liver necrosis	0.00006 ^b	IRIS	a	--
Alpha-BHC	--	--	--	--	--
Anthracene	--	0.3	IRIS	--	--
Benzene	--	a	--	--	--
Benzo(a)anthracene	--	--	--	--	--
Benzo(a)pyrene	--	--	--	--	--
Benzo(b)fluoranthene	--	--	--	--	--
Benzo(g,h,i)perylene	--	--	--	--	--
Benzo(k)fluoranthene	--	--	--	--	--
Benzyl butyl phthalate	Liver, Kidney	0.2	IRIS	--	--
Beta chlordane	Liver necrosis	0.00006 ^b	IRIS	a	--
Beta-BHC	--	--	--	--	--
Bis(2-Ethylhexyl)phthalate	Liver	0.02	IRIS	--	--
Bromodichloromethane	Renal cytomegaly	0.02	IRIS	--	--
Bromoform	Hepatic lesions	0.02	IRIS	--	--
Carbazole	--	--	--	--	--
Carbon disulfide	Fetotoxic	0.1	IRIS	--	--
Carbon tetrachloride	Liver lesions	0.0007	IRIS	--	--
Chlorobenzene	Liver, Kidney	0.02	IRIS	0.005	HEAST
Chlorodibromomethane	Liver	0.02	IRIS	--	--
Chloroform	Liver	0.01	IRIS	--	--
Chrysene	--	--	--	--	--
Dalapon	Increased kidney weight	0.03	HEAST	--	--

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Table 7-16
Dose-Response Variables for Chemicals of Concern-Noncancer Effects
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Chemical	Systemic Toxicity (mg/kg/day)				
	Critical Effect	Oral RfD	Source	Inhalation RfD	Source
Delta-BHC	--	--	--	--	--
Diethyl phthalate	Decreased growth rate	0.8	IRIS	--	--
Dibenzo(a,h)anthracene	--	--	--	--	--
Dibenzofuran	--	--	--	--	--
Dicamba	Maternal, Fetal toxicity	0.03	IRIS	--	--
Dichloroprop	--	--	--	--	--
Dieldrin	Liver	0.00005	IRIS	--	--
Di-n-butyl phthalate	Increased mortality	0.1	IRIS	--	--
Dimethyl phthalate	Kidney	10	HEAST	--	--
Endosulfan I	Kidney	c	IRIS	--	--
Endosulfan II	Kidney	c	IRIS	--	--
Endosulfan sulfate	--	--	--	--	--
Endrin	Liver	0.0003	IRIS	--	--
Endrin aldehyde	--	--	--	--	--
Endrin ketone	--	--	--	--	--
Ethylbenzene	Liver, Kidney	0.1	IRIS	0.29	IRIS
Fluoranthene	--	0.04	IRIS	--	--
Fluorene	Dental fluorosis	0.04	IRIS	--	--
Gamma chlordane	Liver necrosis	0.00006 ^b	IRIS	a	--
Heptachlor	Liver weight in males	0.0005	IRIS	--	--
Heptachlor epoxide	Liver	0.00001	IRIS	--	--
Hexachloroethane	Atropy, Penal tubule degen.	0.001	IRIS	--	--
Isophorone	Kidney pathology	0.2	IRIS	--	--
Indeno(1,2,3-cd)pyrene	--	--	--	--	--

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Table 7-16
Dose-Response Variables for Chemicals of Concern-Noncancer Effects
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Chemical	Systemic Toxicity (mg/kg/day)				
	Critical Effect	Oral RfD	Source	Inhalation RfD	Source
Lindane	Liver, Kidney	0.0003	IRIS	--	--
MCPA	--	0.0005 (subchronic)	HEAST	--	--
MCPP	Increased kidney weight	0.001	IRIS	--	--
Methane	--	--	--	--	--
Methoxychlor	Excessive loss of young	0.005	IRIS	--	--
Methyl chloride	--	--	--	--	--
Methylene chloride	Liver	0.06	IRIS	0.86	HEAST
Naphthalene	Ocular and internal lesions	0.04	HEAST	--	--
Octachlorodibenzo-p-dioxins	--	--	--	--	--
PCB 1248	--	--	--	--	--
PCB 1254	--	--	--	--	--
PCB 1260	--	--	--	--	--
Petroleum hydrocarbons (total recoverable)	CNS, Kidney	0.20	EPA 3/24/92	--	--
Phenanthrene	--	--	--	--	--
Phenol	Reduced fetal body weights	0.6	IRIS	--	--
Pyrene	--	0.03	IRIS	--	--
Tetrachloroethene	Liver	0.01	IRIS	--	--
Toluene	Liver, Kidney	0.2	IRIS	0.11	HEAST
TFH - diesel	Kidney, Liver, Blood, Nasal mucosa	0.02	EPA 3/24/92	--	--
TFH - gasoline	CNS, Kidney, Lungs	0.2	EPA 3/24/92	--	--
Trichloroethylene	--	0.006	ECAO 1992	--	--
Vinyl chloride	--	--	--	--	--
Xylenes (total)	Decreased body weight	2.0	IRIS	--	--

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Table 7-16
Dose-Response Variables for Chemicals of Concern-Noncancer Effects
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Chemical	Systemic Toxicity (mg/kg/day)				
	Critical Effect	Oral RfD	Source	Inhalation RfD	Source
INORGANICS:					
Aluminum	--	--	--	--	--
Antimony	Blood glucose, Cholesterol	0.0004	IRIS	--	--
Arsenic	Keratoses, Hyperpigmentation	0.0003	IRIS	--	--
Barium	Increased blood pressure	0.07	IRIS	0.00014	HEAST
Beryllium	None observed	0.005	IRIS	--	--
Cadmium	Proteinuria	0.0005	IRIS	--	--
Chromium (VI)	None observed	0.005	IRIS	--	--
Cobalt	--	--	--	--	--
Copper	--	--	--	--	--
Cyanide	Thyroid, Myeline degeneration	0.02	IRIS	--	--
Lead	--	d	IRIS	--	--
Manganese	CNS	0.14 ^e	IRIS	0.00011	IRIS
Mercury	CNS, Kidney	0.0003	HEAST	0.000086	HEAST
Nickel	Decreased body/organ weight	0.02	HEAST	--	--
Nitrate	Methemoglobinemia	1.6	IRIS	--	--
Nitrite	Methemoglobinemia	0.1	IRIS	--	--
Selenium	Hair/nail loss, Dermatitis	0.005	IRIS	--	--
Silver	Argyria	0.005	IRIS	--	--
Thallium	Increased SGOT/LDH levels	0.00008	IRIS	--	--
Vanadium	None observed	0.007	HEAST	--	--
Zinc	Anemia	0.3	IRIS	--	--

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Table 7-16
Dose-Response Variables for Chemicals of Concern-Noncancer Effects
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Chemical	Systemic Toxicity (mg/kg/day)				
	Critical Effect	Oral RfD	Source	Inhalation RfD	Source
RADIONUCLIDES:					
Gross alpha	--	--	--	--	--
Gross beta	--	--	--	--	--
<p>Notes:</p> <p>HEAST = Health Effects Assessment Summary Tables (EPA, 1992c).</p> <p>IRIS = Integrated Risk Information System (EPA, 1992b).</p> <p>ECAO = Environmental Criteria and Assessment Office (EPA).</p> <p>EPA = EPA, July 10, 1992, memo from Roseanne M. Lorenzana or March 24, 1992, memo from Joan S. Dollarhide.</p> <p>-- = Information not available.</p> <p>CNS = Central Nervous System.</p> <p>^aToxicity value is pending.</p> <p>^bToxicity value is based on Chlordane.</p> <p>^cToxicity value withdrawn, pending further review.</p> <p>^dEPA work group considered it inappropriate to develop an RfD for inorganic lead.</p> <p>^eToxicity value is for intake from food. The oral RfD for intake from water is 0.005 mg/kg/day.</p>					

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Table 7-17 Dioxin Toxicity Equivalence Factors MCAS El Toro Phase I RI Technical Memorandum	
Compound	DTEF
Mono-, Di-, and Trichlorodibenzodioxin	0
2,3,7,8-Tetrachlorodibenzodioxin	1
Other Tetrachlorodibenzodioxins	0
2,3,7,8-Pentachlorodibenzodioxin	0.5
Other Pentachlorodibenzodioxins	0
2,3,7,8-Hexachlorodibenzodioxins	0.1
Other Hexachlorodibenzodioxins	0
2,3,7,8-Heptachlorodibenzodioxin	0.01
Other Heptachlorodibenzodioxins	0
Octochlorodibenzodioxin	0.001
Mono-, Di-, and Trichlorodibenzofurans	0
2,3,7,8-Tetrachlorodibenzofuran	0.1
Other Tetrachlorodibenzofurans	0
1,2,3,7,8-Pentachlorodibenzofuran	0.05
2,3,4,7,8-Pentachlorodibenzofuran	0.5
Other Pentachlorodibenzofurans	0
2,3,7,8-Hexachlorodibenzofurans	0.1
Other Hexachlorodibenzofurans	0
2,3,7,8-Heptachlorodibenzofurans	0.01
Other Heptachlorodibenzofurans	0
Octochlorodibenzofuran	0.001
Reference: EPA, 1989c	

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- Delays in normal physical and mental development in babies and young children
- Interferences with red blood chemistry
- Small increases in the blood pressure of some adults

Chromium Toxicity Values. Chromium toxicity values presented in Table 7-15 are based on hexavalent chromium. These values are used to assess the potential impacts based on chromium exposure in the absence of species-specific data (i.e., all chromium detected onsite is assumed to be hexavalent chromium).

Data indicate that essentially all chromium (III) compounds are oxidizable to chromium (VI) in soils (Bartlett and James, 1979; Bartlett and James, 1988). However, EPA (1991e) states that reduction of chromium (VI) compounds and oxidation of chromium (III) compounds in soils may occur simultaneously.

Based on this information, chromium is assumed to be in the hexavalent form, an assumption that may lead to an overestimate of risks.

Toxicity of Radionuclides. Screening measurements such as Gross alpha and gross beta particle activity do not specify the radionuclides present, and, therefore, do not have toxicity values for either cancer or noncancer effects. However, EPA designates all radionuclides as Class A carcinogens based on their property of emitting ionizing radiation and on the extensive weight of epidemiological evidence of radiation-induced cancer in humans (EPA, 1992a).

The current maximum contaminant levels (MCL) for gross alpha and gross beta are 15 picoCuries/Liter (pCi/L), and 4 millirem/year, respectively (EPA, 1992e).

7.1.6 Methodology for Development of Risk-Based Concentrations

Developing risk-based concentrations that are expected to be protective of human health requires the following information:

- Site-specific COPC
- Site-specific exposure pathways and routes
- Toxicity values for the site-specific COPC
- Target Risk Levels for cancer and noncancer health effects

Risk-based concentrations are specific to a chemical for a given exposure pathway (i.e., assume single chemical exposure, single medium). They are calculated by selecting a target risk level and solving the risk equation for media-specific concentrations. Risk-based concentrations for chemicals with cancer effects are determined using the following equation (EPA, 1991a):

$$\text{Concentration} = \frac{\text{Target Cancer Risk} \times \text{Body Weight} \times \text{Averaging Time}}{\text{Slope Factor} \times \text{Contact Rate} \times \text{Exposure Frequency} \times \text{Exposure Duration}}$$

In the same way, the equation for noncancer effects can be solved for concentration by the following equation (EPA, 1991a):

$$\text{Concentration} = \frac{\text{Target Noncancer Risk} \times \text{RfD} \times \text{Body Weight} \times \text{Averaging Time}}{\text{Contact Rate} \times \text{Exposure Frequency} \times \text{Exposure Duration}}$$

Risk-based concentrations in this preliminary risk assessment are calculated by setting the target risk for cancer health effects at 10^{-4} , 10^{-5} , and 10^{-6} . A cumulative lifetime risk of 10^{-6} is the NCP point of departure for the analysis for remedial alternatives, and according to EPA (1991), a cumulative lifetime risk of 10^{-4} is the point at which action is generally warranted at a site. The target risk for the risk-based concentrations calculated for noncancer health effects is one (EPA, 1991).

Appendix H1 presents a more detailed description of the methodology used to develop the risk-based concentrations for MCAS El Toro. Appendix H2 (Tables H2-1 through H2-10) presents the spreadsheets used for calculating the risk-based concentrations, which are based on reasonable maximum exposures and, therefore, represent a conservative exposure scenario.

Table 7-18 summarizes the risk-based concentrations for cancer and noncancer health effects based on the residential groundwater exposure scenario. Exposure

Table 7-18
Risk-Based Concentrations - Residential Scenario
Ingestion of Groundwater and Inhalation of
Volatiles from Household Water Use
MCAS El Toro Phase I RI Technical Memorandum

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Chemicals	Target Cancer Risk Concentrations (µg/L)			Target Noncancer Risk Concentration (µg/L)
	1×10^{-4}	1×10^{-5}	1×10^{-6}	
ORGANICS				
1,1,2-Trichloroethane	31	3.1	0.31	31
1,1-Dichloroethane	--	--	--	770
1,1-Dichloroethene	6.8	0.68	0.068	69
1,2-Dichloroethane	20	2	0.2	--
1,2-Dichloroethene	--	--	--	69
2,4,5-Trichloro-phenoxy proprionic acid	--	--	--	290
2,4,5-T	--	--	--	370
2,4-D	--	--	--	370
2,4-DB	--	--	--	290
2-Hexanone	--	--	--	--
4',4'-DDT	25	2.5	0.25	18
4-Methyl-2-pentanone	--	--	--	180
Acetone	--	--	--	770
Benzene	62	6.2	0.62	--
Benzyl butyl phthalate	--	--	--	7,300
Bis(2-ethylhexyl) phthalate	610	61	6.1	730
Bromodichloro-methane	29	2.9	0.29	150
Carbon disulfide	--	--	--	15,000
Carbon tetrachloride	26	2.6	0.26	5.4
Chlorobenzene	--	--	--	46

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Table 7-18
Risk-Based Concentrations - Residential Scenario
Ingestion of Groundwater and Inhalation of
Volatiles from Household Water Use
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Chemicals	Target Cancer Risk Concentrations ($\mu\text{g/L}$)			Target Noncancer Risk Concentration ($\mu\text{g/L}$)
	1×10^{-4}	1×10^{-5}	1×10^{-6}	
Chlorodibromo-methane	100	10	1.0	730
Chloroform	28	2.8	0.28	77
Dalapon	--	--	--	1,100
Dicamba	--	--	--	1,100
Dichloroprop	--	--	--	--
Dieldren	0.53	0.053	0.0053	1.8
Dimethyl phthalate	--	--	--	370,000
Ethyl benzene	--	--	--	1,600
Heptachlor	1.9	0.19	0.019	18
Lindane	6.6	0.66	0.066	11
MCPA	--	--	--	18
MCPP	--	--	--	37
Methyl chloride	230	23	2.3	--
Methylene chloride	620	62	6.2	1,700
Phenol	--	--	--	22,000
Tetrachloroethene	150	15	1.5	77
Toluene	--	--	--	970
TFH-diesel	--	--	--	730
TFH-gasoline	4,300	430	43	7,300
Trichloroethylene	250	25	2.5	46
Vinyl chloride	2.8	0.28	0.028	--
Xylene	--	--	--	15,000
INORGANICS				
Aluminum	--	--	--	--

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**Table 7-18
Risk-Based Concentrations - Residential Scenario
Ingestion of Groundwater and Inhalation of
Volatiles from Household Water Use
MCAS El Toro Phase I RI Technical Memorandum**

Chemicals	Target Cancer Risk Concentrations (µg/L)			Target Noncancer Risk Concentration (µg/L)
	1 x 10 ⁻⁴	1 x 10 ⁻⁵	1 x 10 ⁻⁶	
Antimony	--	--	--	15
Arsenic	4.9	0.49	0.049	11
Barium	--	--	--	2,600
Beryllium	2.0	0.20	0.020	180
Cadmium	--	--	--	18
Chromium	--	--	--	180
Cobalt	--	--	--	--
Copper	--	--	--	--
Cyanide	--	--	--	730
Lead	--	--	--	--
Manganese	--	--	--	180
Mercury	--	--	--	11
Nickel	--	--	--	730
Nitrate/nitrite	--	--	--	3,700
Selenium	--	--	--	180
Silver	--	--	--	180
Thallium	--	--	--	2.9
Vanadium	--	--	--	260
Zinc	--	--	--	11,000
RADIONUCLIDES				
Gross alpha	--	--	--	--
Gross beta	--	--	--	--

Notes:

-- Risk-based concentrations could not be calculated because toxicity values are not available.

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routes included in the calculations include ingestion and inhalation of volatilized chemicals during household use of groundwater.

Table 7-19 summarizes the risk-based concentrations for individual chemical cancer and noncancer health effects based on a residential soil exposure scenario. Individuals could be exposed to COPC in site soils by incidental ingestion of soil, dermal contact with soil, inhalation of volatilized chemicals, and inhalations of airborne particulates.

Under the recreational use scenario, individuals could be exposed to COPC in surface water and sediment by incidental ingestion of sediment or surface water, dermal contact with sediment or surface water, inhalation of volatilized chemicals from sediment, and inhalation of airborne sediment particulates while playing in or near surface water drainages. Risk-based concentrations for cancer and noncancer health effects are presented in Table 7-20 for sediment exposures and Table 7-21 for surface water exposures.

Calculated risk-based concentrations for exposure to volatile chemicals through the soil/sediment pathways were compared to their corresponding soil saturation concentration. Calculated risk-based concentrations greater than saturation concentrations were set to the saturation level. In addition, relatively nontoxic chemicals in soil and sediment with large calculated risk-based concentrations were set at a maximum of 10^8 $\mu\text{g}/\text{kg}$ or 10 percent in soils/sediment (EPA, 1993).

Risk-based concentrations for residential exposures to landfill gas which has migrated to ambient air are presented in Table 7-22. Only inhalation exposure is addressed in these calculations.

Risk-based concentrations have not been calculated for lead (which was detected in soil, sediment, groundwater, and surface water runoff) or for gross alpha and gross beta particle activity (which were detected in groundwater and surface water). As discussed in section 7.1.5.2, a soil concentration of 500 mg/kg is considered an acceptable level for children in a residential setting (EPA, 1991c) and the action level for lead in drinking water is 15 $\mu\text{g}/\text{L}$. The MCL for gross alpha

is 15 pCi/L (EPA, 1992e). These values will be used in the DQO process for evaluation of lead and low level radioactivity.

Chemicals with cancer effects have risk-based concentrations listed for risk levels of 10^{-4} to 10^{-6} . The most appropriate risk-based concentration for comparison to measured concentrations will depend on site-specific characteristics, such as the number of chemicals present and the number of exposure pathways contributing to site risk. Chemical-specific risk-based concentrations are most applicable to single-chemical and single-medium exposure scenarios. When more than one chemical is present (multichemical) or several exposure pathways contribute to site risk (multipathway), total site risks should remain within the appropriate target risk range.

Chemicals with both cancer and noncancer health effects will have more than one risk-based concentration listed in Tables 7-18 through 7-22. The more health conservative of the concentrations (most often the risk-based concentration for cancer effects) should be used for comparison to site chemicals.

7.1.7 Uncertainties and Limitations

Uncertainties in this risk assessment are due to uncertainties in the risk assessment process in general (i.e., the toxicological data base), specific uncertainties in characterizing the site, and uncertainties associated with describing exposures. This risk assessment is subject to uncertainty from a variety of sources including:

- Sampling and analysis
- Fate and transport estimation
- Exposure estimation
- Toxicological data

Uncertainty associated with sampling and analysis include the inherent variability (standard error) in the analysis, representativeness of the samples, sampling errors, and heterogeneity of the sample matrix. While the quality

Table 7-19 Risk-Based Concentrations - Residential Scenario Ingestion of Soil, Dermal Contact with Soil, Inhalation of Soil Particulates, and Inhalation of Soil Volatiles MCAS El Toro Phase I RI Technical Memorandum				
				Page 1 of 5
Chemicals	Target Cancer Risk Concentrations ($\mu\text{g}/\text{kg}$)			Target Noncancer Risk Concentration ($\mu\text{g}/\text{kg}$)
	1×10^{-4}	1×10^{-5}	1×10^{-6}	
ORGANICS				
1,1,1-Trichloroethylene	--	--	--	110,000 ^a
1,2-Dichloroethylene (total)	--	--	--	110,000
2,4-D	--	--	--	1,300,000
2,4-Dimethyl phenol	--	--	--	2,600,000
2,4,5-Trichlorophenoxy propionic acid	--	--	--	1,100,000
2,4,5-T	--	--	--	1,300,000
2,4-DB	--	--	--	1,100,000
2-Butanone	--	--	--	4,500,000 ^a
2-Hexanone	--	--	--	--
2-Methylnaphthalene	--	--	--	--
4',4'-DDD	130,000	13,000	1,300	--
4',4'-DDE	90,000	9,000	900	--
4',4'-DDT	90,000	9,000	900	66,000
4-Methylphenol	--	--	--	6,600,000
4-Methyl-2-pentanone	--	--	--	980,000 ^a
Acenaphthene	--	--	--	3,600,000 ^a
Acenaphthylene	--	--	--	--
Acetone	--	--	--	4,800,000
Aldrin	1,800	180	18	3,900
Alpha chlordane	24,000	2,400	240	7,900
Alpha BHC	4,900	490	49	--
Anthracene	--	--	--	1,300 ^a

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Table 7-19
Risk-Based Concentrations - Residential Scenario
Ingestion of Soil, Dermal Contact with Soil, Inhalation of Soil Particulates,
and Inhalation of Soil Volatiles
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Chemicals	Target Cancer Risk Concentrations ($\mu\text{g}/\text{kg}$)			Target Noncancer Risk Concentration ($\mu\text{g}/\text{kg}$)
	1×10^{-4}	1×10^{-5}	1×10^{-6}	
Benzene	240,000	24,000	2,400	--
Benzo(a)anthracene	4,200	420	42	--
Benzo(a)pyrene	4,200	420	42	--
Benzo(b)fluoranthene	4,200	420	42	--
Benzo(g,h,i)perylene	--	--	--	--
Benzo(k)fluoranthene	4,200	420	42	--
Benzyl butyl phthalate	--	--	--	26,000,000
Beta Chlordane	24,000	2,400	240	7,900
Bis(2-ethylhexyl) phthalate	2,200,000	220,000	22,000	2,600,000
Bromodichloromethane	21,000	2,100	210	1,100,000
Bromoform	3,900,000	390,000	39,000	2,600,000
Carbazole	1,500,000	150,000	15,000	--
Carbon disulfide	--	--	--	250,000 ^a
Carbon tetrachloride	63,000	6,300	630	12,000
Chlorodibromomethane	360,000	36,000	3,600	2,600,000
Chloroform	76,000	7,600	760	220,000
Chrysene	4,200	420	42	--
Dalapon	--	--	--	3,900,000
Delta BHC	--	--	--	--
Di-n-butyl phthalate	--	--	--	27,000,000
Dibenzo(a,h) anthracene	4,200	420	42	--
Dibenzofuran	--	--	--	--
Dichloroprop	--	--	--	--
Dieldren	1,900	190	19	6,600

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Table 7-19
Risk-Based Concentrations - Residential Scenario
Ingestion of Soil, Dermal Contact with Soil, Inhalation of Soil Particulates,
and Inhalation of Soil Volatiles
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Chemicals	Target Cancer Risk Concentrations ($\mu\text{g}/\text{kg}$)			Target Noncancer Risk Concentration ($\mu\text{g}/\text{kg}$)
	1×10^{-4}	1×10^{-5}	1×10^{-6}	
Diethyl phthalate	--	--	--	100,000,000 ^b
Dimethyl phthalate	--	--	--	100,000,000 ^b
Endosulfan I	--	--	--	--
Endosulfan II	--	--	--	--
Endosulfan sulfate	--	--	--	--
Endrin	--	--	--	39,000
Endrin aldehyde	--	--	--	--
Endrin ketone	--	--	--	--
Ethylbenzene	--	--	--	360,000 ^a
Fluoranthene	--	--	--	5,300,000
Fluorene	--	--	--	5,100,000
Gamma chlordane	24,000	2,400	240	7,900
Heptachlor epoxide	3,400	340	34	1,300
Hexachloroethane	2,100,000	210,000	21,000	130,000
Indeno(1,2,3-cd)pyrene	4,200	420	42	--
Isophorone	31,000,000	3,100,000	310,000	26,000,000
Lindane	24,000	2,400	240	39,000
MCPA	--	--	--	66,000
MCPP	--	--	--	130,000
Methoxychlor	--	--	--	660,000
Methylene chloride	39,000 ^a	39,000 ^a	3,900 ^a	39,000 ^a
Naphthalene	--	--	--	60,000 ^a
Octachlorodibenzo-p-dioxins	0.2	0.02	0.002	--
PCB 1248	4,000	400	40	--

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Table 7-19
Risk-Based Concentrations - Residential Scenario
Ingestion of Soil, Dermal Contact with Soil, Inhalation of Soil Particulates,
and Inhalation of Soil Volatiles
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Chemicals	Target Cancer Risk Concentrations ($\mu\text{g}/\text{kg}$)			Target Noncancer Risk Concentration ($\mu\text{g}/\text{kg}$)
	1×10^{-4}	1×10^{-5}	1×10^{-6}	
PCB 1254	4,000	400	40	--
PCB 1260	4,000	400	40	--
Petroleum hydrocarbons (total recoverable)	18,000,000	1,800,000	180,000	26,000,000
Phenanthrene	--	--	--	--
Phenol	--	--	--	79,000,000
Pyrene	--	--	--	3,900,000
Tetrachloroethene	460,000	46,000	4,600	140,000
TFH-diesel	--	--	--	2,600,000
TFH-gasoline	15,000,000	1,500,000	150,000	27,000,000
Toluene	--	--	--	330,000 ^a
Trichloroethylene	930,000	93,000	9,300	170,000
Xylene	--	--	--	98,000 ^a
INORGANICS				
Aluminum	--	--	--	--
Antimony	--	--	--	99,000
Arsenic	33,000	3,300	330	74,000
Barium	--	--	--	17,000,000
Beryllium	13,000	1,300	130	1,200,000
Cadmium	100,000,000 ^b	63,000,000	6,300,000	120,000
Chromium	94,000,000	9,400,000	940,000	1,200,000
Cobalt	--	--	--	--
Copper	--	--	--	--
Cyanide	--	--	--	4,900,000
Lead	--	--	--	--

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Table 7-19
Risk-Based Concentrations - Residential Scenario
Ingestion of Soil, Dermal Contact with Soil, Inhalation of Soil Particulates,
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Chemicals	Target Cancer Risk Concentrations ($\mu\text{g}/\text{kg}$)			Target Noncancer Risk Concentration ($\mu\text{g}/\text{kg}$)
	1×10^{-4}	1×10^{-5}	1×10^{-6}	
Manganese	--	--	--	34,000,000
Mercury	--	--	--	74,000
Nickel	--	--	--	4,900,000
Nitrate/nitrite	--	--	--	25,000,000
Selenium	--	--	--	1,200,000
Silver	--	--	--	1,200,000
Thallium	--	--	--	20,000
Vanadium	--	--	--	1,700,000
Zinc	--	--	--	74,000,000

Notes:

--Risk-based concentrations could not be calculated because toxicity values are not available.

^aFor chemicals with a calculated risk-based concentration higher than the soil saturation concentration, the soil saturation concentration is used.

^bA maximum cap of 10 percent or 100,000,000 $\mu\text{g}/\text{kg}$ was set for relatively nontoxic chemicals with high risk-based concentrations (EPA, 1993).

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Table 7-20 Risk-Based Concentrations - Recreational Scenario Ingestion of Sediment, Dermal Contact with Sediment, Inhalation of Sediment Particulates, and Inhalation of Sediment Volatiles MCAS El Toro Phase I RI Technical Memorandum				
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Chemicals	Target Cancer Risk Concentrations ($\mu\text{g}/\text{kg}$)			Target Noncancer Risk Concentration ($\mu\text{g}/\text{kg}$)
	1×10^{-4}	1×10^{-5}	1×10^{-6}	
ORGANICS				
2,4,5-Trichlorophenoxy propionic acid	--	--	--	14,000,000
2,4-DB	--	--	--	14,000,000
2-Butanone	--	--	--	4,600,000 ^a
2-Hexanone	--	--	--	--
2-Methylnaphthalene	--	--	--	--
4',4'-DDD	7,100,000	710,000	71,000	--
4',4'-DDE	5,000,000	500,000	50,000	--
4',4'-DDT	5,000,000	500,000	50,000	850,000
4-Methyl phenol	--	--	--	85,000,000
Acenaphthene	--	--	--	100,000,000
Acenaphthylene	--	--	--	--
Acetone	--	--	--	14,000,000 ^b
Alpha chlordane	1,300,000	130,000	13,000	100,000
Anthracene	--	--	--	1,300 ^a
Benzene	43,000,000	4,300,000	430,000	--
Benzo(a)anthracene	230,000	23,000	2,300	--
Benzo(a)pyrene	230,000	23,000	2,300	--
Benzo(b)fluoranthene	230,000	23,000	2,300	--
Benzo(g,h,i)perylene	--	--	--	--
Benzo(k)fluoranthene	230,000	23,000	2,300	--

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Table 7-20
Risk-Based Concentrations - Recreational Scenario
Ingestion of Sediment, Dermal Contact with Sediment,
Inhalation of Sediment Particulates, and Inhalation of Sediment Volatiles
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Chemicals	Target Cancer Risk Concentrations ($\mu\text{g}/\text{kg}$)			Target Noncancer Risk Concentration ($\mu\text{g}/\text{kg}$)
	1×10^{-4}	1×10^{-5}	1×10^{-6}	
Benzyl butyl phthalate	--	--	--	100,000,000 ^b
Beta chlordane	1,300,000	130,000	13,000	100,000
Bis(2-ethylhexyl) phthalate	100,000,000 ^b	12,000,000	1,200,000	34,000,000
Carbazole	85,000,000	8,500,000	850,000	--
Carbon tetrachloride	10,000,000	1,000,000	100,000	200,000 ^a
Chrysene	230,000	23,000	2,300	--
Dalapon	--	--	--	51,000,000
Delta BHC	--	--	--	--
Dibenzo(a,h)anthracene	230,000	23,000	2,300	--
Dibenzofuran	--	--	--	--
Dichloroprop	--	--	--	--
Dieldren	110,000	11,000	1,100	85,000
Endosulfan II	--	--	--	--
Endosulfan sulfate	--	--	--	--
Endrin	--	--	--	510,000
Endrin ketone	--	--	--	--
Fluoranthene	--	--	--	68,000,000
Fluorene	--	--	--	68,000,000
Gamma chlordane	1,300,000	130,000	13,000	100,000
Indeno(1,2,3-cd)pyrene	230,000	23,000	2,300	--
MCCP	--	--	--	1,700,000

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Table 7-20 Risk-Based Concentrations - Recreational Scenario Ingestion of Sediment, Dermal Contact with Sediment, Inhalation of Sediment Particulates, and Inhalation of Sediment Volatiles MCAS EI Toro Phase I RI Technical Memorandum				
Page 3 of 4				
Chemicals	Target Cancer Risk Concentrations ($\mu\text{g}/\text{kg}$)			Target Noncancer Risk Concentration ($\mu\text{g}/\text{kg}$)
	1×10^{-4}	1×10^{-5}	1×10^{-6}	
Methoxychlor	--	--	--	8,500,000
Methylene chloride	39,000 ^a	39,000 ^a	39,000 ^a	39,000 ^a
Petroleum hydrocarbons (total recoverable)	100,000,000 ^b	100,000,000	10,000,000	100,000,000 ^b
Phenanthrene	--	--	--	--
Pyrene	--	--	--	51,000,000
Toluene	--	--	--	330,000 ^a
TFH - diesel	--	--	--	34,000,000
TFH - gasoline	100,000,000 ^b	85,000,000	8,500,000	100,000,000
Trichloroethylene	300,000 ^a	300,000 ^a	300,000 ^a	300,000 ^a
INORGANICS				
Aluminum	--	--	--	--
Antimony	--	--	--	2,000,000
Arsenic	2,900,000	290,000	29,000	1,500,000
Barium	--	--	--	100,000,000 ^b
Beryllium	1,200,000	120,000	12,000	25,000,000
Cadmium	100,000,000 ^b	100,000,000 ^b	100,000,000 ^b	2,500,000
Chromium	100,000,000 ^b	100,000,000 ^b	100,000,000 ^b	25,000,000
Cobalt	--	--	--	--
Copper	--	--	--	--
Lead	--	--	--	--
Manganese	--	--	--	100,000,000 ^b

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Table 7-20 Risk-Based Concentrations - Recreational Scenario Ingestion of Sediment, Dermal Contact with Sediment, Inhalation of Sediment Particulates, and Inhalation of Sediment Volatiles MCAS El Toro Phase I RI Technical Memorandum				
Page 4 of 4				
Chemicals	Target Cancer Risk Concentrations (µg/kg)			Target Noncancer Risk Concentration (µg/kg)
	1 x 10 ⁻⁴	1 x 10 ⁻⁵	1 x 10 ⁻⁶	
Mercury	--	--	--	1,500,000
Nickel	--	--	--	100,000,000
Selenium	--	--	--	25,000,000
Silver	--	--	--	25,000,000
Thallium	--	--	--	400,000
Vanadium	--	--	--	35,000,000
Zinc	--	--	--	100,000,000 ^b

Notes:
 -- Risk-based concentrations could not be calculated because toxicity values are not available.

^aFor chemicals with a calculated risk-based concentration higher than the soil saturation concentration, the soil saturation concentration is used.

^bA maximum cap of 10 percent or 100,000,000 µg/kg was set for relatively nontoxic chemicals with high risk-based concentrations (EPA, 1993).

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Table 7-21
Risk-Based Concentrations - Recreational Scenario
Ingestion of Surface Water and
Dermal Contact with Surface Water
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Chemicals	Target Cancer Risk Concentrations (µg/L)			Target Noncancer Risk Concentration (µg/L)
	1×10^{-4}	1×10^{-5}	1×10^{-6}	
ORGANICS				
1,1,1-Trichloroethane	--	--	--	190,000
2-Butanone	--	--	--	--
2-Methylnaphthalene	--	--	--	--
4,4-DDE	680	68	6.8	--
4',4'-DDT	380	38	3.8	65
4-Nitrophenol	--	--	--	--
Acetone	--	--	--	470,000
Benze butyl phthalate	--	--	--	940,000
Beta-BHC	2,600	260	26	--
Bis(2-ethylhexyl) phthalate	94,000	9,400	940	26,000
Chloroform	67,000	6,700	670	4,100
Delta-BHC	--	--	--	--
Endosulfan sulfate	--	--	--	--
Gamma chlordane	710	71	7.1	55
Methylene chloride	510,000	51,000	5,100	230,000
TFH-diesel	--	--	--	94,000
Toluene	--	--	--	11,000
INORGANICS				
Aluminum	--	--	--	--
Antimony	--	--	--	2,000
Arsenic	2,800	280	28	1,500

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Table 7-21
Risk-Based Concentrations - Recreational Scenario
Ingestion of Surface Water and
Dermal Contact with Surface Water
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Chemicals	Target Cancer Risk Concentrations ($\mu\text{g/L}$)			Target Noncancer Risk Concentration ($\mu\text{g/L}$)
	1×10^{-4}	1×10^{-5}	1×10^{-6}	
Barium	--	--	--	340,000
Beryllium	1,100	110	11	25,000
Cadmium	--	--	--	2,500
Chromium	--	--	--	25,000
Cobalt	--	--	--	--
Copper	--	--	--	--
Cyanide	--	--	--	98,000
Lead	--	--	--	--
Manganese	--	--	--	25,000
Mercury	--	--	--	1,500
Nickel	--	--	--	98,000
Nitrate/nitrite	--	--	--	490,000
Selenium	--	--	--	25,000
Thallium	--	--	--	390
Vanadium	--	--	--	34,000
Zinc	--	--	--	1,500,000
RADIONUCLIDES				
Gross alpha	--	--	--	--
Gross beta	--	--	--	--

Notes:

-- Risk-based concentrations could not be calculated because toxicity values are not available.

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<p align="center">Table 7-22 Risk-Based Concentrations - Residential Scenario Inhalation of Landfill Gas MCAS El Toro Phase I RI Technical Memorandum</p>				
Chemicals	Target Cancer Risk Concentrations ($\mu\text{g}/\text{m}^3$)			Target Noncancer Risk Concentration ($\mu\text{g}/\text{m}^3$)
	1×10^{-4}	1×10^{-5}	1×10^{-6}	
ORGANICS				
Benzene	29	2.9	0.29	--
Chloroform	11	1.1	0.11	37
Methane	--	--	--	--
Methylene chloride	520	52	5.2	3,100
Tetrachloroethene	470	47	4.7	37
Trichloroethylene	140	14	1.4	22
<p>Notes: -- Risk-based concentrations could not be calculated because toxicity values are not available.</p>				

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assurance/quality control program used in the RI serves to reduce these errors, it cannot eliminate all errors associated with sampling and analysis.

The estimation of risk-based concentrations required numerous assumptions to describe potential exposure situations. There are a number of uncertainties regarding likelihood of exposure, frequency of contact with contaminated media, and the time period of exposure. These tend to simplify and approximate actual site conditions.

The toxicological data base is also a source of uncertainty. The EPA outlined some of the sources of uncertainties in its *Guidelines for Carcinogen Risk Assessment* (U.S. EPA, 1986a). They include extrapolation from high to low doses and from animals to humans; species, gender, age, and strain differences in uptake, metabolism, organ distribution, and target site susceptibility; and human population variability with respect to diet, environment, activity patterns, and cultural factors.

In particular, there is uncertainty surrounding the cancer slope factors used in the evaluation of trichloroethylene. Animal studies have shown increases in cancers of various types following inhalation or oral exposure to trichloroethylene. As a result, EPA classified trichloroethylene in Weight-of-Evidence Group B2 (probable human carcinogen) in the 1985 Health Assessment Document (HAD) for trichloroethylene. At that time, oral and inhalation cancer slope factors were also provided, and these values were updated in a 1987 Addendum to the HAD. However, in 1988, EPA's Science Advisory Board questioned whether the available evidence supported a Group B2 ranking, and suggested that the weight-of-evidence was somewhere between the Group C and Group B2 continuum. As a result, EPA withdrew the IRIS carcinogenicity file in July 1989. The cancer slope estimates have been reviewed by EPA's IRIS-Crave Workgroup, but will not be verified pending resolution of the weight-of-evidence classification.

The PRG developed for trichloroethylene in this report assumes that the oral and inhalation slope factors are equivalent to those derived in the 1985 HAD and the 1987 Addendum. If trichloroethylene is judged by EPA to be in Group C rather

than Group B2, this PRG (as well as the current MCL) could change, and their application to human exposure situations becomes less certain.

Uncertainty in the risk assessment is a function of the "state-of-the-practice" of risk assessment in general and also a function of the uncertainty specific to MCAS El Toro site in particular. Table 7-23 lists general uncertainty factors in risk assessment, and specific uncertainty factors related to the site.

7.2 Ecological Risk Assessment

This section presents the results of the preliminary baseline ecological risk assessment for organisms potentially exposed to contaminants at OUs 1, 2, and 3 of the MCAS El Toro. The areas of ecological concern are those where contaminants may be present in surface water or sediment for OU 1 (e.g., San Diego Creek), and near-surface soil, sediment, and surface water at sites within OUs 2 and 3.

The baseline risk assessment evaluates potential threats to the environment in the absence of any remedial action (the no-action alternative). It identifies and characterizes the toxicity of chemicals of potential ecological concern, the possible exposure pathways, the potential ecological receptors, and the upper boundary on possible risks under the conditions defined for the Station. The no-action alternative assumes that no corrective actions will take place and no restrictions will be placed on future uses of the areas comprising OUs 1, 2, and 3. The baseline ecological risk assessment addresses potential risks from those sites under current land uses.

The overall purpose of the risk assessment is to provide a qualitative and/or quantitative appraisal of actual or potential effects of contaminants on animals other than domesticated animals and humans and on plants. This will help determine whether there is a need for remedial action and the scale of the remedial action.

This evaluation is based on the following major assumptions:

- No remedial actions will be taken (baseline risk assessment).

