Appendix J


San Juan Power Plant
Shiprock
THE HOGBACK
San Juan River
Morgan Lake
Four Corners Power Plant
THE HOGBACK
Table Mesa
Navajo Nation
Chaco River

RISK ANALYSIS
FOR AIR TOXICS
DESERT ROCK ENERGY PROJECT

DRAFT

April 9, 2007

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ABBREVIATIONS AND ACRONYMS

A-REL	acute reference exposure level
AAQG	Arizona Ambient Air quality Guidelines
AEGL-1	level 1 acute inhalation exposure guidelines
BAF	bioaccumulation factor
BCF	bioconcentration factor
bw	body weight
C_b	baseline soil concentration
C_s	soil concentration
C_w	water concentration
CALEPA	California Environmental Protection Agency
COEC	chemicals of ecological concern
COPC	chemical of potential concern
COPEC	chemical of potential ecological concern
CSM	conceptual site model
DD	dry deposition
EDA	exploratory data analysis
EPC	exposure point concentration
ERPG-1	level 1 emergency planning guidelines
ESL	ecological screening level
HAP	hazardous air pollutant
I	incomplete
IR_f	food ingestion rate
IR_s	soil ingestion rate
IR_w	water ingestion rate
LANL	Los Alamos National Laboratory
LD_{50}	lethal dose
LOAEL	lowest observed adverse effect level
LOEC	lowest observed effect concentration
m^3/mg	microgram of chemical
mg/m^3	cubic meter of air
MVUE	minimum variance unbiased estimator
NA	not applicable
NAPI	Navajo Agricultural Products Industries
NOAEL	no observed adverse effect level
NQ	not quantifiable
ORNL	Oak Ridge National Laboratorys
P	plant
PCDD	polychlorinated debenzo-p-dioxin
PCDF	polychlorinated debenzofurans
PRG	preliminary remediation goal
PW	predominant winds

RfC	reference concentration
RfD	reference dose
S	soil
SF	slope factors
SVOC	semi-volatile organic compound
TCDD	tetrachlorodibenzo(p)dioxin
TEC	toxity equivalence concentration
TEEL-1	level 1 temporary emergency exposure limit
TEF	toxity equivalence factors
TRV	toxicity reference level
UCL	upper confidence limit
URF	unit risk factor
USEPA	United Stated Environmental Protection Agency
VOC	volatile organic compound
WD	wet deposition
WHO	World Health Organization

1.0 INTRODUCTION

This risk analysis evaluates potential human and ecological health risks from chemicals other than the criteria pollutants (referred to as “air toxics”) that could be emitted from the proposed Desert Rock Energy Company power plant in northwestern New Mexico. Sixty-two of the hazardous air pollutants (HAPs), could be emitted, based on U.S. Environmental Protection Agency (USEPA) evaluations of bituminous coal combustion (USEPA 1998). HAPs include volatile organic compounds (VOCs), semi-volatile organic compounds (SVOC), and metals (e.g., mercury, arsenic, chromium VI). Not all of these chemicals will necessarily be emitted from the proposed Desert Rock plant because of plant-to-plant variations that are the result of the specific type of coal and combustion processes used. However, the risk assessment began the evaluation with the full list of HAPs that could be released during coal combustion in order to assess whether emissions of any of the possible chemicals could potentially result in adverse effects to humans or the environment.

Potential risks to humans and ecological receptors from the proposed plant’s chemical emissions are evaluated in combination with the concentrations of these chemicals already present in the environment, to the extent that existing conditions are known. The risk analysis generally follows risk assessment procedures developed by USEPA (1989, 1991, 1992, 1998, 2005a,b). Risks are calculated using predicted air concentrations and deposition rates for the proposed plant plus baseline data from soil and plant tissue. These baseline data were collected within the proposed plant study area as part of the biological evaluation (also see Sections 3.3 and 4.3 in the body of the report).

This appendix is organized as follows.

- **Section 1** contains the purpose of the assessment and provides general information on methodology.
- **Section 2** discusses the data available for risk analysis.
- **Section 3** presents the human health risk analysis, including selection of chemicals of potential concern (COPCs), assessing exposure and toxicity, and calculating risks.
- **Section 4** presents the ecological risk analysis, including selection of chemicals of potential ecological concern (COPECs), assessing exposure and toxicity, and characterizing risks.
- **Section 5** lists the references cited in the appendix.

2.0 DATA COLLECTION AND EVALUATION

The primary objective of the data collection and evaluation process in risk analysis is to develop a data set of sufficient quality and quantity to adequately evaluate the potential chemical impacts to human and ecological receptors. The source of chemicals is air emissions from the proposed Desert Rock plant. From these emissions, the following data are applicable, either directly or indirectly, to risk analysis.

- Existing concentrations of metals in soil and plants. This risk analysis is concerned with cumulative impacts; therefore, plant emissions are considered not only in isolation, but also on how they might increase the concentrations already present.
- Modeled concentrations of chemicals in air. Air concentrations of chemicals were calculated based on estimated chemical emission rates and modeling conducted as part of the permit application process for the plant (ENSR 2006a,b).
- Modeled concentrations of chemicals in soil. Airborne chemicals would be deposited on the soil in the surrounding area throughout the operational life of the plant. Current levels of metals in soil along with predicted soil concentrations after years of deposition are used to estimate future concentrations of chemicals in soil.
- Modeled concentrations of chemicals in plants. Airborne chemicals could be directly deposited on plants. In addition, chemicals in soil could be taken into the plants through the roots. Current levels of metals in plants and soil along with predicted soil concentrations after years of deposition are used to estimate future concentrations of chemicals in plants.

Surface water and sediment could potentially be impacted via deposition and/or runoff; however, because of the ephemeral nature of the streams in the vicinity of the proposed plant (including Chaco River), the long distance to the nearest permanent water bodies, and the low amount of rainfall in the area, these media are not considered to be significantly impacted (additional details regarding surface water and human health are presented in Section 3.2.1.1). Possible impacts to humans and animals that could ingest impacted soil and plants are discussed in Sections 3 and 4.

2.1 BASELINE CONCENTRATIONS IN SOIL AND VEGETATION

2.1.1 Objective

Soil and vegetation samples were collected for chemical analysis of metals. Results will be used as baseline concentrations in the assessment of impacts from airborne dispersal and deposition of particulates on soils and plants, and ultimately, on wildlife and humans. Soil and vegetation are direct exposure media for wildlife and for humans, including Native Americans (i.e., use of herbs and roots). Baseline concentrations of metals in crops within the Navajo Agricultural Products Industries (NAPI) area also are evaluated.

By sampling vegetation, the conservative assumptions used in estimating uptake from soil to plants are avoided, and resulting risk estimates are more defensible. In addition, by collecting soil and vegetation metals data, site-specific uptake rates can be generated for use in estimating metals concentrations in plants through the end-of-plant operation.

2.1.2 Sampling Methods

Twenty-four sampling locations within a 25-km radius air impact area (1,962 km^2) were sampled over the period of June 12–15, 2006. At each location, samples of four media were collected:

- Surface soil (0-2 cm)
- Subsurface soil (2 cm down to the root zone [typically less than 40 cm])
- Vegetation leaves and stems (exposure of humans and wildlife eating above-ground tissues)
- Vegetation roots or tubers (exposure of humans eating below-ground plant parts)

ENSR (Conners, pers. comm. 2006) modeled particulate deposition rates (wet, dry, and total) of the proposed boilers using CALPUF and three years of meteorological data (2001-2003). Wet deposition dominated the total deposition rates in all three years by approximately two orders of magnitude. Based on a stack emissions rate of 1 gm/sec, the highest total annual deposition rate was 1.29E-04 ug/m^2/sec. The overall wet-deposition sampling area extended from 0.25 to 25 km. Total deposition maximums for all modeled years were located 0.26 to 0.81 km from the stacks at a bearing of 32 to 37 degrees. This general area was the primary soil- and vegetation-sampling region.

The predominant winds in the area of the project are from the east quadrant, with somewhat less frequent winds from the west. The highest annual dry-deposition areas modeled by ENSR are at a bearing of 124 degrees and approximately 5.3 km distance. Therefore, the two potential dry-deposition sampling areas were located in regions in the general directions of west and southeast of the project. Pie-shaped areas extending from 1 to 25 km. were sampled in the two down-wind/dry deposition directions.

The approximate degrees of the compass (0 degrees = North) included in the three sampled areas are as follows:

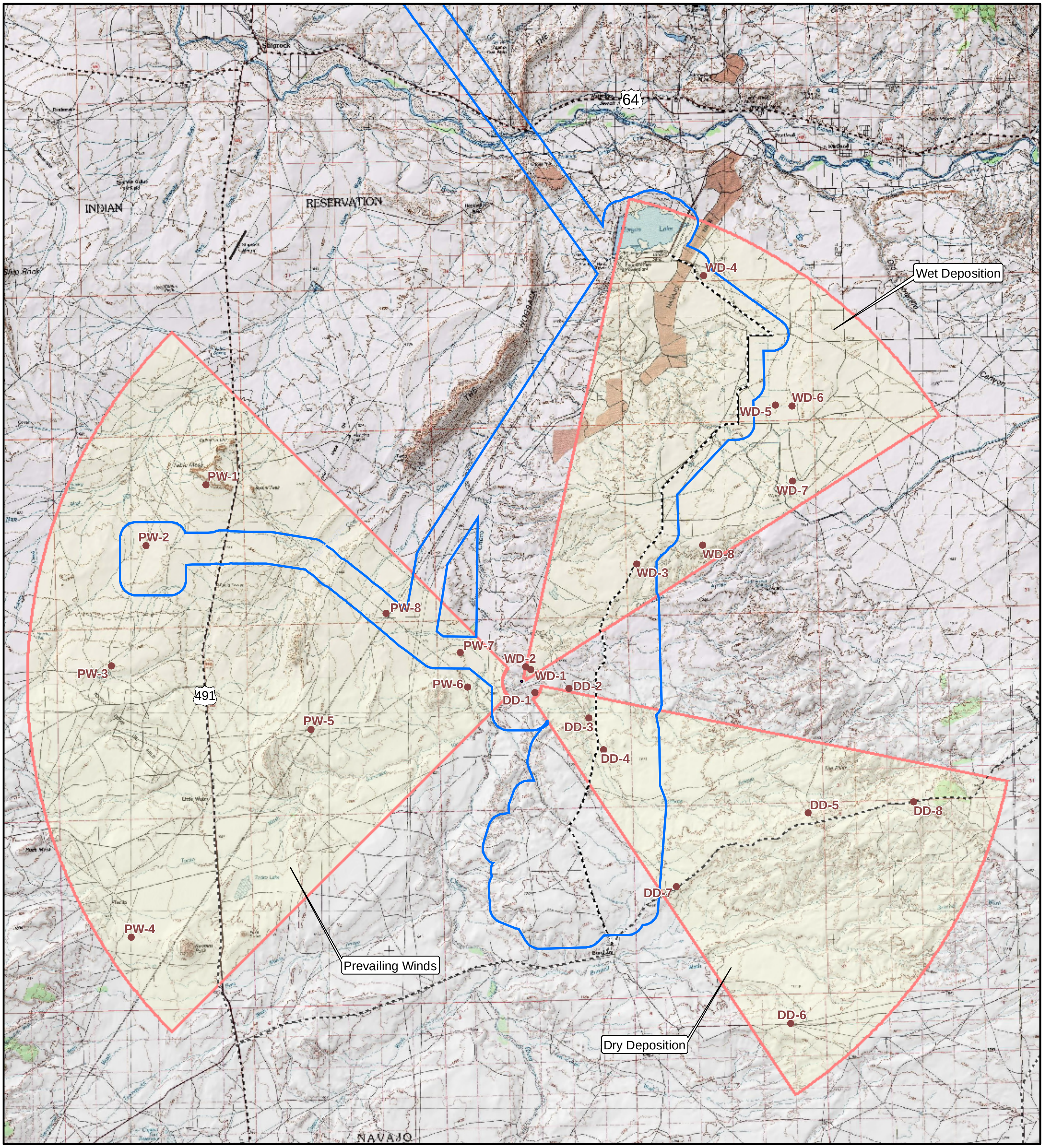
- Wet deposition (WD) Area: 45-degree arc centered at 35 degrees (0.25-25 km distance)
- Predominant (easterly) winds (PW) Area: 90-degree arc centered at 270 degrees (1-25 km distance)
- Dry deposition (DD) Area: 45-degree arc centered at 124 degrees (1-25 km distance)

The three sampled areas and 24 sampling locations (eight per area) are shown in Figure 2.1-1**.**

At each sampling location, two soil samples (surface and subsurface) and two vegetation tissue samples (above-ground and below-ground vegetation) were collected. The plants collected for analysis were identified to genus and species. Plant parts collected for analysis had the excess soil shaken off, but they were not washed in order to get a direct measurement of the total metals levels potentially ingested by wildlife or by Native Americans who may ingest plants gathered in the field.

The plant species collected (one species per location) included the following:

- Shadscale (Atriplex confertifolia)
- Alkali saccaton (Sporobolus airoides)
- New Mexico saltbush (*Atriplex obovata*)



Legend

WD-1 ● Sampling Location and ID

🟦 Desert Rock Energy Project Study Area

🟥 Proposed Plant Site

🟨 Soil Sampling Areas

Source:

URS Corporation, 2006
Black & Veatch, 2003.
BHP_Billiton, 2005.
ESRI, 2004.
Map created with TOPO!(tm) (c)2002 National Geographic Holdings (www.topo.com)

UTM, NAD83, Zone12, Meters

0 4 8
Kilometers

N
W E
S

Figure 2.1-1
Soil and Vegetation
Sampling Locations

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DESERT ROCK
ENERGY PROJECT

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- Four-winged saltbush (*Atriplex canescens*)
- Torrey's ephedra (*Ephedra torreyana*)
- Broom snake weed (Gutierrezia sarothrae)
- Common wheat (Triticum aestivum)

The six native plants species were selected for collection for the purposes of this investigation, because these plants represent the dominant species in the area. In addition, a Tribal Member accompanied the field crew during the sampling investigation and identified these native plants as the most likely to be used by Native Americans for herbal or medicinal use.

Soil samples were placed in 4-oz. jars (2 per location); plant samples (approximately 50 gm) were placed in heavy resealable plastic bags. All samples were placed in coolers with ice for shipment to the analytical laboratory.

2.1.3 Chemical Analysis

Each sample was analyzed for the eight naturally occurring RCRA metals most likely to represent a health concern for either human or ecological receptors – arsenic, barium, cadmium, chromium, lead, mercury, selenium, and silver. Six of these metals (excluding barium and silver) are also listed as HAPs that could be deposited on soil and plants in the air impact area. Other chemicals potentially emitted were not included because they are not naturally occurring. The moisture content of all plant and soil samples also was determined, as was the pH and total organic carbon of all soil samples. Baseline metals concentration results were reported on a dry-weight basis.

2.1.4 Baseline Conditions

Samples were identified by sampled area (i.e., WD, PW, or DD); by sampling location within the area (1-8); by sample type (S – soil, P – plant); and by soil depth or plant part (1 – surface soil, 24 – up to 24 in (61 cm) depth soil at the root zone of the plant being analyzed; PU – plant/upper, PL – plant/lower). Results for soil and plant metals analyses at each sampling location are presented in Attachment 1, Tables 1-1 through 1-24. Summaries of surface, subsurface, and surface-subsurface soil (combined) results are shown in Tables 2.1-1, 2.1-2, and 2.1-3.

The combined soil summaries are based on the higher of surface or subsurface soil concentrations at each sampling location. In each table, summary statistics (minimum, maximum, mean, and standard deviation), and the calculated 95% upper confidence level (UCL) of the mean are presented. A 95% UCL is an upper-bound (conservative) estimate of the mean. A detailed description of the procedures used to calculate the 95% UCLs is provided in Attachment 2 to this appendix.

Concentrations of metals in surface soils were found to not be substantially different from area to area. For all metals except cadmium, the highest area mean concentration was within one standard deviation of all other mean concentrations. The highest mean concentration of cadmium was well within two standard deviations of all other means. In general, the highest mean concentrations were measured in surface soil samples collected in the Prevailing Winds area located west of the proposed site location. The lowest concentrations were generally measured in the Dry Deposition area, southeast of the Site. Because there were no significant differences among areas, the surface soil metals data were combined for all further analyses.

Table 2.1-1
Surface Soil Summary Statistics

Exposure Area	Analyte	Units	Number of Samples	Detection Rate	Summary Statistics				Goodness-of-Fit Test	Upper Confidence Limit (UCL)	
					Mean	Standard Deviation	Minimum	Maximum	Distribution	Method of UCL Calculation	Assessed 95% UCL
Prevailing Winds	Arsenic	mg/kg	8	100%	3.20	1.56	1.1	6.4	Normal	95% Student's-t UCL	4.25
Prevailing Winds	Cadmium	mg/kg	8	100%	0.0940	0.0431	0.039	0.17	Normal	95% Student's-t UCL	0.123
Prevailing Winds	Chromium	mg/kg	8	100%	7.28	2.90	3.7	11	Normal	95% Student's-t UCL	9.22
Prevailing Winds	Lead	mg/kg	8	100%	7.79	2.69	3.4	11	Normal	95% Student's-t UCL	9.59
Prevailing Winds	Mercury	mg/kg	8	75%	0.0109	0.0070	0.0075	0.02	Normal	95% Student's-t UCL	0.0156
Prevailing Winds	Selenium	mg/kg	8	100%	0.414	0.172	0.18	0.69	Normal	95% Student's-t UCL	0.529
Prevailing Winds	Percent Moisture	%	8	100%	1.01	0.66	0.4	2.5	Gamma	95% Approximate Gamma UCL	1.54
Prevailing Winds	Total Organic Carbon	g/kg	8	100%	4.24	2.80	1.1	9.8	Normal	95% Student's-t UCL	6.12
Dry Deposition	Arsenic	mg/kg	8	100%	2.43	0.79	1.7	4.2	Gamma	95% Approximate Gamma UCL	3.00
Dry Deposition	Cadmium	mg/kg	8	100%	0.0580	0.0241	0.033	0.11	Normal	95% Student's-t UCL	0.0741
Dry Deposition	Chromium	mg/kg	8	100%	3.45	1.32	1.2	5.6	Normal	95% Student's-t UCL	4.33
Dry Deposition	Lead	mg/kg	8	100%	5.25	1.69	2.9	8.7	Normal	95% Student's-t UCL	6.38
Dry Deposition	Mercury	mg/kg	8	100%	0.0109	0.0081	0.0036	0.026	Normal	95% Student's-t UCL	0.0163
Dry Deposition	Selenium	mg/kg	8	100%	0.239	0.088	0.13	0.37	Normal	95% Student's-t UCL	0.297
Dry Deposition	Percent Moisture	%	8	100%	1.13	0.87	0.3	3	Normal	95% Student's-t UCL	1.71
Dry Deposition	Total Organic Carbon	g/kg	8	88%	2.34	1.34	1.6	4.7	Normal	95% Student's-t UCL	3.24
Wet Deposition	Arsenic	mg/kg	8	100%	2.63	1.26	1.4	4.9	Lognormal	95% Student's-t UCL	3.47
Wet Deposition	Cadmium	mg/kg	8	100%	0.0849	0.0472	0.041	0.17	Normal	95% Student's-t UCL	0.116
Wet Deposition	Chromium	mg/kg	8	100%	4.69	2.26	2.2	9.4	Normal	95% Student's-t UCL	6.20
Wet Deposition	Lead	mg/kg	8	100%	6.46	3.09	3.8	13	Normal	95% Student's-t UCL	8.53
Wet Deposition	Mercury	mg/kg	8	50%	0.00650	0.00971	0.0051	0.03	Gamma	95% Approximate Gamma UCL	0.0161
Wet Deposition	Selenium	mg/kg	8	100%	0.331	0.171	0.21	0.69	Lognormal	95% Student's-t UCL	0.446
Wet Deposition	Percent Moisture	%	8	100%	1.09	1.21	0.23	3.3	Gamma	95% Approximate Gamma UCL	2.44
Wet Deposition	Total Organic Carbon	g/kg	8	88%	3.01	2.13	0.92	6.3	Normal	95% Student's-t UCL	4.43
Combined	Arsenic	mg/kg	24	100%	2.75	1.23	1.1	6.4	Lognormal	95% Student's-t UCL	3.18
Combined	Cadmium	mg/kg	24	100%	0.0790	0.0408	0.033	0.17	Gamma	95% Approximate Gamma UCL	0.0945
Combined	Chromium	mg/kg	24	100%	5.14	2.70	1.2	11	Gamma	95% Approximate Gamma UCL	6.20
Combined	Lead	mg/kg	24	100%	6.50	2.66	2.9	13	Normal	95% Student's-t UCL	7.43
Combined	Mercury	mg/kg	24	75%	0.00943	0.00822	0.0051	0.03	Gamma	95% Approximate Gamma UCL	0.0133
Combined	Selenium	mg/kg	24	100%	0.328	0.160	0.13	0.69	Gamma	95% Approximate Gamma UCL	0.388
Combined	Percent Moisture	%	24	100%	1.08	0.90	0.23	3.3	Gamma	95% Approximate Gamma UCL	1.43
Combined	Total Organic Carbon	g/kg	24	92%	3.19	2.23	0.92	9.8	Gamma	95% Approximate Gamma UCL	4.25

(1) If duplicates exist, the average of the duplicate results is used as a single data point.
(2) Non-detects are replaced with half of method detection limit (MDL) for summary statistics. The minimum value shown is the minimum detected value.
(3) Goodness-of-Fit Test at 5% significance level is used to test for distributional assumption.
(4) The distributional assumption from (3) is used to select the appropriate UCL calculation method. For normal distribution, the UCL is based on the t-statistics. For lognormal distribution, gamma distribution, and non-parametric assumption, the UCL is based on the recommendations from USEPA (2002) and Singh et al. (2004).

U. S. Environmental Protection Agency (USEPA). 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Report No. OSWER 9285.6-10.

Singh, A., A.K. Singh, and R. Maichle. 2004. ProUCL Version 3.0 User Guide. Office of Research and Development, U.S. Environmental Protection Agency, Report No. EPA/600/R04/079.

g/kg = grams per kilogram
mg/kg = milligrams per kilogram

Table 2.1-2
Subsurface Soil Summary Statistics

Exposure Area	Analyte	Units	Number of Samples	Detection Rate	Summary Statistics				Goodness-of-Fit Test	Upper Confidence Limit (UCL)	
					Mean	Standard Deviation	Minimum	Maximum	Distribution	Method of UCL Calculation	Assessed 95% UCL
Prevailing Winds	Arsenic	mg/kg	8	100%	4.01	1.85	1.3	6.7	Normal	95% Student's-t UCL	5.25
Prevailing Winds	Cadmium	mg/kg	8	100%	0.0786	0.0250	0.055	0.12	Normal	95% Student's-t UCL	0.0954
Prevailing Winds	Chromium	mg/kg	8	100%	8.49	2.60	5.2	12	Normal	95% Student's-t UCL	10.2
Prevailing Winds	Lead	mg/kg	8	100%	8.43	2.23	4.5	11	Normal	95% Student's-t UCL	9.92
Prevailing Winds	Mercury	mg/kg	8	100%	0.0131	0.0074	0.0042	0.024	Normal	95% Student's-t UCL	0.0180
Prevailing Winds	Selenium	mg/kg	8	100%	0.456	0.145	0.23	0.65	Normal	95% Student's-t UCL	0.553
Prevailing Winds	Percent Moisture	%	8	100%	4.10	3.23	1.9	9.7	Non-parametric	95% Chebyshev (Mean, Sd) UCL	9.07
Prevailing Winds	Total Organic Carbon	g/kg	8	100%	2.58	0.62	1.8	3.8	Normal	95% Student's-t UCL	2.99
Dry Deposition	Arsenic	mg/kg	8	100%	2.81	1.43	1.3	4.8	Normal	95% Student's-t UCL	3.77
Dry Deposition	Cadmium	mg/kg	8	100%	0.0453	0.0234	0.028	0.1	Gamma	95% Approximate Gamma UCL	0.0625
Dry Deposition	Chromium	mg/kg	8	100%	3.61	1.69	2.6	7.7	Non-parametric	95% Student's-t UCL	4.75
Dry Deposition	Lead	mg/kg	8	100%	4.71	1.74	3.4	8.8	Non-parametric	95% Student's-t UCL	5.88
Dry Deposition	Mercury	mg/kg	8	88%	0.0138	0.0190	0.0014	0.058	Gamma	95% Approximate Gamma UCL	0.0338
Dry Deposition	Selenium	mg/kg	8	100%	0.288	0.152	0.17	0.62	Gamma	95% Approximate Gamma UCL	0.405
Dry Deposition	Percent Moisture	%	8	100%	1.93	0.60	1.1	2.9	Normal	95% Student's-t UCL	2.32
Dry Deposition	Total Organic Carbon	g/kg	8	100%	1.44	0.88	0.61	3.4	Normal	95% Student's-t UCL	2.03
Wet Deposition	Arsenic	mg/kg	8	100%	2.64	1.62	1.3	6.3	Gamma	95% Approximate Gamma UCL	3.90
Wet Deposition	Cadmium	mg/kg	8	100%	0.0670	0.0517	0.028	0.18	Gamma	95% Approximate Gamma UCL	0.111
Wet Deposition	Chromium	mg/kg	8	100%	4.75	2.48	2.8	10	Gamma	95% Approximate Gamma UCL	6.72
Wet Deposition	Lead	mg/kg	8	100%	6.26	3.96	2.9	15	Gamma	95% Approximate Gamma UCL	9.49
Wet Deposition	Mercury	mg/kg	8	38%	0.00958	0.01730	0.0014	0.051	Non-parametric	97.5% Chebyshev (Mean, Sd) UCL	0.0478
Wet Deposition	Selenium	mg/kg	8	100%	0.319	0.146	0.17	0.59	Normal	95% Student's-t UCL	0.417
Wet Deposition	Percent Moisture	%	8	100%	3.84	3.97	1.2	13	Gamma	95% Approximate Gamma UCL	7.35
Wet Deposition	Total Organic Carbon	g/kg	8	100%	4.47	5.07	0.45	16	Gamma	95% Approximate Gamma UCL	10.0
Combined	Arsenic	mg/kg	24	100%	3.15	1.69	1.3	6.7	Gamma	95% Approximate Gamma UCL	3.82
Combined	Cadmium	mg/kg	24	100%	0.0636	0.0370	0.028	0.18	Gamma	95% Approximate Gamma UCL	0.0771
Combined	Chromium	mg/kg	24	100%	5.62	3.05	2.6	12	Non-parametric	95% Chebyshev (Mean, Sd) UCL	8.33
Combined	Lead	mg/kg	24	100%	6.47	3.10	2.9	15	Lognormal	95% Student's-t UCL	7.55
Combined	Mercury	mg/kg	24	75%	0.0121	0.0149	0.0014	0.058	Gamma	95% Approximate Gamma UCL	0.0182
Combined	Selenium	mg/kg	24	100%	0.354	0.160	0.17	0.65	Gamma	95% Approximate Gamma UCL	0.416
Combined	Percent Moisture	%	24	100%	3.29	3.01	1.1	13	Non-parametric	95% Chebyshev (Mean, Sd) UCL	5.97
Combined	Total Organic Carbon	g/kg	24	100%	2.83	3.13	0.45	16	Gamma	95% Approximate Gamma UCL	3.81