Table 7-23		
Uncertainties Associated With Risk-Based Concentration Estimations		
MCAS El Toro Phase I RI Technical Memorandum		
Page 1 of 2		
Uncertainty Factor	Effects of Uncertainty	Comment
I. Exposure Assessment		
Exposure assumptions	May under- or overestimate risk	Assumptions regarding media intake, population characteristics, and exposure patterns may not characterize exposures.
Dermal contact with chemicals of concern	May overestimate risks	Assumes sufficient time of contact for chemical to desorb from soil and absorb in skin.
Use of applied dose to estimate risks	May over- or underestimate risks	Assumes that the absorption of the chemical is the same as it was in the study that derived the toxicity value. Assumes that absorption is equivalent across species (animal to humans). Absorption may vary with age and species.
Risk-based concentrations developed on a chemical-specific basis	May over- or underestimate risks	Joint effects of mixtures may be greater or less than the sum of the individual toxicants.
Population characteristics	May over- or underestimate risks	Assumes weight, lifespan, ingestion rate, etc., are potentially representative for a potentially exposed population.
Intake	May underestimate risks	Assumes all intake of COPC is from the exposure medium being evaluated (no relative source contribution).
II. Toxicity Assessment		
Slope factor	May overestimate risks	Slope factors are upper 95th percent confidence limits derived from a linearized model. Considered unlikely to underestimate risk.
Toxicity values derived from animal studies	May over- or underestimate risks	Extrapolation from animal to humans may induce error because of differences in pharmacokinetics, target organs, and population variability.

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Table 7-23 Uncertainties Associated With Risk-Based Concentration Estimations MCAS El Toro Phase I RI Technical Memorandum		
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Toxicity values derived primarily from high doses; most exposures are at low doses	May over- or underestimate risks	Assumes linear at low doses. Tends to have conservative exposure assumptions.
Toxicity values	May over- or underestimate risks	Not all values represent the same degree of certainty. All are subject to change as new evidence becomes available.
Toxicity values derived from homogeneous animal populations	May over- or underestimate risks	Human population may have a wide range of sensitivities to a chemical.
Not all chemicals at the site have toxicity values	May underestimate risks	These chemicals are not addressed quantitatively.
III. Risk Estimation		
Risk-based concentrations assume single chemical exposure	May underestimate risk	Potential exposure to multiple chemicals
Estimation of risks across exposure routes	May under- or overestimate risk	Some exposure routes have greater uncertainty associated with their risk estimates than others.
Cancer risk estimates--no threshold assumed	May overestimate risks	Possibility that some thresholds do exist.
Cancer risk estimate--low dose linearity	May overestimate risks	Response at low doses is not known.

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- The media of primary ecological concern are soils within 4 feet of the ground surface, sediment, and surface water.
- For the purpose of risk assessment, chemical concentrations will not change over time.
- Future land uses will be similar to current uses.

This ecological evaluation is based on the data collected during the remedial investigation supporting information is presented in earlier sections of this report, as follows:

- Section 1 describes ecosystems and potential receptors in the habitats that occur on the Station (including special-status species).
- Section 2 describes procedures used in the field investigations (including ecological surveys, sampling, and chemical analyses).
- Section 4 provides information on nature and extent of contamination where ecological receptors may be exposed in the vicinity of each site.
- Section 7.1.4.3 describes characteristics, release mechanisms, environmental fate, and transport pathways for contaminants.

The baseline ecological evaluation was performed in accordance with the following guidance documents and work plans:

- *Risk Assessment Guidance for Superfund: Volume II, Environmental Evaluation Manual* (EPA 1989e)
- *Ecological Assessment of Superfund Sites: An Overview* (EPA 1991f).
- *Developing a Scope of Work for Ecological Assessments* (EPA 1992f).
- *Framework for Ecological Risk Assessment* (EPA 1992g).
- Draft Final RI/FS Work Plan (Navy, 1991).

The Work Plan (Navy, 1991) describes the ecological risk assessment for MCAS El Toro, which is being conducted in a phased approach. Such an approach is recommended by the EPA (EPA, 1991f, 1992e) to ensure that all the necessary work is done, but only that which is necessary. Using this approach, the data and observations from one

phase are used to determine whether further studies are needed to meet the objectives of the assessment.

This document represents the first phase of that process. It involves identifying the presence and levels of contaminants at the various sites and evaluating whether exposure pathways to ecological receptors exist. This phase also includes comparisons of contaminant concentrations at the sites to available criteria, standards, and reference values. This phase of work is intended to provide the information that is needed for the Problem Formulation part of a complete risk assessment, as described by more recent guidelines (EPA 1991f, 1992f, 1992g). Because of the limited data that were developed during the Phase I work, a screening approach is taken in assessing exposure, ecological effects, and risks to ecological receptors in subsequent sections.

The general objectives (i.e., the assessment endpoints or environmental values to be protected) for the ecological risk assessment at MCAS El Toro are as follows:

- Reduce ecological risks to an acceptable level
- Protect food chain integrity
- Protect water quality
- Maintain biotic diversity
- Protect ecosystem structure.

The measurement endpoints include the following:

General habitat conditions, including vegetation and animals on or near the sites and areas comprising OU 1, OU 2 and OU 3, as assessed through qualitative surveys.

- Evidence of impaired ecosystem health, as shown by actual or potential contaminant impacts on plants and animals through comparisons of observed concentrations to documented effect levels and ARARs.

This risk assessment is organized to present the evaluations for ecological resources under the following topics:

- **Contaminants of Potential Ecological Concern** screens contaminants identified in Section 4 to determine which ones should be considered further in the ecological risk assessment.

- **Exposure Assessment** describes the habitats, receptors, and pathways by which exposures can occur, and estimates the magnitude of actual or potential ecological exposures and the frequency and duration of these exposures.
- **Ecological Effects Assessment** presents toxicity information available on chemicals of potential ecological concern to determine their potential to cause adverse effects in aquatic or terrestrial ecological receptors.
- **Risk Characterization** integrates the exposure and toxicity assessments to estimate the likelihood of impacts to ecological receptors from exposure to chemicals of potential ecological concern.
- **Conclusions and Limitations** summarizes the basic conclusions of the ecological evaluation and the limitations or uncertainties associated with the data and methodology.

7.2.1 Contaminants of Potential Ecological Concern

Chemicals detected in near-surface soil, sediment and surface water were evaluated as chemicals of potential ecological concern (COPEC). Subsection 7.1 presents a summary of chemicals detected at El Toro; chemicals detected (by medium) are given in Tables 7-2 through 7-7. Soil from 0 to 4 feet below ground surface (bgs), referred to as near-surface soil, is considered to be the zone of potential exposure by ecological receptors; burrowing animals and plant root zones may occupy depths to 4 feet in the vicinity of the RI/FS sites. This provides a conservative assessment of potential maximum concentration available for exposure, and provides consistency with the human health risk assessment.

COPEC were selected for each of three media evaluated (near-surface soil, sediment, and surface water). Following the same protocol as the human health risk assessment (Section 7.1):

- Chemicals not detected in a given medium were eliminated from consideration on a site-by-site basis
- Inorganic constituents commonly found in the environment at relatively nontoxic levels were detected in the Phase I RI sampling. These constituents include calcium, chloride, iron, magnesium, nitrate, phosphorous, potassium, sodium, and sulfate. They were not regarded as COPECs since they are

common ions in the environment, act as macronutrients to living organisms, or are relatively nontoxic.

Background concentrations were not available for screening potential chemicals of concern. Therefore, for evaluation, the maximum observed concentration of inorganic chemicals in near-surface soil was compared to remediation criteria developed by the Canadian Council of Ministers of the Environment (CCME, 1991) and western United States values from the literature (Shacklette and Boerngen, 1984).

Soil criteria to protect environmental receptors have not been developed in the United States and a number of variables affect the validity of any soil criteria, such as soil type and organic carbon content of the soil. However, interim Canadian environmental quality criteria for contaminated sites (CCME, 1991) have been developed. These criteria for inorganic constituents are presented in Table 7-24. The Canadian criteria are intended for generic use and do not address site-specific conditions, but they are considered generally protective of human and environmental health (CCME, 1991). The criteria presented in Table 7-24 are those for agricultural uses of soils and serve as benchmarks to evaluate the need for further investigation for remediation with respect to such use (e.g., potential effects on plants or bioaccumulation into them). Concentrations of inorganic compounds found in soils throughout the western United States (Shacklette and Boerngen, 1984) also serve as useful reference values. These criteria were used to evaluate the range of inorganic concentrations found at the MCAS El Toro sites for risk screening purposes. Inorganics were retained if they exceeded either of the criteria.

Comparing the maximum values detected to the Canadian criteria and western United States upper 95 percent literature values, eight inorganic constituents were below the Canadian criteria, and four were at or below the 95 percent value for concentrations in western United States surficial soils. Arsenic, beryllium and selenium were at or below reference values in both sources. Several of these chemicals were retained, however, because they exceeded one of the criteria or are also COPEC for sediment (see below); these include antimony, arsenic,

<p align="center">Table 7-24 Ecological Benchmark Criteria for Inorganic Constituents Detected in Near-surface Soil MCAS El Toro Phase I RI Technical Memorandum</p>			
	<p align="center">Canadian Remediation Criteria (Agricultural)^a</p>	<p align="center">Western U.S. Soils Upper 95% Value^b</p>	<p align="center">Maximum Value Detected at El Toro</p>
INORGANIC PARAMETERS (mg/kg)			
Aluminum	--	232,080	29,800
Antimony	20	2.2	11.1
Arsenic	20	22	14.3
Barium	750	1,700	2610
Beryllium	4	3.6	1.7
Cadmium ^d	3	--	108
Chromium (total)	750	200	365
Cobalt	40	28	83.3
Copper ^d	150	90	226
Cyanide (total)	5	--	1
Lead ^d	375	55	2870
Manganese	--	1490	797
Mercury	0.8	0.25	15.1
Nickel	150	66	138
Selenium	2	1.4	1.4
Silver	20	--	21.4
Thallium	1	--	0.64
Vanadium	200	270	800
Zinc ^d	600	180	2070
<p>^aCanadian Council of Ministers of the Environment, 1991, "Interim Canadian Environmental Quality Criteria for Contaminated Sites," CCME EPC-CS34, prepared by the CCME Subcommittee on Environmental Quality Criteria for Contaminated Sites, Ottawa, Ontario, September.</p> <p>^bShacklette, H. T., and J. G. Boerngen, 1984. "Element Concentrations in Soils and Other Surficial Materials of the Conterminous United States," U.S. Geological Survey Professional Paper 1270. U.S. Government Printing Office.</p> <p>^dValues from Bengtsson, G. and L. Tranvick, 1989, "Critical Metal Concentrations for Forest Soil Invertebrates," <u>Water, Air, and Soil Pollution</u>, Vol. 47, pp. 381-417, for protection of invertebrates are:</p> <p align="center"> Cadmium = 10-50 mg/kg Copper = <100 mg/kg Lead = 100-200 mg/kg Zinc = <500 </p> <p>--=Information not available</p>			

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beryllium, chromium, manganese, nickel, selenium, and thallium. One inorganic chemical, cyanide was below the reference values, but was not a COPEC for sediments, and was therefore eliminated as a COPEC for near-surface soil.

Chemicals detected in near-surface soil and remaining following this selection process were carried through the baseline environmental evaluation as COPEC for soil. All chemicals detected in sediments and surface water were retained for evaluation as COPEC in the ecological risk assessment. Sediment and water quality criteria are given in the ecological effects assessment section of the ecological risk assessment (Section 7.2.3).

Table 7-25 presents those chemicals retained as COPEC for the MCAS El Toro Ecological Risk Assessment. Separate COPECs are presented for near-surface soil, sediment, and surface water. For near-surface soil, 74 organic and 18 inorganic constituents were retained as COPEC; in sediment, 49 organic and 18 inorganic constituents were retained; and, in surface water, 17 organic and 19 inorganic compounds were retained as COPEC.

7.2.2 Exposure Assessment

This section describes habitat and receptors at the MCAS El Toro, identifies potential exposure pathways, and discusses site-specific migration and exposure routes for ecological receptors.

7.2.2.1 Ecological Habitats and Receptors

Four habitat types have been identified at the MCAS El Toro, including grassland, coastal sage scrub, riparian, and aquatic and wetland habitat. Much of MCAS El Toro is annual grassland habitat with areas that are covered by gravel or by compacted soil and asphalt. For ecological risk assessment purposes, the riparian habitat can be combined with aquatic and wetland habitat because of their close association and similarity in receptor populations.

The general ecology (including habitats, special-status species, and common plant and animal species) of MCAS El Toro was described in Section 1.3.10; methods used in the ecological investigations at the Station were described in Section 2.2.8. Ecological receptors within each of these habitats could potentially come into contact with COPEC at the MCAS El Toro sites. The habitats and known potential receptors are further described in the following subsections. Within each of the habitat types, potential assessment species were selected for further consideration in risk assessment. These species include special-status species that are known to occur (or are very likely to occur) in the habitat, important species in that ecosystem, and species most similar to those species for which toxicological information is available.

Vegetation at the MCAS El Toro was identified by existing biological reports (Brown and Caldwell 1986; CDFG 1989), a reconnaissance survey conducted May 4 through 8, 1992, and professional experience with southern California ecology.

Grassland. For the purposes of this report, grassland includes typical annual grassland habitat as described in Section 1.3.10 and other disturbed and managed habitats with annual grassland plant species. Many of these areas are highly disturbed but do offer habitat used by wildlife. The vegetation in the grassland habitat is primarily made up of invader species such as introduced annual grasses, mustard, filaree, clover, groundsel, wild oat, pineapple weed, and other broadleaf weed species. Vegetation in areas bordering grassland habitats increases the diversity of animals using the grasslands. Trees planted along the roads are eucalyptus and other non-native ornamental trees. Planted trees along roads surrounding and within the facility provide corridors for wildlife movement and resting as well as nesting habitat for a variety of birds. Vegetation growing in areas not maintained along the creeks and washes provides foraging and shelter areas for wildlife that also use the grassland habitat, and the base is surrounded by agricultural fields and urban areas that provide additional habitat for wildlife using the base. Sites 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 19, 20, 21, and 22 are in grassland and disturbed habitats.

Table 7-25
MCAS El Toro Chemicals of Potential Ecological Concern by Medium
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Chemical	Near-surface Soil	Sediment	Surface Water
ORGANICS			
1,1,1-Trichloroethane			X
1,2-Dichloroethene (total)	X		
2,4,5-Trichlorophenoxy proprionic acid	X	X	
2,4,5-T	X		
2,4-D	X		
2,4-DB	X	X	
2,4-Dimethyl phenol	X		
2-Butanone	X	X	X
2-Hexanone	X	X	
2-Methylnaphthalene	X	X	
4,4'-DDD	X	X	
4,4'-DDE	X	X	X
4,4'-DDT	X	X	X
4-Methyl-2-Pentanone	X		
4-Methylphenol	X	X	
4-Nitrophenol			X
Acenaphthene	X	X	
Acenaphthylene	X	X	
Acetone	X	X	X
Aldrin	X		
Alpha-chlordane	X	X	
Anthracene	X	X	
Benzene	X	X	
Benzo(a)anthracene	X	X	
Benzo(a)pyrene	X	X	
Benzo(b)fluoranthene	X	X	
Benzo(g,h,i)perylene	X	X	
Benzo(k)fluoranthene	X	X	
Benzyl butyl phthalate	X	X	X

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Table 7-25			
MCAS EI Toro Chemicals of Potential Ecological Concern by Medium			
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			Page 2 of 4
BHC-ALPHA	X		
BHC-BETA			X
BHC-DELTA	X	X	X
BHC-GAMMA (Lindane)	X		
Bis(2-Ethylexyl)phthalate	X	X	X
Carbazole	X	X	
Carbon disulfide	X		
Carbon tetrachloride	X	X	
Chloroform			X
Chrysene	X	X	
Dalapon	X	X	
Dibenzo(a,h)anthracene		X	
Dibenzofuran	X	X	
Di-n-butyl phthalate	X		
Dicamba			
Dichloroprop	X	X	
Dieldrin	X	X	
Diethyl phthalate	X		
Dimethyl phthalate	X		
Endosulfan I	X		
Endosulfan II	X		
Endosulfan sulfate	X	X	X
Endrin	X		
Endrin aldehyde	X		
Endrin ketone	X		
Ethylbenzene	X		
Fluoranthene	X	X	
Fluorene	X	X	
Gamma-chlordane	X	X	X
Heptachlor epoxide	X		
Hexachloroethane	X		

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Table 7-25			
MCAS EI Toro Chemicals of Potential Ecological Concern by Medium			
MCAS EI Toro Phase I RI Technical Memorandum			
			Page 3 of 4
Indeno(1,2,3-CD)Pyrene	X	X	
Isophorone	X		
MCPP	X	X	
Methoxychlor	X	X	
Methyl chloride			X
Methylene chloride	X	X	X
Naphthalene	X		
Octachlorodibenzo-p-dioxin	X		
PCB-1248	X		
PCB-1254	X		
PCB-1260	X		
Phenanthrene	X	x	
Phenol	X		
Pyrene	X	X	
Tetrachloroethene	X		
TFH - diesel		X	X
TFH - gasoline	X	X	
Toluene	X	X	X
Total recoverable petroleum hydrocarbons	X	X	
Trichloroethylene	X	X	
Xylene (total)	X		
INORGANICS			
Aluminum	X	X	X
Antimony	X	X	X
Arsenic	X	X	X
Barium	X	X	X
Beryllium	X	X	X
Cadmium	X	X	X
Chromium	X	X	X
Cobalt	X	X	X
Copper	X	X	X

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Table 7-25			
MCAS El Toro Chemicals of Potential Ecological Concern by Medium			
MCAS El Toro Phase I RI Technical Memorandum			
			Page 4 of 4
Cyanide			X
Lead	X	X	X
Manganese	X	X	X
Mercury	X	X	X
Nickel	X	X	X
Selenium	X	X	X
Silver	X	X	X
Thallium	X	X	X
Vanadium	X	X	X
Zinc	X	X	X

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Wildlife known to occur at MCAS El Toro in grassland habitats and the potential exposure routes are listed in Table 7-26. The assessment species for this habitat include western fence lizard, gopher snake, California quail, loggerhead shrike, black-tailed hare, southwestern pocket gopher, California pocket mouse, and the deer mouse.

Coastal Sage Scrub. Native coastal sage scrub vegetation was found at Sites 1, 2, and 17. Vegetation at these sites included bunchgrasses, buckwheat, deer weed, yucca, sagebrush, and beavertail cactus. Although these sites have been disturbed in the past, there is little activity or management occurring at these sites now. These locations provide habitat and specific habitat elements for a number of native wildlife species. These habitat elements include beavertail cactus used by cactus wrens as nest sites, open areas with patches of brush and rocks used by orange-throated whiptails for foraging, or chaparral habitat with soft soil used by California and San Diego pocket mice for their burrows.

Wildlife known to occur at MCAS El Toro in coastal sage scrub are listed in Table 7-27. During the spring 1992 reconnaissance, cactus wrens were observed north of Sites 1 and 17; nests were seen east of Site 1. In addition, orange-throated whiptails were observed in the vicinity of Site 2. The assessment species for coastal sage scrub include western fence lizard, orange-throated whiptail, gopher snake, California quail, cactus wren, loggerhead shrike, California gnat-catcher, black-tailed hare, southwestern pocket gopher, little pocket mouse, San Diego pocket mouse, California pocket mouse, and deer mouse.

Riparian. Riparian habitat occurs along washes and San Diego Creek (Site 18) adjacent to both grassland and coastal sage scrub habitat at MCAS El Toro. Vegetation in this habitat includes willows, elderberry, cattail, sedges, rushes, and tree tobacco. Riparian habitat may provide sheltered movement corridors for wildlife and resting and hunting perches for birds.

Wildlife known to occur at MCAS El Toro in riparian habitats are listed in Table 7-28. Most of these species also are associated with aquatic and wetland

habitats. The assessment species for this habitat include bullfrog, California quail, mallard, raccoon, southwestern pocket gopher, and deer mouse.

Aquatic and Wetland Habitat. Aquatic habitat is limited at MCAS El Toro. Washes within the Station are intermittent in flow, and surface water on the base is usually limited to isolated pools in the washes or rainwater pools at various other locations during the winter season. Aquatic habitats of concern include the Marshburn Channel, Bee Canyon Wash, Agua Chinon Wash, and Borrego Canyon Wash as channels with intermittent flow that drain the base sites (Figure 7-1). These channels drain to San Diego Creek, which eventually drains to Upper Newport Bay. San Diego Creek was flowing in May, 1992 and is assumed to be wet throughout much of the year in the lower reach of the creek from the point of receiving the Station drainage to the confluence with Upper Newport Bay. Upper Newport Bay is of concern as aquatic habitat potentially impacted by MCAS El Toro because the bay provides habitat for several threatened or endangered species, most notably the light-footed clapper rail.

San Diego Creek could provide habitat for fish and amphibians and the animals that feed upon them (birds, mammals). Bullfrogs were observed in the Creek in May 1992. The lower reach of San Diego Creek is generally a sandy or muddy bottomed, low relief stream, characterized as warm-water fish habitat. The fish fauna is probably similar to the low elevation sections of other Southern California coastal streams in the Santa Ana area. Such fauna typically consist of introduced species such as bullhead or bass coexisting with a few remaining native species of suckers, stickleback, or chub (Faber et al. 1989). However, the fish fauna was not included in the reconnaissance survey.

Wetlands in the vicinity of MCAS El Toro have been mapped by the U.S. Fish and Wildlife Service through the National Wetlands Inventory (Figure 7-1). Upstream portions of Borrego Canyon Wash in the vicinity of Site 2 and farther upstream are classified as R4SBW, which designates riverine streambeds that are intermittently

Table 7-26
Potential Wildlife Exposure to Contaminants
in Grassland and Disturbed Habitats at MCAS El Toro
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Common Name	Ingestion	Inhalation	Dermal
Amphibians			
Western toad	Food, water, sediment	No	Water
Reptiles			
Western fence lizard	Food, soil	Burrows (dust, vapor)	Soil
Side-blotched lizard	Food, soil	Burrows (dust, vapor)	Soil
Coast horned lizard	Food, soil	Burrows (dust, vapor)	Soil
California whipsnake	Food, soil	Burrows (dust, vapor)	Soil
Gopher snake	Food, soil	Burrows (dust, vapor)	Soil
Common kingsnake	Food, soil	Burrows (dust, vapor)	Soil
Western Rattlesnake	Food, soil	Burrows (dust, vapor)	Soil
Birds			
Turkey vulture	Food, water	Dust	Bathing (soil, water)
Black-shouldered kite	Food, water	Dust	Bathing (soil, water)
Northern harrier	Food, water	Dust	Bathing (soil, water)
Coopers hawk	Food, water	Dust	Bathing (soil, water)
Red-shouldered hawk	Food, water	Dust	Bathing (soil, water)
Red-tailed hawk	Food, water	Dust	Bathing (soil, water)
Golden eagle	Food, water	Dust	Bathing (soil, water)
California quail	Food, water	Dust	Bathing (soil, water)
Mourning dove	Food, water	Dust	Bathing (soil, water)
Greater roadrunner	Food, water	Dust	Bathing (soil, water)
Common barn owl	Food, water	Dust	Bathing (soil, water)
Horned lark	Food, water	Dust	Bathing (soil, water)
Northern mockingbird	Food, water	Dust	Bathing (soil, water)
Loggerhead shrike	Food, water	Dust	Bathing (soil, water)
Rufous-crowned sparrow	Food, water	Dust	Bathing (soil, water)
Lark sparrow	Food, water	Dust	Bathing (soil, water)
Grasshopper sparrow	Food, water	Dust	Bathing (soil, water)
Western meadowlark	Food, water	Dust	Bathing (soil, water)
Mammals			
Black-tailed hare	Food, water, soil	Dust (dust, vapor)	No
California ground squirrel	Food, water, soil	Burrows (dust, vapor)	Burrows (soil)
Southwestern pocket gopher	Food, water, soil	Burrows (dust, vapor)	Burrows (soil)
California pocket mouse	Food, water, soil	Burrows (dust, vapor)	Burrows (soil)
Western harvest mouse	Food, water, soil	Burrows (dust, vapor)	Burrows (soil)
Deer mouse	Food, water, soil	Burrows (dust, vapor)	Burrows (soil)

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**Table 7-26
 Potential Wildlife Exposure to Contaminants
 in Grassland and Disturbed Habitats at MCAS El Toro
 MCAS El Toro Phase I RI Technical Memorandum**

Common Name	Ingestion	Inhalation	Dermal
Dusky-footed woodrat	Food, water, soil	Burrows (dust, vapor)	Burrows (soil)
California vole	Food, water, soil	Burrows (dust, vapor)	Burrows (soil)
Coyote	Food, water, soil	Burrows (dust, vapor)	Burrows (soil)

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Table 7-27
Potential Wildlife Exposure to Contaminants in Coastal Sage Scrub Habitats
to Wildlife Known to Occur at MCAS El Toro
MCAS El Toro Phase I RI Technical Memorandum

Page 1 of 2

Common Name	Ingestion	Inhalation	Dermal
Amphibians			
Western toad	Food, water, sediment	No	Water, sediment
Reptiles			
Western fence lizard	Food, soil	Burrows (dust, vapors)	Soil
Side-blotched lizard	Food, soil	Burrows (dust, vapors)	Soil
San Diego horned lizard	Food, soil	Burrows (dust, vapors)	Soil
Coast horned lizard	Food, soil	Burrows (dust, vapors)	Soil
Western skink	Food, soil	Burrows (dust, vapors)	Soil
Orange-throated whiptail	Food, soil	Burrows (dust, vapors)	Soil
Western blind snake	Food, soil	Burrows (dust, vapors)	Soil
Rosy boa	Food, soil	Burrows (dust, vapors)	Soil
Gopher snake	Food, soil	Burrows (dust, vapors)	Soil
Common kingsnake	Food, soil	Burrows (dust, vapors)	Soil
Western rattlesnake	Food, soil	Burrows (dust, vapors)	Soil
Birds			
Cooper's hawk	Food, water	Dust	Bathing (soil, water)
Red-tailed hawk	Food, water	Dust	Bathing (soil, water)
California quail	Food, water	Dust	Bathing (soil, water)
Mourning dove	Food, water	Dust	Bathing (soil, water)
Greater roadrunner	Food, water	Dust	Bathing (soil, water)
Common barn owl	Food, water	Dust	Bathing (soil, water)
Anna's hummingbird	Food, water	Dust	Bathing (soil, water)
Say's phoebe	Food, water	Dust	Bathing (soil, water)

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**Table 7-27
Potential Wildlife Exposure to Contaminants in Coastal Sage Scrub Habitats
to Wildlife Known to Occur at MCAS El Toro
MCAS El Toro Phase I RI Technical Memorandum**

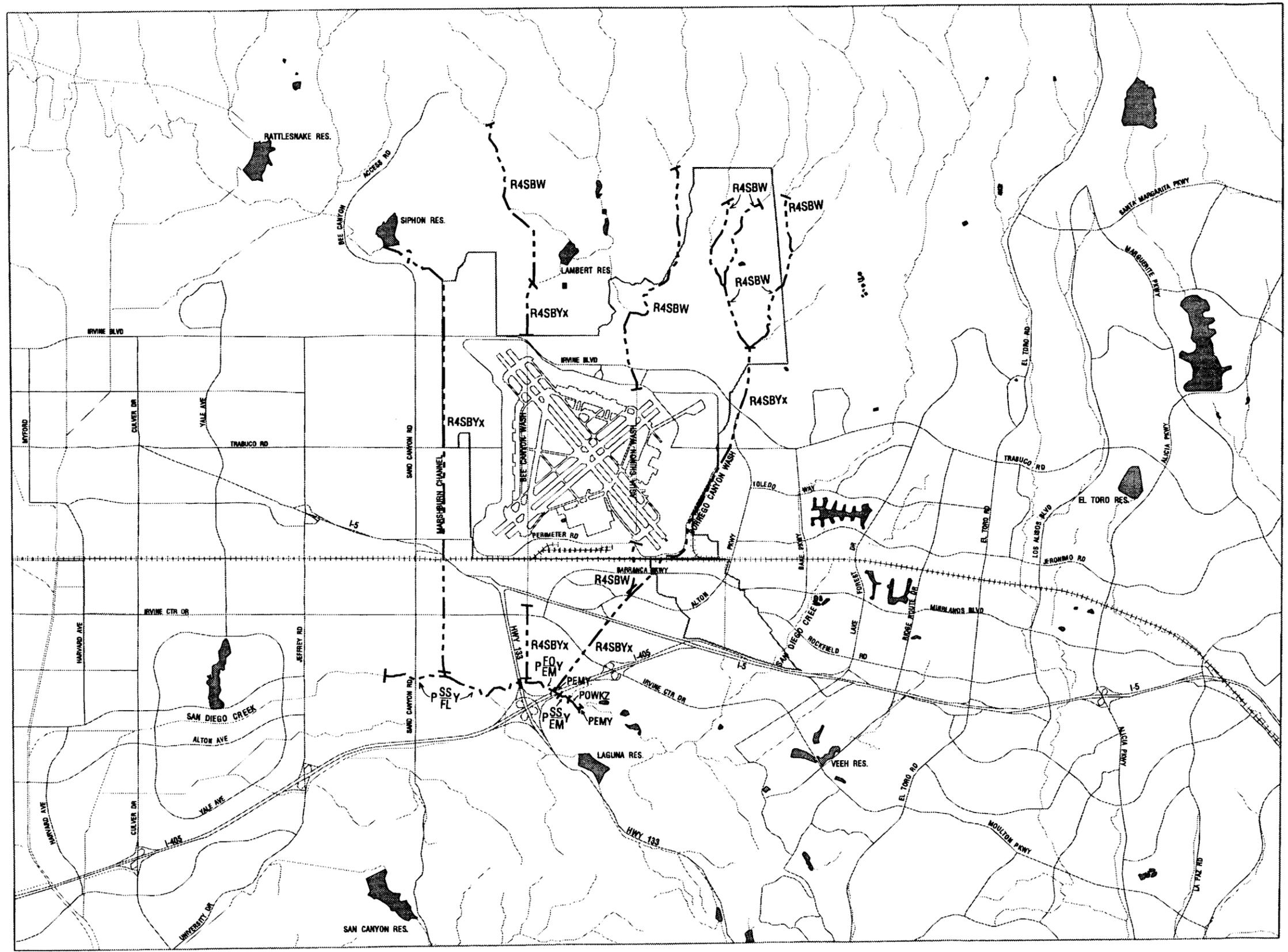
Page 2 of 2

Hermit thrush	Food, water	Dust	Bathing (soil, water)
California gnatcatcher	Food, water	Dust	Bathing (soil, water)
Cactus wren	Food, water	Dust	Bathing (soil, water)
Northern mockingbird	Food, water	Dust	Bathing (soil, water)
Loggerhead shrike	Food, water	Dust	Bathing (soil, water)
California towhee	Food, water	Dust	Bathing (soil, water)
Black-chinned sparrow	Food, water	Dust	Bathing (soil, water)
Sage sparrow	Food, water	Dust	Bathing (soil, water)
White-crowned sparrow	Food, water	Dust	Bathing (soil, water)
Western meadowlark	Food, water	Dust	
Mammals			
Pallid bat	Food, water, soil	Dust	No
Brush rabbit	Food, water, soil	Dust	Burrows
Desert cottontail	Food, water, soil	Dust	Burrows
Black-tailed hare	Food, water, soil	Burrows (dust, vapor)	No
Southwestern pocket gopher	Food, water, soil	Burrows (dust)	Burrows (soil)
Pacific kangaroo rat	Food, water, soil	Burrows, dust	Burrows
Little pocket mouse	Food, water, soil	Burrows (dust)	Burrows (soil)
San Diego pocket mouse	Food, water, soil	Burrows (dust)	Burrows (soil)
California pocket mouse	Food, water, soil	Burrows (dust)	Burrows (soil)
Cactus mouse	Food, water, soil	Burrows (dust)	Burrows (soil)
California mouse	Food, water, soil	Burrows (dust)	Burrows (soil)
Deer mouse	Food, water, soil	Burrows (dust)	Burrows (soil)
Coyote	Food, water, soil	Burrows (dust)	Burrows (soil)
Gray fox	Food, water, soil	Burrows (dust)	Burrows (soil)
Striped skunk	Food, water, soil	Burrows (dust)	Burrows (soil)

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Table 7-28 Potential Wildlife Exposure to Contaminants in Riparian and Wetland Habitats to Wildlife Known to Occur at MCAS El Toro MCAS El Toro Phase I RI Technical Memorandum			
Common Name	Ingestion	Inhalation	Dermal
Amphibians			
Bullfrog	Food, water, sediment	No	Water, sediment
Birds			
Red-tailed hawk	Food, water	Dust	Bathing (soil, water)
Common raven	Food, water	Dust	Bathing (soil, water)
Black-headed grosbeak	Food, water	Dust	Bathing (soil, water)
Plain titmouse	Food, water	Dust	Bathing (soil, water)
California quail	Food, water	Dust	Bathing (soil, water)
Bushtit	Food, water	Dust	Bathing (soil, water)
Black phoebe	Food, water	Dust	Bathing (soil, water)
Ash-throated flycatcher	Food, water	Dust	Bathing (soil, water)
Mallard	Food, water, sediment	No	Water, sediment
Lesser goldfinch	Food, water	Dust	Bathing (soil, water)
Mammals			
Brush rabbit	Food, water, soil	Burrows (dust, vapor)	Burrows
Raccoon	Food, water, soil	Burrows (dust, vapor)	Water, sediment
Coyote	Food, water, soil	Burrows (dust, vapor)	Burrows (soil)

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FEATURES:

- WETLAND
- WASH OR STREAM
- ROAD
- RAILROAD
- AIRFIELD
- LAKE OR RESERVOIR

- R4SBW AND R4SBYx RIVERINE STREAM BEDS
- PEMY AND P(SS/EM)Y PALUSTRINE SCRUB/SHRUB OR EMERGENT WETLANDS
- POWKZ ARTIFICIAL PALUSTRINE OPEN WATER
- P(FO/EM)Y FORESTED/EMERGENT PALUSTRINE WETLANDS
- P(SS/FL)Y SCRUB/SHRUB/FLAT PALUSTRINE WETLANDS

NOTE: LINED OR CULVERTED SECTIONS OF THE WASHES AND STREAMS ARE DISPLAYED ON FIGURE A2-1.

**FIGURE 7-1
WETLANDS HABITAT IN THE
VICINITY OF MCAS EL TORO**

**MCAS EL TORO PHASE 1 RI
TECHNICAL MEMORANDUM**

SOURCE: USFWS, 1974

PAGE NUMBER 2-10

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flooded. This wetland type extends downstream to about where the Wash crosses the Station boundary upstream of Irvine Boulevard. The R4SBW wetland type also occurs along Agua Chinon Wash where it emerges from the aqueduct (which passes under the Station) to just upstream from its junction with Borrego Canyon Wash. Most of Borrego Canyon Wash along the southwest portions of the Station as well as downstream portions of Agua Chinon Wash and Bee Canyon Wash are classified as R4SBYx. This habitat is similar to R4SBW except that it is typically saturated or semi-permanent, at least seasonally.

Within San Diego Creek, the areas just upstream of Agua Chinon Wash are classified as P(SS/EM)Y, PEMY, and POWKZ. The P(SS/EM)Y and PEMY types designate palustrine scrub/shrub or emergent wetlands that are seasonally saturated or semi-permanent. (Palustrine wetlands are nontidal wetlands that are typically dominated by trees, shrubs, persistent emergent, or similar vegetation.) The POWKZ type designates artificial palustrine open water which is intermittently exposed/permanent. In the portion of the creek where Agua Chinon and Bee Canyon Washes enter, the wetlands are classified as P(FO/EM)Y (forested/emergent palustrine wetlands that are seasonally saturated or semipermanent). Farther downstream the wetlands are P(SS/FL)Y (scrub-shrub/flat palustrine wetlands, seasonally saturated or semipermanent).

7.2.2.2 Identification of Potential Exposure Pathways

This section addresses potential exposure pathways for receptors of site-related contaminants. As described in the human health risk assessment, complete exposure pathways include a source, release and transport mechanisms, a point of exposure, routes and media of exposure, and receptors (EPA, 1989a, b). If any of these components are missing, the pathway is not complete. However, the transport medium may be missing and the pathway may still be complete if the point of contact is directly at the source of the chemical.

Figure 7-2 presents potential ecological exposure pathways associated with the Station. The components of each of these exposure pathways are discussed

below. Near-surface soil, subsurface soil and buried waste, and sediment are considered to be sources for chemicals detected at the Station.

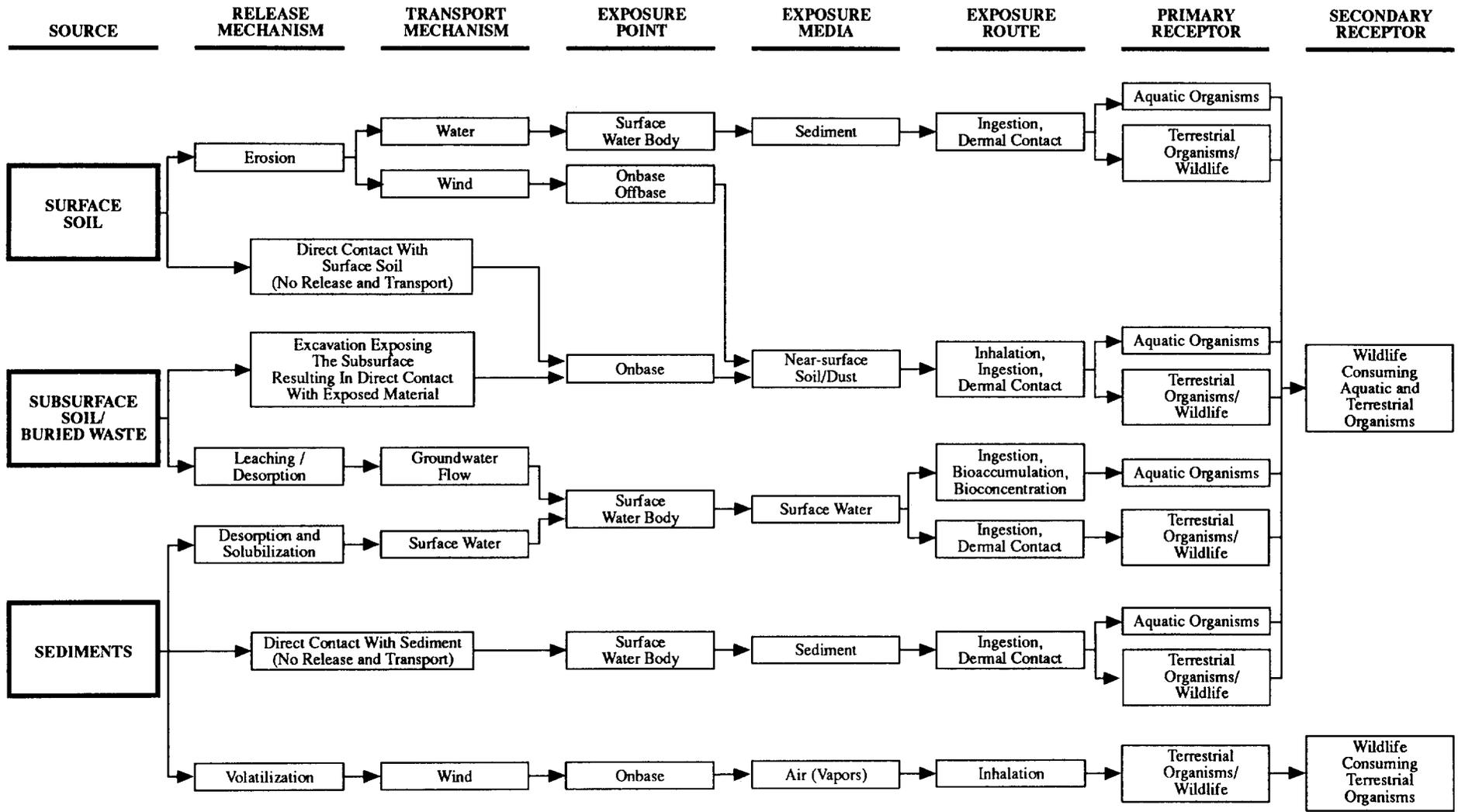
Release and Transport Mechanisms.