(1) If duplicates exist, the average of the duplicate results is used as a single data point.
(2) Non-detects are replaced with half of method detection limit (MDL).
(3) Goodness-of-Fit Test at 5% significance level is used to test for distributional assumption.
(4) The distributional assumption from (3) is used to select the appropriate UCL calculation method. For normal distribution, the UCL is based on the t-statistics. For lognormal distribution, gamma distribution, and non-parametric assumption, the UCL is based on the recommendations from USEPA (2002) and Singh (2004).

U.S. Environmental Protection Agency (USEPA). 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Report No. OSWER 9285.6-10.
Singh, A., A.K. Singh, and R. Maichle. 2004. ProUCL Version 3.0 User Guide. Office of Research and Development, U.S. Environmental Protection Agency, Report No. EPA/600/R04/079.

g/kg = grams per kilogram
mg/kg = milligrams per kilogram

Table 2.1-3
Combined Depths Soil Summary Statistics

Exposure Area	Analyte	Units	Number of Samples	Detection Rate	Summary Statistics				Goodness-of-Fit Test	Upper Confidence Limit (UCL)	
					Mean	Standard Deviation	Minimum	Maximum	Distribution	Method of UCL Calculation	Assessed 95% UCL
Prevailing Winds	Arsenic	mg/kg	8	100%	4.13	1.85	1.3	6.7	Normal	95% Student's-t UCL	5.36
Prevailing Winds	Cadmium	mg/kg	8	100%	0.0996	0.0390	0.055	0.17	Normal	95% Student's-t UCL	0.126
Prevailing Winds	Chromium	mg/kg	8	100%	8.75	2.71	5.2	12	Normal	95% Student's-t UCL	10.6
Prevailing Winds	Lead	mg/kg	8	100%	8.75	2.18	4.5	11	Normal	95% Student's-t UCL	10.2
Prevailing Winds	Mercury	mg/kg	8	100%	0.0148	0.0070	0.0042	0.024	Normal	95% Student's-t UCL	0.0195
Prevailing Winds	Selenium	mg/kg	8	100%	0.473	0.154	0.23	0.69	Normal	95% Student's-t UCL	0.576
Prevailing Winds	Percent Moisture	%	8	100%	4.10	3.23	1.9	9.7	Non-parametric	95% Chebyshev (Mean, Sd) UCL	9.07
Prevailing Winds	Total Organic Carbon	g/kg	8	100%	4.45	2.64	1.8	9.8	Normal	95% Student's-t UCL	6.22
Dry Deposition	Arsenic	mg/kg	8	100%	3.04	1.29	1.7	4.8	Gamma	95% Approximate Gamma UCL	4.13
Dry Deposition	Cadmium	mg/kg	8	100%	0.0596	0.0225	0.041	0.11	Gamma	95% Approximate Gamma UCL	0.0763
Dry Deposition	Chromium	mg/kg	8	100%	3.93	1.65	2.6	7.7	Gamma	95% Approximate Gamma UCL	5.14
Dry Deposition	Lead	mg/kg	8	100%	5.39	1.56	3.7	8.8	Normal	95% Student's-t UCL	6.43
Dry Deposition	Mercury	mg/kg	8	100%	0.0151	0.0183	0.0036	0.058	Gamma	95% Approximate Gamma UCL	0.0320
Dry Deposition	Selenium	mg/kg	8	100%	0.296	0.147	0.17	0.62	Gamma	95% Approximate Gamma UCL	0.409
Dry Deposition	Percent Moisture	%	8	100%	1.94	0.62	1.1	3	Normal	95% Student's-t UCL	2.35
Dry Deposition	Total Organic Carbon	g/kg	8	100%	2.40	1.23	0.73	4.7	Normal	95% Student's-t UCL	3.23
Wet Deposition	Arsenic	mg/kg	8	100%	2.83	1.64	1.4	6.3	Lognormal	95% Student's-t UCL	3.93
Wet Deposition	Cadmium	mg/kg	8	100%	0.0863	0.0497	0.042	0.18	Normal	95% Student's-t UCL	0.120
Wet Deposition	Chromium	mg/kg	8	100%	4.94	2.37	2.9	10	Gamma	95% Approximate Gamma UCL	6.79
Wet Deposition	Lead	mg/kg	8	100%	6.76	3.70	3.8	15	Gamma	95% Approximate Gamma UCL	9.66
Wet Deposition	Mercury	mg/kg	8	50%	0.0101	0.0171	0.0014	0.051	Gamma	95% Approximate Gamma UCL	0.0296
Wet Deposition	Selenium	mg/kg	8	100%	0.346	0.163	0.21	0.69	Gamma	95% Approximate Gamma UCL	0.472
Wet Deposition	Percent Moisture	%	8	100%	3.84	3.97	1.2	13	Gamma	95% Approximate Gamma UCL	7.35
Wet Deposition	Total Organic Carbon	g/kg	8	100%	5.31	4.73	1.4	16	Gamma	95% Approximate Gamma UCL	9.75
Combined	Arsenic	mg/kg	24	100%	3.33	1.65	1.3	6.7	Lognormal	95% Student's-t UCL	3.90
Combined	Cadmium	mg/kg	24	100%	0.0818	0.0407	0.041	0.18	Gamma	95% Approximate Gamma UCL	0.0970
Combined	Chromium	mg/kg	24	100%	5.87	3.05	2.6	12	Gamma	95% Approximate Gamma UCL	7.04
Combined	Lead	mg/kg	24	100%	6.97	2.89	3.7	15	Gamma	95% Approximate Gamma UCL	8.04
Combined	Mercury	mg/kg	24	83%	0.0134	0.0145	0.0014	0.058	Gamma	95% Approximate Gamma UCL	0.0193
Combined	Selenium	mg/kg	24	100%	0.372	0.166	0.17	0.69	Gamma	95% Approximate Gamma UCL	0.435
Combined	Percent Moisture	%	24	100%	3.29	3.01	1.1	13	Non-parametric	95% Chebyshev (Mean, Sd) UCL	5.97
Combined	Total Organic Carbon	g/kg	24	100%	4.06	3.31	0.73	16	Gamma	95% Approximate Gamma UCL	5.23

(1) If duplicates exist, the average of the duplicate results is used as a single data point. The maximum concentration of surface and subsurface samples of the same location is used in this analysis.
(2) Non-detects are replaced with half of method detection limit (MDL).
(3) Goodness-of-Fit Test at 5% significance level is used to test for distributional assumption.
(4) The distributional assumption from (3) is used to select the appropriate UCL calculation method. For normal distribution, the UCL is based on the t-statistics. For lognormal distribution, gamma distribution, and non-parametric assumption, the UCL is based on the recommendations from USEPA (2002) and Singh (2004).
U.S. Environmental Protection Agency (USEPA). 2002. Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites. Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Report No. OSWER 9285.6-10.
Singh, A., A.K. Singh, and R. Maichle. 2004. ProUCL Version 3.0 User Guide. Office of Research and Development, U.S. Environmental Protection Agency, Report No. EPA/600/R04/079.

g/kg = grams per kilogram
mg/kg = milligrams per kilogram

A similar pattern of metals concentrations among areas was seen in the subsurface soils. The highest mean concentrations were, with the exception of mercury, found in the Prevailing Winds area. Most of the lowest concentrations were found in the Dry Deposition area. The variability in subsurface soil concentrations was somewhat greater than in the surface soil, but concentrations from area to area were well within two standard deviations of each other. Therefore, the subsurface soil metals data were combined for all further analyses.

Mean concentrations of metals (mg/kg, dry) in surface and subsurface soils (surface soil / subsurface soil) from the three areas are as follows:

Metal	Prevailing Winds	Dry Deposition	Wet Deposition
Arsenic	3.20 / 4.0	2.43 / 2.8	2.63 / 2.6
Cadmium	0.094 / 0.079	0.0580 / 0.045	0.0849 / 0.067
Chromium	7.28 / 8.5	3.45 / 3.6	4.69 / 4.8
Lead	7.79 / 8.4	5.25 / 4.7	6.46 / 6.3
Mercury	0.0109 / 0.013	0.0109 / 0.014	0.0065 / 0.010
Selenium	0.414 / 0.46	0.239 / 0.29	0.331 / 0.32

Differences among metal uptake rates in the various plants (subsurface soils to upper plant parts) and in the exposure areas also were examined. Data were compiled by the five plant genera sampled (the saltbushes [*Atriplex* spp.]) were combined). Uptake rates varied substantially among species and areas. The highest uptake rates for three metals (arsenic, mercury, and selenium) were seen in the saltbushes. Highest uptake rates for three other metals (cadmium, chromium, and lead) were seen in broom snakeweed. Lowest uptake rates for the metals were seen in alkalai saccaton (cadmium, mercury, and selenium); common wheat (arsenic and chromium); and Torrey's ephedra (lead). The highest overall uptake rates to the upper plant parts were seen in the Dry Deposition area (chromium and selenium) and in the Wet Deposition area (arsenic, cadmium, chromium [same as in Dry Deposition area] lead, and mercury). The highest uptake rates to plant roots also were seen in the Dry Deposition and Wet Deposition areas. The lowest uptake rates for the metals were generally seen in the Prevailing Winds area.

Because different plants were sampled in the three exposure areas, uptake rates varied among areas and among plants, and uptake rates were different for each metal, the overall combined 90th percentile uptake rates for each plant part (upper or lower) and each metal are used in the subsequent analyses. Summaries of plant uptake rates (ratios of subsurface soil to upper plant parts and subsurface soil to lower plant parts [i.e., roots]) are shown in Tables 2.1-4 and 2.1-5. All uptake rates are based on dry-weight metals concentrations. The 90th percentiles of uptake rates for each metal are shown in the last column in each table.

2.2 MODELED CONCENTRATIONS OF CHEMICALS IN AIR FROM PLANT EMISSIONS

A total of 62 different air toxic chemicals can be emitted from bituminous coal combustion, according to USEPA (1998). The maximum 24-hour and maximum annual air concentrations for each of the chemicals can be predicted using information on the energy released per pound from the coal that will be used in the proposed plant, information on how the coal will be burned in the proposed plant (boiler specifications), local meteorological data, and USEPA generic emission rates for the 62 chemicals. Tables 2.2-1 through 2.2-3 present this information using meteorological data for years 2001 through

Table 2.1-4
Plant Uptake Summary - Upper Plant Portions

Exposure Area	Uptake Media	Analyte	Number of Paired Samples	Summary Statistics (uptake rate)				
				Mean	Standard Deviation	Minimum	Maximum	90th Percentile
Prevailing Winds	Subsurface Soil to Upper Plant Leaves and Stems	Arsenic	8	0.14	0.15	0.038	0.49	0.26
Prevailing Winds		Cadmium	8	0.48	0.22	0.16	0.73	0.73
Prevailing Winds		Chromium	8	0.24	0.063	0.16	0.34	0.32
Prevailing Winds		Lead	8	0.056	0.021	0.027	0.081	0.08
Prevailing Winds		Mercury	8	1.3	0.76	0.21	2.1	2.1
Prevailing Winds		Selenium	8	1.2	1.2	0.14	3.5	2.6
Dry Deposition	Subsurface Soil to Upper Plant Leaves and Stems	Arsenic	8	0.094	0.068	0.027	0.25	0.15
Dry Deposition		Cadmium	8	1.8	0.96	0.70	3.4	2.9
Dry Deposition		Chromium	8	0.55	0.21	0.18	0.92	0.75
Dry Deposition		Lead	8	0.075	0.038	0.024	0.15	0.12
Dry Deposition		Mercury	8	2.7	2.7	0.45	9.3	4.5
Dry Deposition		Selenium	8	3.6	4.6	0.61	14	8.9
Wet Deposition	Subsurface Soil to Upper Plant Leaves and Stems	Arsenic	8	0.15	0.22	0.0057	0.60	0.44
Wet Deposition		Cadmium	8	3.3	5.9	0.43	18	8.3
Wet Deposition		Chromium	8	0.46	0.19	0.26	0.76	0.75
Wet Deposition		Lead	8	0.054	0.058	0.0086	0.15	0.13
Wet Deposition		Mercury	8	6.0	5.3	0.39	14	13
Wet Deposition		Selenium	8	2.0	2.6	0.24	7.2	5.7
Combined	Subsurface Soil to Upper Plant Leaves and Stems	Arsenic	24	0.13	0.15	0.0057	0.60	0.34
Combined		Cadmium	24	1.9	3.5	0.16	18	3.2
Combined		Chromium	24	0.42	0.21	0.16	0.92	0.73
Combined		Lead	24	0.062	0.041	0.0086	0.15	0.11
Combined		Mercury	24	3.3	3.9	0.21	14	8.9
Combined		Selenium	24	2.2	3.1	0.14	14	6.3

(1) Nondetects are replaced with half of the method detection limit (MDL) to calculate summary statistics and uptake rates.
(2) If duplicates exist, the average of the duplicates is used.
(3) Each paired sample consists of the ratio of upper plant leaves and stems concentration divided by subsurface soil concentration.

Table 2.1-5
Plant Uptake Summary - Lower Plant Portions

Exposure Area	Uptake Media	Analyte	Number of Paired Samples	Summary Statistics (uptake rate)				
				Mean	Standard Deviation	Minimum	Maximum	90th Percentile
Prevailing Winds	Subsurface Soil to Lower Plant Roots	Arsenic	8	0.26	0.27	0.054	0.88	0.51
Prevailing Winds		Cadmium	8	1.2	0.62	0.60	2.4	1.9
Prevailing Winds		Chromium	8	0.36	0.22	0.17	0.85	0.53
Prevailing Winds		Lead	8	0.22	0.23	0.029	0.737	0.44
Prevailing Winds		Mercury	8	1.2	1.3	0.14	3.8	2.9
Prevailing Winds		Selenium	8	0.58	0.24	0.29	0.91	0.82
Dry Deposition	Subsurface Soil to Lower Plant Roots	Arsenic	8	0.33	0.44	0.030	1.3	0.81
Dry Deposition		Cadmium	8	3.2	2.2	0.69	7.6	5.5
Dry Deposition		Chromium	8	0.64	0.21	0.41	1.1	0.80
Dry Deposition		Lead	8	0.25	0.33	0.036	0.96	0.68
Dry Deposition		Mercury	8	3.4	3.1	0.43	10	6.8
Dry Deposition		Selenium	8	3.8	5.5	0.64	17	8.6
Wet Deposition	Subsurface Soil to Lower Plant Roots	Arsenic	8	0.43	0.28	0.096	0.81	0.76
Wet Deposition		Cadmium	8	5.0	5.8	0.46	19	10
Wet Deposition		Chromium	8	0.64	0.32	0.28	1.3	1.0
Wet Deposition		Lead	8	0.31	0.24	0.0071	0.67	0.63
Wet Deposition		Mercury	8	9.4	8.0	0.76	21	19
Wet Deposition		Selenium	8	1.2	0.4	0.48	1.6	1.6
Combined	Subsurface Soil to Lower Plant Roots	Arsenic	24	0.34	0.33	0.030	1.3	0.79
Combined		Cadmium	24	3.2	3.8	0.46	19	6.2
Combined		Chromium	24	0.54	0.28	0.17	1.3	0.86
Combined		Lead	24	0.26	0.26	0.0071	0.96	0.65
Combined		Mercury	24	4.6	6.0	0.14	21	14
Combined		Selenium	24	1.9	3.4	0.29	17	3.2

(1) Nondetects are replaced with half of the method detection limit (MDL) to calculate summary statistics and uptake rates.
(2) If duplicates exist, the average of the duplicates is used.
(3) Each paired sample consists of the ratio of lower plant roots concentration divided by subsurface soil concentration.

Table 2-2.1

Desert Rock Energy Project
Chemical Prediction Concentrations
2001 Data

New Mexico Coal Specs [1]

LHV (Btu/lb)	8,479
HHV (Btu/lb)	8,910

Boiler Specs

Combined Unit Gross Output (MW)	1,500
Boiler Heat Rate, Design (Btu/kWh)	9,067
Combined Boiler Input Rating (MMBtu/hr)	13,601

Max Concentration = the highest predicted concentration at any receptor for a 24-hour or annual average

Max Deposition Flux = Maximum predicted deposition rate per unit of soil area, at any receptor, over a daily or annual averaging period

Fine Particle (Organics and Elemental Mercury)

Coal Combustion (tons/yr)	6,200,000

CALPUFF Results: [Unit Emission Rate Case, Max Conc. (@1 g/s)]

microg/m^3		**microg/m^2/s**		**microg/m^2/s**		**microg/m^2/s**	
6.245E-02	3.214E-03	1.225E-02	1.718E-04	3.671E-06	2.424E-07	1.225E-02	1.718E-04
		mg/m^2/yr		**mg/m^2/yr**		**mg/m^2/yr**	
-	-	-	5.417E+00	-	7.643E-03	-	5.418E+00

CONTAMINANT	[2] **AP-42 Emission Factor (lb/ton)**	**EMISSIONS**		**MAX CONCENTRATION**		**MAX WET DEPOSITION FLUX**		**MAX DRY DEPOSITION FLUX**		**TOTAL DEPOSITION MAX RATE**	
		(lb/yr)	**(g/s)**	**24-hour Avg. (micro g/m^3)**	**Annual Avg. (micro g/m^3)**	**24-hour Avg. (mg/m^2 day)**	**Annual Avg. (mg/m^2 yr)**	**24-hour Avg. (mg/m^2 day)**	**Annual Avg. (mg/m^2 yr)**	**24-hour Avg. (mg/m^2 day)**	**Annual Avg. (mg/m^2 yr)**
Acetaldehyde	5.7E-04	3.53E+03	5.08E-02	3.17E-03	1.63E-04	5.38E-02	2.75E-01	1.61E-05	3.89E-04	5.38E-02	2.75E-01
Acetophenone	1.5E-05	9.30E+01	1.34E-03	8.35E-05	4.30E-06	1.42E-03	7.25E-03	4.24E-07	1.02E-05	1.42E-03	7.25E-03
Acrolein	2.9E-04	1.80E+03	2.59E-02	1.62E-03	8.31E-05	2.74E-02	1.40E-01	8.20E-06	1.98E-04	2.74E-02	1.40E-01
Benzene	1.3E-03	8.06E+03	1.16E-01	7.24E-03	3.73E-04	1.23E-01	6.28E-01	3.68E-05	8.86E-04	1.23E-01	6.28E-01
Benzyl chloride	7.0E-04	4.34E+03	6.24E-02	3.90E-03	2.01E-04	6.61E-02	3.38E-01	1.98E-05	4.77E-04	6.61E-02	3.38E-01
1,1-Biphenyl	1.7E-06	1.05E+01	1.52E-04	9.47E-06	4.87E-07	1.60E-04	8.21E-04	4.81E-08	1.16E-06	1.60E-04	8.21E-04
Bis(2-ethylhexyl)phthalate	7.3E-05	4.53E+02	6.51E-03	4.07E-04	2.09E-05	6.89E-03	3.53E-02	2.06E-06	4.98E-05	6.89E-03	3.53E-02
Bromoform (tribromomethane)	3.9E-05	2.42E+02	3.48E-03	2.17E-04	1.12E-05	3.68E-03	1.88E-02	1.10E-06	2.66E-05	3.68E-03	1.88E-02
Carbon disulfide	1.3E-04	8.06E+02	1.16E-02	7.24E-04	3.73E-05	1.23E-02	6.28E-02	3.68E-06	8.86E-05	1.23E-02	6.28E-02
2-Chloroacetophenone	7.0E-06	4.34E+01	6.24E-04	3.90E-05	2.01E-06	6.61E-04	3.38E-03	1.98E-07	4.77E-06	6.61E-04	3.38E-03
Chlorobenzene	2.2E-05	1.36E+02	1.96E-03	1.23E-04	6.31E-06	2.08E-03	1.06E-02	6.22E-07	1.50E-05	2.08E-03	1.06E-02
Chloroform	5.9E-05	3.66E+02	5.26E-03	3.29E-04	1.69E-05	5.57E-03	2.85E-02	1.67E-06	4.02E-05	5.57E-03	2.85E-02
Cumene (isopropylbenzene)	5.3E-06	3.29E+01	4.73E-04	2.95E-05	1.52E-06	5.00E-04	2.56E-03	1.50E-07	3.61E-06	5.00E-04	2.56E-03
Cyanide (hydrogen)	2.5E-03	1.55E+04	2.23E-01	1.39E-02	7.17E-04	2.36E-01	1.21E+00	7.07E-05	1.70E-03	2.36E-01	1.21E+00
1,2-Dibromoethane (EDB)	1.2E-06	7.44E+00	1.07E-04	6.68E-06	3.44E-07	1.13E-04	5.80E-04	3.39E-08	8.18E-07	1.13E-04	5.80E-04
2,4-Dinitrotoluene	2.8E-07	1.74E+00	2.50E-05	1.56E-06	8.03E-08	2.64E-05	1.35E-04	7.92E-09	1.91E-07	2.64E-05	1.35E-04
Ethylbenzene	9.4E-05	5.83E+02	8.38E-03	5.24E-04	2.69E-05	8.87E-03	4.54E-02	2.66E-06	6.41E-05	8.87E-03	4.54E-02
Ethyl chloride	4.2E-05	2.60E+02	3.75E-03	2.34E-04	1.20E-05	3.96E-03	2.03E-02	1.19E-06	2.86E-05	3.96E-03	2.03E-02
Formaldehyde	2.4E-04	1.49E+03	2.14E-02	1.34E-03	6.88E-05	2.27E-02	1.16E-01	6.79E-06	1.64E-04	2.27E-02	1.16E-01
n-Hexane	6.7E-05	4.15E+02	5.97E-03	3.73E-04	1.92E-05	6.32E-03	3.24E-02	1.89E-06	4.57E-05	6.32E-03	3.24E-02
Hydrazine, monomethyl	1.7E-04	1.05E+03	1.52E-02	9.47E-04	4.87E-05	1.60E-02	8.21E-02	4.81E-06	1.16E-04	1.60E-02	8.21E-02
Hydrogen Chloride	1.2E+00	7.44E+06	1.07E+02	6.68E+00	3.44E-01	1.13E+02	5.80E+02	3.39E-02	8.18E-01	1.13E+02	5.80E+02
Hydrogen fluoride	1.5E-01	9.30E+05	1.34E+01	8.35E-01	4.30E-02	1.42E+01	7.25E+01	4.24E-03	1.02E-01	1.42E+01	7.25E+01
Isophorone	5.8E-04	3.60E+03	5.17E-02	3.23E-03	1.66E-04	5.47E-02	2.80E-01	1.64E-05	3.95E-04	5.47E-02	2.80E-01
Mercury (elemental) [3]	NA	1.34E+02	1.93E-03	1.21E-04	6.20E-06	2.04E-03	1.05E-02	6.12E-07	1.48E-05	2.04E-03	1.05E-02
Methylene bromide	1.6E-04	9.92E+02	1.43E-02	8.91E-04	4.59E-05	1.51E-02	7.73E-02	4.53E-06	1.09E-04	1.51E-02	7.73E-02
Methylene chloride	2.9E-04	1.80E+03	2.59E-02	1.62E-03	8.31E-05	2.74E-02	1.40E-01	8.20E-06	1.98E-04	2.74E-02	1.40E-01
Methyl ethyl ketone (2-Butanone)	3.9E-04	2.42E+03	3.48E-02	2.17E-03	1.12E-04	3.68E-02	1.88E-01	1.10E-05	2.66E-04	3.68E-02	1.88E-01
Methyl methacrylate	2.0E-05	1.24E+02	1.78E-03	1.11E-04	5.73E-06	1.89E-03	9.66E-03	5.66E-07	1.36E-05	1.89E-03	9.66E-03
Methyl tertbutyl ether (MTBE)	3.5E-05	2.17E+02	3.12E-03	1.95E-04	1.00E-05	3.30E-03	1.69E-02	9.90E-07	2.39E-05	3.30E-03	1.69E-02
Phenol	1.6E-05	9.92E+01	1.43E-03	8.91E-05	4.59E-06	1.51E-03	7.73E-03	4.53E-07	1.09E-05	1.51E-03	7.73E-03
Acenaphthene	5.1E-07	3.16E+00	4.55E-05	2.84E-06	1.46E-07	4.81E-05	2.46E-04	1.44E-08	3.48E-07	4.81E-05	2.46E-04
Anthracene	2.1E-07	1.30E+00	1.87E-05	1.17E-06	6.02E-08	1.98E-05	1.01E-04	5.94E-09	1.43E-07	1.98E-05	1.01E-04
Benz[a]anthracene	8.0E-08	4.96E-01	7.13E-06	4.46E-07	2.29E-08	7.55E-06	3.86E-05	2.26E-09	5.45E-08	7.55E-06	3.87E-05
Benzo[a]pyrene	3.8E-08	2.36E-01	3.39E-06	2.12E-07	1.09E-08	3.59E-06	1.84E-05	1.07E-09	2.59E-08	3.59E-06	1.84E-05
Chrysene	1.0E-07	6.20E-01	8.92E-06	5.57E-07	2.87E-08	9.44E-06	4.83E-05	2.83E-09	6.82E-08	9.44E-06	4.83E-05
Fluoranthene	7.1E-07	4.40E+00	6.33E-05	3.95E-06	2.04E-07	6.70E-05	3.43E-04	2.01E-08	4.84E-07	6.70E-05	3.43E-04
Fluorene	9.1E-07	5.64E+00	8.12E-05	5.07E-06	2.61E-07	8.59E-05	4.40E-04	2.57E-08	6.20E-07	8.59E-05	4.40E-04
Indeno[1,2,3-cd]pyrene	6.1E-08	3.78E-01	5.44E-06	3.40E-07	1.75E-08	5.76E-06	2.95E-05	1.73E-09	4.16E-08	5.76E-06	2.95E-05
Naphthalene	1.3E-05	8.06E+01	1.16E-03	7.24E-05	3.73E-06	1.23E-03	6.28E-03	3.68E-07	8.86E-06	1.23E-03	6.28E-03