Ecological receptors may be exposed by direct exposure to the source. Receptors may also be exposed if chemicals have migrated from a site to adjacent areas or points of deposition. Chemicals in soil, waste or sediment may be released and transported by several mechanisms:

- Erosion and transport of surface soil by water
- Erosion and transport of surface soil via wind
- Leaching to the saturated zone, transport via groundwater, and discharge of groundwater to surface water
- Desorption and transport via surface runoff to surface water
- Volatilization to the air and transport via wind

The actual release or transport mechanism for a given COPEC or site is based on the physical-chemical properties of the chemicals. Section 7.1.4.3 provides a discussion of the fate and transport mechanisms governing movement of chemicals in and from soil, sediment, and surface water, and provides values for the physical-chemical properties of the chemicals detected at the Station.

In general, chemicals with a strong affinity for soil (indicated by high K_{OC} values, see Table 7-9) tend to be transported primarily via soil erosion resulting from surface runoff or entrainment of wind-borne particulates. Chemicals with a lesser affinity for soil may also dissolve in soil pore water and leach through soil to groundwater or dissolve into surface water runoff and be transported. Chemicals that leach into groundwater may be transported to surface waters if the groundwater has a surface-water discharge point. For volatile compounds, loss to the atmosphere from soil or water represents the most significant migration pathway.



**FIGURE 7-2
POTENTIAL EXPOSURE PATHWAYS
ECOLOGICAL RISK ASSESSMENT
MCAS EL TORO PHASE 1 RI
TECHNICAL MEMORANDUM**

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Through these processes, near-surface soil, sediment, surface water, and air become potential exposure media for ecological receptors.

Routes of Exposure

Potential environmental exposure routes include the following:

- Dermal contact with contaminated soils, sediments, or waters
- Ingestion of contaminated soils, sediments, or waters
- Inhalation of organic vapors
- Inhalation of wind-borne contaminated particulates
- Direct contact and absorption of soil-related contamination for plants
- Direct uptake from surface water by aquatic organisms

In addition, secondary routes of exposure are possible through ingestion of chemicals that have bioaccumulated into foods (including plants and animals).

Dermal Contact. Environmental receptors may be exposed to COPEC in soils via dermal contact. Significant exposure via dermal contact would be limited to organic chemicals that are lipophilic (i.e., have an affinity for fats) and can cross the epidermis of the exposed organism. Mammals are less susceptible to exposure via dermal contact with soils because their fur reduces soil contact with their skin. Terrestrial organisms may come in contact with water-borne chemicals as a result of wading or swimming in contaminated waters. Aquatic organisms inhabiting the waters would be in constant contact with COPECs. Exposure to chemicals in sediments via dermal contact may occur, especially for benthic organisms.

Ingestion. Ingestion of soil, sediment and surface water may result from a number of different behaviors. An organism may inadvertently ingest soil while grooming, burrowing, or consuming plants, insects, or burrowing invertebrates found in the soil. Some animals, such as deer, deliberately ingest soil as a source of minerals. Some aquatic organisms consume sediment and ingest the organic material from the sediment. Inadvertent ingestion of sediments may occur as a result of feeding on benthic organisms and plants. Terrestrial organisms may

also ingest water-borne chemicals if wildlife use affected waters as a drinking water source.

Vapor Inhalation. Inhalation of organic vapors would be limited to those chemicals considered volatile based on vapor pressure and other physical-chemical processes (see Table 7-9). The potential for a burrowing animal to be exposed to organic vapors from the surrounding soils is significant. Terrestrial organisms may be exposed to organic vapors resulting from the volatilization of organics in soil or water. Significant exposure to volatiles via water would probably be limited to terrestrial organisms that spend most of their time near or on the water (e.g., waterfowl and turtles, etc.).

Dust Inhalation. Exposure via inhalation of fugitive dust would be limited to chemicals present in near-surface soil at or near a site that was devoid of either vegetation or hardscape that would prevent the erosion of soil particles. Intake via this mechanism is probably minimal relative to the other pathways. However, the off-site transport of soil may result in the exposure of organisms that are not present on the site.

Biological Uptake. Certain classes of chemicals are hydrophobic, meaning that they tend to partition from the water phase to the organic phase. The octanol-water partition coefficient (K_{ow}) is a measurement of this preference for the organic phase; K_{ow} is equal to the ratio of contaminant concentration in octanol to that in water.

$$K_{ow} = c_{\text{octanol}} / c_{\text{water}}$$

The octanol-water partition coefficient may also be used as an indicator of the potential for bioconcentration of organic compounds in aquatic organisms. Bioconcentration is the uptake of a chemical directly from aqueous solution into the body of an aquatic organism. It is of concern because concentrations of a chemical that appear to be safe for some organisms can accumulate to levels that are harmful to the organisms that feed on them. The bioconcentration factor (BCF) is defined as the concentration of chemical in an organism to the concentration in water at equilibrium (Lyman, 1990).

$$BCF = c_{org} / c_{water}$$

Values for K_{ow} and BCF's are presented in Tables 7-9 and 7-29, respectively.

Exposure via secondary pathways would be limited to chemicals that bioaccumulate within the food chain, including chemicals bioaccumulated from soil into plants or into animals that ingest the soil. These plants and/or animals may be consumed by animals higher on the food chain. Water-borne chemicals may bioaccumulate into aquatic organisms, plants, or animals that frequent the waters. These chemicals may be passed up the food chain or affect organisms within the next ecological tier. Organochlorines and metals are the contaminants of greatest concern for food-chain bioaccumulation.

7.2.2.3 Potential Receptors and Associated Pathways

Terrestrial wildlife at the MCAS El Toro may be exposed via incidental ingestion of contaminated media (e.g., soils, sediment, or water during foraging or other activities), inhalation of vapors or particulates, and secondary exposure via ingestion of contaminated food (e.g., prey). Dermal exposure to COPEC in near-surface soil may be the most significant exposure route for burrowing animals; animals that spend considerable time in surface water could also be exposed.

Mammals may potentially be exposed to contaminants by all three exposure routes. Dermal exposure is a significant route for burrowing and digging mammals, which also may be exposed through inhalation of vapors and particles as they forage for prey items or burrow for shelter. Oral exposure is an important route by ingestion of food (e.g., plant tissues, invertebrates, and vertebrate prey), water, and incidental ingestion of contaminated media as they go about their normal activities.

Birds may be exposed to contaminants at the MCAS El Toro by dermal contact while bathing, inhalation of dust and vapors, and, most significantly, by oral ingestion of contaminated food (e.g., plant tissue, invertebrates, and small birds and mammals if chemicals bioaccumulate in them). Birds may also ingest

contaminants while preening their feathers, ingesting water, or incidentally ingesting contaminated media during their normal activities.

Wildlife species known to occur in the grassland and sage scrub habitat at MCAS El Toro and the potential route of exposure are listed in Tables 7-26 and 7-27, respectively.

Aquatic receptors such as invertebrates, amphibians, and fish could be exposed to contaminants primarily through dermal contact with water and sediment (including transport across the gill membranes), by oral exposure through ingestion of food (especially for lipophilic organics), and incidental ingestion of contaminated media. Riparian and wetland wildlife receptors are listed in Table 7-28.

7.2.2.4 Exposure Point Concentration

The maximum observed concentration for each site was used as a conservative estimate of exposure point concentration in the evaluation process of COPEC. The maximum value detected at a site is a conservative estimate of long-term exposure, and therefore protective of ecological receptors. This approach was selected for several reasons:

- The Station has not been thoroughly characterized for ecological habitat or receptors
- Minimal data were collected for each site to establish a baseline understanding of contaminants and their concentrations.

With minimal data and limited characterization of the habitat, conservative use of data and toxicological information is advised in assessing potential effects.

<p align="center">Table 7-29 Chemicals Detected at El Toro: Bioconcentration Factors MCAS El Toro Phase I RI Technical Memorandum</p>				
				Page 1 of 7
Chemical	BCF	Exposure Duration	Species	BCF Source
ORGANICS:				
1,1,1-Trichloroethane	8.9	28 days	Bluegill sunfish (<i>Lepomis macrochirus</i>)	xx
1,2-Dichloroethene (total)	15 (cis) 22 (trans)		Calculated Calculated	xx xx
2,4,5-Trichlorophenoxy propionic acid				
2,4-DB				
2,4-D				
2,4,5-T				
2,4-Dimethyl phenol	15.1	28 days	Bluegill sunfish (<i>Lepomis macrochirus</i>)	w
2-Butanone	1			mm
2-Hexanone				
2-Methylnaphthalene				
4,4'-DDD	2720 4460		Alga Snail	rr rr
4,4'-DDE	59,000 59,000 51,000 25,000	32 days	Snail Mosquito larvae Fathead minnow (<i>Pimephales promelas</i>) Sculpin	rr rr uu uu
4,4'-DDT	3600-34,500 1210 5060 29,400; 37,000	30 days 30 days 32 days	Snail Duckweed Crayfish Fathead minnow (<i>Pimephales promelas</i>)	rr rr rr uu
4-Methyl-2-pentanone				
4-Methylphenol (p-cresol)				
4-Nitrophenol				
Acenaphthene	380.2		Fish	ww
Acenaphthylene	242		Fish	e
Acetone	0.69 0.03		Adult haddock ?	mm nn
Aldrin				
Alpha chlordane				
Alpha-BHC	130		Fish	e
Anthracene	100-2000 760 3500 485	1 hour 24 hours 28 hours 2-3 days	Water flea (<i>Daphnia magna</i>) <i>Daphnia pulex</i> Mayfly Fathead minnow (<i>Pimephales promelas</i>)	nn oo oo pp
Benzene	3.5 4.4 4.3		Eels (<i>Anguilla japonica</i>) Pacific herring (<i>Clupea harengus pallasii</i>) Goldfish (<i>Carassius auratus</i>)	xx xx xx

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**Table 7-29
Chemicals Detected at El Toro: Bioconcentration Factors
MCAS El Toro Phase I RI Technical Memorandum**

Chemical	BCF	Exposure Duration	Species	BCF Source
Benzo(a)anthracene				
Benzo(a)pyrene				
Benzo(b)fluoranthene				
Benzo(g,h,i)perylene				
Benzo(k)fluoranthene				
Benzyl butyl phthalate	776.2		Fish	ww
Beta BHC				
Bis(2-ethylhexyl)phthalate	91-569 54-2700	56 days	Fathead minnow (<i>Pimephales promelas</i>) Aquatic organisms	oo qq
Carbazole				
Carbon Disulfide	7.9		Calculated	yy
Carbon tetrachloride	17.4		Fish	ww
Chloroform	6 3.34-10.35 1.6-2.5 2.9-3.1 3.3-3.7		Bluegill sunfish (<i>Lepomis macrochirus</i>) Rainbow trout (<i>Salmo gairdneri</i>) Bluegill (<i>Lepomis macrochirus</i>) Largemouth bass (<i>Micropterus salmoides</i>) Catfish (<i>Ictalurus punctatus</i>)	xx xx xx xx xx
Chrysene				
Dalapon	3 <1	3 days 3 days	Fish Snails	tt tt
Delta-BHC	130		Fish	e
Dibenzo(a,h)anthracene				
Dibenzofuran				
Di-n-butyl phthalate	31.6 16.6 11.7		American oyster Brown shrimp Sheepshead minnow	yy yy yy
Dicamba				
Dichloroprop				
Dieldrin	4760		Fish	e
Diethylphthalate	117 15-16		Bluegill sunfish (<i>Lepomis Macrochirus</i>) Mullet (<i>mugil cephalus</i>)	yy yy
Dimethyl phthalate	4.7 5.4	24 hours 24 hours	Brown shrimp Sheepshead minnow	yy yy
Endosulfan I				
Endosulfan II				
Endosulfan sulfate				
Endrin				
Endrin aldehyde				

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Table 7-29
Chemicals Detected at El Toro: Bioconcentration Factors
MCAS El Toro Phase I RI Technical Memorandum

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Chemical	BCF	Exposure Duration	Species	BCF Source
Endrin ketone				
Ethylbenzene	15.5 4.7		Goldfish (<i>Carassius auratus</i>) Clams	yy yy
Fluoranthene	1150		Fish	e
Fluorene	1288.2		Fish	ww
Gamma chlordane				
Heptachlor epoxide	15,700		Fish	e
Hexachloroethane	138		Fish	ww
Indeno(1,2,3-cd)pyrene				
Isophorone	7.08		Fish	ww
Lindane	323.6		Fish	ww
MCPP				
Methoxychlor				
Methyl chloride				
Methylene chloride				
Naphthalene	426.6		Fish	ww
Octachlorodibenzo-p-dioxin				
PCB 1248	100000 (PCB's)		Fish	e
PCB 1254	100000 (PCB's)		Fish	e
PCB 1260	100000 (PCB's)		Fish	e
Petroleum hydrocarbons (total recoverable)	N/A			
Phenanthrene	2630.3		Fish	ww
Phenol	1.9 227 20 200 3.5		Goldfish (<i>Carassius auratus</i>) Water flea (<i>Daphnia magna</i>) Gold orfe Algae(<i>Chlorella fusca</i>) Freshwater phytoplankter (<i>Scenedesmus quadricauda</i>)	yy yy yy yy yy
Pyrene	2691.5		Fish	ww
Tetrachloroethene	38.9 49		Fathead minnow (<i>Pimephales promelas</i>) Bluegill sunfish (<i>Lepomis macrochirus</i>)	xx xx
Toluene	26-27.1			nn
TFH-diesel	N/A			
TFH-gasoline	N/A			

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**Table 7-29
Chemicals Detected at El Toro: Bioconcentration Factors
MCAS El Toro Phase I RI Technical Memorandum**

Chemical	BCF	Exposure Duration	Species	BCF Source
Trichloroethylene	17		Bluegill sunfish (<i>Lepomis macrochirus</i>)	xx
	39		Rainbow trout (<i>Salmo gairdenri</i>)	xx
Xylenes (total)	1,2-Xylene 21.4		Eels (<i>Anguilla japonica</i>)	xx
	6.2		Clams	xx
	1,3-Xylene 23.4		Eels (<i>Anguilla japonica</i>)	xx
	6.0		Clams	xx
	1,4-Xylene 23.4		Eels (<i>Anguilla japonica</i>)	xx
	158.5		Fish	xx
INORGANICS:				
Aluminum				
Antimony	0		Fish	e
Arsenic	Arsenic III 3 10 9 4	28 days	Snail	
		21 days	Water flea (<i>Daphnia magna</i>)	
		28 days	Stonefly	
		28 days	Bluegill sunfish (<i>Lepomis macrochirus</i>)	
	Arsenic IV 3 4 7 219	28 days	Snail	
		21 days	Water flea (<i>Daphnia magna</i>)	
		28 days	Stonefly	
		28 days	Water flea (<i>Daphnia magna</i>)	q
Barium	120		Plankton	r
	260		Brown algae	r r
Beryllium	100		Freshwater/marine plants, invertebrates, fish	t
	19		Bluegill sunfish	s
Cadmium	4100	8 weeks	<i>Gambusia affinis</i>	w
	2550	1.4 weeks	algae (<i>Chlorella vulgaris</i>)	w
	116-131	3 weeks	molluscs	w
	3500	66 weeks	Crustaceans	w
	2.6		<i>Formica sanguinea</i>	x
	3-8		<i>Helix aspersa</i>	x
0.6-93, 5		<i>Lumbricus rubellus</i>	x	
Chromium	1	30 days	Rainbow trout (<i>Salmo gairdneri</i>)	
	2.8	180 days	Rainbow trout (<i>Salmo gairdneri</i>)	
Cobalt	100-4000		Marine fish	r
	40-1000		Freshwater fish	r
Copper	1.5-10		<i>Helix aspersa</i>	x
	11.4		<i>Lumbricus terrestris</i>	x
	0.01-0.6		<i>Lumbricus rubellus</i>	x
	2000	20 hours	Algae(<i>Chlorella regularis</i>)	y
Cyanide				

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**Table 7-29
Chemicals Detected at El Toro: Bioconcentration Factors
MCAS El Toro Phase I RI Technical Memorandum**

Chemical	BCF	Exposure Duration	Species	BCF Source
Lead	1700	120 days	Snail	
	738	28 days	Stonefly	
	45		Bluegill sunfish (<i>Lepomis macrochirus</i>)	
	2366	14 days	Mayfly	
	0.01-4, 1-3		Lumbricus rubellus	x
	1.3, 1.1		Helix pomatia	x
	26,000	28 days	Alga (<i>S. capricornutum</i>)	z
1000-9000	28 days	Aquatic invertebrates	z	
Manganese	2500-6300		Phytoplankton	aa
	35-930		Coastal fish	aa
	100-600		Fish	bb
Mercury	13,000	14 days	Alga	ee
	91	29 days	Bluegill sunfish	ee
	27,000	30 days	Mosquitofish	ee
	179; 200; 14; 360	24 hours	Marine copepod	dd
Nickel	40-100		Fish	cc
	36		Carnivorous fish	gg
	100	12 weeks	Mussels	hh
Selenium	460	2 days	Mosquitofish	ii
	32,000	2 days	Freshwater gastropod	ii
	2100	2 days	Daphnids	ii
	2600	2 days	Plankton	ii
	3300	2 days	Killifish	ii
	>680	2 days	Freshwater diatoms	ii
Silver	3080		Fish	
Thallium	18.2		Clams	r
	11.7		Mussels	r
	34		Bluegill sunfish (<i>Lepomis macrochirus</i>)	r
Vanadium	10,000		Seasquirts	r
Zinc	1-9		Helix pomatia	jj
	0.15-2.8		Lumbricus rubellus	jj
	0.3-2		Helix aspersa	jj
	51-1130		Freshwater animals	kk
	1000		Fish	ll
	10,000		Aquatic Invertebrates	ll

NOTE: Updated as of March 18, 1993

Sources:

- a. Howard, P.H. (ed.). 1990. Handbook of Environmental Fate and Exposure Data. Vol II: Solvents. Lewis Pub., Inc. Chelsea, MI.
- b. Howard, P.H. (ed.). 1991. Handbook of Environmental Degradation Rates. Lewis Pub., Inc., Chelsea, MI.
- c. Howard, P.H. (ed.). 1989. Handbook of Environmental fate and Exposure data. Vol. I: Large Production and Priority Pollutants. Lewis Pub., Inc., Chelsea, MI.
- d. Howard, P.H. (ed.). 1991. Handbook of Environmental Fate and Exposure Data. Vol. III: Pesticides. Lewis Pub., Inc., Chelsea, MI.
- e. USEPA. 1987. Superfund Public Health Evaluation Manual. EPA 540/1-86/060. U.S. Environmental Protection Agency, Washington DC.

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Table 7-29
Chemicals Detected at El Toro: Bioconcentration Factors
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Chemical	BCF	Exposure Duration	Species	BCF Source
f.				Lugg, G.A., "Diffusion Coefficients of Some Organic and Other Vapors in Air"; Analytical Chemistry, Vol.40, No.7, pp.1072-1077, June 1978.
g.				Calculated using method from Lyman, Warren J, et al; "Handbook of Chemical Property Estimation Methods"; Washington, DC; p.17-9, 1991.
h.				USEPA. 1990. Guidance on Remedial Actions for Superfund Sites with PCB Contamination. EPA/540/G-90/007. U.S. Environmental Protection Agency.
k.				HSDB: Hazardous Substance Databank. National Library of Medicine, Bethesda, MD (Cd-ROM version). Micromedex, Inc., Denver, CO. 1993.
l.				BEIA. 1989.
m.				Mackay, D, Shui, WY, and KC Ma. 1992. Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals, Vol. I: Monoaromatic Hydrocarbons, Chlorobenzenes, and PCBs. Lewis Pub, Boca Raton.
n.				Worthing, Charles R. 1987. The Pesticide Manual, A World Compendium.
o.				Zarogian, GE. 1982. Memorandum to John H. Gentile, U.S. EPA, Narragansett, Rhode Island
p.				Mackay, D, Shui, WY, and KC Ma. 1992. Illustrated Handbook of Physical-Chemical Properties and Environmental Fate for Organic Chemicals, Vol. II: Polynuclear Aromatic Hydrocarbons, Polychlorinated Dioxins and Dibenzofurans. Lewis Publishers, Boca Raton.
q.				Eisler, R. 1988. Arsenic hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish & Wildlife Services Biological Report. 85(1.12). 92pp.
r.				ATSDR. 7/92
s.				EPA. 1980. Ambient water quality criteria for beryllium. Washington, DC: Office of Water Regulations and Standards, Criteria and Standards Division, U.S. Environmental Protection Agency. EPA-440/5-80-024
t.				Callahan MA, Slimak MW, Gabel NW, et al. 1979. Water-related environmental fate of 129 priority pollutants. Washington, DC: U.S. Environmental Protection Agency. EPA-440/4-79-029a.
u.				CHR. 4/90.
v.				ATSDR. February 19, 1993. Chlordane.
w.				Eisler R. 1985. Cadmium hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish & Wildlife Service Biological Report. 85(1.2). 46 pp.
x.				Dallinger, 1993
y.				EPA. 1985. Ambient water quality criteria for copper. Washington, DC: Office of Water Regulations and Standards, Criteria and Standards Division, U.S. Environmental Protection Agency. EPA-440/5-84-031
z.				Eisler R. 1988. Lead hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish & Wildlife Service Biological Report 85(1.14). 134 pp.
aa.				Folsom TR, Young DR, Johnson JN, et al. 1963. Manganese-54 and Zinc-65 in coastal organisms of California. Nature 200:327-329.
bb.				Thompson SE, Burton CA, Quinn DJ, et al. 1972. Concentration factors of chemical elements in edible aquatic organisms. Lawrence Livermore Laboratory, Bio-Medical Division, University of California, Livermore, CA.
cc.				EPA. 1980. Ambient water quality criteria for mercury. Washington, DC: Office of Water Regulations and Standards, Criteria and Standards Division, U.S. Environmental Protection Agency. EPA-440/5-80-058
dd.				Eisler R. 1987. Mercury hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish & Wildlife Service Biological Report. 85(1.10). 90 pp.
ee.				EPA, 1983.
ff.				Eisler R. 1989. Molybdenum hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish & Wildlife Service Biological Report. 85(1.19). 61 pp.
gg.				Birge WJ, Beach JA, 1980. Aquatic Toxicology of Nickel. In: Nriagu JO, ed. Nickel in the Environment. New York, NY: John Wiley and Sons, Inc., 354-355.
hh.				Zarogian GE, Johnson M, 1984. Nickel uptake and loss in the bivalves Crassostrea Virginica and Mytilus edulis. Arch ives Environmental Contaminants Toxicol 13:411-418.
ii.				Eisler R. 1985. Selenium hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish & Wildlife Service Biological Report. 85(1.5). 57 pp.
jj.				Dallinger, 1993.
kk.				EPA. 1987. Ambient water quality criteria for zinc. Washington, DC: Office of Water Regulations and Standards, Criteria and Standards Division, U.S. Environmental Protection Agency. EPA-440/5-87-067.
ll.				Fishbein L. 1981. Source, transport, and alterations of metal compounds: An overview: 1. Arsenic, beryllium, cadmium, chromium, and nickel. Environ Health Perspect 40:43-64.
mm.				Howard PH, Sage GW, Jarvis WF, Gray DA. 1990. Handbook of Environmental Fate and Exposure Data for Organic Chemicals. Lewis Pub., Chelsea, MI.
nn.				BEIA, 1989.

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Chemicals Detected at El Toro: Bioconcentration Factors
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Chemical	BCF	Exposure Duration	Species	BCF Source
<p>oo. Acquire, 1993.</p> <p>pp. Eisler R. 1985. Polycyclic aromatic hydrocarbon hazards to fish, wildlife, and invertebrates: a synoptic review. U.S. Fish & Wildlife Service. Biol. Rep. 85(1.11). 81 pp.</p> <p>qq. Barrows ME, Tetrocelli SR, Macek KJ, et al. 1980. Bioconcentrations and elimination of selected water pollutants by blue gill sunfish. In: Haque R. ed. Dynamics, exposure, and hazard assessment of toxic chemicals. Ann Arbor, MI: Ann Arbor Science Publishers.</p> <p>rr. Verschuren, 1983.</p> <p>ss. EPA. 1980. Ambient water quality criteria for phthalate esters. Washington, DC: Office of Water Regulations and Standards, Criteria and Standards Division, U.S. Environmental Protection Agency. EPA-440/5-87-067.</p> <p>tt. Howard PH, Sage GW, Jarvis WF, Gray DA. 1991. Handbook of Environmental Fate and Exposure Data for Organic Chemicals. Lewis Pub., Chelsea, MI.</p> <p>uu. Lyman RW, Reehl WF, Rosenblatt DH. 1982. Handbook of chemical property estimation methods. McGraw-Hill Book Co., New York, NY.</p> <p>vv. Geyer H, Scheunert I, Korte F. 1986. Bioconcentration potential for organic environmental chemical in humans. Regul Toxicol Pharmacol 6:313-347.</p> <p>ww. Banerjee, S. and G. L. Baughman. 1991. Bioconcentration factors and lipid solubility. Environmental Science and Technology. 25:536-539.</p> <p>xx. Howard, Philip H. 1989. Handbook of Environmental Fate and Exposure Data for Organic Chemicals - Solvents. Vol. II., Lewis Publishers.</p> <p>yy. Howard, Philip H. 1989. Handbook of Environmental Fate and Exposure Data for Organic Chemicals - Large Production and Priority Pollutants. Vol. I., Lewis Publishers.</p> <p>aaa. Mabey, W.R. et al. 1981. Aquatic Fate Process Data for Organic Priority Pollutants. USEPA Office of Water Regulations and Standards.</p> <p>bbb. Means, J.C.; Wood, S.G.; Hassett, J.J.; Banwart, W.L. 1982. Sorption of amino- and carboxy-substituted PAH by sediments and soils. ES&T 16:93-98.</p> <p>ccc. Jeng, Chang Y., Chen, Daniel H., Yaws, Carl L. 1992. Data Compilation for Soil Sorption Coefficient. Pollution Engineering, June 15, pp 54-60.</p> <p>ddd. Risk Assistant. 1991. CD-ROM version. Hampshire Research Institute, Alexandria, VA.</p>				

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7.2.3 Ecological Effects Assessment

COPEC were researched in the literature and various databases of toxicological information including HSDB (1993), AQUIRE (1993) and PHYTOTOX (1993) databases. Information addressing toxicity to terrestrial animals, terrestrial invertebrates, plants, and aquatic receptors is presented below by media of ecological concern. General discussion on the toxicity of organic and inorganic COPECs follows.

7.2.3.1 Soil

Terrestrial Mammals

Small mammals ingest soil during feeding, grooming, and burrowing activities. In order to assess potential for ecological effects, acceptable doses for soil ingestion were derived for the COPEC in soil, by dividing the toxicity dose reported in species specific literature by the body weight of that species to generate an acceptable soil exposure dose, presented as mg/kg-day.

$$\text{Derived Acceptable Soil Dose (mg/kg-day)} = \frac{\text{Literature Reported Dose (mg/day)}}{\text{Body Weight (kg)}}$$

The toxicity dose value was derived from literature values for the no- or lowest-observed adverse effect level (NOAEL and LOAEL, respectively) for the corresponding species. Of the various species that had literature values for NOAELs and LOAELs, the rat was the species most likely to be representative of mammals present at the Station, and for which data were most frequently reported (Table 7-30). Therefore, toxicity dose values were calculated for rats except where NOAEL and LOAEL data for rats were not available. In these cases, other suitable species were used (i.e., mouse or mallard).

Chronic exposure derived NOAEL and then LOAEL values were preferably chosen for the no adverse effect calculations. However, where chronic NOAEL and

LOAEL values were absent, other toxicity values (subchronic/acute LOAELs or oral LD₅₀s) had to be used. NOAEL and LOAEL values are literature derived toxicity values based upon toxicological investigations using laboratory or wild animal species. Data related to chronic oral exposure studies (gavage, drinking water, or diet) were used in preference to data derived from intraperitoneal or intramuscular exposure studies. Inhalation toxicity data were not included in the toxicity assessments. Dermal exposure criteria were not addressed in this document because of the uncertainty in correlating dermal toxicity under laboratory conditions (concentrated solutions, shaved skin of test animals) with toxicity under field conditions (generally dilute concentrations mixed with soil or water, contact with various body surfaces that can be covered with hair or are calloused). The NOAEL, LOAEL, and LD₅₀ available in the literature are presented in Table 7-30; those selected values used for the exposure assessment calculations are presented in Appendix H3. Criteria were not established for analytes that had little or no available literature toxicity values.

Exposure based on intake of soil was estimated for a rat, calculated as shown.

$$\text{SoilDose (mg/kg-day)} = \frac{\text{Ingestion Rate (mg/day)} \times \text{maximum observed concentration (mg/kg)}}{\text{BodyWeight(kg)}}$$

Using an index approach, the estimated soil ingestion dose was divided by a derived toxicity dose (based on the same species). If the index exceeded unity (one), soil concentrations associated with that COPEC could cause an adverse effect on terrestrial animals at the MCAS El Toro. Observed maximum concentrations resulting in an estimated dose that fell below this criteria (had an index of less than one) are unlikely to result in adverse effects to the animal receptor. The results of these comparisons are presented in Appendix H3, on a site-by-site basis.

Inhalation exposure was not assessed because airborne concentrations of organic and inorganic chemicals were not measured in areas where ecological receptors could be exposed.

Table 7-30
Literature Toxicity Values for the Protection of Terrestrial Mammals and Birds for COPEC in Soil
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Chemical	Criteria Protective of Animals			Reference
	Species	Toxicity Value	Description	
Organic Chemicals (µg/kg)				
1,1,1-Trichloroethane				
1,2-Dichloroethene (total)				
2,4,5-Trichlorophenoxy Propionic Acid				
2,4,5-T				
2,4-D				
2,4-DB				
2,4-Dimethylphenol				
2-Butanone	Rat	173 mg/kg bw/day	Subchronic NOAEL	Ralston et al., 1985
	Rat	1,080 mg/kg bw/day	Acute LOAEL	Brown and Hewitt, 1984
2-Hexanone				
2-Methylnaphthalene				
4,4'-DDD	Rat	3.4 g/kg	Acute oral LD ₅₀	Vershueren, 1983
4,4'-DDE				
	White-throated sparrow	4 ppm	Adverse effect	Beyer and Gish, 1980
4,4'-DDT	Rat	113 mg/kg bw/day	Acute oral LD ₅₀	Vershueren, 1983
	Bullfrog	>2,000 mg/kg bw/day	LD ₅₀	USFWS, 1984
	Mallard	>2,240 mg/kg bw/day	LD ₅₀	USFWS, 1984
	California Quail	595 mg/kg bw/day	LD ₅₀	USFWS, 1984
	Sandhill Crane	>1,200 mg/kg bw/day	LD ₅₀	USFWS, 1984
	Rat	2,510 mg/kg	Acute oral dermal LD ₅₀	Vershueren, 1983
	Quail and pheasants	311-1,869 mg/kg	LC ₅₀	Beyer and Gish, 1980
	Robin	53-204 ppm	Toxic	Beyer and Gish, 1980
	Thrushes	13-29 mg/kg bw/day	Toxic	Beyer and Gish, 1980
	White-throated sparrows	5-25 ppm	Adverse effect	Beyer and Gish, 1980
4-Methyl-2-pentanone				
4-Methylphenol				
Acenaphthene				
Acenaphthylene				
Acetone	Rabbit	10 ml/kg	Acute lethal dose	Vershueren, 1983
	Dog	8,000 gm/kg	Acute lethal dose	Vershueren, 1983
	Rat	9,750 mg/kg bw/day	Acute LD ₅₀	Vershueren, 1983
Aldrin	Rat	67 mg/kg bw/day	Acute LD ₅₀	Vershueren, 1983
	Rat	98 to 200 mg/kg bw/day	Acute dermal LD ₅₀	Vershueren, 1983

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**Table 7-30
Literature Toxicity Values for the Protection of Terrestrial Mammals and Birds for COPEC in Soil
MCAS El Toro Phase I RI Technical Memorandum**

Chemical	Criteria Protective of Animals			Reference
	Species	Toxicity Value	Description	
Aldrin (continued)	Mallard	520 mg/kg bw/day	LD ₅₀	USFWS, 1984
	Bobwhite Quail	6.59 mg/kg bw/day	LD ₅₀	USFWS, 1984
	Pheasant	16.8 mg/kg bw/day	LD ₅₀	USFWS, 1984
	Mule Deer	18.8 to 37.5 mg/kg	LD ₅₀	USFWS, 1984
Anthracene	Rat	25 mg/kg bw/day	Chronic LOAEL	Vershueren, 1983
	Rodent	3,300 mg/kg bw/day	Chronic effect	Eisler, 1987a
	Northern Bobwhite Quail	5,760 mg/kg diet	LD ₅₀	Eisler, 1987a
	Mallard	19,650 mg/kg diet	Acute LD ₅₀	Eisler, 1987a
Benzene	Rat	2.35 mg/kg bw/day	Acute NOAEL	Deichman et al., 1963
	Rat	17.65 mg/kg bw/day	Subchronic NOAEL	EPA, 1980
Benzo(a)anthracene	Rodent	0.006 mg/kg bw	Chronic effect	Eisler, 1987a
Benzo(a)pyrene	Mallard	4,000 mg/kg diet	Effects obs	Eisler, 1987a
	Rat	50 mg/kg bw/day	Acute oral LD ₅₀	Eisler, 1987a
	Rodent	0.002 mg/kg	Chronic effect	Eisler, 1987a
Benzo(b)fluoranthene	Rodent	4.0 mg/kg	Chronic effect	Eisler, 1987a
Benzo(g,h,i)perylene				
Benzo(k)fluoranthene	Rodent	72 mg/kg bw/day	Chronic effect	Eisler, 1987a
Benzyl butyl phthalate	Rat	735 mg/kg	Acute oral LD ₅₀	Vershueren, 1983
	Mouse	568 mg/kg	Acute oral LD ₅₀	Vershueren, 1983
	Rat	2,330 mg/kg	Acute oral LD ₅₀	IARC, 1980a
BHC alpha				
BHC delta	Rat	88 to 91 mg/kg	Acute oral LD ₅₀	Vershueren, 1983
	Rat	900 to 1,000 mg/kg	Acute dermal	Vershueren, 1983
Gamma BHC (lindane)				
Bis(2-ethylhexyl)phthalate	Rat	65 mg/kg bw/day	Chronic NOAEL	Carpenter et al., 1953
	Rat	200 mg/kg bw/day	Chronic LOAEL	Carpenter et al., 1953
	Rat	31 g/kg	Oral LD ₅₀	USDHHS, 1983
Carbazole				
Carbon disulfide				
α Chlordane	Rat	457 to 590 mg/kg	Acute oral LD ₅₀	Vershueren, 1983
	Mallard	1,200 mg/kg bw/day	LD ₅₀	USFWS, 1984
	California Quail	14.1 mg/kg bw/day	LD ₅₀	USFWS, 1984
	Pheasant	24 to 72 mg/kg bw/day	LD ₅₀	USFWS, 1984
	Rat	15 mg/kg bw/day	Acute LOAEL	Vershueren, 1983
	Rat	0.273 mg/kg bw/day	Chronic LOAEL	Velsicol, 1983
	Rat	0.055 mg/kg bw/day	Chronic NOAEL	Velsicol, 1983

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Table 7-30
Literature Toxicity Values for the Protection of Terrestrial Mammals and Birds for COPEC in Soil
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Chemical	Criteria Protective of Animals			Reference
	Species	Toxicity Value	Description	
gamma Chlordane	Rat	457 to 590 mg/kg	Acute oral LD ₅₀	Vershueren, 1983
	Rat	15 mg/kg	Acute LOAEL	Vershueren, 1983
Chrysene	Animals	99 mg/kg	Carcinogenicity	Sims and Overcash, 1983
Dalapon	Rat	7,570 to 9,330 mg/kg bw/day	Acute LD50	Vershueren, 1983
	Rat	50 mg/kg bw/day	Chronic LOAEL	Vershueren, 1983
	Rat	15 mg/kg bw/day	Chronic NOAEL	Vershueren, 1983
Dibenzofuran	Rat	1 mg/kg bw/day	Acute NOAEL	Moore et al., 1976
	Mouse	6 mg/kg bw/day	Acute NOAEL	Moore et al., 1976
	Rat	6 mg/kg bw/day	Acute NOAEL	Moore et al., 1976
Di-n-butylphthalate	Rat	8,000 mg/kg bw/day	Acute LD ₅₀	Lewis, 1992
Dichloroprop				
Dieldrin	Rat	46 to 63 mg/kg	Acute oral LD ₅₀	Vershueren, 1983
	Mallard	381 mg/kg bw/day	LD ₅₀	USFWS, 1984
	Pheasant	79 mg/kg bw/day	LD ₅₀	USFWS, 1984
	Rock Dove	26.6 mg/kg bw/day	LD ₅₀	USFWS, 1984
	House sparrow	47.6 mg/kg bw/day	LD ₅₀	USFWS, 1984
	Rat	52 to 117 mg/kg	Acute dermal LD ₅₀	Vershueren, 1983
	Quail and pheasant	37-169 mg/kg	LC ₅₀	Beyer and Gish, 1980
	Thrush	12 ppm diet	Lethal	Beyer and Gish, 1980
	Loggerhead shrikes	2 ppm diet	Adverse effect	Beyer and Gish, 1980
	Mule deer	75 to 100 mg/kg bw/day	LD ₅₀	Connell and Miller, 1984
	Domestic Goat	100 to 200 mg/kg bw/day	LD ₅₀	Connell and Miller, 1984
Diethyl phthalate				
Dimethyl phthalate				
Endosulfan I	Rat	18 to 100 mg/kg	Acute oral LD ₅₀	Vershueren, 1983
	Rat	74 to 359 mg/kg	Acute oral LD ₅₀	Vershueren, 1983
	Rat	0.15 mg/kg	Chronic LOAEL	American Hoeschst, 1984
	Rat	2.0 mg/kg bw/day	NOAEL	American Hoeschst, 1984
Endosulfan II	Mallard duck	200 to 750 mg/kg bw	LD ₅₀	Vershueren, 1983
Endosulfan sulfate				

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Table 7-30
Literature Toxicity Values for the Protection of Terrestrial Mammals and Birds for COPEC in Soil
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Chemical	Criteria Protective of Animals			Reference
	Species	Toxicity Value	Description	
Endrin	Rat	7.5 to 17.5 mg/kg	Acute oral LD ₅₀	Vershueren, 1983
	Rock dove	2 to 5 mg/kg bw/day	LD ₅₀	USFWS, 1984
	Mallard	5.64 mg/kg bw/day	LD ₅₀	USFWS, 1984
	California Quail	1.19 mg/kg bw/day	LD ₅₀	USFWS, 1984
	Pheasant	1.78 mg/kg bw/day	LD ₅₀	USFWS, 1984
	Mule Deer	6.25 to 12.5 mg/kg bw/day	LD ₅₀	USFWS, 1984
	Goat	25 to 50 mg/kg bw/day	LD ₅₀	Connell and Miller, 1984
	Rat	15 mg/kg bw/day	Acute dermal LD ₅₀	Vershueren, 1983
Endrin aldehyde				
Endrin ketone				
Ethylbenzene	Rat	97.1 mg/kg bw/day	Subchronic NOAEL	Wolf et al., 1956
	Rat	291 mg/kg bw/day	Subchronic LOAEL	Wolf et al., 1956
Fluoranthene	Mouse	125 mg/kg bw/day	Subchronic NOAEL	EPA, 1988a
	Mouse	250 mg/kg bw/day	Subchronic LOAEL	EPA, 1988a
	Rat	2,000 mg/kg	Oral LD ₅₀	USDHHS, 1983
Fluorene				
Heptachlorepoide	Rat	0.25 mg/kg bw/day	Chronic LOAEL	Verlicol, 1959
	Rat	0.25 mg/kg bw/day	Chronic NOAEL	Verlicol, 1954
Hexachloroethane				
Indeno(1,2,3)pyrene	Rodent	72 mg/kg bw/day	Chronic effect	Eisler, 1987a
Isophorone				
MCPP				
Methoxychlor	Rat	6,000 mg/kg bw/day	Acute oral LD ₅₀	Vershueren, 1983
	Mallard	>2,000 mg/kg bw/day	LD ₅₀	USFWS, 1984
	California Quail	>2,000 mg/kg bw/day	LD ₅₀	USFWS, 1984
Methylene chloride	Rat	5.85 to 6.47 mg/kg bw/day	Chronic NOAEL	NCA, 1982
	Rat	52.58 to 58.32 mg/kg bw/day	Chronic LOAEL	NCA, 1982
Naphthalene	Rat	41 mg/kg bw/day	Chronic NOAEL	Schmahl, 1955
	Mouse	300 mg/kg bw/day	Acute LOAEL	Plasterer, 1985
	Rat	1,780 mg/kg	Oral LD ₅₀	USDHHS, 1983
Octachlorodibenzo-p-dioxin				
PCB 1248				

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Table 7-30
Literature Toxicity Values for the Protection of Terrestrial Mammals and Birds for COPEC in Soil
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Chemical	Criteria Protective of Animals			Reference
	Species	Toxicity Value	Description	
PCB 1254	Rat	5 to 800 mg/kg bw/day	EC, diet	Vershueren, 1983
	Birds (mallard, pheasant, and quail)	745 to 5,000 mg/kg bw/day	LC ₅₀	Connell and Miller, 1984
	Chickens	30 to 250 mg/kg bw/day	Toxic	Connell and Miller, 1984
	Rats, mice, rabbits	1.3 to 2.5 mg/kg bw/day	LD ₅₀	Connell and Miller, 1984
PCB 1260	Birds (mallard, pheasant, quail)	745 to 500 mg/kg bw/day	LC ₅₀	Connell and Miller, 1984
	Chickens	30 to 250 mg/kg bw/day	Toxic	Connell and Miller, 1984
	Rat	20 to 100 mg/kg bw/day	No effect	Wasserman et al., 1979
Phenanthrene	Mouse	10 mg/kg bw/day	Acute NOAEL	Mackenzie and Angervine, 1981
	Mouse	40 mg/kg bw/day	Acute LOAEL	Mackenzie and Angervine, 1981
Pyrene	Mouse	125 mg/kg bw/day	Subchronic NOAEL	EPA, 1988a
	Mouse	250 mg/kg bw/day	Subchronic LOAEL	EPA, 1988a
Tetrachloroethene				
Toluene	Rat	223 mg/kg bw/day	Acute NOAEL	NTP, 1989a
	Rat	446 mg/kg bw/day	Subchronic LOAEL	NTP, 1989a
	Rat	5,000 mg/kg	Oral LD ₅₀	USDHHS, 1983
Trichloroethylene	Mouse	17.9 mg/kg bw/day	Subchronic NOAEL	NCI, 1976
	Mouse	393 mg/kg bw/day	Subchronic LOAEL	NCI, 1976
	Rat	4,950 mg/kg	Oral LD ₅₀	Lewis, 1992
Xylene	Rat	179 mg/kg bw/day	Chronic NOAEL	NTP, 1986
	Rat	357 mg/kg bw/day	Chronic LOAEL	NTP, 1986
Inorganic Chemicals (mg/kg)				
Aluminum	Mouse	19 mg/kg bw/day	Chronic NOAEL	Paternain et al., 1988
	Rat	14 mg/kg bw/day	Subchronic LOAEL	Ondreicka et al., 1966
	Swine, poultry, horse, rabbit	200 ppm	a	NAS, 1980
	Cattle, sheep	1,000 ppm	a	NAS, 1980
Antimony				
Arsenic	Rat	6.4 mg/kg bw/day	Chronic LOAEL	Byron et al., 1967
	Cattle, sheep, swine, poultry	50 ppm (inorganic)	a	NAS, 1980
	Cattle, sheep, swine, poultry	100 ppm (organic)	a	NAS, 1980

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Table 7-30
Literature Toxicity Values for the Protection of Terrestrial Mammals and Birds for COPEC in Soil
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Chemical	Criteria Protective of Animals			Reference
	Species	Toxicity Value	Description	
Barium	Rat	0.25 mg/kg bw/day	Chronic NOAEL	Schroeder and Mitchner, 1975a
	Mouse	0.825 mg/kg bw/day	Chronic NOAEL	Schroeder and Mitchner, 1975a
	Cattle, sheep, swine, poultry, horse, rabbit	20 ppm	a	NAS, 1980
Beryllium	Rat	0.85 mg/kg bw/day	Chronic LOAEL	Schroeder and Mitchner, 1975a
	Rat	0.54 mg/kg bw/day	Chronic NOAEL	Schroeder and Mitchner, 1975a
Cadmium	Rat	0.004 mg/kg bw/day	Chronic NOAEL	Kopp et al., 1982
	Rat	0.014 mg/kg bw/day	Chronic LOAEL	Kopp et al., 1982
	Cattle, sheep, swine, poultry, horse, rabbit	0.5 ppm	a	NAS, 1980
Chromium (total)	Rat	0.46 mg/kg bw/day	Chronic NOAEL	Schroeder et al., 1965
	Cattle, sheep, swine, poultry, horse, rabbit	1,000 to 3,000 ppm	a	NAS, 1980
Cobalt	Rat	0.05 mg/kg bw/day	Subchronic NOAEL	Krasovski and Fridlyand, 1971
	Rat	0.5 mg/kg bw/day	Subchronic LOAEL	Krasovski and Fridlyand, 1971
Copper	Rat	12.5 mg/kg bw/day	Subchronic NOAEL	Murthy et al., 1981
	Mouse	4.2 mg/kg bw/day	Chronic LOAEL	Massie and Aiello, 1984
	Cattle	100 ppm	a	NAS, 1980
	Sheep	25 ppm	a	NAS, 1980
	Poultry	300 ppm	a	NAS, 1980
	Rabbit	200 ppm	a	NAS, 1980
Lead	Rat	0.45 mg/kg bw/day	Chronic NOAEL	Perry et al., 1988
	Rat	2.8 mg/kg bw/day	Chronic LOAEL	Azar et al., 1973
	Cattle, sheep, swine, poultry, rabbit	30 ppm	a	NAS, 1980
	Surface dwelling animals	0.1 ppm	LOAEL	EPA, 1992h
	Shrew	138.6 ppm reduced population		Quarles et al., 1974
Manganese				
Mercury	Rat	0.003 mg/kg bw/day	Chronic NOAEL	Fitzhugh et al., 1950
	Rat	0.015 mg/kg bw/day	Chronic LOAEL	Fitzhugh et al., 1950
	Cattle, sheep, swine, poultry, rabbit	2 ppm	a	NAS, 1980

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Table 7-30
Literature Toxicity Values for the Protection of Terrestrial Mammals and Birds for COPEC In Soil
MCAS El Toro Phase I RI Technical Memorandum

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Chemical	Criteria Protective of Animals			Reference
	Species	Toxicity Value	Description	
Nickel	Rat	5 mg/kg bw/day	Chronic NOAEL	Ambrose et al., 1976
	Rat	50 mg/kg bw/day	Chronic LOAEL	Ambrose et al., 1976
	Cattle, sheep, swine, poultry, rabbit	50 ppm	a	NAS, 1980
Selenium	Cattle, sheep, swine, poultry, rabbit	2 ppm	a	NAS, 1980
Silver	Rat	181.2 mg/kg bw/day	Acute NOAEL	Walker, 1971
	Mouse	18.1 mg/kg bw/day	Subchronic LOAEL	Rungby and Danscher, 1984
	Swine, poultry	100 ppm	a	NAS, 1980
Thallium	BD			
Vanadium	Rat	0.7 mg/kg bw/day	Chronic NOAEL	Schroeder et al., 1970
	Rat	2.8 mg/kg bw/day	Chronic LOAEL	Kowalski, 1988
	Cattle, sheep	50 ppm	a	NAS, 1980
	Swine, poultry, horse, rabbit	10 ppm	a	NAS, 1980
Zinc	Rat	98.3 mg/kg bw/day	Subchronic NOAEL	Drinker et al., 1927
	Mouse	38 mg/kg bw/day	Chronic LOAEL	Aughey et al., 1977
	Sheep	300 ppm	a	NAS, 1980
	Cattle, swine, poultry, horse, rabbit	500 ppm	a	NAS, 1980

^aMaximum tolerance level of dietary minerals for domestic animals (concentration in ppm).

^bTotal Dose—was derived by multiplying the toxicity value by the average body weight of the organism tested (Rat = 0.2 kg; mouse = 0.025 kg; bird [wild specie] = 0.04 kg; chicken = 0.8 kg; duck = 2.5 kg; goat = 60 kg; quail = 0.1 kg; dog = 10 kg; rabbit = 2 kg; guinea pig = 0.5 kg).

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Invertebrates

Available toxicity information for terrestrial invertebrates was compiled for each of the COPEC in soil and is presented in Table 7-31. Observed maximum detected concentrations were compared to the toxicity values.

Plants

Literature reported toxicity values for COPEC in soil are presented in Table 7-32. Background levels, tolerable levels and excessive (toxic) levels are presented, where available. Observed maximum detected concentrations were compared to the toxicity values.

7.2.3.2 Sediment

Sediment concentrations of concern were derived using ambient water quality criteria (AWQC) and an equilibrium partitioning approach for nonpolar organic compounds detected in the sediment. This approach is consistent with that used by EPA in the development of sediment quality criteria. A basic assumption is that exposure occurs primarily to the dissolved fraction of chemical. The protective concentration in sediment can be estimated by knowing what concentration of a nonpolar chemical is protective in surface water (e.g., AWQC), the chemical-specific partition coefficient for organic carbon to water (K_{OC}), and the organic carbon content of the sediment.

The equation used for the derivation (EPA 1988b) is as follows:

$$C_{\text{sediment}} = K_{OC} \times AWQC \times 10^{-3}$$

where:

$$C_{\text{sediment}} = \text{Sediment concentration of concern } (\mu\text{g chemical} / \text{g organic carbon})$$

K_{OC}	=	Partition coefficient for organic carbon to water (ml/g) (Table 7-9)
AWQC	=	Chronic surface water criterion ($\mu\text{g/L}$).
10^{-3}	=	Unit conversion

The sediment concentration of concern can be specified to the particular sediment of concern by multiplying the organic carbon content (OC) of the sediment as follows:

$$\text{Normalized } C_{\text{sediment}} (\text{ug/kg sediment}) = C_{\text{sediment}} (\text{ug chemical/gram OC}) \times \text{OC (g/kg sediment)}$$

A default organic carbon content of 2 percent (20 g/kg) was used for calculating sediment criteria for the El Toro MCAS (EPA, 1989a).

The derived sediment criteria and the maximum concentrations of organic compounds detected in sediment at each site are presented in Table 7-33. Sediment levels of concern were not developed for organic compounds which did not have AWQC or for inorganic compounds. Concentrations of inorganics in surface water cannot be estimated reliably from sediment concentrations using the above described approach. Instead, surface water criteria or comparative sediment criteria from other areas are assumed to represent screening levels for inorganic compounds for sediments at MCAS El Toro.

While AWQC for aquatic life protection currently exist for some PAHs (for example, naphthalene, fluoranthene, and phenanthrene [proposed]) no criteria are available for other PAHs detected. In lieu of this information, the criterion value for naphthalene is used as a surrogate. In general, toxicity of relatively soluble PAHs to aquatic organisms increases with increasing molecular weight, to a point where low water solubility becomes limiting and the acute toxicity of high molecular weight PAHs is reduced (Eisler, 1987a).

7.2.3.3 Surface Water Evaluation Methodology

Table 7-31 Literature Criteria Protective of Terrestrial Invertebrates for COPEC in Soil MCAS El Toro Phase 1 RI Technical Memorandum				
Page 1 of 6				
Chemical	Effect Levels or Criteria Protective of Soil Invertebrates			Reference
	Species	Dose	Description	
Organic Chemicals				
1,1,1-Trichloroethane				
1,2-Dichloroethene (total)				
2,4,5-Trichlorophenoxy propionic Acid				
2,4,5-T				
2,4-D				
2,4-DB				
2,4-Dimethylphenol				
2-Butanone				
2-Hexanone				
2-Methylnaphthalene				
4,4'-DDD	Earthworm	2,000 ppm	LC50	Roberts and Dorough, 1983
4,4'-DDE				
4,4'-DDT	Earthworm	3 ppm	Weight loss	Johnson, 1976
4-Methyl-2-pentanone				
4-Methylphenol				
Acenaphthene	Earthworm	98 ppm ^a	LC50	Neuhauser et al., 1985a
Acenaphthylene				
Acetone	Earthworm	200 to 2,000 ppm	LC50	Roberts and Dorough, 1983
Aldrin				
Anthracene				
Benzene	Earthworm	196 ppm	LC50	Neuhauser et al., 1985a
Benzo(a)anthracene				
Benzo(a)pyrene	Earthworm	2,000 ppm	LC50	Roberts and Dorough, 1983
Benzo(b)fluoranthene				
Benzo(g,h,i)perylene				
Benzo(k)fluoranthene				
Benzylbutyl phthalate				
Bis(2-ethylhexyl)phthalate	Earthworm	50,000 ppm ^a	LC50	Neuhauser et al., 1985a
alpha-BHC				
Delta-BHC				
gamma-BHC				
Carbazole				
Carbon disulfide				
Carbon Tetrachloride				
α Chlordane	Nightcrawler	>32 lb ai/A	3 days LD50	Ruppel, 1977
beta Chlordane				
gamma Chlordane				
Chrysene				
Dalapon				
Dibenzofuran				
Di-n-butylphthalate	Earthworm	2,720 ppm	LC50	Neuhauser et al., 1985a
Dichlorprop				
Dieldrin	Earthworm (<i>Eisenia foetida</i>)	25 mg/kg	4 to 6 weeks, decrease growth, cocoon production	Neuhauser, 1990

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Table 7-31 Literature Criteria Protective of Terrestrial Invertebrates for COPEC in Soil MCAS El Toro Phase 1 RI Technical Memorandum				
Page 2 of 6				
Chemical	Effect Levels or Criteria Protective of Soil Invertebrates			Reference
	Species	Dose	Description	
Diethylphthalate	Earthworm	1,700 ppm ^a	LC50	Neuhauser et al., 1985a
Dimethylphthalate				
Endosulfan I				
Endosulfan II				
Endosulfan sulfate				
Endrin				
Endrin aldehyde				
Endrin ketone				
Ethylbenzene	Earthworm	94 ppm ^a	LC50	Neuhauser et al., 1985a
Fluoranthene	Earthworm	4,320 ppm ^a	LC50	Neuhauser et al., 1985a
Fluorene	Earthworm	342 ppm ^a	LC50	Neuhauser et al., 1985a
	Earthworm	173 ppm	LC50	Neuhauser et al., 1985a
	Earthworm (<i>Eisenia foetida</i>)	23,600 mg/kg	Reproduction inhibition	Neuhauser, 1990
Heptachlor epoxide				
Hexachloroethane				
Indeno(1,2,3)pyrene				
Isophorone				
MCPP				
Methoxychlor				
Methylene chloride	Earthworm	1,216 µg/g	LC50	Neuhauser et al., 1985a
Naphthalene	Earthworm	9,340 ppm ^a	LC50	Neuhauser et al., 1985a
Octachlorodibenzo-p-dioxin				
PCB 1248				
PCB 1254				
PCB 1260				
Phenanthrene	Forest soil invertebrate	1 g/m ²	Adverse effects	Eisler, 1987a
	Soil invertebrate	1 to 5 g/m ²	Adverse effects	Eisler, 1987a
Phenol				
Pyrene				
Tetrachloroethene				
Toluene	Earthworm	150 ppm ^a	LC50	Neuhauser et al., 1985a
	Earthworm	1 percent	Growth inhibition	Hartenstein, 1982
Trichloroethylene	Earthworm	210 ppm ^a	LC50	Neuhauser et al., 1985a
Xylene				
Inorganic Chemicals				
Aluminum	Woodlouse (<i>Porcello scaber</i>)	2,500 to 2,800 ppm	55 to 75 percent survival	Beyer et al., 1985
Antimony				
Arsenic	Bacteria, nematodes, earthworms, fungi	230 to 972 ppm	Effects observed	Bisessar, 1982
Barium				
Beryllium				

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Table 7-31
Literature Criteria Protective of Terrestrial Invertebrates for COPEC in Soil
MCAS El Toro Phase 1 RI Technical Memorandum

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Chemical	Effect Levels or Criteria Protective of Soil Invertebrates			Reference
	Species	Dose	Description	
Cadmium	Earthworm	20 ppm	Threshold for effects	Neuhauser et al., 1985b
	Forest soil invertebrate	10 to 50 ppm	No effect	Bengtsson and Tranvik, 1989
	Earthworm	1,800 to 18,000 (ppm)	Growth inhibition	Hartenstein et al., 1981
	Soil invertebrates	0.2 µg/g	HC5 ^D	van Straalen, 1993
	<i>Dendrobaena rubida</i>	100 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Lumbricus rubellus</i>	10 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Eisenia foetida</i>	25 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Helix aspersa</i>	10 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Porcellio scaber</i>	10 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Orchesella cincta</i>	56 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Folsomia candida</i>	73 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Platynothrus peltifer</i>	2.9 µg/g dry weight		van Straalen, 1993
	Earthworm (<i>Eisenia foetida</i>)	1,800 to 18,000 mg/kg	8 weeks, growth inhibition	Hartenstein, 1981
	Earthworm (<i>Eisenia foetida</i>)	3,500 to 35,000 mg/kg	8 weeks, toxic	Hartenstein, 1981
	Earthworm (<i>Eisenia foetida</i>)	100 µg/g	5 weeks, cocoon production decrease	Neuhauser, et al., 1984b
	Earthworm (<i>Eisenia foetida</i>)	100 ppm, dry weight	4 to 6 weeks, decreased growth rates	Malecki et al., 1982
	Earthworm (<i>Eisenia foetida</i>)	50 ppm, dry weight	20 weeks, reproduction inhibition	Malecki et al., 1982
Marine Amphipod (<i>Ampelisca abdita</i>)	1.12E-04 g/gm	10 days, toxic	DiToro, 1992	
Marine Amphipod (<i>Rhepoxynius hudsoni</i>)	1.12E-04 g/gm	10 days, toxic	DiToro, 1992	
Freshwater snail (<i>Helisoma sp.</i>)	1.12E-04 g/gm	10 days, toxic	DiToro, 1992	
Freshwater Oligochaete (<i>Lumbricus variegatus</i>)	1.12E-04 g/gm	10 days, toxic	DiToro, 1992	
Chromium (total)		100 ppm	Toxic	Cottenie, 1977
Cobalt	Earthworm	300 to 3,000 ppm	Growth inhibition	Hartenstein et al., 1981
	Earthworm (<i>Eisenia foetida</i>)	300 to 3,000 mg/kg	8 weeks, growth inhibition	Hartenstein et al., 1981
	Earthworm (<i>Eisenia foetida</i>)	30,000 mg/kg	8 weeks, toxic	Hartenstein et al., 1981
	Earthworm (<i>Eisenia foetida</i>)	82.5 µg/g food source	172 days, growth/reproduction inhibition	Neuhauser et al., 1984a
Copper	Forest soil invertebrate	< 100 ppm	No effect	Bengtsson and Tranvik, 1989
	Earthworm	1,100 to 11,000 ppm	Growth inhibition	Hartenstein et al., 1981
	Soil invertebrates	2.7 µg/g	HC5 ^D	van Straalen, 1993
	Earthworm	131 ppm	Threshold for effects	Ma et al., 1983
	Earthworm	60 ppm	Threshold for effects	Ma et al., 1983

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Table 7-31
Literature Criteria Protective of Terrestrial Invertebrates for COPEC in Soil
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Chemical	Effect Levels or Criteria Protective of Soil Invertebrates			Reference
	Species	Dose	Description	
Copper (continued)	<i>Dendrobaena rubida</i>	122 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Lumbricus rubellus</i>	30 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Eisenia foetida</i>	60 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Allolobophora caliginosa</i>	50 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Arion ater</i>	25 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Onychiurus armatus</i>	2,608 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Platynothrus peltifer</i>	168 µg/g dry weight	NOAEL	van Straalen, 1993
	Lumbricidae	106 mg/kg	Growth inhibition	Martin, 1986
	Earthworm (<i>Eisenia foetida</i>)	1,100 to 11,000 mg/kg	8 weeks, growth inhibition	Hartenstein, 1981
	Earthworm (<i>Eisenia foetida</i>)	22,000 mg/kg	8 weeks, toxic	Hartenstein, 1981
	Earthworm (<i>Eisenia foetida</i>)	1,000 µg/g	5 weeks, cocoon production decrease	Neuhauser, 1984
	Earthworm (<i>Eisenia foetida</i>)	500 ppm, dry weight	4 to 6 weeks, decreased growth rates	Malecki et al., 1982
	Earthworm (<i>Eisenia foetida</i>)	2,000 ppm, dry weight	20 weeks, reproduction inhibition	Malecki et al., 1982
	Lead		0 to 95 ppm	No effect	Williamson & Evans, 1972
Earthworm		5,000 ppm	Reduction in reproduction No effect	Neuhauser et al., 1984b
Forrest soil invertebrate		100 to 200 ppm	No effect	Bengtsson and Tranvik, 1989
Soil invertebrates		77 µg/g	HC5 ^D	van Straalen, 1993
<i>Dendrobaena rubida</i>		560 µg/g dry weight	NOAEL	van Straalen, 1993
<i>Lumbricus rubellus</i>		200 µg/g dry weight	NOAEL	van Straalen, 1993
<i>Eisenia foetida</i>		1,000 µg/g dry weight	NOAEL	van Straalen, 1993
<i>Allolobophora caliginosa</i>		1,000 µg/g dry weight	NOAEL	van Straalen, 1993
<i>Arion ater</i>		1,000 µg/g dry weight	NOAEL	van Straalen, 1993
<i>Onychiurus armatus</i>		1,096 µg/g dry weight	NOAEL	van Straalen, 1993
<i>Aiolopus thalassinus</i>		100 µg/g dry weight	NOAEL	van Straalen, 1993
<i>Platynothrus peltifer</i>		431 µg/g dry weight	NOAEL	van Straalen, 1993
<i>Onychiurus armatus</i>		45 ppm	Decreased growth	Bengtsson et al., 1983
Woodlice		12,800 ppm	Reduced life-span	Byer and Anderson, 1985
Soil invertebrates and soil communities		15 µg/g	LOAEL	EPA, 1992h
Earthworm (<i>Eisenia foetida</i>)		5,000 µg/g	5 weeks, cocoon production decrease	Neuhauser et al., 1984b
Earthworm (<i>Eisenia foetida</i>)		12,000 ppm, dry weight	4 to 6 weeks, decreased growth rates	Malecki et al., 1982

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Table 7-31 Literature Criteria Protective of Terrestrial Invertebrates for COPEC In Soil MCAS El Toro Phase 1 RI Technical Memorandum				
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Chemical	Effect Levels or Criteria Protective of Soil Invertebrates			Reference
	Species	Dose	Description	
Lead (continued)	Earthworm (<i>Eisenia foetida</i>)	>5,000 ppm, dry weight	20 weeks, reproduction inhibition	Malecki et al., 1982
Manganese				
Mercury		10 ppm	Toxic	Horvarth et al., 1983
	Earthworm	480 to 4,800 ppm	Growth inhibition	Hartenstein et al., 1981
	<i>Eisenia foetida</i>	3.25 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Octochaetes pattoni</i>	0.25 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Arion ater</i>	10 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Aiolopus thalassinus</i>	0.12 µg/g dry weight	NOAEL	van Straalen, 1993
	Earthworm (<i>Eisenia foetida</i>)	480 to 4,800 mg/kg	8 weeks, growth inhibition	Hartenstein et al., 1981
	Earthworm (<i>Eisenia foetida</i>)	2,400 to 24,000 mg/kg	8 weeks, toxic	Hartenstein et al., 1981
Nickel	Earthworm	500 ppm	Reduced growth	Neuhauser et al., 1984
	<i>Eisenia foetida</i>	100 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Lumbricus rubellus</i>	50 µg/g dry weight	NOAEL	van Straalen, 1993
	Earthworm	1,200 to 12,000 ppm	Growth inhibition	Hartenstein et al., 1981
	Earthworm (<i>Eisenia foetida</i>)	1,200 to 12,000 mg/kg	8 weeks, growth inhibition	Hartenstein et al., 1981
	Earthworm (<i>Eisenia foetida</i>)	1,200 to 12,000 mg/kg	8 weeks, toxic	Hartenstein et al., 1981
	Earthworm (<i>Eisenia foetida</i>)	250 µg/g	5 weeks, cocoon production decrease	Neuhauser et al., 1984b
	Earthworm (<i>Eisenia foetida</i>)	200 ppm, dry weight	4 to 6 weeks, decreased growth rates	Malecki et al., 1982
	Earthworm (<i>Eisenia foetida</i>)	400 ppm, dry weight	20 weeks, reproduction inhibition	Malecki et al., 1982
Selenium				
Silver				
Thallium				
Vanadium		<500 ppm	No effect	Bengtsson and Tranvik, 1989
Zinc	Woodlouse	100 to 3,200 ppm	No adverse effect	Beyer and Anderson, 1985
	Earthworm	662 ppm	LC50	Neuhauser et al., 1985b
	<i>Eisenia foetida</i>	1,000 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Arion ater</i>	100 µg/g dry weight	NOAEL	van Straalen, 1993
	<i>Porcellio scaber</i>	398 µg/g dry weight	NOAEL	van Straalen, 1993
	Earthworm	1,300 to 13,000 ppm	Growth inhibition	Hartenstein et al., 1981
	Forest soil invertebrate	<500 ppm	No effect	Bengtsson and Tranvik, 1989
	Earthworm (<i>Eisenia foetida</i>)	1,300 to 13,000 mg/kg	8 weeks, growth inhibition	Hartenstein et al., 1981
	Earthworm (<i>Eisenia foetida</i>)	26,000 mg/kg	8 weeks, toxic	Hartenstein et al., 1981

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Table 7-31 Literature Criteria Protective of Terrestrial Invertebrates for COPEC in Soil MCAS El Toro Phase 1 RI Technical Memorandum				
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Chemical	Effect Levels or Criteria Protective of Soil Invertebrates			Reference
	Species	Dose	Description	
Zinc (continued)	Earthworm (<i>Eisenia foetida</i>)	2,500 µg/g	5 weeks, cocoon production decrease	Neuhauser et al., 1984b
	Earthworm (<i>Eisenia foetida</i>)	2,000 ppm, dry weight	4 to 6 weeks, decreased growth rates	Malecki et al., 1982
	Earthworm (<i>Eisenia foetida</i>)	>5,000 ppm, dry weight	20 weeks, reproduction inhibition	Malecki et al., 1982
<p>^aValues derived from Neuhauser et al., 1985a were converted to ppm (mg/kg).</p> <p>^bHazardous concentration for 5 percent of the species.</p> <p>Notes:</p> <p>NOAEL = No observed adverse effect level.</p> <p>LOAEL = Lowest observed adverse effect level.</p> <p>ppm = mg chemical/kg soil</p>				

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Table 7-32
Literature Toxicity Values for the Protection of Terrestrial Plants for COPEC in Soil
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Chemical	Effect Levels or Criteria Protective of Plants			Reference
	Background (Normal)	Excessive (Toxic)	Tolerable	
Organic Chemicals				
1,1,1-Trichloroethane				
1,2-Dichloroethene (total)				
2,4,5-T				
2,4-D				
2,4-DB				
2,4-Dimethyl phenol				
2-Butanone				
2-Hexanone				
2-Methylnaphthalene		8E-05 m (allium cepa)		Phytotox, 1993
		1.6E-04 m (allium cepa)		Phytotox, 1993
		100% (lettuce)		Phytotox, 1993
4,4'-DDD				
4,4'-DDE				
4,4'-DDT		12.5 ppm 50 ppm 100 ppm		ICF, 1989
		30 ppm (soybean) 30 ppm (wheat) 50 ppm (wheat)		Phytotox, 1993
4-Methyl-2-pentanone				
4-Methylphenol				
Acenaphthene		0.00125 m (Phelum pratense and (Allium Cepa)		Phytotox, 1993
		1 g/Petri dish (Allium fistulosum)		Phytotox, 1993
		100% (Brassica alboglabra)		Phytotox, 1993
Acenaphthylene				
Acetone		1 m (potato)		Phytotox, 1993
		4 mg/mL (Camellia sasarquua)		Phytotox, 1993
		25 µL (Deltapine 16)		Phytotox, 1993
		5 mL (lettuce)		Phytotox, 1993
Aldrin		12.5 ppm (maize) 50 ppm (maize) 100 ppm (maize)		Bengtsson and Tranvik, 1989
Anthracene		1E-04 (maize)		Phytotox, 1993
Benzene		8 mL (barley)		Phytotox, 1993
		2.7 m/L (barley)		Phytotox, 1993
		8 mL (carrot)		Phytotox, 1993
		8 mL (flax)		Phytotox, 1993
		100% (lettuce)		Phytotox, 1993
Benzo(a)anthracene		1E-06 (Nicotiana tabacum)		Phytotox, 1993
		1E-05 (Nicotiana tabacum)		Phytotox, 1993
Benzo(a)pyrene		0.01 ppm (mericopa)		Phytotox, 1993
		0.02 ppm (merit)		Phytotox, 1993
		0.0005 ppm (merit)		Phytotox, 1993
Benzo(b)fluoranthene				
Benzo(g,h,i)perylene				
Benzo(k)fluoranthene				
Benzyl butyl phthalate				
Bis(2-ethylhexyl)phthalate				
alpha- BHC				

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Table 7-32
Literature Toxicity Values for the Protection of Terrestrial Plants for COPEC in Soil
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Chemical	Effect Levels or Criteria Protective of Plants			Reference
	Background (Normal)	Excessive (Toxic)	Tolerable	
Delta-BHC		12.5 ppm (valentine beans)		ICF, 1989
		50 ppm		ICF, 1989
		100 ppm		ICF, 1989
BHC-gamma				
Carbazole				
Carbon disulfide				
Carbon tetrachloride				
α Chlordane				
beta Chlordane				
gamma Chlordane				
Chrysene				
Dalapon				
Dibenzofuran				
Di-n-butyl phthalate				
Dichloroprop				
Dieldrin		12.5 ppm (valentine beans) 50 ppm 100 ppm		ICF, 1989
		0.84 lb/A (cabbage) (0.51 ppm) 0.84 lb/A (eggplant) (0.51 ppm)		Phytotox, 1993
Diethyl phthalate				
Dimethyl phthalate				
Endosulfan I		1,000 ppm (tomato)		Phytotox, 1993
Endosulfan II				
Endosulfan sulfate				
Endrin				
Endrin aldehyde				
Endrin ketone				
Ethylbenzene		8 mL (carrot)		Phytotox, 1993
Fluoranthene				
Fluorene				
Heptachlor epoxide				
Hexachloroethane				
Indeno(1,2,3)pyrene				
Isophorone				
MCPP				
Methoxychlor				
Methylene chloride		0.5 L/m ² (acroptilon picris)		Phytotox, 1993
		6 tons/ha (acroptilon picris)		Phytotox, 1993
		0.3 L/m ² (acroptilon picris)		Phytotox, 1993
Naphthalene		3.12E-04 (allium cepa)		Phytotox, 1993
Octachlorodibenzo-p-dioxin				
PCB 1248				
PCB 1254		1,000 ppm (corn)		Phytotox, 1993
		1 ppm (soybean)		Phytotox, 1993
		1,000 ppm (soybean)		Phytotox, 1993
PCB 1260				
Phenanthrene		0.3 mg/L		Eisler, 1987a
Phenol				
Pyrene				
Tetrachlorothene				

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Table 7-32
Literature Toxicity Values for the Protection of Terrestrial Plants for COPEC in Soil
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Chemical	Effect Levels or Criteria Protective of Plants			Reference
	Background (Normal)	Excessive (Toxic)	Tolerable	
Toluene		2 mL (Helianthus annuus)		Phytotox, 1993
Trichloroethylene				
Xylene		1.6 lb/gal (tobacco)		Phytotox, 1993
Inorganic Chemicals (mg/kg)				
Aluminum		0.56 ppm (alfalfa)	0.5 ppm	Kabata-Pendias and Pendias, 1984
		0.1 to 6.8 ppm (reduction in crop yield)		Chapman, 1966
		2 to 80 ppm (reduction in grass yield)		Chapman, 1966
Antimony				
Arsenic	0.01 to 1.7 ppm	3 to 20 ppm	--	ICF, 1989
		3 to 10 ppm (phytotoxic level in foliage)		Chaney, 1985
		≤10 ppm (suspected growth inhibition)		Chapman, 1966
		>2 ppm (damage to alfalfa and barley)		Chapman, 1966
		70 ppm (toxicity to tomato plants)		Chapman, 1966
Barium				
Beryllium	<1 to 7 ppm	10 to 50 ppm		Kabata-Pendias and Pendias, 1984
Cadmium	0.1 to 0.8 ppm	5 to 700 ppm	3 ppm	Kabata-Pendias, and Pendias, 1984
Chromium (total)	0.01 to 1 ppm	5 to 30 ppm	2 ppm	Kabata-Pendias, and Pendias, 1984
		100 ppm (toxic level in soil)		Cottenie, 1977
		4 to 8 ppm (toxicity to corn)		Chapman, 1966
		18 to 34 ppm (toxicity to tobacco)		Chapman, 1966
		16 ppm (reduced growth to tomato, potato, oat, and kale)		Chapman, 1966
Cobalt	0.02 to 1 ppm	15 to 50 ppm	5 ppm	Kabata-Pendias, and Pendias, 1984
Copper	4 to 30 ppm	20 to 100 ppm	50 ppm	Kabata-Pendias, and Pendias, 1984
		100 ppm (toxic level in soil)		Cottenie, 1977
Lead	0.1 to 10 ppm	30 to 300 ppm	10 ppm	Kabata-Pendias, and Pendias, 1984
		100 ppm (toxic level in soil)		Cottenie, 1977
		1.7 ppm reduced root growth to rye grass		Khan and Frankland, 1984
		500 ppm reduced root biomass to oat		Wong and Bradshaw, 1982
Manganese				
Mercury		1 to 3 ppm		Kabata-Pendias, and Pendias, 1984
Nickel	0.1 to 5 ppm	50 to 100 ppm	50 ppm	Kabata-Pendias, and Pendias, 1984
		100 ppm (toxic level in soil)		Cottenie, 1977
		34 ppm (damage to oats)		Patterson, 1971
		20 ppm (damage to potatoes)		Patterson, 1971
Selenium				
Silver	0.5 ppm	5 to 10 ppm		Kabata-Pendias, and Pendias, 1984
Thallium		20 ppm		Kabata-Pendias, and Pendias, 1984
Vanadium		150 ppm (rice)	10 ppm	ICF, 1989
Zinc	8 to 150 ppm	>300 to 1,500 ppm	300 ppm	Kabata-Pendias, and Pendias, 1984
		100 ppm (toxic level in soil)		Cottenie, 1977
Notes:				
ppm = mg/kg.				

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Table 7-33
MCAS El Toro Chemicals of Potential Ecological Concern
Sediment Maxima vs. Sediment Criteria, All Sites
MCAS El Toro Phase I RI Technical Memorandum

Chemical	Koc (ml/g)	Koc source	Chronic Water Quality Criteria (µg/l)	1,2	EqP Based Sediment Criteria ^a (µg/kg)	Sediment LEL Criteria ^b (µg/kg)	Site 2	Site 3	Site 4	Site 6	Site 12	Site 14	Site 18 ^c										Site 20	Site 21		
													Borrego Canyon		Agua Chinon		Bee Canyon		Marshburn Channel		San Diego Creek					
													Dn	Up	Dn	Up	Dn	Up	Dn	Up	AC ^d	BC ^e			MC ^f	
Maximum Sediment Concentration (µg/kg)																										
ORGANICS:	Estimated TOC = 20 g/kg																									
Chromium			210(CrIII)	(p)	31	12.5	13.5	20.8	10.1	24.7	6	1.6	10.2	2.5	17.5	2.8	10.4	8.5	2.1	1.8	9.3	8.6	96.8	29.1		
Cobalt						7	4.1	6.4	2.8	11.7	2.3		2.1	1.6	6.2	1.9	5.5	4.7		1.8	4.1	5.8	6.2	11.5		
Copper			12	(p)	25	9	8.7	49.4	8.3	20.1	5.1		4	3.5	15.9	6.8	11.5	12.4	1.4	1.4	6.8	6.4	226	41.4		
Lead			3.2	(p)	31	14.6	5.2	258	36.9	289	21	1.1	1.1	4.6	12.1	5	3.7	6.1	0.96	1.5	4.1	2.9	900	171		
Manganese					457	294	145	224	154	455	45.1	62.8	127	64.6	380	52.7	267	221	58.2	180	176	200	355	468		
Mercury			0.012		0.12			0.12		1.3	1.4	0.18		0.28		0.22		0.45	0.31	0.35		0.25		0.95		
Nickel			160	(p)	31	9	6.1	22.1	10.7	18.1	5.2		6.1	2.2	19.9	2.2	9.6	6.1		2.2	5.8	7.7	55.3	20.4		
Selenium			5			0.25									0.37		0.22				0.12		0.34	0.17		
Silver			0.12					0.62	0.45	1.1					0.98							0.53				
Thallium			40	(i)		0.25				0.38					0.42		0.31				0.28			0.19		
Vanadium						44.9	37.1	17.2	21	80.5	7.2	4.7	15.4	7.3	48.2	8.6	32.8	22.6	4	6.3	24.1	20.4	21.8	54.2		
Zinc			110	(p)	110	60.7	37.8	126	102	247	57.9	10.9	15.5	13.1	88	26.1	48.8	41.1	9.6	14.3	31.3	30.1	2070	507		

Criteria:
 (1) Amendments of the Water Quality Control Plan for Inland Surface Waters of California, Functional Equivalent Document, California State Water Resources Control Board, November 1992
 (2) Quality Criteria for Water, USEPA, 1992i.
 (3) From "Sediments: Chemistry and Toxicity of In-Place Pollutants", R.Baudo et al. 1990.
 3b - Table 4. Sediment Quality Criteria (µg/g Dry Weight for Metals and Nutrients) Proposed by the Ontario Ministry of Environment

Comments:
 (a) Calculated as a function of TOC.
 (b) Soil Criteria Types: LEL (Lowest Effect Level)
 (c) Maximum detected concentrations for Site 18 were taken from the 4/2/93 database. Maximums for all other sites were taken from the 3/29/93 database.
 (d) AC = Confluence of Agua Chinon Wash with San Diego Creek.
 (e) BC = Confluence of Bee Canyon Wash with San Diego Creek.
 (f) MC = Confluence of Marshburn Channel with San Diego Creek.
 (g) No criterion is available. Value listed is for naphthalene.
 (h) Criteria levels for DDT refer to the sum of the p,p' and o,p' isomers of DDT, DDD (TDE), and DDE
 (i) Data insufficient to develop standard. Value is L.O.E.L.
 (j) EPA Proposed Sediment Quality Criteria is listed.

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**Table 7-33
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Sediment Maxima vs. Sediment Criteria, All Sites
MCAS El Toro Phase I RI Technical Memorandum**

Chemical	Koc (ml/g)	Koc source	Chronic Water Quality Criteria (µg/l)	1,2	EqP Based Sediment Criteria ^a (µg/kg)	Sediment LEL Criteria ^b (µg/kg)	Site 2	Site 3	Site 4	Site 6	Site 12	Site 14	Site 18 ^c										Site 20	Site 21		
													Borrego Canyon		Agua Chinon		Bee Canyon		Marshburn Channel		San Diego Creek					
													Dn	Up	Dn	Up	Dn	Up	Dn	Up	AC ^d	BC ^e			MC ^f	
ORGANICS:							Estimated TOC = 20 g/kg															Maximum Sediment Concentration (µg/kg)				
<p>(k) Criteria levels for chlordane refer to the sum of chlordane-alpha, chlordane-gamma, chlrodene-alpha, chlrodene-gamma, nonachlor-alpha, nonachlor-gamma, and oxychlrodane for water and "Chlordane" for sediment criteria.</p> <p>(l) Proposed.</p> <p>(m) Value for technical BHC is listed.</p> <p>(n) Sum of endosulphan-alpha, and -beta and endosulfan sulfate.</p> <p>(o) Generic criterion for halomethanes is listed.</p> <p>(p) Calculation of the water quality criteria is based on the water hardness expressed as mg/L of CaCO3</p> <p>(-) Not available</p> <p>K_{oc} Sources:</p> <p>A - USEPA. 1987a. Superfund Public Health Evaluation Manual. EPA 540/1-86/060. U.S. Environmental Protection Agency, Washington DC.</p> <p>B - HSDB: Hazardous Substance Databank. National Library of Medicine, Bethesda, MD (Cd-ROM version). Micromedex, Inc., Denver, CO. 1993.</p> <p>C - Jeng, Chang Y., Chen, Daniel H., Yaws, Carl L. 1992. Data Compilation for Soil Sorption Coefficient. Pollution Engineering, June 15, pp 54-60.</p> <p>D - ATSDR. February 19, 1993. Chlordane.</p> <p>E - Risk Assistant. 1991. CD-ROM version. Hampshire Research Institute, Alexandria, VA.</p> <p>F - Howard, P.H. (ed.). 1991. Handbook of Environmental Fate and Exposure Data. Vol. III: Pesticides.</p>																										

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Federal and State of California water quality criteria and standards established for protection of aquatic life represent the maximum concentration that likely will not have an acute or chronic toxic impact upon aquatic organisms. They apply to single chemical concentrations and do not address the potential toxicity associated with exposure to a mixture of chemicals. The criteria used for this assessment are presented in Table 7-34 along with maximum concentration for each site where contaminants were detected in surface water.