CONTAMINANT	[2] AP-42 Emission Factor (lb/ton)	EMISSIONS		MAX CONCENTRATION		MAX WET DEPOSITION FLUX		MAX DRY DEPOSITION FLUX		TOTAL DEPOSITION MAX RATE	
		(lb/yr)	(g/s)	24-hour Avg. (micro g/m^3)	Annual Avg. (micro g/m^3)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)
Pyrene	3.3E-07	2.05E+00	2.94E-05	1.84E-06	9.46E-08	3.11E-05	1.59E-04	9.33E-09	2.25E-07	3.11E-05	1.59E-04
Styrene	2.5E-05	1.55E+02	2.23E-03	1.39E-04	7.17E-06	2.36E-03	1.21E-02	7.07E-07	1.70E-05	2.36E-03	1.21E-02
2,3,7,8-TCDD (dioxin)	1.43E-11	8.87E-05	1.28E-09	7.96E-11	4.10E-12	1.35E-09	6.91E-09	4.04E-13	9.75E-12	1.35E-09	6.91E-09
Total PCDD/PCDF	1.76E-09	1.09E-02	1.57E-07	9.80E-09	5.04E-10	1.66E-07	8.50E-07	4.98E-11	1.20E-09	1.66E-07	8.50E-07
Tetrachloroethylene (PCE)	4.3E-05	2.67E+02	3.83E-03	2.39E-04	1.23E-05	4.06E-03	2.08E-02	1.22E-06	2.93E-05	4.06E-03	2.08E-02
Toluene	2.4E-04	1.49E+03	2.14E-02	1.34E-03	6.88E-05	2.27E-02	1.16E-01	6.79E-06	1.64E-04	2.27E-02	1.16E-01
1,1,1-Trichloroethane	2.0E-05	1.24E+02	1.78E-03	1.11E-04	5.73E-06	1.89E-03	9.66E-03	5.66E-07	1.36E-05	1.89E-03	9.66E-03
Vinyl acetate	7.6E-06	4.71E+01	6.78E-04	4.23E-05	2.18E-06	7.17E-04	3.67E-03	2.15E-07	5.18E-06	7.17E-04	3.67E-03
Xylenes	3.7E-05	2.29E+02	3.30E-03	2.06E-04	1.06E-05	3.49E-03	1.79E-02	1.05E-06	2.52E-05	3.49E-03	1.79E-02
Xylenes	3.7E-05	2.29E+02	3.30E-03	2.06E-04	1.06E-05	3.49E-03	1.79E-02	1.05E-06	2.52E-05	3.49E-03	1.79E-02

Particle Mass Weighted (Other Metals & Oxidized / Particle Bound Mercury)

CALPUFF Results: [Unit Emission Rate Case, Max Conc. (@1 g/s)]

microg/m^3		microg/m^2/s		microg/m^2/s		microg/m^2/s	
6.245E-02	3.214E-03	6.665E-02	9.245E-04	2.801E-04	1.044E-05	6.665E-02	9.255E-04
		mg/m^2/yr		mg/m^2/yr		mg/m^2/yr	
-	-	-	2.915E+01	-	3.293E-01	-	2.919E+01

CONTAMINANT	[2] AP-42 Emission Factor (lb/ton)	EMISSIONS		MAX CONCENTRATION		MAX WET DEPOSITION FLUX		MAX DRY DEPOSITION FLUX		TOTAL DEPOSITION MAX RATE	
		(lb/yr)	(g/s)	24-hour Avg. (micro g/m^3)	Annual Avg. (micro g/m^3)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)
Antimony and compounds	1.8E-05	1.12E+02	1.61E-03	1.00E-04	5.16E-06	9.24E-03	4.68E-02	3.88E-05	5.29E-04	9.24E-03	4.68E-02
Arsenic	4.1E-04	2.54E+03	3.66E-02	2.28E-03	1.18E-04	2.11E-01	1.07E+00	8.85E-04	1.20E-02	2.11E-01	1.07E+00
Beryllium and compounds	2.1E-05	1.30E+02	1.87E-03	1.17E-04	6.02E-06	1.08E-02	5.46E-02	4.53E-05	6.17E-04	1.08E-02	5.47E-02
Cadmium and compounds	5.1E-05	3.16E+02	4.55E-03	2.84E-04	1.46E-05	2.62E-02	1.33E-01	1.10E-04	1.50E-03	2.62E-02	1.33E-01
Chromium III	2.6E-04	1.61E+03	2.32E-02	1.45E-03	7.45E-05	1.34E-01	6.76E-01	5.61E-04	7.64E-03	1.34E-01	6.77E-01
Chromium VI	7.9E-05	4.90E+02	7.05E-03	4.40E-04	2.26E-05	4.06E-02	2.05E-01	1.70E-04	2.32E-03	4.06E-02	2.06E-01
Cobalt	1.0E-04	6.20E+02	8.92E-03	5.57E-04	2.87E-05	5.14E-02	2.60E-01	2.16E-04	2.94E-03	5.14E-02	2.60E-01
Lead	4.2E-04	2.60E+03	3.75E-02	2.34E-03	1.20E-04	2.16E-01	1.09E+00	9.06E-04	1.23E-02	2.16E-01	1.09E+00
Manganese and compounds	4.9E-04	3.04E+03	4.37E-02	2.73E-03	1.40E-04	2.52E-01	1.27E+00	1.06E-03	1.44E-02	2.52E-01	1.28E+00
Mercury (oxidized / particle bound) [3]	NA	2.68E+01	3.85E-04	2.41E-05	1.24E-06	2.22E-03	1.12E-02	9.33E-06	1.27E-04	2.22E-03	1.13E-02
Nickel	2.8E-04	1.74E+03	2.50E-02	1.56E-03	8.03E-05	1.44E-01	7.28E-01	6.04E-04	8.22E-03	1.44E-01	7.29E-01
Selenium	1.3E-03	8.06E+03	1.16E-01	7.24E-03	3.73E-04	6.68E-01	3.38E+00	2.81E-03	3.82E-02	6.68E-01	3.38E+00

PCDD = Polychlorinated Dibenzo-P-Dioxins
PCDF = Polychlorinated Dibenzofurans
HHV = Higher Heating Value
LHV = Lower Heating Value

[1] Coal Specs obtained from ENSR PSD Application dated April 15, 2004

[2] AP-42 for External Combustion Sources - Bituminous And Subbituminous Coal Combustion 9/98 (Emission Factors for controlled coal combustion)

[3] Mercury emissions calculated based on BHP coal analysis data which assumes an average coal mercury content of 0.065 ppm. The 161 lb/year of mercury was estimated to distributed as follows: 26.8 lb/year of oxidized / particle bound mercury and 134.2 lb/year of elemental mercury.

Table 2-2.2

Desert Rock Energy Project
Chemical Prediction Concentrations
2002 Data

New Mexico Coal Specs [1]

LHV (Btu/lb)	8,479
HHV (Btu/lb)	8,910

Boiler Specs

Combined Unit Gross Output (MW)	1,500
Boiler Heat Rate, Design (Btu/kWh)	9,067
Combined Boiler Input Rating (MMBtu/hr)	13,601

Coal Combustion (tons/yr) 6,200,000

Max Concentration = the highest predicted concentration at any receptor for a 24-hour or annual average

Max Deposition Flux = Maximum predicted deposition rate per unit of soil area, at any receptor, over a daily or annual averaging period

Fine Particle (Organics and Elemental Mercury)

CALPUFF Results: [Unit Emission Rate Case, Max Conc. (@1 g/s)]

microg/m^3		microg/m^2/s		microg/m^2/s		microg/m^2/s	
7.978E-02	3.451E-03	2.604E-02	1.831E-04	4.117E-06	2.802E-07	2.604E-02	1.832E-04
		mg/m^2/yr		mg/m^2/yr		mg/m^2/yr	
-	-	-	5.775E+00	-	8.835E-03	-	5.776E+00