The aquatic toxicity of some heavy metals (e.g., Cd, Cr(III), Cu, Pb, Ni, and Zn) depends upon on surface water hardness, and derived criteria for these metals are thus hardness-based. To derive area-specific criteria for these metals, the surface water hardness was estimated by summing the calcium and magnesium concentrations.

7.2.3.4 Toxicity of Inorganic COPEC

The toxicity of the inorganic elements has been reviewed in relation to their effects on mammals, birds, and amphibians by various authors (see Romanoff 1972; Luckey and Venugopal 1977; Underwood 1977; Venugopal and Luckey 1978; Friberg et al. 1979; Eisler 1985a, 1985b, 1986, 1987b, 1988a, 1988b; and Scheuhammer 1987).

A number of inorganic elements are essential in small amounts for animal nutrition because they are an integral part of at least one enzyme (Underwood 1977; Clarkson 1979; Robbins 1983). Examples include arsenic, calcium, chromium, copper, iron, magnesium, manganese, potassium, sodium, and zinc, among those measured at El Toro. The animal body has developed a variety of homeostatic mechanisms with regard to these essential macro and trace elements, so they are less likely to produce toxic effects at elevated concentrations than are the non-essential elements such as cadmium and lead. Nevertheless, some essential elements can overwhelm or circumvent those control mechanisms to produce toxic effects in wild birds and mammals (for example, selenium; see Ohlendorf 1989).

An element's toxicity is greatly influenced by the chemical state in which it occurs in the animals' food, water, or air. Therefore, total concentrations of these elements in water, soil, or air are not generally good indicators of potentially toxic exposure; concentrations in the food are usually the most important. However, because potentially toxic trace elements occur in many different forms, even the total concentration of some elements in the diet may not be a good predictor of toxicity.

The toxicity of inorganic elements in the diet varies so widely that it is generally not practical to list specific concentrations that cause adverse effects under conditions of acute or chronic exposure. The reported concentrations in sediments/soils or surface water cannot reasonably be extrapolated to the concentrations that might occur in foods of birds and mammals living at the Station; only the concentrations measured in plants or animals eaten by other animals are useful for this purpose. However, in order to provide a screening level evaluation, literature reported toxicity values for inorganic compounds have been included in Tables 7-30, 7-31, 7-32, 7-33, and 7-34.

The following general summary of the relative toxicity of inorganic elements is based primarily on reviews by Romanoff (1972), Underwood (1977), Luckey and Venugopal (1977), Venugopal and Luckey (1978), Friberg et al. (1979), Gough et al. (1979), Sax (1984), Eisler (1985a, 1985b, 1986, 1987a, 1988a, 1988b), and Scheuhammer (1987). The various elements are divided into bond valence groups as depicted on the periodic table of elements.

Group I

Potassium and sodium are essential macroelements that are considered to be harmless and generally nontoxic. Copper is an essential trace metal that stimulates growth when moderately high levels (about 100 times the dietary allowances) are fed to mammals, even though it is highly toxic to aquatic organisms. Observed LD₅₀ values for laboratory rats include 140 mg/kg body weight (copper chloride), 29 mg/kg body weight (cupric perchlorate), 940 mg/kg body weight (cupric nitrate) and 960 mg/kg body weight (copper sulfate) in the

Table 7-34
EI Toro Chemicals of Potential Ecological Concern
Surface Runoff (All Sites)
Maximum Concentration Detected vs Water Quality Criteria for the Protection of Aquatic Life
MCAS EI Toro Phase I RI Technical Memorandum

	EPA or State Chronic Water Quality Criteria (1,2)	Site 2 Detected Concentrations	Site 3 Detected Concentrations	Site 18 Detected Concentrations ^a										
				Borrego Canyon	Agua Chinon		Bee Canyon		Marshburn Channel		San Diego Creek			
				Dn ^b	Up ^c	Dn ^b	Up ^c	Dn ^b	Up ^c	Dn ^b	Up ^c	AC ^d	BC ^e	MC ^f
ORGANICS: (µg/L)														
1,1,1-Trichloroethane	18,000 r													10
2-Butanone	NA				13.00									
4,4'-DDE	0.001 l									0.034				
4,4'-DDT	0.001 l									0.119				
4-Nitrophenol	150 i,m				5.00		5.00							
Acetone	NA		39.00				5.00	7.00						
Benzyl butyl phthalate	3.0 i,n				3.00									3.00
Beta BHC	0.08 i,o					0.014								
Bis(2-ethylhexyl)phthalate	360 g		15.00											
Chloroform	1240 i					8.00			46.00					
Delta BHC	0.08 i,o					0.135				0.051				
Endosulfan sulfate	0.056 p								0.112					
Gamma chlordane	0.0043 q						0.015			0.004			0.01	
Methyl chloride	11,000 s			2	3	2	4		2			0.7	0.7	1
Methylene chloride	11,000 i,r,s		14.00						2.00					
TFH - diesel	NA	408.00	287.00		457.00			319.00						
Toluene	17,500 i,r								0.70					
INORGANICS: (µg/L)														
Aluminum	87	269,000	99,000	184,000	65,000	22,600	145,000	29,600	69,800	21,600	34,000	158,000	18,800	78,000
Antimony	30 g	12.90	16.80	15.20	15.20	15.20	13.00		18.20	15.20	15.20	15.20	11.60	18.40
Arsenic	190 h	26.60	9.10	18.30	7.80	3.00	26.50	7.90	10.80	7.70	6.30	16.30	6.10	9.60
Barium	NA	3,200.00	1,080.00	1640.00	577.00	188.00	1340.00	457.00	737.00	188.00	324.00	1,850.00	378.00	583.00

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**Table 7-34
 El Toro Chemicals of Potential Ecological Concern
 Surface Runoff (All Sites)
 Maximum Concentration Detected vs Water Quality Criteria for the Protection of Aquatic Life
 MCAS El Toro Phase I RI Technical Memorandum**

				Site 18 Detected Concentrations ^a										
				Borrego Canyon	Agua Chínon		Bee Canyon		Marshburn Channel		San Diego Creek			
Beryllium	5.3 i	17.70	5.20	10.10	3.20	1.00	7.40	1.40	5.00	1.00	1.80	10.00	2.00	4.40
Cadmium	3.6/1.2/2.5 j	43.20	84.50	17.50	4.60	4.90	13.20	12.10	9.00	3.41	6.40	22.40	5.00	18.40
Chromium	694/212/474 h,j	253.00	134.00	157.00	96.60	28.60	144.00	37.10	99.30	28.80	37.90	148.00	22.60	88.60
Cobalt	NA	125.00	49.30	67.20	24.60	8.40	64.80	15.50	53.00	10.40	16.20	73.40	14.60	33.30
Copper	42/12/28 j	233.00	143.00	126.00	75.80	28.10	146.00	590.0	179.00	46.90	38.60	131.00	37.00	59.60
Cyanide			3.1			0.5		3.90	18.80	27.60	3.40		3.40	
Lead	20.9/3.3/11.5 j	66.20	38.30	30.60	19.00	12.60	45.60	27.10	61.70	19.30	19.00	33.6	20.90	40.10
Manganese	NA	5,840.00	1,620.00	3050.00	836.00	302.00	2,520.00	689.00	2,230.00	480.00	660.00	3370	745.00	1,560.00
Mercury	0.012		0.15	0.21	0.13	0.12	0.10		0.15	0.93	0.17	0.1	0.11	
Nickel	550/162/371 j	279.00	113.00	143.00	99.50	28.40	104.00	27.7	82.10	25.80	30.0	156.00	24.70	69.90
Selenium	5	22.30	24.30	0.61		2.20					0.5		0.5	
Silver	0.12					2.40								1.10
Thallium	40 i	1.80				0.90			1.00			2.50	1.00	
Vanadium	NA	629.00	267.00	424.00	211.00	65.40	388.00	101.00	226.00	67.40	101.00	415.00	71.10	197.00
Zinc	371/109/250 j	1,240.00	460.00	671.00	267.00	129.00	683.00	248.00	502.00	166.00	185.00	702.00	188.00	358.00

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Table 7-34
EI Toro Chemicals of Potential Ecological Concern
Surface Runoff (All Sites)
Maximum Concentration Detected vs Water Quality Criteria for the Protection of Aquatic Life
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				Site 18 Detected Concentrations^a				
				Borrego Canyon	Agua Chinon	Bee Canyon	Marshburn Channel	San Diego Creek

Sources for Water Quality Criteria:

- (1) USEPA Quality Criteria for Water, 1992i
- (2) Amendments of the Water Quality Control Plan for Inland Surface Waters of California, Functional Equivalent Document, California State Water Resources Control Board, November 1992

Comments:

- ^aMaximum detected concentrations for Site 18 taken from the 4/2/93 database. Maximums for all other sites taken from the 3/29/93 database.
- ^bDn = Downstream sampling station.
- ^cUp = Upstream sampling station.
- ^dAC = Confluence of Agua Chinon Wash with San Diego Creek.
- ^eBC = Confluence of Bee Canyon Wash with San Diego Creek.
- ^fMC = Confluence of Marshburn Channel with San Diego Creek.
- ^gProposed criterion.
- ^hFor the trivalent form.
- ⁱData insufficient to develop criterion. Value is L.O.E.L.
- ^jCalculation of the water quality criterion is based on the water hardness. Site-specific hardness was estimated by summing calcium and magnesium concentrations to yield 438, 103, and 275 mg/l as CaCO3 for Sites 2, 3, and 18, respectively.
- ^kValue listed is for naphthalene.
- ^lCriterion levels for DDT refer to the sum of the p,p' and o,p' isomers of DDT, DDD (TDE), and DDE.
- ^mValue listed is the generic criterion for nitrophenols.
- ⁿValue listed is the generic criterion for phthalate esters.
- ^oValue listed is for technical BHC.
- ^pValue listed is for the sum of endosulfan-alpha, -beta, and endosulfan sulfate.
- ^qCriteria levels for chlordane refer to the sum of chlordane-alpha, chlordane-gamma, chlordene-alpha, chlordene-gamma, nonachlor-alpha, nonachlor-gamma, and oxychlordane. Criteria are for 1 day average exposure.
- ^rNo chronic criterion was available, and the value listed is the acute criterion.
- ^sValue listed is a generic criterion for halomethanes.
- NA = Not Available.

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diet (Venugopal and Luckey 1978). The maximum chronic tolerated level in grazing animal diets is 25 to 300 mg/kg (Bodek et al. 1988). Based on subchronic laboratory studies, a NOAEL of 12.5 mg Cu/kg body weight/day and a LOAEL of 4.2 mg Cu/kg body weight/day were derived for rats (Murthy et al. 1981; Massie and Aiello 1984.) Silver is a nonessential metal that is moderately toxic but poorly absorbed from the gut when ingested.

Group II

Magnesium and calcium also are essential macroelements for animals, and barium is stimulatory but not essential. All three are considered relatively nontoxic at physiologic levels but definitely toxic at higher levels. Reported LD₅₀ values for laboratory animals exposed orally to barium include 54 mg/kg body weight (barium chloride-mouse), 150 mg/kg body weight (barium chloride-rat), and 175 mg/kg body weight (barium silicofluoride-rat) (Venugopal and Luckey 1978). Lifetime exposure of rats and mice to 5 mg/L barium in drinking water (approximately 0.25 mg/kg/day for rats and 0.825 mg/kg/day for mice) resulted in no adverse effects (Schroeder and Mitchener 1975a, 1975b). Beryllium, cadmium, and mercury are nonessential elements that are stimulatory at very low doses but become highly toxic at relatively low levels. Beryllium and mercury are more toxic than other metals in this group. However, gastrointestinal absorption of soluble beryllium salts in mammals is poor and depends on the ingested dose. There are few reports of beryllium toxicity following oral exposure. In a study using rats, a NOAEL of 0.54 mg/kg body weight/day and a LOAEL of 0.85 mg/kg body weight/day were reported for chronic oral exposure to beryllium (Schroeder and Mitchener 1975a and b). Homeostatic mechanisms maintain normal levels of magnesium and calcium, and to a certain extent barium and strontium, but beryllium and cadmium are not controlled by homeostasis.

Cadmium toxicity to mammals varies widely and is influenced by external factors. Cadmium exposure can cause derangement in carbohydrate and mineral metabolism in renal, hepatic, testicular, and prostate functions and disturbs the integrity of the central nervous system (Venugopal and Luckey 1978). Various LD₅₀ values reported for laboratory animals exposed orally to cadmium salts

include: 88 mg/kg body weight (cadmium chloride-rat), 150 mg/kg body weight (cadmium fluoride-guinea pig), and 660 mg/kg body weight (cadmium succinate-rat). Chronic ingestion of cadmium at low levels by rats, rabbits, lambs, pigs, and calves results in diminished growth and feed consumption (Nomiya et al 1973; Doyle et al. 1974; and Cousins et al. 1973). Using laboratory rats, a NOAEL of 0.004 mg/kg body weight/day and a LOAEL of 0.014 mg/kg body weight/day were derived for oral exposure to cadmium (Kopp 1982).

Barium, beryllium, cadmium, and mercury are retained in the tissues, and the body levels of these metals increase with age. Zinc is an essential trace metal that is relatively nontoxic because of efficient homeostatic mechanisms that maintain a proper balance within the body. Reported LD₅₀ values for laboratory animals exposed to zinc salts orally include: 45.7 mg/kg body weight (zinc phosphide-rat), 250 mg/kg body weight (zinc chloride-guinea pigs), and 350 mg/kg body weight (zinc chloride-mice and rats) (Venugopal and Luckey 1978). A subchronic NOAEL of 98.3 mg/kg body weight/day was reported for rats orally exposed to zinc in their feed (Drinker et al. 1927). Similarly, a chronic LOAEL of 38 mg/kg body weight/day was derived for mice exposed to zinc in drinking water (Aughey et al. 1977).

Group III

No Group III metals are known to be an essential element in animal nutrition. Intestinal absorption of aluminum is generally very poor and its toxicity is low in comparison to that of many other metals. Thallium is potentially toxic when administered orally, but behaves like potassium in its metabolism. There apparently are no homeostatic mechanisms to control the levels of Group III metals in animals.

Group IV

Lead is a nonessential metal that is readily absorbed from the digestive tract. Organic lead compounds are more toxic than are inorganic salts, because of their greater lipid solubility, stability in biological fluids, and penetration into tissues

such as brain and lodgement in the central nervous system. Soluble lead salts are more toxic than insoluble salts, and rabbits and guinea pigs are more susceptible to lead poisoning than rats and mice (Venugopal and Luckey 1978). Reported oral LD₅₀ toxicity values for laboratory animals include: 100 mg/kg body weight (lead arsenate-rat), 125 mg/kg body weight (lead arsenate-rabbit), 2,000 mg/kg body weight (lead chloride-guinea pig), and 3,000 mg/kg body weight (lead lactate-guinea pig). A chronic NOAEL of 0.45 mg/kg body weight/day and LOAEL of 2.8 mg/kg body weight/day have been reported for rats (Perry et al. 1988; Azar et al. 1973). Adverse effects on aquatic biota have been reported at waterborne lead concentrations of 1 to 5 µg/L. Lead salts are only toxic to birds at a high dietary dose (100 mg/kg or more), with most experiments conducted on chickens and other gallinaceous birds (WHO 1989). Exposure of quail from hatching through reproductive age resulted in effects on egg production at dietary levels of 10 mg/kg.

Group V

Arsenic, antimony, and vanadium are nonessential, potentially toxic elements. In general, inorganic arsenic compounds are more toxic than organic arsenic compounds, and trivalent compounds (in the form of soluble arsenite) are far more toxic than pentavalent compounds (arsenates). Arsenic is a teratogen and carcinogen that produces death and malformations in many species of mammals. Reported oral LD₅₀ values for rats and mice include: 8 mg/kg body weight (arsenic pentoxide-rat), 14 mg/kg body weight (potassium arsenite-rat), 43 mg/kg body weight (arsenic trioxide-mouse), 143 mg/kg body weight (arsenic trioxide-rat), and 794 mg/kg body weight (calcium arsenate-mouse) (Venugopal and Luckey 1978; Eisler 1988a). In chronic studies with dogs, a NOAEL of 1.2 mg/kg body weight/day and a LOAEL of 6.4 mg/kg body weight/day were reported for ingestion of arsenic in drinking water (Byron et al. 1967). Antimony salts are inherently toxic, but they are relatively insoluble and less toxic than antimony metal.

Acute vanadium exposure to animals affects the central nervous system, lungs, and kidneys (Klaassen et al. 1986). Acute studies of laboratory animals have

shown that inhalation of vanadium in dust results in respiratory depression, whereas subacute studies have suggested that the liver, bone marrow, and adrenal glands may also be affected. In chronic studies in which rats were exposed to vanadium in drinking water, a NOAEL of 0.7 mg/kg body weight/day and LOAEL of 2.8 mg/kg body weight/day were reported (Schroeder et al. 1970; Kowalski 1988).

Group VI

Chromium and selenium are essential trace elements for animals, but both are toxic at high doses. Hexavalent chromium is the most biologically active form, although little is known about the properties of organochromium compounds, water-soluble species, or their interactions in complex mixtures. However, in mammals hexavalent chromium is chemically reduced in the acid fluid of the stomach. A NOAEL of 0.46 mg/kg body weight/day has been reported for rats chronically exposed to chromium in the diet; however, no LOAEL was reported (Schroeder et al. 1965). Chromium concentrations are usually highest in the lowest trophic levels, and no biomagnification has been observed in food chains.

Selenium is more toxic than chromium and the difference between essential dietary levels and toxic levels is narrow. Selenium is teratogenic and has significant toxic effects on reproduction and calcification. Excretory mechanisms exist for maintaining tissue levels of both chromium and selenium, but they are limited in their ability at high dietary concentrations.

Soils can contain greater than 300 mg/kg of selenium; however; typical concentrations range between 0.1 and 2.0 mg/kg. Selenium in soil is more available to plants if the soil is alkaline and in areas of low rainfall. Higher concentrations of selenium in soil can be less toxic to plants if found in acid soil. Sulfate and phosphorous can decrease and increase, respectively, the plant uptake of selenium from soil (Ohlendorf, 1989).

There are general relationships between water-extractable selenium concentrations in soils and selenium concentrations found in plants. However, this relationship is

apparently influenced by many variables, including plant species, rainfall, temperature, soil pH and sulfate concentrations, plant growth rates, root depth, and distribution of selenium in the soil profile (Huang and Wu, 1991; Wu and Huang, 1991; Kabata-Pendias and Pendias, 1992).

Birds are the wildlife species that are most sensitive to chronic selenium toxicosis because of reproductive effects (Ohlendorf, 1989). Previous reports have shown that selenium is bioaccumulated by frogs and snakes (Ohlendorf et al., 1988). Amphibian eggs and tadpoles may be affected by waterborne selenium, but they are not likely to be more sensitive than aquatic birds.

Group VII

Manganese salts appear to be the least toxic of the essential metals. An efficient homeostatic mechanism prevents manganese accumulation in tissues, and toxic effects of manganese are not clearly manifested. In one study, a NOAEL of 290 mg/kg body weight/day and a LOAEL of 930 mg/kg body weight/day were reported for rats exposed chronically to manganese in the diet (Hejtmancik et al. 1987a, 1987b).

Group VIII

Iron is an essential metal that is generally considered to be of very low toxicity to animals. Reported oral LD₅₀ values for iron exposure to laboratory animals include: 900 mg/kg body weight (ferric chloride-rat), 984 mg/kg body weight (ferrous chloride-rat), 1,170 mg/kg body weight (ferrous sulfate-mouse), 1,480 mg/kg body weight (ferrous sulfate-rat), and 3,250 mg/kg body weight (ferric nitrate-rat) (Venogopal and Luckey 1978). Nickel is presumed to be an essential element but its metabolic functions are less known than those for iron. Nickel is relatively nontoxic, ranking with iron, cobalt, copper, chromium, and zinc. A NOAEL of 5 mg/kg body weight/day and LOAEL of 50 mg/kg body weight/day were reported for rats chronically exposed to nickel in the diet (Ambrose et al. 1976). Cobalt is an essential metal that has a potential for toxicity if excessive amounts are ingested (Klaassen et al. 1986). In a subchronic study, a NOAEL of

0.05 mg/kg body weight/day and a LOAEL of 0.5 mg/kg body weight/day were reported for rats orally exposed to cobalt (Krasovski and Fridlyand 1971).

Additional information is summarized here for toxicity of various inorganics to amphibians because the kinds of exposures that are typically tested are more applicable to toxicity assessment.

Metals are toxic to amphibians and readily accumulate in body tissues (Power et al. 1989). Metal concentrations present in tissues are often much greater than environmental levels, and can be bioaccumulated in the food chain. Amphibians are most sensitive to the toxic effects of metals while still in the egg. The larval form is slightly less sensitive followed by the adult which is the most resistant.

In an acute study, *Gastrophryne carolinensis* eggs exposed to arsenic from fertilization to 4 days posthatch exhibited a 96-hour LC₅₀ of 0.04 mg/L (Power et al. 1989).

Cadmium affects the development and survival of amphibians (Power et al. 1989). Leopard frog (*Rana pipiens*) eggs which were exposed to 2.5 mg/L of cadmium showed no further development. Exposure to lower concentrations greatly decreased survival. Exposure of the salamander *Notophthalmus viridescens* to 2.0 to 6.75 mg/L of cadmium for 51 days resulted in retarded limb regeneration at the lower concentrations and mortality at the higher concentrations. Limb regeneration in those that survived was retarded and numerous abnormalities were present. A 96-hour LC₅₀ of 0.04 mg/L was reported for *G. carolinensis* eggs exposed to cadmium from fertilization to 4 days posthatch.

Chromium residues measured in field collected *R. esculenta* frogs showed that residue levels were much lower in the neometamorphosed frogs than in tadpoles (Power et al. 1989). The decrease in residue levels was due to the change in diet. Tadpoles were primarily herbivorous, whereas the adults were insectivorous. Acute studies with *G. carolinensis* eggs resulted in a 96-hour LC₅₀ of 0.03 mg/L.

Cobalt alters epithelial cell membrane permeability by combining with sulfhydryl groups within the membrane (Power et al. 1989). An acute 96-hour LC₅₀ for *G. carolinensis* eggs exposed from fertilization to 4 days posthatch was reported as 0.05 mg/L.

Copper is often present in acid mine drainage (Power et al. 1989). Acute 96-hour LC₅₀ values reported for different amphibians include: 0.32 mg/L for *Bufo meianosticus* tadpoles, 5.04 and 5.38 mg/L for 1 week old and 4 week old *Microhyla ornata*, respectively, and 0.04 mg/L for *G. carolinensis*.

Lead has a number of toxic effects in amphibians (Power et al. 1989). Lead has been shown to bind to melanin present in amphibian skin. Toads with darker skin (more melanin) accumulated significantly more lead than toads with light colored skin (less melanin). Lead also inhibits hematopoietic tissues resulting in a reduction in the number of red and white blood cells, causes discoloration of the liver, and affects vision. Acute 96-hour LC₅₀ for *G. carolinensis* has been reported as 0.04 mg/L.

Manganese alters the sodium permeability in membranes and may decrease metabolic rates (Power et al. 1989). *G. carolinensis* eggs exposed to manganese from fertilization to 4 days posthatch were reported to have a 96-hour LC₅₀ of 1.42 mg/L.

Nickel has been shown to affect myelinated nerves by slowing down the kinetics of the potassium system (Power et al. 1989). Decreased metabolic rates in frogs located near metallurgic worksites have also been reported. An acute 96-hour LC₅₀ of 0.05 mg/L has been reported for *G. carolinensis* exposed from fertilization to 4 days posthatch.

Selenium is an essential trace element, but can be toxic at higher concentrations (Power et al., 1989). Exposure of *Xenopus laevis* embryos to low concentrations of selenium had increased survival rates compared to controls not exposed to selenium. At increased concentrations of 2.0 mg/L and higher, decreased survival rates were observed. Survivors from the higher concentrations exhibited

numerous abnormalities. Eggs treated with selenium exhibited spine curvatures, tail flexures, and malformed heads. Tadpoles treated with selenium exhibited epithelial blisters, abdominal edema, degeneration of muscle cells, erratic swimming, and sluggishness. *G. carolinensis* eggs were much more sensitive to selenium than *X. laevis* with a 96-hour LC₅₀ of 0.09 mg/L.

Zinc exerts its toxic effects on the nervous system and on epithelial cells (Power et al. 1989). Zinc slows the kinetics of the potassium system in myelinated nerves and alters sodium and potassium kinetics across cell membranes. *Bufo boreas* tadpoles were much more resistant to zinc than *G. carolinensis* eggs. Exposure of *B. boreas* to 0.1 mg/L for 61 days resulted in no mortality, whereas *G. carolinensis* had a 96-hour LC₅₀ of 0.01 mg/L.

7.2.4 Risk Characterization

Organic and inorganic COPEC were screened using available ecological criteria; this screening was used to identify those chemicals present at concentrations potentially posing a threat to ecological receptors. Maximum concentrations of COPEC detected at each site in near-surface soil, sediment, and surface water were used to evaluate exposure. If the observed maximum concentrations of chemicals exceed the criteria, adverse effects to the exposed receptors could occur. As described above, screening values are based on applicable criteria and standards established by regulatory agencies, or on derived criteria. Criteria comparisons were completed for each medium; this process is described in the following paragraphs. Results are presented on a site-by-site basis, and then summarized for the entire Station.

7.2.4.1 Media-Specific Risk Evaluation

Soils

COPECs for near-surface soil were evaluated based on comparison to toxicity values for mammals, invertebrates and plants.

Mammals. Potential effects on mammals were evaluated using the index approach described in Section 7.2.3.1, for terrestrial mammals. The rat was used as an indicator species. Appendix H3 presents the estimated soil intake, the derived acceptable dose, and the results of their comparison for each site. Table 7-35 presents a summary of those chemicals where the estimated soil intake exceeded the derived acceptable dose. These results are discussed on a site-by-site basis below.

Invertebrates. The maximum concentration of each COPEC detected at each site was compared to the toxicity information found for terrestrial invertebrates, presented in Table 7-31. The results of this comparison are presented on a site-by-site basis below and are summarized in Table 7-35.

Plants. The maximum concentrations detected at each of the sites were compared to the values presented in Table 8-30. Site-specific results of this comparison are discussed below and summarized in Table 8-33.

Sediments

The detected chemicals with sediment concentrations exceeding the derived criteria, as presented in Table 7-33, are indicated in Table 7-36, and discussed on a site-specific basis below.

Surface Water

The possibility of ecological impacts in surface water habitats at MCAS El Toro resulting from potential exposures to COPEC are indicated by comparing maximum detected concentrations to levels that are known to be protective for most organisms. These concentrations are given in Table 7-34. Table 7-37 summarizes for Sites 2, 3, and the washes and San Diego Creek (Site 18), those criteria that were exceeded by the maximum COPEC concentration detected at a site.

7.2.4.2 Site-Specific Ecological Risk Characterization

In this subsection, the results of the above-described ecological effects criteria compared to the maximum observed values are presented for each medium at each site in the Station. Habitat and potential pathways associated with each site are discussed to the extent possible given the limited nature of the ecological reconnaissance survey.

For each site, results are presented for each medium sampled; first for soil (terrestrial mammals, invertebrates and plants), then for sediment, and finally for surface water. It should be noted that while background soil data were available, methodology for using background values for comparison to onsite concentrations has not yet been established by the Navy and the appropriate agencies. This approach will be determined in the DQOs for MCAS El Toro. Because data have not been evaluated relative to background levels, several inorganic compounds present at theoretically toxic levels may actually be representing local background concentrations, and therefore may not present any increased stress to the ecological receptors found at or around the sites within the Station. In addition, literature toxicity values may be appropriate because they may represent chemical forms or conditions not present at MCAS El Toro.

Site 1 Explosive Ordinance Disposal Range

Site 1 is characterized as coastal sage scrub habitat. Cactus wren, a sensitive species, and their nests were observed in the vicinity of Site 1 during the reconnaissance visit in May 1992. Soil samples were collected at Site 1; sediment and surface water samples were not collected here.

Soil - Mammals. Near-surface soil concentrations of organic compounds detected at Site 1 did not exceed toxicity value derived for a rat, but toxicity values were not available for petroleum hydrocarbons.

Two inorganic compounds (aluminum and barium) exceeded the toxicity value derived by greater than a factor of 10. Four other compounds (cobalt, lead, mercury, and vanadium) were detected at concentrations that resulted in doses

**Table 7-35
MCAS El Toro Chemicals of Potential Ecological Concern in Soil Exceeding Criteria
MCAS El Toro Phase I RI Technical Memorandum**

Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
ORGANICSs																						
1,1,1-Trichloroethane									-nn													
1,2-Dichloroethene(total)										-nn												
2,4,5-T																						nnn
2,4,5-Trichloro phenoxy propionic acid			-nn		-nn																	
2,4-D												nnn										
2,4-DB		nnn																nnn				
2,4-Dimethyl phenol																		nnn				
2-Butanone (MEK)		-nn	-nn					-nn	-nn			-nn					-nn			-nn		-nn
2-Hexanone		nnn	nnn					nnn									nnn			n		nnn
2-Methylnaphthalene				nnn													nnn			nnn	nnn	nnn
4',4'-DDD		n-n	n-n	n-n			n-n	n-n			n-n	n-n						n-n			n-n	n-n
4',4'-DDE		nnn	nnn	nnn			nnn	nnn			nnn	nnn						nnn			nnn	nnn
4',4'-DDT																						
4-Methyl-2-pentanone		nnn																				
4-Methylphenol																		nnn				
Acenaphthene																				n-n		n-n
Acenaphthylene																				nnn		nnn
Acetone		--n	--n	--n		--n	--n			--n		--n	--n	--n	--n	--n	--n			--n	--n	--n
Aldrin		-n-																				
Alpha chlordane		-nn		-nn				-nn				-nn						-nn				-nn
Anthracene														-nn						-nn		-nn

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**Table 7-35
MCAS EI Toro Chemicals of Potential Ecological Concern in Soil Exceeding Criteria
MCAS EI Toro Phase I RI Technical Memorandum**

Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Benzene		--n					--n									--n						
Benzo(a)anthracene							Mnn			Mnn		Mnn		M-nn			Mnn		Mnn		Mnn	Mnn
Benzo(a)pyrene				--P			--P	--P		--P		--P	--P	--P			--P		--P	--P	--P	--P
Benzo(b)fluoranthene				-nn			-nn			-nn		-nn	-nn	-nn					-nn		-nn	-nn
Benzo(g,h,i)perylene							nnn	nnn		nnn		nnn	nnn	nnn			nnn		nnn	nnn	nnn	
Benzo(k)fluoranthene				-nn			-nn			-nn		-nn	-nn	-nn					-nn		-nn	-nn
Benzyl butyl phthalate		nn		-nn		-nn		-nn					-nn			-nn					-nn	
Beta chlordane								nn														
Alpha-BHC								nnn													nnn	
Delta-BHC				-n-															-n-		-n-	
Gamma BHC																						nnn
Bis(2-ethylhexyl)phthalate		--n	--n	--n		--n	--n	--n		--n		--n	--n	--n	--n	--n			--n	--n	--n	--n
Carbazole							nnn							nnn					nnn		nnn	nnn
Carbon disulfide												-nn										
Carbon Tetrachloride		nnn	nnn			nnn	nnn		nnn			nnn		nnn		nnn					nnn	
Chrysene				-nn			-nn	-nn		-nn		-nn	-nn	-nn	-nn		-nn		-nn		-nn	-nn
Dalapon		-nn										-nn									-nn	
Dibenzofuran																-nn			-nn		-nn	
Di-n-butylphthalate								--n														
Dichlorprop		-nn																				
Dieldrin																						
Diethylphthalate							n-n			n-n												
Dimethylphthalate								-nn	-nn													

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**Table 7-35
MCAS EI Toro Chemicals of Potential Ecological Concern in Soil Exceeding Criteria
MCAS EI Toro Phase I RI Technical Memorandum**

Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	
Endosulfan I				-n-				-n-														-n-	
Endosulfan II				-nn				-nn			nn												-nn
Endosulfan sulfate				nnn			nnn	nnn				nnn					nnn			nnn	nnn		
Endrin				-nn			-nn	-nn			nn										-nn	-nn	
Endrin aldehyde				nnn				nnn			nnn	nnn											
Endrin ketone				nnn			nnn	nnn				nnn					nnn			nnn	nnn		
Ethyl benzene		--n						--n								--n							
Fluoranthene				--n		--n	--n	--n		--n		--n	--n	--n		--n	--n		--n		--n	--n	--n
Fluorene																n-n			n-n		n-n		
Gamma chlordane		nn		-nn				-nn				-nn					-nn			-nn	-nn		
Heptachlor epoxide																	-nn						
Hexachloroethane								nnn															
Indeno(1,2,3-cd)pyrene							-nn	-nn		-nn		-nn	-nn	-nn			-nn		-nn		-nn	-nn	-nn
Isophorone																							nnn
Methoxychlor				-nn	-nn			-nn				-nn					-nn					-nn	
Methylene chloride		--n	--n			--n	--n	--n				--n		--n	--n	--n	--n			--n	--n		
MCPP		nnn										nnn											
Naphthalene				--n												--n			--n	--n		--n	
Octachlorodibenzo-p-dioxin			nnn																				
PCB 1248								nnn															
PCB 1254								nP				nnP											
PCB 1260								-nn			nn					-nn							

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**Table 7-35
MCAS EI Toro Chemicals of Potential Ecological Concern in Soil Exceeding Criteria
MCAS EI Toro Phase I RI Technical Memorandum**

Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Phenanthrene							-nn			-nn		-nn	-nn	-nn	-nn	-nn			-nn		-nn	-nn
Phenol				-nn																		
Pyrene				-nn		-nn	-nn	-nn		-nn		-nn	-nn	-nn		-nn	-nn		-nn	-nn	-nn	-nn
Tetrachloroethene								nnn		nnn												
Toluene	--n		--n	--n	--n	--n	--n	--n		--n	--n	--n		--n	--n	--n	--n	--n	--n		--n	--n	--n	--n
Petroleum hydrocarbons (total recoverable)	nnn	nnn	nnn		nnn	nnn	nnn	nnn	nnn	nnn		nnn	nnn	nnn	nnn	nnn	nnn		nnn	nnn	nnn	nnn
TFH-diesel	nnn	nnn	nnn			nnn	nnn	nnn	nnn	nnn		nnn	nnn		nnn		nnn		nnn		nnn	nnn
TFH-gasoline	nnn		nnn	nnn	nnn	nnn	nnn	nnn	nnn	nnn	nnn		nnn	nnn	nnn	nnn	nnn	nnn		nnn	nnn	nnn	nnn
Trichloroethylene		--n																				
Xylenes (total)		nn		-nn			-nn	-nn				-nn				-nn				-nn		
INORGANICS																						
Aluminum	MIP		MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP	MIP		MIP	MIP	MIP	MIP	MIP	MIP		MIP	MIP	MIP	MIP
Antimony	nnn	nnn		nnn		nnn		nnn					nnn	nnn		nnn	nnn		nnn	nnn		nnn
Arsenic		P	P	P	P	P	P	P	P	P		P	P	P	P	P	P		P	P	P	P
Barium	Mnn		Mnn	Mnn	Mnn	Mnn	Mnn	Mnn	Mnn	Mnn	Mnn		Mnn	Mnn	Mnn	Mnn	Mnn	Mnn		Mnn	Mnn	Mnn	Mnn
Beryllium		-n-		-n-		-n-	-n-	-n-	-n-	-n-		-n-		-n-	n-	-n-	-n-	-n-	-n-		-n-	n-	-n-	-n-
Cadmium		M	M	MIP	M	MP	M	MIP	M	M		MP	M	MP	M	M	MP		M	MP	M	M
Chromium		MP	MP	MP	MP	MIP	MP	MIP	MP	MP		MP	MP	MP	MP	MP	MIP		MP	MP	MP	MP
Cobalt	M	M	M	M	M	M	MP	M	M	M		M	M	M	M	M	M		MP	MP	M	M
Copper								MIP								P	P			MIP		
Lead	M	MI	MIP	IM		MIP	MIP	MIP	MIP	MIP	MIP		M	MIP	IMP	IMP						
Manganese	-nn		-nn	-nn	-nn	-nn	-nn	-nn		-nn	-nn	-nn	-nn									

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Table 7-35
MCAS El Toro Chemicals of Potential Ecological Concern in Soil Exceeding Criteria
MCAS El Toro Phase I RI Technical Memorandum

Parameter	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22
Mercury	Mn	M	M	M	M	M	M	MIP		M		MP	M	MP	M	M	M		M	M	M	M
Nickel								MP				MP					MIP				P	
Selenium	nnn	nnn			nnn	nnn	nnn	nnn	nnn	nnn		nnn	nnn	nnn	nnn	nnn	nnn		nnn	nnn	nnn	nnn
Silver		-n	-n	-n	-n	-n		-nP		-n		-nP	-n	-nP	-n	-n	-n		-n	-n		
Thallium		nn	nn	nn	nn	nn	nn	nn	nn	nn		nn	nn	nn	nn	nn	nn		nn	nn	nn	nn
Vanadium	M	MP	MP	MP	MP	MP	MP	MP	MP	MP		MIP	MP	MP	MP	MP	M		MP	MP	MP	MP
Zinc				IP		I	I	MIP				IP		I		I	I				MIP	I

Notes: (blank means chemical not detected or did not exceed criteria)

M Mammalian soil ingestion dose exceeded acceptable ingestion dose for a rat (Appendix H3).

I Invertebrate criteria were exceeded by maximum soil concentration (Table 7-29).

P Plant criteria were exceeded by maximum soil concentration (Table 7-30).

n no toxicity values available for mammals, invertebrate, plants (e.g., --n means not criteria for plant toxicity).

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equivalent to the LOAEL (cobalt) and NOAEL based toxicity value, so these levels are not expected to ecologically affect terrestrial mammals. Aluminum toxicity values were based on an LOAEL and therefore exceedances greater than ten times could indicate potential for an effect on terrestrial mammals.

Soil - Invertebrates. Petroleum hydrocarbons were the only organics that did not have available toxicity literature for terrestrial invertebrates; other detected organics did not exceed available literature-reported effect levels. Aluminum exceeded the literature reported LD₄₅ for woodlouse; five inorganics had no available criteria for comparative evaluation (antimony, barium, manganese, mercury, and selenium).

Soil - Plants. Literature information to evaluate the four organic compounds detected in soil (TFH-diesel, TFH-gasoline, total recoverable petroleum hydrocarbons, and toluene) was not available. Aluminum was detected at concentrations exceeding the reported tolerable levels for plants. Four inorganics did not have criteria available for comparison (antimony, barium, manganese, selenium).

Site 2 - Magazine Road Landfill

Site 2 is characterized as sage scrub habitat. Various mouse species and orange-throated whiptail were observed in the vicinity of Site 2. Soil, surface water, and sediment samples were collected.

Soil - Mammals. Ten organics detected did not have toxicity values available for evaluation of potential effects to animals: 2,4-DB, 2-hexanone, 4,4'-DDE, 4,4'-DDD, 4-methyl-2-pentanone, carbon tetrachloride, MCP, TFH-diesel, TFH-gasoline, and total recoverable, petroleum hydrocarbons. Information was available for DDT, the precursor to DDE; using the DDT toxicity value, DDE was detected at approximately one million times below the level that would result in the LOAEL for rats.