CONTAMINANT	[2] AP-42 Emission Factor	EMISSIONS		MAX CONCENTRATION		MAX WET DEPOSITION FLUX		MAX DRY DEPOSITION FLUX		TOTAL DEPOSITION MAX	
		(lb/yr)	(g/s)	24-hour Avg. (micro g/m^3)	Annual Avg. (micro g/m^3)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)
Acetaldehyde	5.7E-04	3.53E+03	5.08E-02	4.06E-03	1.75E-04	1.14E-01	2.94E-01	1.81E-05	4.49E-04	1.14E-01	2.94E-01
Acetophenone	1.5E-05	9.30E+01	1.34E-03	1.07E-04	4.62E-06	3.01E-03	7.72E-03	4.76E-07	1.18E-05	3.01E-03	7.73E-03
Acrolein	2.9E-04	1.80E+03	2.59E-02	2.06E-03	8.93E-05	5.82E-02	1.49E-01	9.20E-06	2.28E-04	5.82E-02	1.49E-01
Benzene	1.3E-03	8.06E+03	1.16E-01	9.25E-03	4.00E-04	2.61E-01	6.69E-01	4.12E-05	1.02E-03	2.61E-01	6.70E-01
Benzyl chloride	7.0E-04	4.34E+03	6.24E-02	4.98E-03	2.15E-04	1.40E-01	3.60E-01	2.22E-05	5.52E-04	1.40E-01	3.61E-01
1,1-Biphenyl	1.7E-06	1.05E+01	1.52E-04	1.21E-05	5.23E-07	3.41E-04	8.75E-04	5.39E-08	1.34E-06	3.41E-04	8.76E-04
Bis(2-ethylhexyl)phthalate	7.3E-05	4.53E+02	6.51E-03	5.19E-04	2.25E-05	1.46E-02	3.76E-02	2.32E-06	5.75E-05	1.46E-02	3.76E-02
Bromoform (tribromomethane)	3.9E-05	2.42E+02	3.48E-03	2.77E-04	1.20E-05	7.82E-03	2.01E-02	1.24E-06	3.07E-05	7.82E-03	2.01E-02
Carbon disulfide	1.3E-04	8.06E+02	1.16E-02	9.25E-04	4.00E-05	2.61E-02	6.69E-02	4.12E-06	1.02E-04	2.61E-02	6.70E-02
2-Chloroacetophenone	7.0E-06	4.34E+01	6.24E-04	4.98E-05	2.15E-06	1.40E-03	3.60E-03	2.22E-07	5.52E-06	1.40E-03	3.61E-03
Chlorobenzene	2.2E-05	1.36E+02	1.96E-03	1.57E-04	6.77E-06	4.41E-03	1.13E-02	6.98E-07	1.73E-05	4.41E-03	1.13E-02
Chloroform	5.9E-05	3.66E+02	5.26E-03	4.20E-04	1.82E-05	1.18E-02	3.04E-02	1.87E-06	4.65E-05	1.18E-02	3.04E-02
Cumene (isopropylbenzene)	5.3E-06	3.29E+01	4.73E-04	3.77E-05	1.63E-06	1.06E-03	2.73E-03	1.68E-07	4.18E-06	1.06E-03	2.73E-03
Cyanide (hydrogen)	2.5E-03	1.55E+04	2.23E-01	1.78E-02	7.69E-04	5.02E-01	1.29E+00	7.93E-05	1.97E-03	5.02E-01	1.29E+00
1,2-Dibromoethane (EDB)	1.2E-06	7.44E+00	1.07E-04	8.54E-06	3.69E-07	2.41E-04	6.18E-04	3.81E-08	9.45E-07	2.41E-04	6.18E-04
2,4-Dinitrotoluene	2.8E-07	1.74E+00	2.50E-05	1.99E-06	8.62E-08	5.62E-05	1.44E-04	8.88E-09	2.21E-07	5.62E-05	1.44E-04
Ethylbenzene	9.4E-05	5.83E+02	8.38E-03	6.69E-04	2.89E-05	1.89E-02	4.84E-02	2.98E-06	7.41E-05	1.89E-02	4.84E-02
Ethyl chloride	4.2E-05	2.60E+02	3.75E-03	2.99E-04	1.29E-05	8.43E-03	2.16E-02	1.33E-06	3.31E-05	8.43E-03	2.16E-02
Formaldehyde	2.4E-04	1.49E+03	2.14E-02	1.71E-03	7.39E-05	4.82E-02	1.24E-01	7.61E-06	1.89E-04	4.82E-02	1.24E-01
n-Hexane	6.7E-05	4.15E+02	5.97E-03	4.77E-04	2.06E-05	1.34E-02	3.45E-02	2.13E-06	5.28E-05	1.34E-02	3.45E-02
Hydrazine, monomethyl	1.7E-04	1.05E+03	1.52E-02	1.21E-03	5.23E-05	3.41E-02	8.75E-02	5.39E-06	1.34E-04	3.41E-02	8.76E-02
Hydrogen Chloride	1.2E+00	7.44E+06	1.07E+02	8.54E+00	3.69E-01	2.41E+02	6.18E+02	3.81E-02	9.45E-01	2.41E+02	6.18E+02
Hydrogen fluoride	1.5E-01	9.30E+05	1.34E+01	1.07E+00	4.62E-02	3.01E+01	7.72E+01	4.76E-03	1.18E-01	3.01E+01	7.73E+01
Isophorone	5.8E-04	3.60E+03	5.17E-02	4.13E-03	1.79E-04	1.16E-01	2.99E-01	1.84E-05	4.57E-04	1.16E-01	2.99E-01
Mercury (elemental) [3]	8.3E-05	1.34E+02	1.93E-03	1.54E-04	6.66E-06	4.34E-03	1.11E-02	6.87E-07	1.71E-05	4.34E-03	1.11E-02
Methylene bromide	1.6E-04	9.92E+02	1.43E-02	1.14E-03	4.92E-05	3.21E-02	8.24E-02	5.07E-06	1.26E-04	3.21E-02	8.24E-02
Methylene chloride	2.9E-04	1.80E+03	2.59E-02	2.06E-03	8.93E-05	5.82E-02	1.49E-01	9.20E-06	2.28E-04	5.82E-02	1.49E-01
Methyl ethyl ketone (2-Butanone)	3.9E-04	2.42E+03	3.48E-02	2.77E-03	1.20E-04	7.82E-02	2.01E-01	1.24E-05	3.07E-04	7.82E-02	2.01E-01
Methyl methacrylate	2.0E-05	1.24E+02	1.78E-03	1.42E-04	6.16E-06	4.01E-03	1.03E-02	6.34E-07	1.58E-05	4.01E-03	1.03E-02

-	-	-	5.775E+00	-	8.835E-03	-	5.776E+00

Methyl tertbutyl ether (MTBE)	3.5E-05	2.17E+02	3.12E-03	2.49E-04	1.08E-05	7.02E-03	1.80E-02	1.11E-06	2.76E-05	7.02E-03	1.80E-02
Phenol	1.6E-05	9.92E+01	1.43E-03	1.14E-04	4.92E-06	3.21E-03	8.24E-03	5.07E-07	1.26E-05	3.21E-03	8.24E-03
Acenaphthene	5.1E-07	3.16E+00	4.55E-05	3.63E-06	1.57E-07	1.02E-04	2.63E-04	1.62E-08	4.02E-07	1.02E-04	2.63E-04
Anthracene	2.1E-07	1.30E+00	1.87E-05	1.49E-06	6.46E-08	4.21E-05	1.08E-04	6.66E-09	1.65E-07	4.21E-05	1.08E-04
Benz[a]anthracene	8.0E-08	4.96E-01	7.13E-06	5.69E-07	2.46E-08	1.61E-05	4.12E-05	2.54E-09	6.30E-08	1.61E-05	4.12E-05
Benzo[a]pyrene	3.8E-08	2.36E-01	3.39E-06	2.70E-07	1.17E-08	7.62E-06	1.96E-05	1.21E-09	2.99E-08	7.62E-06	1.96E-05
Chrysene	1.0E-07	6.20E-01	8.92E-06	7.11E-07	3.08E-08	2.01E-05	5.15E-05	3.17E-09	7.88E-08	2.01E-05	5.15E-05
Fluoranthene	7.1E-07	4.40E+00	6.33E-05	5.05E-06	2.19E-07	1.42E-04	3.66E-04	2.25E-08	5.59E-07	1.42E-04	3.66E-04
Fluorene	9.1E-07	5.64E+00	8.12E-05	6.47E-06	2.80E-07	1.83E-04	4.69E-04	2.89E-08	7.17E-07	1.83E-04	4.69E-04
Indeno[1,2,3-cd]pyrene	6.1E-08	3.78E-01	5.44E-06	4.34E-07	1.88E-08	1.22E-05	3.14E-05	1.93E-09	4.81E-08	1.22E-05	3.14E-05
Naphthalene	1.3E-05	8.06E+01	1.16E-03	9.25E-05	4.00E-06	2.61E-03	6.69E-03	4.12E-07	1.02E-05	2.61E-03	6.70E-03
Pyrene	3.3E-07	2.05E+00	2.94E-05	2.35E-06	1.02E-07	6.62E-05	1.70E-04	1.05E-08	2.60E-07	6.62E-05	1.70E-04
Styrene	2.5E-05	1.55E+02	2.23E-03	1.78E-04	7.69E-06	5.02E-03	1.29E-02	7.93E-07	1.97E-05	5.02E-03	1.29E-02
2,3,7,8-TCDD (dioxin)	1.43E-11	8.87E-05	1.28E-09	1.02E-10	4.40E-12	2.87E-09	7.36E-09	4.54E-13	1.13E-11	2.87E-09	7.37E-09
Total PCDD/PCDF	1.76E-09	1.09E-02	1.57E-07	1.25E-08	5.42E-10	3.53E-07	9.06E-07	5.58E-11	1.39E-09	3.53E-07	9.07E-07
Tetrachloroethylene (PCE)	4.3E-05	2.67E+02	3.83E-03	3.06E-04	1.32E-05	8.63E-03	2.21E-02	1.36E-06	3.39E-05	8.63E-03	2.21E-02
Toluene	2.4E-04	1.49E+03	2.14E-02	1.71E-03	7.39E-05	4.82E-02	1.24E-01	7.61E-06	1.89E-04	4.82E-02	1.24E-01
1,1,1-Trichloroethane	2.0E-05	1.24E+02	1.78E-03	1.42E-04	6.16E-06	4.01E-03	1.03E-02	6.34E-07	1.58E-05	4.01E-03	1.03E-02
Vinyl acetate	7.6E-06	4.71E+01	6.78E-04	5.41E-05	2.34E-06	1.52E-03	3.91E-03	2.41E-07	5.99E-06	1.52E-03	3.91E-03
Xylenes	3.7E-05	2.29E+02	3.30E-03	2.63E-04	1.14E-05	7.42E-03	1.91E-02	1.17E-06	2.92E-05	7.42E-03	1.91E-02
Xylenes	3.7E-05	2.29E+02	3.30E-03	2.63E-04	1.14E-05	7.42E-03	1.91E-02	1.17E-06	2.92E-05	7.42E-03	1.91E-02

Particle Mass Weighted (Other Metals & Oxidized / Particle Bound Mercury)

CALPUFF Results: [Unit Emission Rate Case, Max Conc. (@1 g/s)]

microg/m^3		microg/m^2/s		microg/m^2/s		microg/m^2/s	
7.978E-02	3.451E-03	9.430E-02	8.743E-04	2.786E-04	1.283E-05	9.430E-02	8.757E-04
		mg/m^2/yr		mg/m^2/yr		mg/m^2/yr	
-	-	-	2.757E+01	-	4.044E-01	-	2.762E+01

CONTAMINANT	[2] AP-42 Emission Factor	EMISSIONS		MAX CONCENTRATION		MAX WET DEPOSITION FLUX		MAX DRY DEPOSITION FLUX		TOTAL DEPOSITION MAX	
		(lb/yr)	(g/s)	24-hour Avg. (micro g/m^3)	Annual Avg. (micro g/m^3)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)
Antimony and compounds	1.8E-05	1.12E+02	1.61E-03	1.28E-04	5.54E-06	1.31E-02	4.43E-02	3.86E-05	6.49E-04	1.31E-02	4.43E-02
Arsenic	4.1E-04	2.54E+03	3.66E-02	2.92E-03	1.26E-04	2.98E-01	1.01E+00	8.80E-04	1.48E-02	2.98E-01	1.01E+00
Beryllium and compounds	2.1E-05	1.30E+02	1.87E-03	1.49E-04	6.46E-06	1.53E-02	5.16E-02	4.51E-05	7.57E-04	1.53E-02	5.17E-02
Cadmium and compounds	5.1E-05	3.16E+02	4.55E-03	3.63E-04	1.57E-05	3.71E-02	1.25E-01	1.09E-04	1.84E-03	3.71E-02	1.26E-01
Chromium III	2.6E-04	1.61E+03	2.32E-02	1.85E-03	8.00E-05	1.89E-01	6.39E-01	5.58E-04	9.38E-03	1.89E-01	6.40E-01
Chromium VI	7.9E-05	4.90E+02	7.05E-03	5.62E-04	2.43E-05	5.74E-02	1.94E-01	1.70E-04	2.85E-03	5.74E-02	1.95E-01
Cobalt	1.0E-04	6.20E+02	8.92E-03	7.11E-04	3.08E-05	7.27E-02	2.46E-01	2.15E-04	3.61E-03	7.27E-02	2.46E-01
Lead	4.2E-04	2.60E+03	3.75E-02	2.99E-03	1.29E-04	3.05E-01	1.03E+00	9.02E-04	1.51E-02	3.05E-01	1.03E+00

Table 2-2.3

Desert Rock Energy Project
Chemical Prediction Concentrations
2003 Data

New Mexico Coal Specs [1]

LHV (Btu/lb)	8,479
HHV (Btu/lb)	8,910

Boiler Specs

Combined Unit Gross Output (MW)	1,500
Boiler Heat Rate, Design (Btu/kWh)	9,067
Combined Boiler Input Rating (MMBtu/hr)	13,601

Max Concentration = the highest predicted concentration at any receptor for a 24-hour or annual average

Max Deposition Flux = Maximum predicted deposition rate per unit of soil area, at any receptor,
over a daily or annual averaging period

Coal Combustion (tons/yr) 6,200,000

Fine Particle (Organics and Elemental Mercury)

CALPUFF Results: [Unit Emission Rate Case, Max Conc. (@1 g/s)]

microg/m^3		microg/m^2/s		microg/m^2/s		microg/m^2/s	
8.940E-02	3.379E-03	3.140E-02	1.767E-04	5.538E-06	2.090E-07	3.140E-02	1.768E-04
		mg/m^2/yr		mg/m^2/yr		mg/m^2/yr	
-	-	-	5.573E+00	-	6.592E-03	-	5.577E+00

CONTAMINANT	[2] AP-42 Emission Factor	EMISSIONS		MAX CONCENTRATION		MAX WET DEPOSITION FLUX		MAX DRY DEPOSITION FLUX		TOTAL DEPOSITION MAX RATE	
		(lb/yr)	(g/s)	24-hour Avg. (micro g/m^3)	Annual Avg. (micro g/m^3)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)
Acetaldehyde	5.7E-04	3.53E+03	5.08E-02	4.54E-03	1.72E-04	1.38E-01	2.83E-01	2.43E-05	3.35E-04	1.38E-01	2.83E-01
Acetophenone	1.5E-05	9.30E+01	1.34E-03	1.20E-04	4.52E-06	3.63E-03	7.46E-03	6.40E-07	8.82E-06	3.63E-03	7.46E-03
Acrolein	2.9E-04	1.80E+03	2.59E-02	2.31E-03	8.74E-05	7.02E-02	1.44E-01	1.24E-05	1.70E-04	7.02E-02	1.44E-01
Benzene	1.3E-03	8.06E+03	1.16E-01	1.04E-02	3.92E-04	3.15E-01	6.46E-01	5.55E-05	7.64E-04	3.15E-01	6.47E-01
Benzyl chloride	7.0E-04	4.34E+03	6.24E-02	5.58E-03	2.11E-04	1.69E-01	3.48E-01	2.99E-05	4.12E-04	1.69E-01	3.48E-01
1,1-Biphenyl	1.7E-06	1.05E+01	1.52E-04	1.36E-05	5.12E-07	4.11E-04	8.45E-04	7.25E-08	9.99E-07	4.11E-04	8.45E-04
Bis(2-ethylhexyl)phthalate	7.3E-05	4.53E+02	6.51E-03	5.82E-04	2.20E-05	1.77E-02	3.63E-02	3.11E-06	4.29E-05	1.77E-02	3.63E-02
Bromoform (tribromomethane)	3.9E-05	2.42E+02	3.48E-03	3.11E-04	1.18E-05	9.44E-03	1.94E-02	1.66E-06	2.29E-05	9.44E-03	1.94E-02
Carbon disulfide	1.3E-04	8.06E+02	1.16E-02	1.04E-03	3.92E-05	3.15E-02	6.46E-02	5.55E-06	7.64E-05	3.15E-02	6.47E-02
2-Chloroacetophenone	7.0E-06	4.34E+01	6.24E-04	5.58E-05	2.11E-06	1.69E-03	3.48E-03	2.99E-07	4.12E-06	1.69E-03	3.48E-03
Chlorobenzene	2.2E-05	1.36E+02	1.96E-03	1.75E-04	6.63E-06	5.32E-03	1.09E-02	9.39E-07	1.29E-05	5.32E-03	1.09E-02
Chloroform	5.9E-05	3.66E+02	5.26E-03	4.70E-04	1.78E-05	1.43E-02	2.93E-02	2.52E-06	3.47E-05	1.43E-02	2.93E-02
Cumene (isopropylbenzene)	5.3E-06	3.29E+01	4.73E-04	4.23E-05	1.60E-06	1.28E-03	2.63E-03	2.26E-07	3.12E-06	1.28E-03	2.64E-03
Cyanide (hydrogen)	2.5E-03	1.55E+04	2.23E-01	1.99E-02	7.53E-04	6.05E-01	1.24E+00	1.07E-04	1.47E-03	6.05E-01	1.24E+00
1,2-Dibromoethane (EDB)	1.2E-06	7.44E+00	1.07E-04	9.57E-06	3.62E-07	2.90E-04	5.96E-04	5.12E-08	7.05E-07	2.90E-04	5.97E-04
2,4-Dinitrotoluene	2.8E-07	1.74E+00	2.50E-05	2.23E-06	8.44E-08	6.77E-05	1.39E-04	1.19E-08	1.65E-07	6.77E-05	1.39E-04
Ethylbenzene	9.4E-05	5.83E+02	8.38E-03	7.49E-04	2.83E-05	2.27E-02	4.67E-02	4.01E-06	5.53E-05	2.27E-02	4.67E-02
Ethyl chloride	4.2E-05	2.60E+02	3.75E-03	3.35E-04	1.27E-05	1.02E-02	2.09E-02	1.79E-06	2.47E-05	1.02E-02	2.09E-02
Formaldehyde	2.4E-04	1.49E+03	2.14E-02	1.91E-03	7.23E-05	5.81E-02	1.19E-01	1.02E-05	1.41E-04	5.81E-02	1.19E-01
n-Hexane	6.7E-05	4.15E+02	5.97E-03	5.34E-04	2.02E-05	1.62E-02	3.33E-02	2.86E-06	3.94E-05	1.62E-02	3.33E-02
Hydrazine, monomethyl	1.7E-04	1.05E+03	1.52E-02	1.36E-03	5.12E-05	4.11E-02	8.45E-02	7.25E-06	9.99E-05	4.11E-02	8.45E-02
Hydrogen Chloride	1.2E+00	7.44E+06	1.07E+02	9.57E+00	3.62E-01	2.90E+02	5.96E+02	5.12E-02	7.05E-01	2.90E+02	5.97E+02
Hydrogen fluoride	1.5E-01	9.30E+05	1.34E+01	1.20E+00	4.52E-02	3.63E+01	7.46E+01	6.40E-03	8.82E-02	3.63E+01	7.46E+01
Isophorone	5.8E-04	3.60E+03	5.17E-02	4.62E-03	1.75E-04	1.40E-01	2.88E-01	2.47E-05	3.41E-04	1.40E-01	2.88E-01
Mercury (elemental) [3]	NA	1.34E+02	1.93E-03	1.73E-04	6.52E-06	5.24E-03	1.08E-02	9.24E-07	1.27E-05	5.24E-03	1.08E-02
Methylene bromide	1.6E-04	9.92E+02	1.43E-02	1.28E-03	4.82E-05	3.87E-02	7.95E-02	6.83E-06	9.41E-05	3.87E-02	7.96E-02
Methylene chloride	2.9E-04	1.80E+03	2.59E-02	2.31E-03	8.74E-05	7.02E-02	1.44E-01	1.24E-05	1.70E-04	7.02E-02	1.44E-01
Methyl ethyl ketone (2-Butanone)	3.9E-04	2.42E+03	3.48E-02	3.11E-03	1.18E-04	9.44E-02	1.94E-01	1.66E-05	2.29E-04	9.44E-02	1.94E-01
Methyl methacrylate	2.0E-05	1.24E+02	1.78E-03	1.59E-04	6.03E-06	4.84E-03	9.94E-03	8.53E-07	1.18E-05	4.84E-03	9.95E-03
Methyl tertbutyl ether (MTBE)	3.5E-05	2.17E+02	3.12E-03	2.79E-04	1.05E-05	8.47E-03	1.74E-02	1.49E-06	2.06E-05	8.47E-03	1.74E-02
Phenol	1.6E-05	9.92E+01	1.43E-03	1.28E-04	4.82E-06	3.87E-03	7.95E-03	6.83E-07	9.41E-06	3.87E-03	7.96E-03
Acenaphthene	5.1E-07	3.16E+00	4.55E-05	4.07E-06	1.54E-07	1.23E-04	2.53E-04	2.18E-08	3.00E-07	1.23E-04	2.54E-04

-	-	-	5.573E+00	-	6.592E-03	-	5.577E+00

Anthracene	2.1E-07	1.30E+00	1.87E-05	1.67E-06	6.33E-08	5.08E-05	1.04E-04	8.96E-09	1.23E-07	5.08E-05	1.04E-04
Benz[a]anthracene	8.0E-08	4.96E-01	7.13E-06	6.38E-07	2.41E-08	1.94E-05	3.98E-05	3.41E-09	4.70E-08	1.94E-05	3.98E-05
Benzo[a]pyrene	3.8E-08	2.36E-01	3.39E-06	3.03E-07	1.14E-08	9.19E-06	1.89E-05	1.62E-09	2.23E-08	9.19E-06	1.89E-05
Chrysene	1.0E-07	6.20E-01	8.92E-06	7.97E-07	3.01E-08	2.42E-05	4.97E-05	4.27E-09	5.88E-08	2.42E-05	4.97E-05
Fluoranthene	7.1E-07	4.40E+00	6.33E-05	5.66E-06	2.14E-07	1.72E-04	3.53E-04	3.03E-08	4.17E-07	1.72E-04	3.53E-04
Fluorene	9.1E-07	5.64E+00	8.12E-05	7.25E-06	2.74E-07	2.20E-04	4.52E-04	3.88E-08	5.35E-07	2.20E-04	4.53E-04
Indeno[1,2,3-cd]pyrene	6.1E-08	3.78E-01	5.44E-06	4.86E-07	1.84E-08	1.48E-05	3.03E-05	2.60E-09	3.59E-08	1.48E-05	3.03E-05
Naphthalene	1.3E-05	8.06E+01	1.16E-03	1.04E-04	3.92E-06	3.15E-03	6.46E-03	5.55E-07	7.64E-06	3.15E-03	6.47E-03
Pyrene	3.3E-07	2.05E+00	2.94E-05	2.63E-06	9.94E-08	7.98E-05	1.64E-04	1.41E-08	1.94E-07	7.98E-05	1.64E-04
Styrene	2.5E-05	1.55E+02	2.23E-03	1.99E-04	7.53E-06	6.05E-03	1.24E-02	1.07E-06	1.47E-05	6.05E-03	1.24E-02
2,3,7,8-TCDD (dioxin)	1.43E-11	8.87E-05	1.28E-09	1.14E-10	4.31E-12	3.46E-09	7.11E-09	6.10E-13	8.41E-12	3.46E-09	7.11E-09
Total PCDD/PCDF	1.76E-09	1.09E-02	1.57E-07	1.40E-08	5.30E-10	4.26E-07	8.75E-07	7.51E-11	1.03E-09	4.26E-07	8.75E-07
Tetrachloroethylene (PCE)	4.3E-05	2.67E+02	3.83E-03	3.43E-04	1.30E-05	1.04E-02	2.14E-02	1.83E-06	2.53E-05	1.04E-02	2.14E-02
Toluene	2.4E-04	1.49E+03	2.14E-02	1.91E-03	7.23E-05	5.81E-02	1.19E-01	1.02E-05	1.41E-04	5.81E-02	1.19E-01
1,1,1-Trichloroethane	2.0E-05	1.24E+02	1.78E-03	1.59E-04	6.03E-06	4.84E-03	9.94E-03	8.53E-07	1.18E-05	4.84E-03	9.95E-03
Vinyl acetate	7.6E-06	4.71E+01	6.78E-04	6.06E-05	2.29E-06	1.84E-03	3.78E-03	3.24E-07	4.47E-06	1.84E-03	3.78E-03
Xylenes	3.7E-05	2.29E+02	3.30E-03	2.95E-04	1.11E-05	8.95E-03	1.84E-02	1.58E-06	2.18E-05	8.95E-03	1.84E-02
Xylenes	3.7E-05	2.29E+02	3.30E-03	2.95E-04	1.11E-05	8.95E-03	1.84E-02	1.58E-06	2.18E-05	8.95E-03	1.84E-02

Particle Mass Weighted (Other Metals & Oxidized / Particle Bound Mercury)