Eight inorganic COPEC (aluminum, barium, cadmium, chromium, cobalt, lead, mercury, and vanadium) exceeded the toxicity value derived for a rat. However, the toxicity values are based on NOAELs for six of the compounds (barium, cadmium, chromium, lead, mercury, and vanadium); these levels are not expected to cause an ecological effect on terrestrial mammals. Aluminum and cobalt toxicity values were based on LOAELs, and the estimated dose exceeded by greater than ten times; this could indicate potential for an effect to terrestrial mammals.

Soil - Invertebrates. Several organic compounds (acetone, benzene, bis(2-ethylhexyl)phthalate, 4,4'-DDD, ethylbenzene, trichloroethylene, methylene chloride and toluene) were detected at concentrations below the literature reported toxicity levels. DDE has no reported effect level available; however, when compared to criteria for DDT, it was nearly 100 times below that criteria. Other organics had no available literature values for comparison: 2,4-DB, 2-butanone, 2-hexanone, aldrin, alpha and gamma chlordane, benzyl butyl phthalate, 4-methyl-2-pentanone, carbon tetrachloride, dalapon, dichlorprop, MCP, TFH-diesel, TFH-gasoline, total recoverable petroleum hydrocarbons, and xylenes.

Two inorganic elements, aluminum and lead, exceeded the literature reported LD₄₅ and LOAEL, respectively; six inorganics were detected but had no available criteria for comparative evaluation (antimony, barium, beryllium, manganese, silver, and thallium). The remaining detected inorganics were below the reported effect levels.

Soil - Plants. Literature information was not available to evaluate most organics detected in soil. However, DDT and aldrin were detected at concentrations well below those reported as excessive in plants. For inorganics, aluminum, arsenic, and chromium were detected at concentrations exceeding the reported tolerable levels for plants. Vanadium was above the reported tolerable level but three times below the reported toxic level. Two inorganics did not have criteria available for comparison (barium and manganese).

Sediments. Three organic COPEC (4,4'-DDT, bis-(2ethylhexyl)phthalate, and benzyl butyl phthalate) were present at concentrations exceeding derived criteria; 2,4-DB, acetone, benzene, carbon tetrachloride, MCP, and the petroleum hydrocarbons (total recoverable and TFH-gasoline) did not have available criteria and could not be evaluated.

Because criteria were not derived for inorganics in sediment, they were evaluated using lowest effect level (LEL) values when possible; cadmium concentrations in sediment exceeded this value. No criteria were available for aluminum, antimony, barium, beryllium, cobalt, selenium, thallium, or vanadium.

Surface Water. Acetone and TFH-diesel, the only organics detected in surface water, could not be evaluated because no criteria were found. Seven inorganic COPEC had maximum concentrations that exceeded water quality criteria; aluminum and selenium exceeded EPA or State of California water quality criteria; cadmium, copper, lead and zinc exceeded water quality criteria corrected for site-specific hardness. Beryllium exceeded the only available criterion, an LOEL.

Site 3 - Original Landfill

Site 3 is primarily covered by concrete or is disturbed, barren, and covered with crushed rock. The drainage ditch and grassland habitat exist around this site. Soil, sediment, and surface water samples collected were collected from Site 3.

Soil - Mammals. Nine organic compounds detected at Site 3 had no available toxicity information in the available literature. Six organics resulted in doses below the toxicity values. Eight inorganic COPEC exceeded the derived toxicity values for ingestion; toxicity values were based on NOAELs with the exception of aluminum and cobalt which were based on LOAELs. Chromium and vanadium exceeded the NOAELs by less than 5 times, and therefore may not present a potential ecological effect to terrestrial animals. However, barium, cadmium, lead, and mercury exceeded the NOAELs by 10 to 100 times and therefore may present a potential risk. Aluminum and cobalt exceed the LOAEL toxicity criteria by

70 and 10 times, respectively, and could therefore result in a potential threat to receptors.

Soil - Invertebrates. No organic compounds detected exceeded toxicity values; however, toxicity values were not available for nine of the organic chemicals. Two inorganic elements, aluminum and lead, exceeded threshold toxicity values reported in the literature. Toxicity values were not available for five inorganics detected at Site 3: barium, beryllium, manganese, silver, and thallium.

Soil - Plants. Toxicity values were not available for the organic compounds detected. For inorganics, five exceeded literature effects levels (aluminum, arsenic, chromium, lead, and vanadium). Literature information was not available for barium and manganese. All other inorganics were below reported effects levels.

Sediments. Two organics were found at concentrations exceeding derived toxicity values, 4,4'-DDT and bis(2-ethylhexyl)phthalate; criteria were not available for 2-hexanone, acetone, TFH-diesel, TFH-gasoline, or total recoverable petroleum hydrocarbons. Cadmium exceeded lowest effect levels (LELs); no criteria were available for aluminum, barium, beryllium, cobalt, and vanadium.

Surface Water. Seven COPEC were detected at a maximum concentration that exceeded criteria. Aluminum, mercury and selenium exceeded published criteria; cadmium, copper, lead, and zinc exceeded criteria based on water hardness at Site 3. Water quality criteria were not available for acetone, TFH-diesel, barium, cobalt, cyanide, manganese, or vanadium.

Site 4 - Ferrocene Spill Area

Site 4 is made up of asphalted areas and portions of a drainage swale feeding Agua Chion. Habitat near this site is mostly grassland and some bare ground. Soil and sediment were sampled at this site.

Soil - Terrestrial Animals. Organic compounds detected at Site 4 were below toxicity values. 4,4'-DDT, alpha chlordane, and gamma chlordane were five orders of magnitude below LOAELs; acetone, benzo(a)pyrene, delta-BHC, dieldrin endosulfar II, and methoxychlor were equally below toxicity value based on the acute LD₅₀. No toxicity information was available for seven organic compounds.

Eight inorganics (aluminum, barium, cadmium, chromium, cobalt, lead, mercury, and vanadium) exceeded the derived toxicity value. With the exception of aluminum and cobalt, these toxicity values are based on NOAELs; the NOAELs were exceeded by approximately ten to 400 times. Toxicity criteria for aluminum and cobalt are based on LOAELs and were exceeded 150 and 15 times, respectively. These results indicate a potential for ecological impact to animal receptors.

Soil - Invertebrates. Many of the organics detected at Site 4 did not have literature values available for assessment of potential impacts; seven (4,4'-DDD, acetone, benzo(a)pyrene, bis(2-ethylhexyl)phthalate, fluoranthenes, naphthalene, and toluene) were below concentrations corresponding to effect levels in invertebrates.

Using literature reported effects levels, NOAELS and other toxic effect criteria, aluminum, cadmium, lead, and zinc were present at concentrations potentially causing ecological effects. Criteria were not available for antimony, barium, manganese, silver, and thallium.

Soil - Plants. Criteria to evaluate the majority of organic compounds detected in soil at Site 4 were not found in the literature; however, benzo(a)pyrene was detected at a maximum concentration exceeded literature reported effect levels. Likewise, criteria to evaluate three inorganics detected in soil (antimony, barium, and manganese) were not available. For other inorganics detected, seven (including aluminum, arsenic, cadmium, chromium, lead, vanadium, and zinc) were above reported no effect ranges or in reported effect ranges.

Sediments. Criteria were not available to evaluate acetone, the only organic detected in sediments. Four inorganics exceeded LEL values based on site

specific water hardness: cadmium, copper, lead and zinc. No criteria were available for aluminum, antimony, barium, cobalt, silver, and vanadium.

Site 5 - Perimeter Road Landfill

Approximately half of Site 5 has been graded and amended with imported soil to make cells for storing soil cuttings; these are surrounded by grassland habitat. Site 5 was sampled for soil; sediment and surface water were not present and therefore were not sampled.

Soil - Mammals. Seven organic compounds and 21 inorganic compounds were detected in near-surface soil samples from Site 18. For four of the organics (2,4,5-Trichlorophenoxy propionic acid, 2,4,5-T, TFH-gasoline, and total recoverable petroleum hydrocarbons), no toxicity values were found in the literature. Methoxychlor, DDT, and toluene were well below toxicity levels derived using NOAEL and LOAEL values.

Eight inorganics exceeded the criteria derived from NOAELs (barium, cadmium, chromium, lead, mercury, and vanadium) and LOAELs (aluminum and cobalt only). However, aluminum, barium and cadmium were the only compounds that exceeded the criteria by more than 6 times; these three could potentially be present at concentrations that could cause an effect to terrestrial animals.

Soil - Invertebrates. Of the seven organics detected in soil, three (2,4,5-T, 4,4'-DDT, and toluene) were present at concentrations below reported effects levels to invertebrates; the remaining four had no available criteria for comparison. Aluminum and lead were the only inorganics that exceeded literature reported effects levels; however, literature values were not available for barium, manganese, selenium, silver, and thallium.

Soil - Plants. Literature reported effect levels were available for DDT and 2,4,5-T, which were detected well below the reported levels. However other organics detected in soil did not have levels available for evaluating plant effects. For

inorganics, aluminum, arsenic, chromium, lead and vanadium concentrations exceeded reported plant effects levels.

Site 6 - Drop Tank Drainage Area No. 1

Site 6 is comprised of grassland habitat that is periodically mowed; soil and sediment were sampled from this site. Eleven organics and eighteen inorganics were detected in Site 6 soil.

Soil - Mammals. Toxicity criteria were not available to assess potential effects of carbon tetrachloride, TFH-diesel, TFH-gasoline, and total recoverable petroleum hydrocarbons to terrestrial animals; however, criteria were available for the remaining organics detected, none of which exceeded the toxicity values. Six inorganic compounds detected at Site 6 exceeded the toxicity values derived using NOAELs (barium, cadmium, chromium, lead, mercury, and vanadium); aluminum and cobalt exceeded the toxicity values derived based on LOAELs by approximately 100 and 15 times, respectively. These exceedances may indicate ecological effects.

Soil - Invertebrates. Organics with available criteria did not exceed these values; however, toxicity criteria were not available for six organic compounds. For inorganics, aluminum, chromium, lead, and zinc were detected at maximum concentrations that were above reported effect levels. All other detected inorganic compounds were below reported effect levels in invertebrates.

Soil - Plants. Reported effect levels were exceeded for six inorganics (aluminum, arsenic, cadmium, chromium, lead, and vanadium). Criteria were not available to evaluate the detected organics or antimony, barium, manganese, or selenium.

Sediments. Bis(2-ethylhexyl)phthalate was the only organic detected at greater than the derived sediment criteria; criteria were not available for total recoverable petroleum hydrocarbons, TFH-diesel, or TFH-gasoline. Inorganics were compared to LEL values; cadmium and lead exceeded these values; aluminum, barium, cobalt, silver, and vanadium had no criteria for comparison.

Site 7 - Drop Tank Drainage Area No. 2

This site is predominantly covered with concrete pavement, asphalt, or Marsden matting (metal sheets with intermittent holes). A catch basin draining to Agua Chinon and grassland are adjacent to the site. Soil was the ecological medium of concern sampled.

Soil - Mammals. One organic and eight inorganic compounds exceeded derived toxicity values for terrestrial animals: benzo(a)anthracene, aluminum, barium, cadmium, chromium, cobalt, lead, mercury, and vanadium. Aluminum and cobalt toxicity values were based on LOAELs and therefore detected maximum concentration may be within toxic effects ranges. Other inorganic toxicity criteria were based on NOAELs and therefore effects may or may not be caused by the maximum reported concentration at Site 7. Toxicity values were not available for 12 organic and 2 inorganic compounds. DDD and DDE, when compared to the toxicity value for DDT did not exceed derived criteria based on NOAEL; for other compounds without derived criteria, potential for effects cannot be assessed.

Soil - Invertebrates. Aluminum, lead, and zinc were the only chemicals that exceeded reported effect level ranges. Criteria were not available for 19 organic and 4 inorganic COPEC.

Soil - Plants. Reported toxicity values were exceeded for benzo(a)pyrene and several inorganic compounds including aluminum, arsenic, chromium, cobalt, lead, and vanadium. Manganese and the majority of organics detected did not have reported values that could be used for comparison. When DDD and DDE are compared to DDT criteria, they do not exceed.

Site 8 - DRMO Storage Area

Site 8 includes the current storage yard covered with asphalt or bare ground and crushed rock, and the old yard which is covered with 10 to 15 feet of imported fill and currently is a dirt parking area. Surrounding areas are described as

grassland habitat. Soil samples were collected, but sediment and surface water samples were not collected.

Soil - Mammals. Eight inorganics were detected at maximum concentrations that exceeded toxicity values derived from NOAELs, and three additional inorganics (aluminum, cobalt, and copper) exceeded toxicity values derived from LOAELs. Fifteen organics and three inorganics did not have toxicity criteria and could not be evaluated. For the remaining COPEC, maximum concentrations were well below available toxicity values. For three organics, the toxicity value was based on LOAELs; for nine organics, the toxicity value was based on LD₅₀. However, the derived intake, based on the maximum detected concentration, was 1,000 times below these toxicity values based on LOAELs and LD₅₀'s values. Compounds having toxicity values based on LD₅₀ may indicate potential for ecological effects.

Soil - Invertebrates. Toxicity values reported for invertebrates were exceeded for the maximum detected concentration of 7 inorganics: aluminum, cadmium, chromium, copper, lead, mercury, and zinc. Toxicity values were not exceeded for 4 organic and 3 inorganic COPEC. Values were not available for most organics and 6 inorganics.

Soil - Plants. Two organics (PCB 1254 and benzo(a)pyrene) and 11 inorganics (aluminum, arsenic, cadmium, chromium, copper, lead, mercury, nickel, silver, vanadium, and zinc) exceeded literature reported toxicity values for plants.

Site 9 - Crash Crew Pit No. 1

Because Site 9 was used for fire fighting exercises, much of the site is heavily disturbed.

Like most of the Station, Site 9 was likely originally grassland habitat. Three organic and 13 inorganic COPEC were detected at Site 9 in soil samples. Sediment and surface water were not sampled.

Soil - Mammals. No organic compounds having criteria exceeded the acceptable doses. Seven inorganic compounds had maximum detected concentrations that resulted in exceedance of toxicity values (aluminum, barium, cadmium, chromium, cobalt, lead, and vanadium). As previously described aluminum and cobalt toxicity values are based on LOAELs while the other toxicity values are based on NOAELs; therefore exceedance of toxicity values by these chemicals presents a greater potential for toxic effects. Toxicity values were not available for carbon tetrachloride, the petroleum hydrocarbons, selenium, or thallium.

Soil - Invertebrates. Aluminum and lead were detected at maximum concentration which exceeded reported effect levels for invertebrates. Toxicity information was not available for several organics, barium, manganese, selenium, or thallium.

Soil - Plants. Aluminum, arsenic, chromium, lead, and vanadium were detected at a maximum concentration which exceeded plant toxicity effect levels. Criteria were not available for the organics or for barium manganese or selenium.

Site 10 - Petroleum Disposal Area

This site, covered with concrete and Marsden matting (metal sheeting), is used for airplane parking. Hangars and buildings surround the site. Grasses grow around the Marsden matting. Five organic chemicals and several inorganics were detected in soil samples.

Soil - Mammals. Of the nineteen organic COPEC, twelve were well below derived toxicity values. Benzo(a)pyrene exceeded the LD₅₀ based toxicity values by 5 times. Six organics did not have toxicity values and could not be evaluated.

Eight inorganic compounds had maximum values that exceeded the derived toxicity value: aluminum, barium, cadmium, chromium, cobalt, lead, mercury, and vanadium. A toxicity value was not available for selenium or thallium.

Soil - Invertebrates. Most organic chemicals detected could not be evaluated for potential toxic effects due to lack of values. Of the inorganics detected, aluminum and lead exceeded reported effects levels. However, barium, manganese, selenium, silver, and thallium had no toxicity information and could not be evaluated.

Soil - Plants. Most organics detected at Site 10 could not be evaluated for plant toxic effects due to lack of toxicity information. However, benzo(a)pyrene had a maximum concentration that exceeded literature toxicity values. Aluminum, arsenic, chromium, and vanadium exceeded the reported toxicity value.

Site 11 - Transformer Storage Area

Site 11 includes areas covered with concrete pads and asphalted drainage swales. It is adjacent to Sites 9 and 10. Grass is in intermittent patches around the site. Soil was the only medium of ecological concern sampled at this site. Only seven COPEC, all organics, were detected here; no inorganics were detected.

Soil - Mammals. Four of the COPEC were evaluated for terrestrial animal toxicity. DDT, based on an LOAEL, had an estimated exposure dose well below the derived toxic dose; assuming DDD and DDE to have similar toxicity, they had maximum concentrations corresponding to more than 100 times below the toxic dose. PCB-1260, endosulfan II, and endrin were evaluated in comparison to toxicity doses based on LD₅₀s; the maximum concentration of these compounds corresponded to doses more than 1,000 times below the LD₅₀ dose.

Soil - Invertebrates. DDT and DDD were present at levels below literature reported levels toxic to invertebrates. DDE was also below toxicity values for DDT and DDD. Toxicity values were not available for the remaining organics detected.

Soil - Plants. DDT did not exceed literature values, and it can be extrapolated that DDD, present at a similar concentration to DDT, would not present a potential

effect to plants either. Other compounds could not be evaluated due to lack of toxicity information.

Site 12 - Sludge Drying Beds

This site and nearby areas are primarily open habitat of grass and forb vegetation with some Marsden matting. The site includes the former area of the wastewater treatment plant, the sludge drying beds, and drainage course. Twelve organic and 17 inorganic COPEC were detected in Site 12 soils and 31 COPEC in catch basin sediments; surface water was not sampled.

Soil - Mammals. Using the maximum concentrations and toxicity values, one organic COPEC (benzo(a)anthracene) exceeded the dose derived from that criterion. Criteria were not available for thirteen organic COPECs, including DDE and DDD. Assuming DDE and DDD have similar toxicity to DDT, they would pass toxicity criteria screening.

All inorganics except selenium and thallium (which have no available toxicity values) were evaluated. Eight exceeded criteria based on NOAELs; two (aluminum and cobalt) exceeded criteria based on LOAELs by 150 and 18 times, respectively.

Soil - Invertebrates. DDT, aluminum, lead, vanadium, and zinc exceeded literature reported invertebrate toxicity values. Several compounds could not be evaluated because toxicity values were not available.

Soil - Plants. Compounds exceeding available toxicity values for plant effects were benzo(a)pyrene, PCB-1254, aluminum, arsenic, cadmium, chromium, lead, mercury, nickel, silver, vanadium, and zinc. Others had no available toxicity values and could not be evaluated.

Sediments. Using criteria derived from water quality criteria, organic COPEC (bis(2-ethylhexyl)phthalate, DDD, DDE, and DDT) exceeded criteria. Criteria were not available for acetone, carbon tetrachloride, TFH-diesel, TFH-gasoline, dalapon,

and total recoverable petroleum hydrocarbons. Inorganics, compared to lowest effect levels, exceeded for arsenic, cadmium, lead, mercury, and zinc. Some inorganic COPEC could not be evaluated, including: aluminum, barium, cobalt, silver, thallium, and vanadium.

Site 13 - Oil Change Area

Habitat in the vicinity of this site is mostly bare ground with scattered grassland-type vegetation. Ten to twenty percent of the site is asphalted and used as an oil changing area. Sixteen organic and 18 inorganic compounds were detected in soil at this site.

Soil - Mammals. Organic compounds were below the derived toxicity values. Benzo(g,h,i)perylene and the petroleum hydrocarbons could not be evaluated due to lack of toxicity values. Inorganics exceeded derived toxicity values for eight compounds. Aluminum and cobalt exceeded the acceptable dose based on a LOAEL for rats; the other six exceeded acceptable doses based on NOAELs.

Soil - Invertebrates. Aluminum and lead were the only COPEC that exceeded invertebrate toxicity values. However, toxicity values were not available for several organic compounds, antimony, barium, manganese, selenium, silver, and thallium.

Soil - Plants. Aluminum, arsenic, chromium, lead, and vanadium exceeded reported plant toxicity values. Several organics, antimony, barium, manganese, and selenium could not be evaluated because toxicity values were not available.

Site 14 - Battery Acid Disposal Area

Site 14 consists of overgrown grassland habitat that is periodically mowed. Soil and sediment were both sampled at this site.

Soil - Mammals. One organic COPEC (benzo[a]anthracene) and eight inorganic COPEC (aluminum, barium, cadmium, chromium, cobalt, lead, mercury, and

vanadium) exceeded derived criteria when using the maximum concentration detected at the site. The benzo[a]anthracene criterion was derived from a concentration correlating to observed chronic effects (Eisler, 1987a). Acetone and benzo[a]pyrene toxicity values were also based on LD₅₀ values, but estimated doses were more than 1000 times below the toxic dose. Aluminum and cobalt toxicity values are based on LOAELs; all other inorganics are based on NOAELs. Criteria could not be derived for six organic COPEC (benzo[g,h,i]perylene, carbazole, carbon tetrachloride, dibenzo(a,h)anthracene, TFH-gasoline, and total recoverable petroleum hydrocarbons); benzo(g,h,i)perylene was detected at a lower concentration than the other PAHs and is considered to be less toxic to mammals than those PAHs detected (Eisler, 1983); therefore, benzo(a)pyrene is not considered to present a concern to mammals. Toxicity factors were also not available for three inorganics, antimony, selenium, and thallium.

Soil - Invertebrates. Aluminum, lead, and zinc were the only compounds exceeding available toxicity values for invertebrates. Toxicity values were not available for various organics, antimony, barium, manganese, selenium, silver, and thallium.

Soil - Plants. The maximum detected concentration of benzo[a]pyrene exceeded the toxicity value reported for plants; assuming other high molecular weight PAHs to have similar toxicity to plants, benzo[a]anthracene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[k]fluoranthene, indeno[1,2,3-cd]pyrene would also exceed reported plant toxicity values. Eight inorganic compounds exceeded literature-reported plant toxicity values: aluminum, arsenic, cadmium, chromium, lead, mercury, silver, and vanadium. Criteria were not available for antimony, barium, manganese, and selenium.

Sediments. One organic and two inorganic COPEC were detected at levels that exceeded derived sediment criteria (bis(2-ethylhexyl)phthalate) or LEL criteria (cadmium and mercury). Criteria were not available for acetone, total recoverable petroleum hydrocarbon, TFH-diesel, TFH-gasoline, aluminum, barium, cobalt, and vanadium.

Site 15 - Suspended Fuel Tanks

Site 15 included two areas within a larger area; all of the fenced area is heavily trafficked barren ground with crushed rock. Grass grows outside the fencing; this Site was originally grassland habitat. Ten organics and 17 inorganic COPEC were detected in soil; surface water and sediment were not sampled.

Soil - Mammals. No organic COPEC exceeded the derived criteria for terrestrial animals; acetone was evaluated against a criterion based on an LD₅₀, but was more than one million times below the criterion. Eight inorganic COPEC exceeded the derived criteria and two inorganics had no criteria available. Aluminum and cobalt exceeded LOAEL based criteria by approximately 100 and 10 times, respectively. Barium, cadmium, chromium, lead, mercury and vanadium exceeded NOAEL-based criteria by 5 (vanadium and lead) to 75 times (barium). Criteria were not available for the petroleum hydrocarbons, selenium or thallium.

Soil - Invertebrates. Aluminum and lead were the only COPEC found to exceed toxicity values for invertebrates; however seven organics and five inorganics (barium, manganese, selenium, silver, and thallium) did not have toxicity values available.

Soil - Plants. Aluminum, arsenic, chromium, lead, and vanadium had maximum values detected at concentrations that exceeded literature values for plant toxicity. Literature toxicity values were not available to assess the organic COPECs detected or barium, manganese, or selenium.

Site 16 - Crash Crew Pit No. 2

Site 16, adjacent to an active fire-fighting area, is overgrown grassland habitat that is periodically mowed. Nineteen organic COPEC and 18 inorganic COPEC were detected at this site in soil; sediment and surface water were not sampled.

Soil - Mammals. Organic COPECs with toxicity information did not exceed derived criteria; three organic chemicals (2-hexanone, 2-methylnaphthalene,

carbon tetrachloride, fluorene, total recoverable petroleum hydrocarbons, and TFH-gasoline) did not have toxicity information available. Eight inorganic COPEC exceeded the derived criteria. Aluminum and cobalt exceeded LOAEL based criteria by approximately 100 and 15 times, respectively. Barium, cadmium, chromium, lead, mercury, and vanadium exceeded NOAEL-based criteria by 1 (mercury) to 120 times (barium). Three inorganics (antimony, selenium, and thallium) had no criteria available.

Soil - Invertebrates. Invertebrate-based toxicity values were exceeded for aluminum, lead, and zinc. Invertebrate toxicity values were exceeded for nine organics and were not available for ten organic COPEC or antimony, barium, manganese, selenium, silver, or thallium.

Soil - Plants. Several inorganic COPEC (aluminum, arsenic, chromium, copper, lead and vanadium) were detected at maximum levels which exceeded reported toxicity values for plants. Criteria were not available for several organic COPEC detected or for antimony, barium, or manganese.

Site 17 - Communication Station Landfill

This area is characterized as coastal sage scrub habitat. During the reconnaissance survey in May 1992, the special status cactus wrens were observed in the area of Site 17. Twenty-seven organic COPEC and 18 inorganic COPEC were detected in soil samples from the Site; sediment and surface water were not sampled.

Soil - Mammals. No organics with toxicity information exceeded derived criteria. Eleven organics including DDD and DDE had no toxicity values derived due to a lack of available information. If assessing DDD and DDE using DDT toxicity criteria for ingestion, criteria were not exceeded.

Nine inorganic COPEC exceeded derived criteria when using the maximum concentration detected at the site. Two of these (aluminum and cobalt) had derived criteria based on LOAELs, which were exceeded by approximately 40 and

10 times, respectively. All other derived criteria were based on NOAELs. Antimony, selenium, and thallium could not be evaluated because they have no available toxicity values.

Soil - Invertebrates. Maximum concentrations of five COPEC exceeded available toxicity values for invertebrates, including aluminum, chromium, lead, nickel and zinc. Toxicity information was not available for several organic compounds and antimony, barium, manganese, selenium, silver, and thallium.

Soil - Plants. Benzo(a)pyrene and several inorganic compounds were detected at maximum concentrations that exceeded literature toxicity values, including aluminum, arsenic, cadmium, chromium, copper, lead, and nickel. Antimony, barium, manganese, selenium, and several organic COPEC were not evaluated due to lack of toxicity values.

Site 18 - Regional Groundwater (OU 1) and Surface Water/Sediments

Site 18 addresses surface water and sediments, including the four washes crossing the Station and San Diego Creek. Consequently these areas are primarily characterized as riparian, aquatic, or wetland habitat. Sediment and surface water were the only ecological media of concern sampled in these areas; near-surface soil was not sampled.

Sediments. Organic chemicals were not consistently detected in the various washes.

Borrego Canyon Wash was not sampled upstream of Site 2, but was sampled downstream. Selected inorganics were the only constituents detected. Mercury exceeded LEL criteria for sediment, and aluminum, barium, and vanadium could not be evaluated due to lack of criteria.

Agua Chinon Wash had very few organic COPEC detected in sediments. TFH-gasoline was the only organic detected downstream of the Station. Criteria were not available to evaluate TFH-gasoline, aluminum, barium, cobalt, and vanadium.

Lead was the only constituent detected in sediment samples from this wash that increased in concentration in downstream samples. Mercury was the only COPEC that exceeded criteria.

Similar to Agua Chinon, only two organic COPEC in samples from Bee Canyon Wash were detected downstream of the Station, bis(2-ethylhexyl)phthalate and dichlorprop. While bis(2-ethylhexyl)phthalate concentrations exceeded available criteria, this chemical is a common laboratory contaminant and may not represent actual environmental contamination levels. All levels of inorganics, with the exception of mercury, decreased in concentration from upstream to downstream of the Station. Mercury was the only inorganic constituent that exceeded criteria (LEL) in downstream samples; it was not detected in upstream samples. Criteria were not available to evaluate dichlorprop, aluminum, barium, beryllium, cobalt, selenium, silver, thallium, and vanadium.

In Marshburn Channel, copper and lead were the only constituents that increased in concentration from the upstream-of-Station to the downstream samples; neither of these exceeded LEL criteria. Four organic compounds (2,4,5-trichlorophenoxy propionic acid, 2,4-DB, dichlorprop, and total recoverable petroleum hydrocarbons) were detected in downstream samples but not upstream of the Station; criteria were not available to evaluate these compounds. Of detected COPEC, mercury was the only one to exceed criteria.

Six organic compounds were detected in San Diego Creek downstream of a portion of the Station: 2-butanone, detected at the confluence with Bee Canyon but not detected in any upstream sediments, had no available criteria for evaluation; DDT was detected below Bee Canyon Wash but not at levels exceeding criteria; 4-methylphenol, detected below Bee Canyon Wash and below Marshburn Channel but not in any other sediment on the Station, had no criteria for evaluation; acetone, detected in sediment samples from Borrego Canyon Wash and Agua Chinon Wash was detected upstream of the Station and at the confluence with Agua Chinon at similar concentrations -- criteria were not available to evaluate acetone; dalapon, detected at the confluence with Agua Chinon, did not have criteria available and therefore could not be evaluated; and TFH-gasoline

which does not have sediment criteria, was detected at the confluence with Bee Canyon.

One inorganic (mercury) detected in San Diego Creek exceeded criteria; upstream concentrations of mercury were only slightly exceeded by concentrations in samples from the confluence with Agua Chinon Wash. Cadmium was detected at concentrations approximately equal to criteria in samples from below Bee Canyon and Marshburn Channel. While sediment concentrations for barium, cobalt, copper, manganese, nickel, vanadium, and zinc increased from upstream-San Diego Creek to downstream of the Station, they did not exceed available criteria and were within the range of concentrations detected in upstream samples from the contributing washes. Criteria were not available for aluminum, antimony, barium, cobalt, selenium, silver, thallium, and vanadium.

Surface Water. Surface water sample concentrations collected downstream of the Station exceeded criteria only for two organic compounds, beta-BHC (Agua Chinon), DDE (Marshburn Channel), and gamma chlordane (San Diego Creek at Bee Canyon). Criteria were exceeded at all sample locations, both up- and downstream of the Station, for aluminum, cadmium, copper, lead, and mercury. Silver exceeded at the only location where it was detected, downstream Agua Chinon Wash. Criteria were not available for evaluating barium, manganese, and vanadium.

Site 19 - Aircraft Expeditionary Refueling (ACER) Site

Site 19 is made up of two separated portions. The west portion has had underground storage tanks removed and was left disturbed. The east portion is bare ground with crushed rock or grassland habitat; soil samples contained 25 organic COPEC and 18 inorganic COPEC. Sediment and surface water samples were not collected.

Soil - Mammals. Estimated soil ingestion doses exceeded derived ingestion toxicity criteria for one organic; the toxicity value for benzo[a]anthracene is based on reported chronic effects in rodents. Eight inorganic compounds exceeded

NOAEL based toxicity. Aluminum, barium, cadmium, and cobalt exceeded by over 50 times. Aluminum and cobalt exceeded LOAEL based toxicity values by approximately 100 and 50 times, respectively. Ten organics, antimony, selenium, and thallium did not have criteria available for evaluation.

Soil - Invertebrates. Aluminum was the only COPEC which exceeded literature reported toxicity values for invertebrates. However, values were not available for various organics and antimony, barium, manganese, selenium, silver, and thallium. If PAHs are assumed to have invertebrate toxicity similar to benzo(a)pyrene, the PAHs would not exceed criteria.

Soil - Plants. Toxicity values for plants were exceeded by the maximum detected concentration of benzo(a)pyrene. Assuming, as above, that the higher molecular weight PAHs have equitoxicity to benzo(a)pyrene, all PAHs would exceed this criteria. Toxicity values were not available for other organics detected. Five inorganics (aluminum, arsenic, chromium, cobalt, and vanadium) were present at maximum concentrations greater than the reported toxicity value for plants. Toxicity values were not available for antimony, barium, manganese, and selenium.

Site 20 - Hobby Shop

This site includes the shop itself, which is surrounded by grassy habitat and two drainage ditches. Both soil and sediment samples were collected at Site 20.

Soil - Mammals. Estimated ingestion doses exceeded derived toxicity doses for ten inorganic compounds: aluminum, barium, cadmium, chromium, cobalt, copper, lead, mercury, vanadium, and zinc. Aluminum and cobalt exceeded their toxicity values based on LOAELs by over 100 times, indicating potential for an ecological effect. Other exceeded toxicity values were based on NOAELs. Toxicity values could not be developed for ten organic and three inorganic COPEC detected at Site 20 including DDD and DDE. Assuming similar toxicity criteria to those of DDT, DDE and DDD would have been significantly below (one million times) criteria.

Soil - Invertebrates. Aluminum, copper, lead, and zinc were the only COPEC to exceed literature-reported toxicity values for invertebrates at Site 20. Values were not available for various organics or antimony, barium, manganese, selenium, silver, and thallium. If DDE is assumed to have toxic responses similar to DDT, it would not exceed toxicity values.

Soil - Plants. Benzo(a)pyrene and ten inorganics exceeded reported toxic levels for plants, including: aluminum, arsenic, cadmium, chromium, cobalt, copper, lead, nickel, vanadium, and zinc. Most organic COPEC and four inorganic COPEC (antimony, barium, manganese and selenium) had no available toxicity information for comparison.

Sediments. One organic constituent was detected in sediment at a maximum concentration exceeding criteria from Site 20 -- bis(2-ethylhexyl)phthalate; this is a common laboratory contaminant and may not represent actual environmental conditions. Seven inorganic COPEC exceeded LEL based criteria: arsenic, cadmium, chromium, copper, lead, nickel, and zinc. Criteria were not available for acetone, total recoverable petroleum hydrocarbons, TFH-diesel, TFH-gasoline, aluminum, antimony, barium, cobalt, selenium, and vanadium.

Site 21 - Waste Management Group, Building 320

Site 21 is a fenced area used for product storage. Half the yard is paved and half is compacted soil with crushed rock. Outside the fenced area is grassland habitat. Soil and sediment from the washes were sampled and 41 organic and 16 inorganic COPEC were detected.

Soil - Mammals. One organic (Benzo(a)anthracene) and eight inorganic COPEC exceeded toxicity criteria for soil ingestion. Aluminum and cobalt maximum detected values resulted in an estimated soil ingestion dose that exceeded LOAEL

based toxicity criteria. Other inorganics including barium, cadmium, chromium, lead, and vanadium exceeded NOAEL-based toxicity criteria. Criteria could not be developed for selenium and thallium, and various organics including DDE and DDD. If DDE and DDD are compared to toxicity criteria for DDT, they would be well below derived criteria.

Soil - Invertebrates. None of the organic COPEC detected at Site 21 exceeded available toxicity values for terrestrial invertebrates; aluminum, lead, and zinc exceeded criteria. Toxicity values were not available for selected organics, barium, manganese, selenium, or thallium. If DDE is assumed to have similar invertebrate toxicity to DDT or DDD, concentrations present at Site 21 would not exceed criteria.

Soil - Plants. Benzo(a)pyrene and three chemicals, aluminum, arsenic, chromium, lead, and vanadium exceeded available plant toxicity values. Toxicity values were not available for various organics, barium, manganese, and selenium.

Sediments. Derived sediment criteria were exceeded for 6 organic (DDD, DDE, DDT, bis[2-ethylhexyl]phthalate, alpha chlordane, and phenanthrene) and 7 inorganic COPEC (arsenic, cadmium, copper, lead, manganese, mercury, and zinc). Criteria were not available for acetone, carbazole, dibenzofuran, fluorene, total recoverable petroleum hydrocarbons, methoxychlor, TFH-diesel, TFH-gasoline, aluminum, barium, cobalt, selenium, and thallium.

Site 22 - Tactical Air Fuel Dispensing System

Site 22, partially within Site 10, is in a heavily used area. The eastern portion of Site 22 is covered with concrete and Marshden matting; the rest is imported, dry sandy soil that supports little or no habitat. This area was sampled for near-surface soil but not sediment or surface water.

Soil - Mammals. Twenty one organic chemicals were present in near-surface soil; toxicity information was not available for 7 of these compounds. Eight inorganics (aluminum, barium, cadmium, chromium, cobalt, lead, mercury, and vanadium)

were detected at maximum concentrations that exceeded the derived criteria based on ingestion of soil. Aluminum and cobalt criteria were based on LOAELs; exceedance of these values may cause an effect in terrestrial mammal receptors. The other six inorganic compound exceeded NOAEL based criteria, by two (cobalt) to 85 (barium) times; these compounds may be present at concentrations that could result in an ecological affect to terrestrial mammals. Criteria were not available for antimony, selenium, and thallium.

Soil - Invertebrates. Aluminum and lead were the only COPEC that exceeded toxicity values for terrestrial invertebrates; values were not available for antimony, barium, manganese, selenium, and thallium, or several organics detected.

Soil - Plants. Benzo(a)pyrene and five inorganic COPEC were detected at maximum concentration that exceeded available plant toxicity values: aluminum, arsenic, chromium, lead, and vanadium.

7.2.5 Conclusions and Limitations

Soil, sediment and surface water results were evaluated for potential to cause harm to ecological receptors found at the MCAS El Toro.

Soil results were evaluated for potential effects on mammals using derived acceptable ingestion doses as compared to estimated ingestion doses, assuming a rat ingests 100 percent soil for its diet. This is a highly conservative approach; therefore, results not exceeding criteria would not be expected to result in ecological harm to mammals. Invertebrate and plant toxicity were assessed by direct comparison to values reported in the literature; NOAELs were preferentially selected as the criteria for comparison. In the absence of NOAELs, LOAELs, or other available information was used.

Sediment contaminant concentrations were evaluated by comparison to derived criteria. Criteria for organic compounds were derived by estimating the maximum concentration that could partition from sediment to pore water without exceeding

AWQC. Inorganic compounds were compared to lowest effect level concentrations.

Similarly, surface water results were compared to AWQC. This criterion was adjusted for water hardness where appropriate. In the absence of AWQC, results were compared to lowest observed effect levels reported in the available literature.

7.2.5.1 Soil

Potential for ecological effects to mammals, invertebrates, and plants could not be clearly determined for many organic compounds due to lack of available criteria. Those COPEC exceeding criteria in soil are presented on a site by site basis in Table 7-35. According to available information, benzo(a)pyrene and benzo(a)anthracene presented a potential threat to plants and mammals, respectively. Literature varies greatly in potential effects of PAHs; criteria and interpretations used in this ecological risk assessment are conservative and should be further evaluated. PCB-1254, detected at Sites 8 and 12, could also pose a potential threat to plant life; however, vegetation at Site 8 is limited to outside of the yard. A more detailed evaluation is also recommended to avoid over-conservative interpretation of these results.

Criteria for several organic compounds are lacking, preventing evaluation of potential effects. These compounds include 2,4,5-T, 2,4-DB, 2-butanone, acetone (plant effects only), chlordane (all isomers), carbazole, dalapon, dibenzofuran (invertebrates and plants only), dichlorprop, the endosulfan and endrin metabolites, PCBs, and petroleum hydrocarbons.

Several inorganics consistently exceeded criteria for mammals, invertebrates, and/or plants. The lack of information on chemical state (species) and dietary concentrations is an important limitation in the assessment of toxicity due to inorganic compounds. In addition, metals have not yet been screened relative to background concentrations; representative background concentrations for metals will be determined in the DQO's for MCAS El Toro, in June 1993. Toxicity may be

greatly influenced by these inorganic compounds. The initial screening as presented here must be viewed as a very conservative estimate of ecological risk. Inorganics exceeding criteria include aluminum, barium (mammals), cadmium, chromium, cobalt, lead, mercury, and vanadium. Others also exceeded criteria, but less frequently. Criteria were not available to evaluate antimony, barium (invertebrates and plants), manganese, selenium, silver, and thallium. Because methodology for evaluating background information has not yet been agreed upon with the agencies, it is unknown whether the concentrations measured were at naturally occurring levels for the vicinity, and therefore of little or no ecological concern to native species. Evaluation of background samples is needed to determine whether the detected concentrations represent ambient levels, before additional ecological characterization is recommended.

7.2.5.2 Sediments

Some organics were consistently detected at concentrations exceeding derived criteria, including DDT, DDE, DDD (most times), and bis(2-ethylhexyl)phthalate (Table 7-36). The latter, used as a plasticizer, is likely a laboratory contaminant from septa and other components of analytical equipment. DDT and metabolites were generally detected at higher concentrations in upstream sediments in Agua Chinon Wash, Bee Canyon Wash, and Marshburn Channel, and at Sites 2, 3, 12, and 21, indicating they may not be present due to MCAS El Toro activities.

Cadmium and mercury frequently reached or exceeded LELs for sediment. Arsenic, copper, lead and zinc intermittently exceeded LEL criteria. Criteria were not available to assess aluminum, antimony, barium, beryllium, cobalt, selenium, silver, thallium, or vanadium. Further evaluation of regional background concentrations for sediments following the DQO process is recommended prior to further sampling or ecological characterization of concentrations detected to determine if the concentrations measured at various sites represent ambient background levels of inorganics.

7.2.5.3 Surface Water

Organics were not detected in surface water samples at concentrations exceeding criteria with any regularity (Table 7-37). In addition, concentrations did not increase in downstream samples. Therefore, impacts to ecological receptors due to organic constituents released from the MCAS El Toro could not be identified. Inorganic COPEC exhibited similar patterns to those described for soils and sediments. Several inorganics consistently exceeded criteria, including aluminum, cadmium, copper, lead, mercury, and zinc. These could represent background concentrations for the area. Some inorganics had no criteria and could not be evaluated, including barium, cobalt, manganese, and vanadium. Again, through characterization of background concentrations is recommended to first determine if these compounds are actually present at levels exceeding ambient background, before further ecological characterization is recommended.

Further, surface water samples were collected during a period when surface runoff was predominant, resulting in relatively turbid surface water conditions for total metals analyses. It is probable that suspended particulates contributed to the total metal concentrations. These particulates likely contain metal that is not normally bioavailable to aquatic organisms. If this was the case, then the criteria comparison for metals is likely to be overly conservative.

The inorganic and organic chemicals of concern that have exceeded criteria in surface water samples are all strongly sediment-associated (e.g. metals, DDT) and therefore, are not likely to be immediately bioavailable. Most detected chemicals were higher in concentrations in the upstream washes than downstream in San Diego Creek, indicating the lack of a strong source on the Station for chemical transport in surface water. Nevertheless, the samples indicate the possibility of some surface water transport from the MCAS El Toro sites to off-Station locations downstream in San Diego Creek and eventually to Upper Newport Bay. Chemicals of concern may be transported with sediment and later released, particularly from anaerobic, highly organic, sediment environments.

**Table 7-36
MCAS El Toro Chemicals of Potential Ecological Concern in Sediment
Comparison to Sediment Criteria
MCAS El Toro Phase I RI Technical Memorandum**

Sheet 1 of 5

Chemical	Site Number ^a																		
	18 ^b														20	21			
	Borrego Canyon		Agua Chinon		Bee Canyon		Marshburn Channel		San Diego Creek										
	2	3	4	6	12	14	Dn ^c	Up ^d	Dn ^c	Up ^d	Dn ^c	Up ^d	Dn ^c	Up ^d	AC ^e	BC ^f	MC ^g		
ORGANICS																			
2,4,5-Trichlorophenoxy propionic acid	--	--	--	--	--	--	--	--	--	--	--	--	C/C	--	--	--	--	--	--
2,4-DB	C/C	--	--	--	--	--	--	C/C	--	--	--	--	C/C	--	--	--	--	--	--
2-Butanone	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	C/C	--	--	--
2-Hexanone		C/C																	
2-Methylnaphthalene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	N/C
4,4'-DDD	--	N/N	--	--	Y/Y	--	--	--	--	--	--	--	--	--	--	--	--	--	Y/Y
4,4'-DDE	--	N/E	--	--	Y/Y	--	--	--	Y/Y	--	Y/Y	N/Y	--	--	--	--	--	--	Y/Y
4',4'-DDT	Y/N	Y/Y	--	--	Y/Y	--	--	--	Y/Y	--	Y/Y	Y/Y	--	--	N/N	--	--	--	Y/Y
4-Methylphenol	--	--	--	--	--	--	--	--	--	--	--	--	--	--	C/C	C/C	--	--	--
Acenaphthene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	N/C
Acenaphthylene ^h	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	N/C
Acetone	C/C	C/C	C/C	--	C/C	C/C		C/C		C/C	--	C/C		C/C	C/C	--	--	C/C	C/C
Alpha chlordane	N/N	--	--	--	N/N	--	--	--	--	--	--	--	--	--	--	--	--	--	N/Y
Anthracene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	N/C
Benzene	C/C																		
Benzo(a)anthracene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	N/C
Benzo(a)pyrene	--	--	--	--	N/N	--	--	--	--	--	--	--	--	--	--	--	--	--	N/C
Benzo(b)fluoranthene	--	--	--	--	N/C	--	--	--	--	--	--	--	--	--	--	--	--	--	N/C

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**Table 7-36
MCAS El Toro Chemicals of Potential Ecological Concern in Sediment
Comparison to Sediment Criteria
MCAS El Toro Phase I RI Technical Memorandum**

Chemical	Site Number ^a																		
	2	3	4	6	12	14	18 ^b											20	21
							Borrego Canyon	Agua Chinon		Bee Canyon		Marshburn Channel		San Diego Creek					
							Dn ^c	Up ^d	Dn ^c	Up ^d	Dn ^c	Up ^d	Dn ^c	Up ^d	AC ^e	BC ^f	MC ^g		
Benzo(g,h,i)perylene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	N/C
Benzo(k)fluoranthene	--	--	--	--	N/N	--	--	--	--	--	--	--	--	--	--	--	--	--	N/C
Benzyl butyl phthalate	Y/C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	N/C
Bis(2-ethylhexyl) phthalate	Y/C	Y/C	--	Y/C	Y/C	Y/C	--	--	--	--	Y/C	--	--	--	--	--	--	Y/C	Y/C
Carbazole	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	C/C
Carbon tetrachloride	C/C	--	--	--	C/C	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Chrysene	--	--	--	--	N/C	--	--	--	--	--	--	--	--	--	--	--	--	--	N/C
Dalapon	--	--	--	--	C/C	--	--	--	--	--	--	--	--	C/C	--	--	--	--	--
Delta BHC	--	--	--	--	--	--	--	--	--	--	--	E/C	--	--	--	--	--	--	--
Dibenzo(a,h) anthracene	--	--	--	--	N/C	--	--	--	--	--	--	--	--	--	--	--	--	--	N/C
Dibenzofuran	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	C/C
Dichloroprop	--	--	--	--	--	--	--	--	--	--	C/C	--	C/C	C/C	--	--	--	--	--
Diieldrin	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	N/N
Endosulfan sulfate	--	--	--	--	N/C	--	--	--	--	--	--	Y/C	--	--	--	--	--	--	--
Fluoranthene	--	--	--	--	N/C	N/C	--	--	--	--	--	--	--	--	--	--	--	--	N/C
Fluorene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	C/C
Gamma chlordanes	N/N	--	--	--	N/N	--	--	--	--	--	--	--	--	--	--	--	--	--	N/E
Indeno(1,2,3-cd)pyrene	--	--	--	--	N/C	N/C	--	--	--	--	--	--	--	--	--	--	--	--	N/C

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Table 7-36
MCAS El Toro Chemicals of Potential Ecological Concern in Sediment
Comparison to Sediment Criteria
MCAS El Toro Phase I RI Technical Memorandum

Sheet 3 of 5

Chemical	Site Number ^a																		
	18 ^b																20	21	
	Borrego Canyon		Agua Chionon		Bee Canyon		Marshburn Channel		San Diego Creek										
	2	3	4	6	12	14	Dn ^c	Up ^d	Dn ^c	Up ^d	Dn ^c	Up ^d	Dn ^c	Up ^d	AC ^e	BC ^f	MC ^g		
MCPP	C/C	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Methoxychlor																			C/C
Methylene chloride	N/C	--	--	N/C	N/C	--	--	N/C	--	N/C	--	N/C	N/C	--	--	--	--	N/C	N/C
Petroleum Hydrocarbons (total recoverable)	C/C	C/C	--	C/C	C/C	C/C	--	--	--	--	--	--	C/C	--	--	--	--	C/C	C/C
Phenanthrene	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	--	Y/C
Pyrene	--	--	--	--	N/C	N/C	--	--	--	--	--	--	--	--	--	--	--	--	N/C
Toluene	N/C	N/C	--	N/C	N/C	--	--	--	--	--	--	--	--	--	--	--	--	--	N/C
Trichloroethylene	C/C																		
TFH-diesel	--	C/C	--	C/C	C/C	C/C	--	--	--	--	--	--	--	--	--	--	--	C/C	C/C
TFH-gasoline	C/C	C/C	--	C/C	C/C	C/C	--	--	C/C	--	--	C/C	--	--	--	C/C	--	C/C	C/C
INORGANICS																			
Aluminum	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C
Antimony	C/C	--	C/C	--	--	--	--	--	--	--	--	--	--	--	--	C/C	C/C	C/C	--
Arsenic	C/N	C/N	C/N	C/N	C/Y	C/N	--	C/N	C/N	C/Y	C/N	C/N	C/N	--	C/N	C/N	C/N	C/Y	C/Y
Barium	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C
Beryllium	C/C	C/C	--	--	--	--	--	--	--	C/C	--	--	--	--	--	--	--	--	--
Cadmium ⁱ	C/Y	C/Y	C/Y	C/Y	C/Y	C/Y	--	C/E	C/N	C/Y	C/N	C/Y	C/E	C/N	--	C/Y	C/Y	C/Y	C/Y
Chromium ⁱ	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/Y	C/N
Cobalt	C/C	C/C	C/C	C/C	C/C	C/C	--	C/C	C/C	C/C	C/C	C/C	C/C	--	C/C	C/C	C/C	C/C	C/C

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**Table 7-36
MCAS El Toro Chemicals of Potential Ecological Concern in Sediment
Comparison to Sediment Criteria
MCAS El Toro Phase I RI Technical Memorandum**

Chemical	Site Number ^a																				
	2	3	4	6	12	14	18 ^b											20	21		
							Borrego Canyon		Agua Chinon		Bee Canyon		Marshburn Channel		San Diego Creek						
							Dn ^c	Up ^d	Dn ^c	Up ^d	Dn ^c	Up ^d	Dn ^c	Up ^d	AC ^e	BC ^f	MC ^g				
Copper ⁱ	C/N	C/N	C/Y	C/N	C/N	C/N	--	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/Y	C/Y	
Lead ⁱ	C/N	C/N	C/Y	C/Y	C/Y	C/N	--	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/Y	C/Y	
Manganese	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/Y	C/Y
Mercury	--	--	C/E	--	C/Y	C/Y	C/Y	--	C/Y	--	C/Y	--	C/Y	C/Y	C/Y	C/Y	--	C/Y	--	C/Y	
Nickel ⁱ	C/N	C/N	C/N	C/N	C/N	C/N	--	C/N	C/N	C/N	C/N	C/N	C/N	--	C/N	C/N	C/N	C/N	C/Y	C/N	
Selenium	C/C	--	--	--	--	--	--	--	--	C/C	--	--	C/C	--	--	C/C	--	C/C	C/C	C/C	
Silver	--	--	C/C	C/C	C/C	--	--	--	--	C/C	--	--	--	--	--	--	--	C/C	--	--	
Thallium ^h	C/C	--	--	--	C/C	--	--	--	--	C/C	--	C/C	C/C	--	--	C/C	--	--	--	C/C	
Vanadium	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	C/C	--	

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Table 7-36
MCAS El Toro Chemicals of Potential Ecological Concern in Sediment
Comparison to Sediment Criteria
MCAS El Toro Phase I RI Technical Memorandum

Sheet 5 of 5

Chemical	Site Number ^a																			
	18 ^b														20	21				
	Borrego Canyon		Agua Chinon		Bee Canyon		Marshburn Channel		San Diego Creek											
	2	3	4	6	12	14	Dn ^c	Up ^d	Dn ^c	Up ^d	Dn ^c	Up ^d	Dn ^c	Up ^d			AC ^e	BC ^f	MC ^g	
Zinc ⁱ	C/N	C/N	C/Y	C/N	C/Y	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/N	C/Y	C/Y

Notes:

- ^aSediment samples were not taken at Sites 1, 5, 7, 8, 9, 10, 11, 13, 15, 16, 17, 19, and 22.
- ^bMaximum concentration used in comparison taken from the 4/2 database. All other sites used maximums reported in the 3/29 database.
- ^cDn=Downstream sampling station.
- ^dUp=Upstream sampling station.
- ^eAC=Confluence of Agua Chinon Wash and San Diego Creek.
- ^fBC=Confluence of Bee Canyon Wash and San Diego Creek.
- ^gMC=Confluence of Marshburn Channel and San Diego Creek.
- ^hData insufficient to develop criteria. Value used in comparison was a LOEL.
- ⁱCriteria used in comparison is hardness dependent.

 Maximum concentration compared to EqP based criteria/maximum concentration compared to LEL criteria.

- Y=Maximum concentration exceeds sediment criteria.
- N=Maximum concentration does not exceed sediment criteria.
- E=Maximum concentration equal sediment criteria (within 0.5).
- C=Sediment criteria not available for chemical.

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**Table 7-37
MCAS EI Toro Chemicals of Potential Concern
in Surface Water Runoff
Comparison to Water Quality Criteria
MCAS EI Toro Phase I RI Technical Memorandum**

Chemical	Site Number ^a													
	2	3	18 ^b											
			Borrego Canyon	Agua Chinon		Bee Canyon		Marshburn Channel		San Diego Creek				
			Dn ^c	Up ^d	Dn ^c	Up ^d	Dn ^c	Up ^d	Dn ^c	Up ^d	Dn ^c	Up ^d	AC ^e	BC ^f	MC^{g}
ORGANICS														
1,1,1-Trichloroethane	--	--	--	--	--	--	--	--	--	--	--	--	--	N
2-Butanone	--	--	--	--	NA	--	--	--	--	--	--	--	--	--
4,4'-DDE	--	--	--	--	--	--	--	--	Y	--	--	--	--	--
4,4'-DDT	--	--	--	--	--	--	--	Y	--	--	--	--	--	--
4-Nitrophenol	--	--	--	--	N,I	--	N,I	--	--	--	--	--	--	--
Acetone	NA	NA	--	--	--	--	NA	NA	--	NA	--	--	--	--
Benzyl butyl phthalate	--	--	--	--	E,I	--	--	--	--	--	--	--	--	E,I
Beta-BHC	--	--	--	N,I	Y	--	--	--	--	--	--	--	--	--
Bis(2-ethylhexyl)phthalate	--	N	--	--	N	--	N	--	--	--	--	--	--	--
Chloroform	--	--	--	N,I	--	--	--	N,I	--	--	--	--	--	--
Delta-BHC	--	--	--	--	N,I	--	--	--	N,I	--	--	--	--	--
Endosulfan sulfate	--	--	--	--	--	--	--	Y	--	--	--	--	--	--
Gamma Chlordane	--	--	--	--	--	Y	--	--	E	--	--	Y	--	--
Methyl chloride	--	--	N	N	N	N	--	N	--	--	N	N	N	N
Methylene chloride	--	N	--	--	--	--	--	N	--	--	--	--	--	--
TFH - diesel	NA	NA	--	NA	--	--	NA	--	--	--	--	--	--	--
Toluene	--	--	--	--	--	--	--	N	--	--	--	--	--	--

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**Table 7-37
MCAS EI Toro Chemicals of Potential Concern
in Surface Water Runoff
Comparison to Water Quality Criteria
MCAS EI Toro Phase I RI Technical Memorandum**

Chemical	Site Number ^a												
	2	3	18 ^b										
			Borrego Canyon	Agua Chinon	Bee Canyon	Marshburn Channel	San Diego Creek						
INORGANICS													
Aluminum	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Antimony	N	N	N	N	N	N	--	N	N	N	N	N	N
Arsenic	N	N	N	N	N	N	N	N	N	N	N	N	N
Barium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Beryllium	Y,l	E,l	Y,l	N,l	N,l	Y,l	N,l	E,l	N,l	N,l	Y,l	N,l	N,l
Cadmium	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h
Chromium	N,h	N,h	N,h	N,h	N,h	N,h	N,h	N,h	N,h	N,h	N,h	N,h	N,h
Cobalt	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Copper	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h
Cyanide	--	NA	--	--	NA	--	NA	NA	NA	NA	--	NA	--
Lead	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h	Y,h
Manganese	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mercury	NA	Y	Y	Y	Y	Y	NA	Y	Y	Y	Y	Y	NA
Nickel	N,h	N,h	N,h	N,h	N,h	N,h	N,h	N,h	N,h	N,h	N,h	N,h	N,h
Selenium	Y	Y	N	--	N	--	--	--	--	N	--	N	--
Silver	--	--	--	--	Y	--	--	--	--	--	--	--	--
Thallium	N,l	--	--	--	N,l	--	--	N,l	--	--	N,l	N,l	--
Vanadium	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

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Table 7-37
MCAS El Toro Chemicals of Potential Concern
in Surface Water Runoff
Comparison to Water Quality Criteria
MCAS El Toro Phase I RI Technical Memorandum

Chemical	Site Number ^a												
	2	3	18 ^b										
			Borrego Canyon	Agua Chinon		Bee Canyon		Marshburn Channel		San Diego Creek			
Zinc	Y,h	Y,h	Y,h	Y,h	N,h	Y,h	Y,h	Y,h	N,h	N,h	Y,h	N,h	Y,h

Notes:

- ^aSurface runoff samples were collected at Sites 2, 3, and 18 only.
- ^bMaximum detected concentrations for Site 18 taken from the 4/2/93 database. Maximums for all other sites taken from the 3/29/93 database.
- ^cDn = Downstream sampling station.
- ^dUp = Upstream sampling station.
- ^eAC = Confluence of Agua Chinon Wash with San Diego Creek.
- ^fBC = Confluence of Bee Canyon Wash with San Diego Creek.
- ^gMC = Confluence of Marshburn Channel with San Diego Creek.

- Y = Maximum detected concentration exceeds criteria
- N = Maximum detected concentration did not exceed water quality criteria.
- E = Maximum detected concentration within 0.05 ug/L of the water quality criteria.
- h = Water quality criterion is based on water hardness.
- l = Water quality criterion could not be developed; comparison value used was a LOEL.

- NA = Water quality criteria not available.
- Chemical not detected at site.

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8.0 SUMMARY AND CONCLUSIONS

8.1 Introduction

The overall goal of the RI/FS at MCAS El Toro is to collect sufficient data to support informed risk management decisions within the time frame designated in the FFA. Phase I of the RI was directed at evaluating the source of observed contamination for the regional groundwater west of the Station, and at making an initial determination as to whether contamination exists and is affecting the environment at sites in OU-2 and OU-3. Detailed objectives were developed for the investigation at the individual sites. The RI *SAP Amendment* also provided the following general objectives for the Phase I investigation:

- Obtain initial soil, sediment, and groundwater samples at the 21 identified on-Station sites to allow a preliminary assessment of the presence and nature of contaminants at the sites.
- At sites where contamination is demonstrated, make an initial evaluation of the main pathways of the conceptual site model.
- Collect sufficient analytical information to perform a preliminary baseline risk assessment.
- Collect sufficient analytical information to assess whether MCAS El Toro operations have caused contamination of local agricultural supply wells that are west of MCAS El Toro (OU-1 regional groundwater VOC contamination investigation).
- Refine the conceptual site model for the regional investigation by characterizing the source and transport pathways of regional groundwater VOC contamination.
- Gather preliminary data to establish viable remedial action alternatives.
- Determine whether emergency removal actions are necessary.
- Provide evidence to allow the list of contaminants of potential concern to be reduced at a given site so that, while the number of samples collected at a site during Phase II may increase, the number of analyses required may decrease.

Limited data were available prior to the Phase I investigation regarding the source of the observed VOC contamination in the regional groundwater system, and the pathways, if any, by which the contaminants may have migrated off-Station from MCAS El Toro.

OCWD had established the general extent of the concentration of contaminated groundwater off-Station, and had found it to occur at depths ranging from 200 to 450 feet bgs. OCWD also concluded that MCAS El Toro is the source of the contamination. Initial investigations conducted by MCAS El Toro had confirmed that groundwater is contaminated with VOCs near the water table (about 100 feet bgs) along the southwestern perimeter of the Station. Based on groundwater samples and soil gas surveys, the contamination had been identified in three separate areas. Two of these areas are located where Agua Chinon Wash and Bee Canyon Wash exit the facility. The third area lies near the cluster wells, just south of Site 14 in the northwest portion of the Station.

Virtually no data were available for the other 21 RI sites. An Initial Assessment Study (IAS) conducted under the Installation Restoration Program in 1985 had developed limited information based on file searches and employee interviews. An Air Solid Waste Assessment Test (SWAT) investigation had measured air emissions at the landfills. A previous spill of JP-5 fuel had been investigated at Site 19. No samples had been collected at any of the other sites prior to the Phase I RI. Therefore, at most sites it was unknown whether contaminants are present, and if so, whether they had been released or pose a risk to human health or the environment.

Migration pathways and potential points of exposure were also unknown. One pathway was considered to be suspended sediments or aqueous solution in surface water runoff from source areas through the surface drainage system. Contaminants could eventually infiltrate with water through cracks in culverts or lined drainage ditches, or through the unlined portion of the washes or San Diego Creek, and eventually migrate to groundwater. Alternatively, contaminants in buried wastes or contaminated surface soils could potentially infiltrate vertically downward through the vadose zone to the groundwater.

Once in groundwater, the contaminants could migrate along regional gradients to the west beneath the Tustin Plain. It was speculated that horizontal flow may occur along relatively more permeable buried stream channels that may roughly parallel the surface washes. It was also believed that vertical gradients may exist that could convey groundwater from shallow zones beneath MCAS El Toro to deeper zones west of the

facility. Downward gradients would be expected because the MCAS El Toro area serves as a recharge zone for the Irvine Subbasin, and because the main groundwater discharge from the basin is to deep wells located west and northwest of the Station. Air transport through wind-borne dust was considered a potential pathway, but not release of volatiles to air, because of the long period of time that had elapsed at most sites since contamination may have occurred.

The 22 investigation sites were grouped into three OUs for the purposes of the RI/FS. OU-1 (Site 18) comprises the regional groundwater VOC contamination investigation, conducted both on- and off-Station. OU-2 includes the sites that are considered potential source areas for the regional groundwater VOC contamination: the four landfill sites (Sites 2, 3, 5, and 17) and the Petroleum Disposal Area (Site 10). The remaining 16 sites were grouped together as OU-3 and are considered to be potential sources for a variety of contaminants.

This section summarizes the main findings of the Phase I RI and evaluates whether the general Phase I objectives have been met. It also provides a discussion of the distribution of groundwater contamination at MCAS El Toro. Conclusions regarding contaminants present at the OU-2 and OU-3 sites, as well as detailed recommendations for the Phase II RI, are deferred until the upcoming Data Quality Objectives (DQOs) process has been completed. The DQO process will provide comprehensive planning for the remainder of the RI/FS.

8.2 Scope of the Phase I RI

The major tasks of the investigation were:

- Analyzing historical aerial photographs and geophysical surveys and preparing a SAP Amendment to modify the RI SAP
- Drilling, geologic logging, installing, and developing 93 monitoring wells and 2 piezometers ranging in depth from 70 to 1,220 feet bgs
- Completing twenty-four of the monitoring wells at different depths in six clusters. The deepest boring at each cluster was also geophysically logged.

- Completing four of the monitoring wells as multiple-port wells, containing a total of 20 sampling intervals.
- Installing a dedicated submersible pump in each of the monitoring wells, except for the multiple-port wells.
- Collecting approximately 1,000 samples (including duplicates) from surface and near-surface soils (0 to 4 feet bgs) and from the vadose zone (25-foot borings, angle borings, and deep borings drilled to groundwater)
- Collecting over 200 groundwater samples (including duplicates) from one complete round of the wells constructed at the 22 RI sites and from wells installed during previous investigations
- Collecting about 50 surface water samples (including duplicates) after three rainstorm events
- Collecting over 55 sediment samples (including duplicates) at OU-1, OU-2, and OU-3 sites
- Collecting and analyzing about 275 field and laboratory samples to check quality assurance (QA) and quality control (QC) through sample validation
- Conducting aquifer testing of 63 new wells by long- or short-term pumping tests or slug tests
- Resampling the groundwater quality in existing monitoring wells
- Validating laboratory analyses of samples
- Managing and analyzing the sample database
- Analyzing geologic, geophysical, hydrogeologic, and geochemical data
- Completing a Phase 1 RI Technical Memorandum to compile and document the procedures followed, the data collected, and the data analytical results and evaluation

8.3 Hydrogeology

MCAS El Toro is located on the edge of the Tustin Plain, a gently sloping surface of alluvial fan deposits derived mainly from the Santa Ana Mountains. The east portion of the Station extends into the foothills of the Santa Ana Mountains, and the elevation ranges from about 215 feet MSL in its west corner to about 760 feet MSL in its east corner in the foothills.

MCAS El Toro lies on Holocene and Pleistocene Age unconsolidated sediments consisting of mainly discontinuous lenses of clayey and silty sands contained within a complex assemblage of sandy clays and silts. Coarser materials tend to predominate near the foothills. Previous investigations and the present investigation suggest that relatively more permeable materials may form elongated deposits roughly corresponding to the current drainage pathways at the surface. The unconsolidated sediments overlie semiconsolidated low-permeability sediments of Pleistocene Age and older that are extensions of similar formations in the foothills surrounding the Station.

Because of the discontinuous nature of the deposits, it is not possible to discern discrete widespread aquifer units beneath the Station. Evidence suggests that vertical hydraulic communication exists among the units, and that the unconsolidated sediments form a single heterogeneous aquifer system. Groundwater was typically found to be semiconfined in the uppermost permeable saturated unit encountered during drilling, with confinement increasing with depth.

Information gathered during drilling shows that the depth to groundwater is shallowest in the foothills, where it is about 45 to 60 feet bgs. In the alluvial basin, groundwater is first encountered at a depth greater than 240 feet on the northern and eastern edge of the Station along Irvine Boulevard, and decreases to a depth of 85 feet bgs on the southwestern edge of the Station. Shallow groundwater appears to follow a regional horizontal gradient of about 0.008 feet per foot toward the northwest in the vicinity of MCAS El Toro.

The distribution of contaminants in groundwater, however, suggests that locally groundwater may preferentially follow subsurface permeable units in a westerly direction. In addition, deeper gradients may follow a westerly direction in response to pumping. Data collected during the RI were inconclusive. Groundwater elevations collected from cluster wells and multiple-port wells revealed a generally downward vertical gradient in the uppermost saturated zones, particularly in the summer months, again most likely in response to deep pumping of irrigation wells that lie west of the Station.

Aquifer testing during the RI found values of hydraulic conductivity ranging from 0.2 to 65 feet/day in the shallow wells, with most values ranging from 1 to 20 feet/day. Hydraulic conductivity measured in the deeper wells ranged from 0.01 to 57 feet/day. The average linear velocity of groundwater flow in general varied from about 0.2 to 0.5 feet/day, but ranged up to about 1.7 feet/day.

8.4 Nature and Extent of Contamination

This section will briefly summarize the main findings regarding the nature and extent of contamination at each site. More complete summaries are provided in Section 4.0 for OU-2 and OU-3 sites; Section 5.0 for the RFA investigation; and Section 6.0 for OU-1 (Site 18). Section 3.0 discusses the hydrogeology, surface water, and sediments in the vicinity of MCAS El Toro. Appendixes A and B contain detailed descriptions of the nature and extent of contamination at all OU-1, OU-2, and OU-3 sites. Table 8-1 lists RI sites at which TCE or PCE was detected. Table 8-2 summarizes the RI and RFA sites, and briefly evaluates their potential to contribute to groundwater contamination. Table 8-3 summarizes the main contaminants found at the Station.

8.4.1 Operable Unit 1

The OU-1 (Site 18) regional groundwater VOC contamination investigation included the collection and analysis of samples of groundwater, surface water, sediment, and soil.

Groundwater

About 150 groundwater samples were collected in association with Site 18, while an additional 56 groundwater samples were collected at OU-2 and OU-3 sites. Twenty-four VOCs were detected in the samples. TCE was the most commonly detected VOC. Other VOCs detected at concentrations and locations sufficient to suggest on-Station sources include PCE, 1,1-DCE, 1,2-DCE, benzene, and carbon tetrachloride. Because these contaminants were detected at multiple sites, they are discussed here as part of OU-1.

**Table 8-1
RI Sites with PCE/TCE
MCAS El Toro Phase I RI Technical Memorandum**

Site	Medium	VOCs	Number of Samples	Number of Detects	Concentration (ppb)	
2-Magazine Road Landfill	Groundwater	PCE	4	2	8 2	
		TCE	4	4	0.6J 82D 1 0.9J	
	Surface and Near-Surface Soils	PCE	12	0	NA	
		TCE	12	0	NA	
	Vadose Zone Soils	PCE	10	0	NA	
		TCE	10	0	NA	
	Sediment	PCE	15	0	NA	
		TCE	15	1	3J	
	5-Perimeter Road Landfill	Groundwater	PCE	4	2	0.8J 0.9J
			TCE	4	1	0.6J
Surface and Near-Surface Soils		PCE	4	0	NA	
		TCE	4	0	NA	
Vadose Zone Soils		PCE	18	0	NA	
		TCE	18	0	NA	
7-Drop Tank Drainage Area No. 2	Groundwater	PCE	6	2	3D 3	
		TCE	6	3	23 120 48	
	Surface and Near-Surface Soils	PCE	43	0	NA	
		TCE	43	0	NA	
	Vadose Zone Soils	PCE	38	0	NA	
		TCE	38	2	27-74 (range)	

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**Table 8-1
RI Sites with PCE/TCE
MCAS El Toro Phase I RI Technical Memorandum**

Site	Medium	VOCs	Number of Samples	Number of Detects	Concentration (ppb)
8-DRMO Storage	Groundwater	PCE	3	2	7 8
		TCE	3	3	140 150 20
	Surface and Near-Surface Soils	PCE	36	1	4J
		TCE	36	0	NA
	Vadose Zone Soils	PCE	42	0	NA
		TCE	42	0	NA
9-Crash Crew Pit No. 1	Groundwater	PCE	2	2	8 8
		TCE	2	2	2000 270
	Surface and Near-Surface Soils	PCE	4	0	NA
		TCE	4	0	NA
	Vadose Zone Soils	PCE	18	0	NA
		TCE	18	0	NA
10-Petroleum Disposal Area	Groundwater	PCE	1	1	8
		TCE	1	1	35
	Surface and Near-Surface Soils	PCE	17	2	19
		TCE	17	0	NA
	Vadose Zone Soils	PCE	18	0	NA
		TCE	18	0	NA
12-Sludge Drying Beds	Groundwater	PCE	2	1	18
		TCE	2	2	0.8J 7
	Surface and Near-Surface Soils	PCE	31	0	NA
		TCE	31	0	NA
	Vadose Zone Soils	PCE	16	0	NA
		TCE	16	0	NA

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**Table 8-1
RI Sites with PCE/TCE
MCAS El Toro Phase I RI Technical Memorandum**

Site	Medium	VOCs	Number of Samples	Number of Detects	Concentration (ppb)
14-Battery Acid Disposal Area	Groundwater	PCE	2	0	NA
		TCE	2	2	2 2
	Surface and Near-Surface Soils	PCE	14	0	NA
		TCE	14	0	NA
	Vadose Zone Soils	PCE	11	0	NA
		TCE	11	0	NA
18-Regional VOC Investigation	Groundwater	PCE	107	27	0-81 (range)
		TCE	107	45	0-370 (range)
	Surface Water	PCE	13	0	NA
		TCE	13	0	NA
	Sediments	PCE	29	0	NA
		TCE	29	0	NA
19-Aircraft Expeditionary Refueling (ACER) Site	Groundwater	PCE	4	2	1 1
		TCE	4	2	0.6J 0.8J
	Surface and Near-Surface Soils	PCE	19	0	NA
		TCE	19	0	NA
	Vadose Zone Soils	PCE	50	0	NA
		TCE	50	0	NA
20-Hobby Shop	Groundwater	PCE	3	0	NA
		TCE	3	1	0.5J
	Surface and Near-Surface Soils	PCE	39	0	NA
		TCE	39	0	NA
	Vadose Zone Soils	PCE	14	0	NA
		TCE	14	0	NA

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**Table 8-1
RI Sites with PCE/TCE
MCAS El Toro Phase I RI Technical Memorandum**

Site	Medium	VOCs	Number of Samples	Number of Detects	Concentration (ppb)
21-Materials Management Group, Building 320	Groundwater	PCE	3	2	0.8J 7
		TCE	3	2	1 11
	Surface and Near-Surface Soils	PCE	8	0	NA
		TCE	8	0	NA
	Vadose Zone Soils	PCE	15	0	NA
		TCE	15	0	NA
22-TAFDS Area	Groundwater	PCE	1	1	7
		TCE	1	1	1000
	Surface and Near-Surface Soils	PCE	16	0	NA
		TCE	16	0	NA
	Vadose Zone Soils	PCE	14	0	NA
		TCE	14	1	6J

J=Estimated
NA=Not applicable
NS=Not sampled

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Table 8-2
OU-1 (Site 18): Summary of MCAS El Toro RI/FS and RFA Sites -
Evaluation of Potential for Contributing
to Regional Groundwater Contamination
MCAS El Toro Phase I RI Technical Memorandum

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Site (OU)	Designation	Possible Contaminant Contribution to the Groundwater	Opinion ^a	Discussion
1 (OU-3)	EOD Range	None suspected	No	Change in groundwater quality between wells 01_DGMW57 and 01_DGMW58 and water-level data indicate a hydrogeologic barrier.
2 (OU-2)	Magazine Road Landfill	VOCs	Yes	Site 2 appears to be contributing to a newly-defined groundwater plume on Station.
3 (OU-2)	Original Landfill	VOCs	Inconclusive	The landfill at Site 3 does not appear to be contributing to groundwater contamination. The RFA incinerator site may be contributing.
4 (OU-3)	Ferrocene Spill Area	Benzene, other VOCs, TFH-diesel	Inconclusive	Contaminants believed to be related to on-going operations at Tank Farm 5.
5 (OU-2)	Perimeter Road Landfill	None suspected	No	Contaminants in groundwater beneath this site appear to be migrating from Site 2.
6 (OU-3)	Drop Tank Drainage Area No. 1	None suspected	No	Changes in groundwater quality appear to be unrelated to activities at MCAS El Toro.
7 (OU-2)	Drop Tank Drainage Area No. 2	VOCs	Yes	Suspected general source area (along with Sites 8, 9, 10, and 22) of concentrations of TCE and PCE. Exact locations unknown between upgradient and downgradient wells.
8 (OU-3)	DRMO Storage	VOCs	Inconclusive	Suspected source of VOCs is in this area, as defined by the groundwater concentrations. Exact locations are unknown, and may be northeast of Site 8 beneath the motor pool area.
9 (OU-3)	Crash Crew Pit 1	VOCs	Yes	Highest values of TCE on Station. No TCEs in the soil samples. Source of groundwater "hotspot" unknown, but probably just upgradient in Sites 9 or 10.
10 (OU-2)	Petroleum Disposal Area	VOCs	Yes	General source area(along with Sites 7, 8, 9, 11, and 22) of concentrations of TCE and PCE.
11 (OU-3)	Transformer Storage Area	PCBs	No	No wells at Site 11. No PCBs in any groundwater sample. VOCs from the general Sites 7, 8, 9, 10, and 22 source areas.
12 (OU-3)	Sludge Drying Beds	VOCs, metals	No	VOCs appear to be from sources upgradient, not from sources at Site 12. Herbicides in the upgradient well are probably not from sludge operations.
13 (OU-3)	Oil Change Area	Benzene, hydrocarbons	Inconclusive	Cross-gradient well has highest values; source of contamination most likely Tank Farm 2, adjacent to Site 13.
14 (OU-3)	Battery Acid Disposal Area	None suspected	No	Minor VOCs appear to be from upgradient contamination.

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Table 8-2
OU-1 (Site 18): Summary of MCAS El Toro RI/FS and RFA Sites -
Evaluation of Potential for Contributing
to Regional Groundwater Contamination
MCAS El Toro Phase I RI Technical Memorandum

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Site (OU)	Designation	Possible Contaminant Contribution to the Groundwater	Opinion ^a	Discussion
15 (OU-3)	Suspended Fuel Tanks	Benzene	No	Unknown source of contaminants. Tank Farm 2, near Site 13, is a possible source.
16 (OU-3)	Crash Crew Pit No. 2	None Detected	No	Change in groundwater quality appears to be from natural sources.
17 (OU-3)	Communication Station Landfill	None Detected	Inconclusive	Only one well at Site 17. General chemistry and changes in quality because of the landfill unknown.
18-Surface	Surface Water and Sediment	Minor sources of contaminants	Inconclusive	The washes, both above and below ground, may provide a conduit for transport of contaminants in an oblique direction from the regional groundwater hydraulic gradient.
19 (OU-3)	Aircraft Expeditionary Refueling (ACER) Site	VOCs	Inconclusive	Low levels detected that may have a local source. Study inconclusive.
20 (OU-3)	Hobby Shop	Trace of TCE	Inconclusive	General chemistry changes are regional. Trace of TCE is inconclusive; additional groundwater sampling needed.
21 (OU-3)	Waste Management Group Building 320	VOCs	No	Groundwater changes appear to be from regional changes or upgradient VOCs.
22 (OU-3)	Tactical Air Fuel Dispensing System	VOCs	Yes	Possible general source area (along with Sites 7, 8, 9, and 10) of concentrations of TCE and PCE.
RFA Sites with TCE or PCE in Soil Samples (See Section 5)				
SWMW/AOC 194 and 113	Incinerator Site, west of RI/FS Site 3	TCE and PCE	Inconclusive	Only RFA site recommended for inclusion in Phase 2 of the RI/FS
SWMW/AOC 181 and 264	Upgradient from RI/FS Site 19	PCE	Inconclusive	All PCE below the CRDL of 10 µg/L
SWMW/AOC 188	Oil/water separator at Agua Chinon Wash	TCE and PCE	Inconclusive	TCE and PCE is from angle boring similar to those drilled during the RI/FS. RFA borings are closer to the oil/water separator.
SWMW/AOC 76	RI/FS Site 7	TCE	Inconclusive	TCE is from soil near Well 07_DBMW71, where TCE was detected in soil at 110 and 120 feet bgs.
SWMW/AOC 198 and 250	Motor pool, downgradient from RI/FS Site 7	PCE	Inconclusive	PCE from soils in the vicinity of RI/FS Sites 7, 9, 10, and 22.
SWMW/AOC 145	Downgradient from RI/FS Site 22	PCE	Inconclusive	PCE from soils in the vicinity of RI/FS Sites 7, 9, 10, and 22.
SWMW/AOC 223	Near Site 22	PCE	Inconclusive	PCE from soils in the vicinity of RI/FS Sites 7, 9, 10, and 22.
^a Opinion as to whether or not the site contributes to OU-1 groundwater contamination.				

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**Table 8-3
Summary of Detected Contaminants in Soil and Groundwater
MCAS El Toro Phase I RI Technical Memorandum**

Groups of Analytes	Soil		Groundwater		Potential Pathways			
	Sites	Compounds	Sites	Suspected Sources				
VOCs	7	TCE	2,7/9/10/22,8/12/21,14	Sites 2, 7, 8, 10, and 22, Motor Pool	Vadose infiltration; groundwater migration			
	10	PCE	2,7/9/10/22,8/12/21,19					
	16, 20	2-Butanone ≥ 1 mg/kg		Possible lab contamination				
	7, 13, 16	Benzene (estimated)	13/15	Tank Farm 2				
	12	Carbon tetrachloride	7,8,9,10,14,22	Inconclusive				
	2,4,7,10,12,16,17,19,20	Toluene	13	Inconclusive				
	16	Ethylbenzene	13,18	Inconclusive				
	4,8,16,20	Xylene	13,15	Tank Farm 2				
SVOCs	Sites with >1 SVOC		SVOC > 10 mg/kg		Vadose infiltration; groundwater migration			
	Sites	Number of Compounds	Sites	Compound				
	4,9,10,18,20	2	16,22	2-Methylnapthalene		Inconclusive		
	7	12	17	4-Methylphenol				
	8	3	6,8,14,20	Bis(2-ethylhexyl) phthalate		Bis(2-ethylhexyl) phthalate	7,13	Various
	12,16	6	4,16	Napthalene				
	14	12						
	19	25						
	22	5						Inconclusive

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**Table 8-3
Summary of Detected Contaminants in Soil and Groundwater
MCAS El Toro Phase I RI Technical Memorandum**

Groups of Analytes	Soil		Groundwater		Potential Pathways
	Sites	Compounds	Sites	Suspected Sources	
Petroleum Hydrocarbons	6,7/22,8,12,13/15,16,17,20,21	TRPH > 1000 mg/kg	None	--	Vadose infiltration; groundwater migration
	16,20,22	TFH-gas > 100 mg/kg	TFH-gas	4,9/22,13/15	
	4,8,12,15,16,17,20,22	TFH-diesel > 1000 mg/kg	TFH-diesel	4,7,13/15	
Pesticides and PCBs	8	PCB-1016,-1221,-1232,-1242,-1248	Trace Pesticides and Herbicides	Regional	--
	11,8	PCB-1260			
	12,8	PCB-1254			
Dioxins and Furans	3	Octachlorodibenzo-p-Dioxion	--	--	Suspended sediment in washes

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Table 8-1 lists RI sites, including Site 18, at which TCE and PCE were detected. This table reveals that these compounds occur in groundwater mainly in two areas at MCAS El Toro: in the eastern portion of the Station near Site 2 (Magazine Road Landfill), and in the southwestern portion of the Station in a broad area that encompasses Site 7 (Drop Tank Drainage Area No. 2), Site 8 (DRMO Storage Yard), Site 9 (Crash Crew Pit No. 1), Site 10 (Petroleum Disposal Area), and Site 22 (Tactical Air Fuel Dispensing System). However, TCE was detected in only four soil samples; three were collected from the screened intervals of wells, and the fourth was collected just above the water table in a well borehole at Site 7. TCE was also detected below the CRDL in a sediment sample at Site 2 (Magazine Road Landfill). PCE was detected in three surface or near-surface samples: two at one sampling station at Site 10, and one beneath the former refuse pile at Site 8. None of these samples contains a concentration sufficiently high to suggest that it is a significant source area.

1,1-DCE, 1,2-DCE, and carbon tetrachloride were also detected in groundwater samples collected in the southwestern portion of MCAS El Toro. It is unknown whether the 1,1-DCE and 1,2-DCE have separate sources or are transformation products of TCE and/or PCE.

Benzene was detected in groundwater samples collected from two locations. One location is at Site 4 (the Ferrocene Spill Area), where the upgradient well contains benzene at a concentration of 3 $\mu\text{g/L}$. The other location was in the western portion of the Station, where benzene was found in samples collected from wells at Site 13 (the Oil Change Area) and Site 15 (the Suspended Fuel Tank Area). The highest value is from the upgradient well at Site 13 (730 $\mu\text{g/L}$). At Site 15, benzene was detected at 120 $\mu\text{g/L}$. Because benzene was detected in upgradient wells at both of these locations, it is possible that it results from activities unrelated to the sites themselves, such as the nearby fuel tank farms. However, no layer of floating hydrocarbons was found in any RI monitoring well at MCAS El Toro, and no benzene was found in any soil sample.

Five SVOCs were detected in groundwater samples at the Station. The highest concentrations are of dimethyl phthalate, ranging from 3 to 220 $\mu\text{g/L}$ in samples

collected from the (non-RI) DW well cluster near Site 14 (Battery Acid Drainage Area). It is speculated that the compound may have originated from the existing pump and drop pipe, removed prior to sampling.

No TRPH was detected in the groundwater samples. TFH-gasoline and TFH-diesel were detected in several samples, with the highest concentrations associated with the same areas in which benzene was collected. For example, TFH-gasoline was found at a concentration of 1,690 $\mu\text{g/L}$ at the upgradient well at Site 13 (Oil Change Area), and at 1,080 $\mu\text{g/L}$ from a sample collected from Well 18_BGMW01E, located south of Site 4 (Ferrocene Spill Area).

Pesticides were detected in samples from 5 RI monitoring wells. Two of these wells are in a cluster in a nursery located outside the Station boundary. One sample was collected from a well located downgradient of Site 3 (the Original Landfill). The highest concentrations in this sample are 4,4-DDT and dieldrin, at 0.11 $\mu\text{g/L}$ each. Ten groundwater samples contain detectable concentrations of herbicides. A downgradient well at Site 3 contains 2.2 $\mu\text{g/L}$ of dalapon. The upgradient well at Site 12 contains detectable concentrations of 8 herbicides, including MCPA at 3,490 $\mu\text{g/L}$ and MCPP at 3,530 $\mu\text{g/L}$.

Surface Water

Thirty-five surface water samples were collected at 11 locations as part of the OU-1/Site 18 investigation. Only a limited variety of contaminants were detected in the surface water samples at relatively low concentrations. No SVOCs were detected above the CRDL in any surface water sample, nor were TRPH or TFH-gasoline detected in any surface water samples. TFH-diesel was detected downstream of the Station, in Bee Canyon Wash at 0.319 mg/l. Several pesticides were detected in surface water samples, both up- and downstream of the Station. Five pesticides were detected in samples collected from Marshburn Channel, and may be indicative of agriculture adjacent to the channel. Gamma-chlordane was found upstream of the Station in Bee Canyon Wash, at 0.015 $\mu\text{g/L}$. BHC-beta was found downstream of MCAS El Toro in the Agua Chinon Wash at concentrations

ranging from nondetect to 0.135 $\mu\text{g/L}$. No herbicides were detected in surface water samples.

Sediment

Twenty-six sediment samples were collected from the same 11 locations as were the surface water samples. No SVOCs were detected above the CRDL and no TFH-diesel was detected in any sediment sample. TRPH was detected at 0.132 mg/kg in a sample collected from Marshburn Channel downstream of the Station. TFH-gasoline was detected at the same location at 0.213 mg/kg. TFH-gasoline was also detected in Agua Chinon Wash downstream of the Station at 16 mg/kg. Other low concentrations of TFH-gasoline were found in San Diego Creek samples. Four pesticides were found in samples both up- and downstream of the Station in Marshburn Channel and Bee Canyon Wash, with no clear pattern that could be associated with MCAS El Toro activities. No other pesticides were found in the sediment samples.

Detected herbicides include dichloroprop at 481 $\mu\text{g/kg}$ and 436 $\mu\text{g/kg}$ downstream of the Station in Marshburn Channel and Bee Canyon Wash, respectively, and 2,4-DB at 76 $\mu\text{g/kg}$ and 2,3,5-trichlorophenoxy propionic acid at 54 $\mu\text{g/kg}$ downstream in Marshburn Channel. No herbicides were detected in upstream samples in these drainages. A few herbicides were detected in samples collected from San Diego Creek and upstream of the Station in Agua Chinon Wash.

Soil (Angle Borings)

A total of 66 soil samples were collected from 10 angle borings drilled beneath the downstream portions of the four main surface drainages at MCAS El Toro as part of the OU-1/Site 18 investigation. Detected VOCs were acetone, methylene chloride, 2-butanone, and toluene. These were found mainly below the CRDL, although acetone (a possible laboratory contaminant) was found ranging up to 91 $\mu\text{g/kg}$ in samples collected beneath Bee Canyon Wash, and up to 49 $\mu\text{g/kg}$ in samples collected beneath Agua Chinon Wash. The only SVOCs found were in samples collected beneath Bee Canyon Wash, and include 2-methylnaphthalene at

concentrations ranging from 2,600 to 4,300 ug/kg, and naphthalene at concentrations ranging from 860 to 1,800 ug/kg. Petroleum hydrocarbons were found in soil samples collected beneath Agua Chinon Wash and Bee Canyon Wash. TRPH was detected in samples at Agua Chinon Wash at concentrations of up to 5,878 mg/kg, while TFH-gasoline was detected at concentrations of up to 131,000 mg/kg and TFH-diesel, at concentrations of up to 2,270 mg/kg. TFH-gasoline was also found beneath Bee Canyon Wash at concentrations ranging up to 1,260 mg/kg. Pesticides were found beneath every wash but Borrego Canyon Wash. 4,4-DDT, 4,4-DDE, and 4,4-DDD were found at a depth of 5 feet beneath Marshburn Channel at concentrations of 514 ug/kg, 527 ug/kg, and 757 ug/kg, respectively.

8.4.2 Operable Unit 2

OU-2 includes five sites originally thought to have the potential to contribute to the regional groundwater VOC contamination: Site 2 (Magazine Road Landfill); Site 3 (Original Landfill); Site 5 (Perimeter Road Landfill); Site 10 (Petroleum Disposal Area); and Site 17 (Communication Station Landfill). Of these, Site 2 and 10 appear to be possible contributors to the regional groundwater VOC contamination.

TCE was found at each well at Site 2, with the highest concentration (82 $\mu\text{g/L}$) in one of the downgradient wells. Other VOCs found at Site 2 above MCLs include 1,2-DCA at 0.9 (estimated) $\mu\text{g/L}$, 1,2-DCE at 8 $\mu\text{g/L}$, and PCE at 8 $\mu\text{g/L}$. No SVOCs, TRPH, pesticides, or PCBs were found in groundwater samples.

Site 2 surface water samples contained low levels of VOCs and petroleum hydrocarbons. Gross alpha and beta particle activity was also detected in all surface water samples. Gross alpha activity ranges from 5.4 to 8.6 pCi/L, while gross beta activity ranges from 14.3 to 127 pCi/L. TCE was found in a sediment sample at a concentration of 4 ug/kg (estimated). Other VOCs detected in sediment samples include methylene chloride at 92 ug/kg, and benzene at 4 ug/kg (estimated). The only SVOC detected in sediments above the CRDL was benzyl-butyl phthalate at 1,200 ug/kg. Pesticides and herbicides were found in

several sediment samples, including the herbicide MCPP at a concentration of 140,000 ug/kg. The majority of contaminants in surface water and sediments were found in the washes surrounding the landfill itself, and in the man-made channel incised into the landfill.

Surface and near-surface soil samples at Site 2 contain low levels of a variety of contaminants, including toluene, petroleum hydrocarbons, and herbicides. One herbicide, MCPP, was detected in one sample at 48,700 ug/kg. Detected contaminants in vadose zone soil samples include toluene, acetone, and herbicides. One herbicide, MCPA, was detected at a concentration of 225,000 ug/kg at a depth of 50 feet.

Site 10 also appears to be a potential contributor to the regional groundwater VOC contamination. At Site 10, the following VOCs exceed primary drinking water standards in groundwater samples: carbon tetrachloride ($2 \mu\text{g/L}$), PCE ($8 \mu\text{g/L}$), and TCE ($35 \mu\text{g/L}$). In addition other chlorinated VOCs (chloroform at $1 \mu\text{g/L}$, chloromethane at <CRDL, and 1,1-DCE at <CRDL) were identified in the groundwater. One SVOC (benzyl butyl phthalate at $19 \mu\text{g/L}$) was detected in groundwater. Site 10 contains one downgradient well; the Phase I results are thus not very conclusive as to the site's potential contribution to regional groundwater contamination.

Soil samples from Site 10 did not contain TCE, but did contain 1,2-DCE (<CRDL) and PCE (<CRDL to 19 ug/kg). Miscellaneous SVOCs (<CRDL to 780 ug/kg) and TRPH (up to 532 mg/kg) were also detected in soil samples from Site 10.

Sites 3, 5, and 17 do not appear to be contributing to the regional groundwater VOC-contamination. Sites 3 and 17 had no detectable TCE or PCE in groundwater samples. Site 5 had TCE/PCE at levels below CRDLs, possibly migrating from Site 2. TCE was identified in the upgradient well at Site 5 at 0.6 (estimated) $\mu\text{g/L}$, while PCE was identified in the upgradient well at 0.9 (estimated) $\mu\text{g/L}$ and the downgradient well at 0.8 (estimated) $\mu\text{g/L}$. At Site 3, dieldrin, gross alpha, nitrate/nitrite, and selenium exceed primary drinking water

standards; at Site 5, gross alpha and gross beta exceed primary drinking water standards. At Site 17, no compounds exceed primary drinking water standards.

Soil samples from Sites 3, 5, and 17 also did not indicate the presence of chlorinated VOCs with the exception of methylene chloride (a possible laboratory contaminant) at Site 3 (50 ug/kg) and Site 17 (47 ug/kg).

8.4.3 Operable Unit 3

Of the 16 sites in OU-3, Sites 7, 8, 9, and 22 appear to be possible contributors to the regional groundwater VOC contamination. These sites (along with Site 10 from OU-2) are all located in the southwestern portion of MCAS El Toro, and indicate that a source of the chlorinated-VOC contamination is located in this part of the Station. Although the general vicinity for this source area is known, an exact location cannot be determined from the Phase I investigation.

At Site 7, carbon tetrachloride (<CRDL to 3 µg/L) and TCE (<CRDL to 120 µg/L) are VOCs that exceed primary drinking water standards. Other VOCs detected in groundwater include chloroform (<CRDL to 4 µg/L), 1,1-DCE (<CRDL), and PCE (<CRDL to 3 µg/L).

In the soil at Site 7, the following chlorinated VOCs were identified: carbon tetrachloride (<CRDL), 1,1-DCA (<CRDL), and TCE (27 to 74 ug/kg). However, only one of the samples containing TCE was collected above the water table. Miscellaneous SVOCs (<CRDL to 6,900 ug/kg) were detected in soil samples. TRPH was detected as high as 32,091 mg/kg in shallow soil, but only as high as 138 mg/kg in vadose zone samples.

At Site 8, carbon tetrachloride (<CRDL to 6 µg/L), PCE (<CRDL to 8 µg/L), and TCE (20 to 140 µg/L) are VOCs that exceed primary drinking water standards. Other VOCs detected in groundwater include benzene (<CRDL), chloroform (<CRDL to 9 µg/L), chloromethane (<CRDL), 1,1-DCE (<CRDL to 8 µg/L), toluene (<CRDL), 1,1,2-TCA (<CRDL), and xylene (<CRDL).

In the soil at Site 8, the following chlorinated VOCs were identified: methylene chloride (<CRDL to 66 $\mu\text{g/L}$) and PCE (<CRDL). Miscellaneous SVOCs (<CRDL to 8,800 ug/kg) were detected in soil samples. TRPH was detected as high as 7,730 mg/kg in shallow soil and 596 mg/kg in vadose zone samples.

At Site 9, carbon tetrachloride (2 to 7 $\mu\text{g/L}$), PCE (5 to 8 $\mu\text{g/L}$), and TCE (270 to 2,000 $\mu\text{g/L}$) are VOCs that exceed primary drinking water standards. Other VOCs detected in groundwater include chloroform (<CRDL to 2 $\mu\text{g/L}$), chloromethane (<CRDL), 1,2-DCA (<CRDL), 1,1-DCE (<CRDL to 4 $\mu\text{g/L}$), and 1,2-DCE (<CRDL to 1 $\mu\text{g/L}$).

In the soil at Site 9, the following chlorinated VOCs were identified: carbon tetrachloride (<CRDL) and 1,1,1-TCA (<CRDL). Miscellaneous SVOCs (<CRDL to 6,500 ug/kg) were detected in soil samples. TRPH was detected at a maximum of 259 mg/kg in soil samples.

At Site 22, carbon tetrachloride (5 $\mu\text{g/L}$), PCE (7 $\mu\text{g/L}$), and TCE (1,000 $\mu\text{g/L}$) are VOCs that exceed primary drinking water standards. Other VOCs detected in groundwater include carbon disulfide (<CRDL) and chloroform (3 $\mu\text{g/L}$).

In the soil at Site 22, TCE (<CRDL) is the only chlorinated VOC identified. Miscellaneous SVOCs (<CRDL to 29,000 ug/kg) were detected in soil samples. TRPH was detected as high as 4,666 mg/kg in shallow soil, but was not detected in vadose zone samples.

Sites 4, 13, and 15 in OU-3 indicate the presence of benzene contamination in groundwater at the Station. Sites 13 and 15 are located in the western portion of the Station near Tank Farm 2; Site 4 is located in the northern part of the Station near Tank Farm 5. Benzene concentrations at each of these sites exceed the primary drinking water standard of 1 $\mu\text{g/L}$: Site 4 (<CRDL to 3 $\mu\text{g/L}$), Site 13 (23 to 730 $\mu\text{g/L}$), and Site 15 (120 $\mu\text{g/L}$).

These sites indicate the presence of a source of benzene contamination, but do not appear to be the source themselves.

8.4.4 RCRA Facility Assessment (RFA)

An RFA was performed at MCAS El Toro to identify and gather information on potential releases of hazardous substances at the Station, to evaluate SWMUs and AOCs, to assess the need for further action at the SWMUs and AOCs and to identify potential sites for further investigation under the RI/FS. Nearly 1,300 soil samples were collected from 140 SWMUs and AOCs during the Sampling Visit portion of the RFA.

The results of the RFA indicate that contamination at most SWMUs and AOCs consists of petroleum hydrocarbons. The RFA did not encounter a significant number of samples with chlorinated VOCs. Table 8-2 summarizes the PCE and TCE detected in the RFA soil samples, and indicates the RI site that is closest to the SWMU or AOC in question.

Based on an evaluation of the sampling results, the RFA report recommended that 22 SWMUs or AOCs be investigated further, and that SWMU 194 (a former incinerator site) be added to the RI/FS. At this site, PCE was detected at concentrations of up to 130 ug/kg, and petroleum hydrocarbons (TRPH) were detected at concentrations of up to 2,680 mg/kg.

8.4.5 The Hydrogeological Conceptual Model

As postulated in the Phase I RI SAP, potential migration pathways for off-Station contaminant migration are surface water and sediment transport and subsurface groundwater flow. Two primary pathways are described below. (Potential airborne transport of contaminated soil/sediments was not investigated in the Phase I RI.)

- On-Station infiltration of contaminants to groundwater and lateral flow of contaminated groundwater off-Station
- Flow of contaminated surface water and sediments from on-Station source areas to off-Station locations through unlined washes; infiltration into groundwater and subsequent migration of contaminated groundwater

The first pathway appears to exist at MCAS El Toro. The location of the highest concentrations of VOCs (primarily TCE, PCE, and their degradation products) in groundwater indicate general source areas in the southwestern quadrant of the Station. The area of VOC groundwater contamination can be traced from the Station westward for approximately three miles.

The second pathway may have previously existed, but is difficult to substantiate. Borrego Canyon, Agua Chinon, Bee Canyon, and Marshburn Channel Washes provide a potential recharge pathway. The streambeds consist of coarse-grained material, and surface runoff is concentrated in these areas. The longer contact time and larger amounts of water maximize the recharge potential. Contaminants can be carried into these washes, then moved downward with succeeding recharge. The soil samples beneath Agua Chinon contain TFH-gasoline that could be leaching to the groundwater. Although groundwater from the nearby well (18_BGMW05D) did not contain TFH-gasoline, a sample from the uppermost screen at Multiple-port Well 18_BGMP09 downstream (off-Station) along Agua Chinon Wash, did show 71 $\mu\text{g/l}$ of TFH-gasoline. Although not proof, the finding may be indicative that the washes are a pathway for contaminant migration.

The Conceptual Site Models (CPMs) for each RI site will be developed during the DQO process.

8.5 Conclusions

A variety of contaminants has been detected in the groundwater, soil, surface water and sediment at MCAS El Toro. Contaminants detected in soil and sediments consist primarily of relatively low concentrations of SVOCs, petroleum hydrocarbons, pesticides and herbicides, with PCBs limited to Sites 8, 11 and 12 (Table 8-3). VOCs have been relatively rare in soils, having been found for the most part at low concentrations. In particular, TCE was found in only one sediment sample and one vadose zone sample (Table 8-1). On the other hand, SVOCs, petroleum hydrocarbons, pesticides and herbicides have been relatively rare in groundwater; contaminants in groundwater have consisted mainly of VOCs. Groundwater data will be updated following the collection of a second round of samples from RI wells during the summer of 1993.

Tables 8-4 through 8-8 list (by site) chemicals detected in groundwater, surface water, sediment, surface and near-surface soil (0-4 feet), and vadose zone soil. Each of the chemicals detected in media at the 22 sites has been selected as a Contaminant of Potential Concern for the Preliminary Baseline Risk Assessment. In addition, vinyl chloride is included because its detection limit during the Phase I RI was above its corresponding MCL.

Detailed analysis of the Phase I RI data will take place during the DQO process. At that time, MCAS El Toro and the regulatory agencies will evaluate the data for each site, and draw conclusions concerning the Contaminants of Potential Concern (COCP), exposure pathways, additional data needs for Phase II, and strategies for obtaining the data. The general objectives for the Phase I RI have been met in the following manner:

- Sufficient samples have been collected at the 21 on-Station sites to allow a preliminary assessment of the presence and nature of contaminants at the sites. This Technical Memorandum provides the data from the Phase I investigation (Sections 4.0 and 6.0; Appendixes A, B, and C). The DQO process will provide a full assessment of the contaminants at each site.
- A preliminary evaluation of the main exposure pathways of the conceptual site model has been provided in the Preliminary Baseline Risk Assessment (Section 7.0). The relative importance of these pathways and information gaps will be addressed during the DQO process.
- Sufficient data have been collected to establish the main areas of groundwater contamination at MCAS El Toro and to link the contamination observed on-Station to that observed off-Station. The main area of TCE contamination occurs in the Southwestern Quadrant of the Station. However, the source of the main area of chlorinated VOC contamination is uncertain, although a secondary source has been identified at Site 2, the Magazine Road Landfill. In addition, two areas of benzene contamination have been identified.
- Adequate data have been gathered to allow the establishment of remedial action alternatives during the Feasibility Study.
- Emergency removal actions do not appear to be necessary at any site at this time.
- A preliminary conclusion may be made that existing data on the regional VOC contamination in groundwater (OU-1) are adequate to proceed directly to a Feasibility Study and Record of Decision (ROD), without the necessity of a Phase II RI. The investigation of the source of the VOC contamination may continue as part of the Phase II RI for OU-2. This conclusion will be reassessed during the DQO process.

Table 8-4
Chemicals of Potential Concern in Groundwater
MCAS El Toro Phase I RI Technical Memorandum

Chemical	Site Number ^a																					
	1	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22	
ORGANICS																						
1,1,1-trichloroethane						.																
1,1,2-Trichloroethane		.						.														
1,1-Dichloroethane		.																.				
1,1-Dichloroethene										
1,2-Dichloroethane ^b									.									.				
1,2-Dichloroethene (total)		.							.									.				
2,4,5-T							
2,4,5-Trichlorophenoxy propionic acid											.											
2,4-D											.											
2,4-DB											.											
2-Hexanone				.														.				
4',4'-DDT			.															.				
4-methyl-2-pentanone																			.			
Acetone																		.				
Benzene							
Benzyl butyl phthalate						.				.												
Bis(2-ethylhexyl)phthalate			.									.						.				
Bromodichloromethane																	.	.				
Carbon disulfide																		.				.
Carbon tetrachloride						
Chlorobenzene ^b																		.				
Chlorodibromomethane																	.	.				
Chloroform		

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Table 8-4
Chemicals of Potential Concern in Groundwater
MCAS El Toro Phase I RI Technical Memorandum

Chemical	Site Number ^a																					
	1	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22	
Dalapon			.								.						.					
Dicamba											.											
Dichloroprop											.						.					
Dieldrin			.														.					
Dimethyl phthalate																	.					
Ethylbenzene												.					.					
Heptachlor			.														.					
Lindane			.														.					
MCPA											.											
MCPP											.						.					
Methyl chloride
Methylene chloride			
Phenol						.																
Tetrachloroethene	
Toluene								.				.					.					
TFH-diesel								
TFH-gasoline			
Trichloroethylene	
Vinyl chloride ^c																	.					
Xylenes (total)		
INORGANICS																						
Aluminum	
Antimony			
Arsenic

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Table 8-4
Chemicals of Potential Concern in Groundwater
MCAS El Toro Phase I RI Technical Memorandum

Chemical	Site Number ^a																					
	1	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22	
Barium
Beryllium						
Cadmium		
Chromium																	.	.				
Cobalt						
Copper		
Cyanide							
Lead																	.					
Manganese
Mercury								
Nickel	
Nitrate/nitrite
Selenium
Silver				
Thallium																.	.				.	
Vanadium
Zinc	
RADIONUCLIDES																						
Gross alpha	
Gross beta			

Notes:
^aGroundwater samples were not taken at Site 11.
^bDetected in OCWD and/or JMM groundwater samples.
^cDue to high detection limits, vinyl chloride has been selected as COPC for this assessment.

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Table 8-5
Chemicals of Potential Concern in Surface and Shallow Soils (0-4 feet)
MCAS El Toro Phase I RI Technical Memorandum

Chemical	Site Number ^a																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	21	22	
ORGANICS																						
1,1,1-Trichloroethane									.													
1,2-Dichloroethene (total)										.												
2,4,5-T																					.	
2,4,5-Trichlorophenoxy propionic acid			.		.																	
2,4-D												.										
2,4-DB		.																.				
2,4-Dimethyl phenol																		.				
2-Butanone	
2-Hexanone	
2-Methylnaphthalene			
4,4'-DDD		
4,4'-DDE		
4,4'-DDT		
4-Methyl-2-pentanone		.																				
4-Methylphenol																		.				
Acenaphthene																			.		.	
Acenaphthylene																			.		.	
Acetone	
Aldrin		.																				
Alpha chlordane		

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Table 8-5
Chemicals of Potential Concern in Surface and Shallow Soils (0-4 feet)
MCAS El Toro Phase I RI Technical Memorandum

Chemical	Site Number ^a																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	21	22	
Alpha BHC								.											.			
Anthracene														.				.		.		
Benzene		.					.									.						
Benzo(a)anthracene							
Benzo(a)pyrene				
Benzo(b)fluoranthene				
Benzo(g,h,i)perylene							
Benzo(k)fluoranthene				
Benzyl butyl phthalate		
Bis(2-ethylhexyl)phthalate		
Carbazole							
Carbon disulfide												.										
Carbon tetrachloride			
Chrysene				
Dalapon		.																		.		
Delta BHC				.														.		.		
Dibenzo (a,h) anthracene							
Dibenzofuran																.		.		.		
Dichloroprop		.																				
Dieldrin				
Diethyl phthalate							.			.												

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Table 8-5
Chemicals of Potential Concern in Surface and Shallow Soils (0-4 feet)
MCAS El Toro Phase I RI Technical Memorandum

Chemical	Site Number ^a																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	21	22	
Dimethyl phthalate								.	.													
Di-n-butyl phthalate								.														
Endosulfan I				.				.											.			
Endosulfan II				
Endosulfan sulfate					
Endrin					
Endrin aldehyde													
Endrin ketone					
Ethylbenzene		.						.									.					
Fluoranthene			
Fluorene																.		.		.		
Gamma chlordane			
Heptachlor epoxide																	.					
Hexachloroethane								.														
Indeno(1,2,3-cd)pyrene						
Isophorone																						.
Lindane (gamma BHC)																				.		
MCPPP		.										.										
Methoxychlor			
Methylene chloride	
Naphthalene			

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Table 8-5
Chemicals of Potential Concern in Surface and Shallow Soils (0-4 feet)
MCAS El Toro Phase I RI Technical Memorandum

Chemical	Site Number ^a																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	21	22	
Octachlorodibenzo-p-dioxins			.																			
PCB 1248								.														
PCB 1254								.				.										
PCB 1260								.			.											
Petroleum hydrocarbons (total recoverable)
Phenanthrene							
Phenol				.																		
Pyrene			
Tetrachloroethene								.		.												
Toluene
TFH-diesel
TFH-gasoline
Trichloroethylene		.																				
Xylenes (total)			
INORGANICS																						
Aluminum
Antimony	
Arsenic	
Barium
Beryllium	

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Table 8-5
Chemicals of Potential Concern in Surface and Shallow Soils (0-4 feet)
MCAS El Toro Phase I RI Technical Memorandum

Chemical	Site Number ^a																					
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	19	20	21	22	
Cadmium	
Chromium
Cobalt
Copper
Cyanide												.										
Lead
Manganese
Mercury
Nickel	
Nitrate/nitrite				.																		
Selenium
Silver			
Thallium	
Vanadium
Zinc

Notes:
^aSurface soil samples were not taken at Site 18 locations.

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**Table 8-6
Chemicals of Potential Concern in Soil Borings (5–10 feet)
MCAS El Toro Phase I RI Technical Memorandum**

Chemical	Site Number ^a																					
	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22		
ORGANICS																						
1,1,1-Trichloroethane												.										
2-Butanone										
2-Hexanone					.		.															
2-methylnaphthalene														.								
4',4'-DDD											.					.					.	
4',4'-DDE										.						.					.	
4',4'-DDT				
Acetone			
Beta chlordane																						
Benzyl butyl phthalate							.	.														
Bis(2-ethylhexyl)phthalate								
Bromodichloromethane																						
Bromoform																						
Carbon disulfide														.								
Chlorodibromomethane																						
Chloroform																						
Dalapon																.						
Delta BHC											.											
Dieldrin																						
Endosulfan II																						

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Table 8-6
Chemicals of Potential Concern in Soil Borings (5–10 feet)
MCAS El Toro Phase I RI Technical Memorandum

Chemical	Site Number ^a																					
	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22		
Endosulfan sulfate												
Endrin																.						
Endrin aldehyde																						
Endrin ketone											.				.							
Ethylbenzene														.								
MCPA															.							
MCPP				.																		
Methylene chloride					.		.							.								
Naphthalene														.								
PCB 1254																						
PCB 1260																						
Petroleum hydrocarbons (total recoverable)									
Toluene		
TFH-diesel											
TFH-gasoline						
Xylenes (total)					.								.	.								
INORGANICS																						
Aluminum	
Antimony				
Arsenic	

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Table 8-6
Chemicals of Potential Concern in Soil Borings (5–10 feet)
MCAS El Toro Phase I RI Technical Memorandum

Chemical	Site Number ^a																					
	2	3	4	5	6	7	8	9	10	12	13	14	15	16	17	18	19	20	21	22		
Barium	
Beryllium			
Cadmium	
Chromium	
Cobalt	
Copper	
Lead	
Manganese	
Mercury				
Nickel	
Selenium					
Silver								
Thallium					
Vanadium	
Zinc	

Notes:
^bSoil boring samples were not taken at Sites 1 and 11.

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**Table 8-7
Chemicals of Potential Concern in Sediment
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Chemical	Site Number								
	2	3	4	6	12	14	18	20	21
ORGANICS									
2,4-DB	.						.		
2,4,5-Trichlorophenoxy proprionic acid							.		
2-Butanone							.		
2-Hexanone		.							
2-Methylnaphthalene									.
4',4'-DDD		.			.				.
4',4'-DDE	
4',4'-DDT
4-Methylphenol							.		
Acenaphthene									.
Acenaphthylene									.
Acetone
Alpha chlordane	.				.				.
Anthracene									.
Benzene	.								
Benzo(a)anthracene									.
Benzo(a)pyrene					.				.
Benzo(b)fluoranthene					.				.
Benzo(g,h,i)perylene									.
Benzo(k)fluoranthene					.				.
Benzyl butyl phthalate	.								.
Beta chlordane									.
Bis(2-ethylhexyl)phthalate

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Table 8-7
Chemicals of Potential Concern in Sediment
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Chemical	Site Number								
	2	3	4	6	12	14	18	20	21
Carbazole									.
Carbon Tetrachloride	.				.				
Chrysene					.				.
Dalapon					.		.		
Delta-BHC							.		
Dibenzo(a,h)anthracene					.				.
Dibenzofuran									.
Dichloroprop							.		
Dieldrin					.				.
Endosulfan II									.
Endosulfan sulfate					.		.		.
Endrin									.
Endrin ketone									.
Fluoranthene					.	.			.
Fluorene									.
Gamma chlordanes	.				.				.
Indeno(1,2,3-cd)pyrene					.	.			.
MCPP	.								
Methoxychlor									.
Methylene chloride
Petroleum Hydrocarbons (total recoverable)
Phenanthrene					.				.
Pyrene					.	.			.

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**Table 8-7
Chemicals of Potential Concern in Sediment
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Chemical	Site Number								
	2	3	4	6	12	14	18	20	21
Toluene
TFH-diesel	
TFH-gasoline
Trichloroethylene	.								
INORGANICS									
Aluminum
Antimony	
Arsenic
Barium
Beryllium	.	.					.		
Cadmium
Chromium
Cobalt
Copper
Lead
Manganese
Mercury		
Nickel
Selenium	.							.	.
Silver				
Thallium	
Vanadium
Zinc

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Table 8-8			
Chemicals of Potential Concern in Surface Water Runoff			
MCAS El Toro Phase I RI Technical Memorandum			
Page 1 of 2			
Chemical	Site Number^a		
	2	3	18
ORGANICS			
1,1,1-Trichloroethane			•
2-Butanone			•
2-Methylnaphthalene			•
4',4'-DDE			•
4,4'-DDT			•
4-Nitrophenol			•
Acetone	•	•	•
Benzyl batyl phthalate			•
Beta-BHC			•
Bis(2-ethylhexyl)phthalate		•	•
Chloroform			•
Delta-BHC			•
Endosulfan sulfate			•
Gamma chlordane		•	•
Methylene chloride		•	
Toluene			•
TPH-diesel	•		•
INORGANICS			
Aluminum	•	•	•
Antimony	•	•	•
Arsenic	•	•	•
Barium	•	•	•
Beryllium	•	•	•

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Table 8-8 Chemicals of Potential Concern in Surface Water Runoff MCAS El Toro Phase I RI Technical Memorandum Page 2 of 2			
Chemical	Site Number ^a		
	2	3	18
Cadmium	•	•	•
Chromium	•	•	•
Cobalt	•	•	•
Copper	•	•	•
Cyanide		•	•
Lead	•	•	•
Manganese	•	•	•
Mercury			•
Nickel	•	•	•
Nitrate/nitrite	•	•	•
Selenium	•	•	•
Thallium	•		•
Vanadium	•	•	•
Zinc	•	•	•
RADIONUCLIDES			
Gross alpha	•		
Gross beta	•		
Notes: ^a Surface runoff samples were collected at Sites 2, 3, and 18 only.			

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MCAS El Toro was originally listed on the National Priorities List (NPL) because of the VOC contamination observed along the Station perimeter and in wells located west of the Station. Concern has focused mainly on TCE, which has been most widespread and has occurred at the highest concentrations. The Phase I RI has identified two areas of concentration for TCE in groundwater at MCAS El Toro. A minor source is the Magazine Road Landfill; TCE originating at this landfill may be a source of low levels of TCE observed at Sites 5 (Perimeter Road Landfill) and 19 (Aircraft Expeditionary Refueling [ACER] Site).

The main area of TCE contamination observed on-Station occurs in a broad region in the southwestern quadrant of MCAS El Toro. Groundwater collected at the following sites have shown detectable levels of TCE: Site 7 (Drop Tank Drainage Area 2); Site 8 (DRMO Storage Area); Site 9 (Crash Crew Pit No. 1); Site 10 (Petroleum Disposal Area); Site 12 (Sludge Drying Beds); Site 14 (Battery Acid Disposal Area); Site 21 (Materials Management Group); and Site 22 (TAFDS Area).

Site 7 appears to define the upgradient extent of the contamination on the east, since samples collected from three wells located on the upgradient edge of this site have not contained detectable levels of TCE. Similarly, the Agua Chinon Wash appears to define the upgradient extent of the contamination on the south, since wells samples to the north of the wash have shown detectable levels of TCE, while Well 18_BGMW14, located just to the south near Borrego Canyon Wash, has not shown a detectable concentration of TCE. Groundwater contamination on-Station also appears to be confined to the uppermost permeable zone. Samples from cluster wells constructed in the main zone of contamination all confirmed this observation, except for Well 18_DGMW4B, which is screened in the second permeable zone at a depth of 190-210 feet bgs. A sample from this well, located near Bee Canyon Wash downgradient of the suspected source area, contains TCE at a concentration of 14 $\mu\text{g/L}$.

The highest concentration of TCE was found in Well 9_DBMW45 at Site 9. A sample collected from this well contained 2,000 $\mu\text{g/L}$ of TCE. Other wells nearby that contained TCE in excess of 100 $\mu\text{g/L}$ include Well 9_DGMW75 (270 $\mu\text{g/L}$), Well 7_DGMW72 (120 $\mu\text{g/L}$), Well 8_DGMW73 (140 $\mu\text{g/L}$), Well 8_DGMW74 (150 $\mu\text{g/L}$), and Well 18_BGMW3E, located between Sites 7 and 10 (370 $\mu\text{g/L}$). No vadose zone soil

sample was collected at any of the sites near the main body of TCE-contaminated groundwater on-Station that contained detectable levels of TCE, except for a sample collected at a depth of 110 feet (4 feet above the water table) in the borehole for Well 7_DGMW71. The TCE concentration in this sample was 74 ug/kg. Low concentrations of TCE were detected in the vicinity in soil samples collected during the RFA.

The lack of detected TCE in soil samples implies that the actual source of the TCE has not been located. However, even though a concentration of 2,000 $\mu\text{g/L}$ is not close to the aqueous solubility of TCE, it is sufficiently elevated to suggest the presence of a nearby source. There is nothing in the record or sampling data that would implicate Site 9 as the source of the TCE. Historical evidence for potential TCE releases as part of dust suppression at Site 10 also do not appear to be the source of TCE in groundwater for several reasons:

- The dust suppression was typically done with waste oil, and TCE is only a hypothesized potential compound that might at times have been contained in the oil mixture.
- During spraying a significant fraction of TCE would have evaporated due to volatilization from the high vapor pressure of TCE before infiltration as free product.
- Spraying does not typically supply a sufficient volume for significant infiltration through the vadose zone (approximately 100 feet thick in this area).

Although Site 7 was not originally considered to be a source area for VOCs, TCE concentrations detected in wells downgradient from Site 7 and upgradient from Sites 9 and 10 suggest that TCE may have originated in this area. This is consistent with the historical record, which indicates that industrial maintenance and repair activities have occurred at this site over the years.

A secondary concentration of TCE in this area was detected in wells in the vicinity of Site 8, which is cross-gradient to contamination located near Sites 7, 9, 10, and 22. Samples collected from the two downgradient wells at this site contained TCE at 140 $\mu\text{g/L}$ and 150 $\mu\text{g/L}$. However, the upgradient wells 8_UGMW29 and 18_BGMW5D

also contained TCE at 20 $\mu\text{g/L}$ and 39 $\mu\text{g/L}$ respectively. In addition, Well PS-3, located just southwest of Site 8 along the Station perimeter, contained TCE at 64 $\mu\text{g/L}$.

These data imply that Site 8 is not the source of this detected TCE. The actual source may lie upgradient at the Motor Pool south of Site 8. Alternatively, the source may be the Agua Chinon Wash, as suggested in previous investigations. Yet another possibility is that contaminants have been drawn to this area from the Site 7 area in response to occasional pumping of an irrigation well south of the station. Data collected during the aquifer test at Well 18_BGMW14 indicated the possible presence of an unidentified irrigation well in this area.

Any explanation for the limited concentration of TCE detected in soil samples and the relatively high concentrations detected in shallow groundwater must be speculative at this time. Often when residual solvents exist at depth, they have been introduced into the subsurface via releases of a considerable volume of solvents over a long term. The TCE may have been released into the subsurface soil through disposal pits or depressions, or a leaking line, sump, or underground tank. These would have provided a sustained head over a period of time. Conversely, smaller uncontrolled releases of solvents may have short-circuited to depth by movement through an open, continuous conduit. For example, OCWD data suggest that there may be an abandoned well in the vicinity of Site 7.

Regardless of the pathway to depth, upon reaching groundwater, aqueous-phase TCE would be subject to downgradient advective and dispersive transport, primarily in the lenses of highest permeability. Movement would likely occur at less than the average linear groundwater velocity due to retardation (sorption, biodegradation, diffusion into low-permeability lenses, etc.).

Data indicate that the TCE seems to be moving in a northwesterly direction, which is generally consistent with the regional groundwater gradient. The TCE is drawn down into deeper zones as the lenses of high-permeable materials becomes thicker at depth toward the west, and in response to vertical gradients induced by operating irrigation wells. It is important to realize that the on-Station distribution of VOC contamination is

based on data collected from only one groundwater sampling event. Future sampling events will further verify and characterize the nature and extent of the contamination.

Finally, no recommendations are made for the Phase II investigation strategy, because this Technical Memorandum is not a full RI report for Phase I activities and its scope is limited to the presentation and preliminary interpretation of the Phase I field data. As mentioned above, the preliminary interpretations of the gathered data were made based on only one round of water quality monitoring data. Thus, conclusions regarding contaminants present at the OU-2 and OU-3 sites, as well as detailed recommendations for the Phase II RI, will be deferred to the upcoming DQO process. This process will address how the Phase I data will be used to prepare the Phase II SAP and Work Plan to complete the RI Report at MCAS El Toro.

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