CALPUFF Results: [Unit Emission Rate Case, Max Conc. (@1 g/s)]

microg/m^3		microg/m^2/s		microg/m^2/s		microg/m^2/s	
8.940E-02	3.379E-03	1.054E-01	6.425E-04	2.283E-04	9.088E-06	1.054E-01	6.463E-04
		mg/m^2/yr		mg/m^2/yr		mg/m^2/yr	
-	-	-	2.026E+01	-	2.866E-01	-	2.038E+01

CONTAMINANT	[2] AP-42 Emission Factor	EMISSIONS		MAX CONCENTRATION		MAX WET DEPOSITION FLUX		MAX DRY DEPOSITION FLUX		TOTAL DEPOSITION MAX RATE	
		(lb/yr)	(g/s)	24-hour Avg. (micro g/m^3)	Annual Avg. (micro g/m^3)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)	24-hour Avg. (mg/m^2 day)	Annual Avg. (mg/m^2 yr)
Antimony and compounds	1.8E-05	1.12E+02	1.61E-03	1.43E-04	5.42E-06	1.46E-02	3.25E-02	3.17E-05	4.60E-04	1.46E-02	3.27E-02
Arsenic	4.1E-04	2.54E+03	3.66E-02	3.27E-03	1.24E-04	3.33E-01	7.41E-01	7.21E-04	1.05E-02	3.33E-01	7.45E-01
Beryllium and compounds	2.1E-05	1.30E+02	1.87E-03	1.67E-04	6.33E-06	1.71E-02	3.79E-02	3.69E-05	5.37E-04	1.71E-02	3.82E-02
Cadmium and compounds	5.1E-05	3.16E+02	4.55E-03	4.07E-04	1.54E-05	4.14E-02	9.21E-02	8.97E-05	1.30E-03	4.14E-02	9.27E-02
Chromium III	2.6E-04	1.61E+03	2.32E-02	2.07E-03	7.83E-05	2.11E-01	4.70E-01	4.57E-04	6.65E-03	2.11E-01	4.73E-01
Chromium VI	7.9E-05	4.90E+02	7.05E-03	6.30E-04	2.38E-05	6.42E-02	1.43E-01	1.39E-04	2.02E-03	6.42E-02	1.44E-01
Cobalt	1.0E-04	6.20E+02	8.92E-03	7.97E-04	3.01E-05	8.12E-02	1.81E-01	1.76E-04	2.56E-03	8.12E-02	1.82E-01
Lead	4.2E-04	2.60E+03	3.75E-02	3.35E-03	1.27E-04	3.41E-01	7.59E-01	7.39E-04	1.07E-02	3.41E-01	7.63E-01
Manganese and compounds	4.9E-04	3.04E+03	4.37E-02	3.91E-03	1.48E-04	3.98E-01	8.85E-01	8.62E-04	1.25E-02	3.98E-01	8.91E-01

2003. The maximum predicted air concentrations occur under 2003 meteorological conditions for the majority of the chemicals (Table 2.2-3). Note that these tables also include the maximum deposition rates for the chemicals, which are discussed further in Section 2.3.

The air concentrations shown on Tables 2.2-1 through 2.2-3 show that, for most of these chemicals, only nanograms of chemical per cubic meter of air are possibly being emitted (nanograms of chemical per cubic meter of air are calculated by multiplying the micrograms chemical per cubic meter of air shown on the tables by 1000). These very low levels of chemicals are likely overestimated, rather than underestimated, because air concentrations were calculated using very conservative assumptions:

- Concentrations in air are the highest predicted at any location within the entire 25-kilometer radius modeled area. Most predicted maximum concentrations are located close to the plant boundary where there are no residences.
- Concentrations assume the plant is operating at "full load" on a 24-hour, 7-day a week basis. It is more likely that the average operating rate over the life of the plant would be 80-85% of maximum capacity.
- Concentrations were calculated using published USEPA AP-42 controlled emission rates. These assumed rates are higher than the actual rates that will be emitted at the proposed plant because of the emissions control technology that will be used.

2.3 MODELED CONCENTRATIONS OF CHEMICALS IN SOIL FROM PLANT EMISSIONS

As noted above, airborne chemicals from plant emissions would be deposited on the soil in the surrounding area throughout the operational life of the plant. In this case, 50 years is assumed to be the operational life of the plant (see Section 2.2.2.1.4 in the body of the report). USEPA (2005) provides equations for estimating soil concentration over the period that the source is operating. The equation takes into account: 1) concentrations already present in soil (i.e., baseline); 2) continual deposition from the source; and 3) concentration losses that address environmental processes that would result in lower soil concentrations over time, such as:

- Erosion
- Biotic and abiotic degradation
- Surface runoff
- Leaching
- Volatilization

A simplified, conservative, version of the equations shown in USEPA (2005) was used to estimate surface soil concentrations over 50 years. This equation assumes that chemical concentrations will not decrease due to any of the environmental processes noted above. Without assuming losses the equation is:

$$Cs = Cb + \frac{DR \times AF \times ED}{(d \times p)}$$

Where:

Cs = average soil concentration in soil following 50 years of deposition (mg/kg)

Cb = baseline soil concentration (95% UCL) prior to start-up of plant

DR = deposition rate (combined maximum annual wet and dry deposition rates from Table 2.2-3, the highest deposition rates for the three years of meteorological data) (mg/m^2-year)

AF = Averaging factor, used to average soil concentrations over the 50 years of deposition (0.5 [unitless]).

ED = exposure duration (50 years)

d = depth of mixing, 0.02 meters (recommended default for untilled soil [USEPA 2005])

(Note: other depths of mixing may be used for specific exposure conditions)

p = soil density, 1500 kg/m^3 (recommended default, based on "loam" soil [USEPA 2005])

The total maximum deposition rates as described in Section 4.1 of the main text were used to estimate the soil concentrations for all air toxics.

Concentrations of chemicals that are naturally occurring and are found on site in the absence of site activities are defined as baseline concentrations and can include inorganic species (i.e., metals) and some organics (e.g., PAHs from wildfires). Of these naturally occurring chemicals, baseline soil concentrations (the "Cb" term) are available for eight metals. However, only six metals (arsenic, cadmium, chromium, lead, mercury, and selenium) are considered HAPs (see Section 2.1). For other emitted chemicals, baseline soil concentrations (Cb) are assumed to be zero (0) in the calculations.

Concentrations of chemicals in surface soil resulting from plant emissions (i.e., without considering baseline soil concentration) over 50 years are shown on Table 2.3-1. Predicted surface soil concentrations are generally highest if the 2003 meteorological conditions are constant for 50 years; however, the predicted 50-year concentration does not vary much between the three years shown. For all but three of the 62 chemicals (selenium, hydrogen fluoride and hydrogen chloride), predicted surface soil concentrations accumulated over 50 years are less than or equal to 1 mg/kg (1 part per million), and in many cases, are several orders of magnitude below 1 mg/kg. These predicted surface soil concentrations are conservative estimates (i.e., over-predict, rather than under-predict concentrations) because:

- Deposition for the gaseous compounds (volatiles) would not occur, or would occur at only a fraction of the estimates presented on the table, because these chemicals would primarily remain in the air.
- Calculations do not take into account any of the processes described above which would reduce soil concentrations, particularly for the volatile and semi-volatile organic compounds.
- Calculations use the maximum deposition rate (assuming continuous plant operations 24/7 for 50 years) that overestimates the average or typical amount of deposition that would actually occur during normal plant operations at an average capacity rate of 85% of maximum capacity.

Table 2.3-1
Desert Rock Energy Project
Surface Soil Concentrations From Proposed Plant Over 50 Years of Deposition
Maximum of 2001-2003 Data

CONTAMINANT	TOTAL DEPOSITION MAX RATE	Concentration in Surface Soil After 50 Years of Deposition [2]	Region 9 Residential Soil PRG	Exceeds Residential Soil PRG?
	Annual Avg. (mg/m^2 yr)	(mg/kg)	(mg/kg)	
ORGANIC CHEMICALS				
Acetaldehyde	2.94E-01	2.45E-01	10.9	NO
Acetophenone	7.73E-03	6.44E-03	7820	NO
Acrolein	1.49E-01	1.24E-01	0.103	YES
Benzene	6.70E-01	5.58E-01	0.643	NO
Benzyl chloride	3.61E-01	3.00E-01	0.89	NO
1,1-Biphenyl	8.76E-04	7.30E-04	3010	NO
Bis(2-ethylhexyl)phthalate	3.76E-02	3.13E-02	34.7	NO
Bromoform (tribromomethane)	2.01E-02	1.67E-02	61.6	NO
Carbon disulfide	6.70E-02	5.58E-02	355	NO
2-Chloroacetophenone	3.61E-03	3.00E-03	0.0326	NO
Chlorobenzene	1.13E-02	9.44E-03	151	NO
Chloroform	3.04E-02	2.53E-02	0.221	NO
Cumene (isopropylbenzene)	2.73E-03	2.28E-03	572	NO
Cyanide (hydrogen)	1.29E+00	1.07E+00	10.8	NO
1,2-Dibromoethane (EDB)	6.18E-04	5.15E-04	0.032	NO
2,4-Dinitrotoluene	1.44E-04	1.20E-04	122	NO
Ethylbenzene	4.84E-02	4.03E-02	395	NO
Ethyl chloride	2.16E-02	1.80E-02	3.03	NO
Formaldehyde	1.24E-01	1.03E-01	9170	NO
n-Hexane	3.45E-02	2.88E-02	110	NO
Hydrazine, monomethyl	8.76E-02	7.30E-02	0.162	NO
Hydrogen Chloride	6.18E+02	5.15E+02	--	NO
Hydrogen fluoride	7.73E+01	6.44E+01	--	NO
Isophorone	2.99E-01	2.49E-01	512	NO
Mercury (elemental) [1]	--	--	--	--
Methylene bromide	8.24E-02	6.87E-02	66.9	NO
Methylene chloride	1.49E-01	1.24E-01	9.11	NO
Methyl ethyl ketone (2-Butanone)	2.01E-01	1.67E-01	22300	NO
Methyl methacrylate	1.03E-02	8.59E-03	2190	NO
Methyl tertbutyl ether (MTBE)	1.80E-02	1.50E-02	16.7	NO
Phenol	8.24E-03	6.87E-03	18300	NO
Acenaphthene	2.63E-04	2.19E-04	3680	NO
Anthracene	1.08E-04	9.01E-05	21900	NO
Benz[a]anthracene	4.12E-05	3.43E-05	0.621	NO
Benzo[a]pyrene	1.96E-05	1.63E-05	0.0621	NO
Chrysene	5.15E-05	4.29E-05	62.1	NO
Fluoranthene	3.66E-04	3.05E-04	2290	NO
Fluorene	4.69E-04	3.91E-04	2750	NO
Indeno[1,2,3-cd]pyrene	3.14E-05	2.62E-05	0.621	NO

Naphthalene	6.70E-03	5.58E-03	55.9	NO
Pyrene	1.70E-04	1.42E-04	2320	NO
Styrene	1.29E-02	1.07E-02	1700	NO
2,3,7,8-TCDD (dioxin)	7.37E-09	6.14E-09	0.0000039	NO
Total PCDD/PCDF	9.07E-07	7.55E-07	--	--
Tetrachloroethylene (PCE)	2.21E-02	1.85E-02	0.484	NO
Toluene	1.24E-01	1.03E-01	520	NO
1,1,1-Trichloroethane	1.03E-02	8.59E-03	1200	NO
Vinyl acetate	3.91E-03	3.26E-03	426	NO
Xylenes	1.91E-02	1.59E-02	271	NO
Xylenes	1.91E-02	1.59E-02	271	NO
INORGANIC CHEMICALS				
Antimony and compounds	4.68E-02	3.90E-02	31.3	NO
Arsenic	1.07E+00	8.92E-01	0.39	YES
Beryllium and compounds	5.47E-02	4.55E-02	154	NO
Cadmium and compounds	1.33E-01	1.11E-01	37	NO
Chromium III	6.77E-01	5.64E-01	100000	NO
Chromium VI	2.06E-01	1.71E-01	30.1	NO
Cobalt	2.60E-01	2.17E-01	903	NO
Lead	1.09E+00	9.11E-01	400	NO
Manganese and compounds	1.28E+00	1.06E+00	1760	NO
Mercury (oxidized / particle bound) [1]	1.13E-02	9.38E-03	23.5	NO
Nickel	7.29E-01	6.07E-01	1560	NO
Selenium	3.38E+00	2.82E+00	391	NO

PCDD = Polychlorinated Dibenzo-P-Dioxins
PCDF = Polychlorinated Dibenzofurans
--: not available
mg/kg: milligram per kilogram
mg/m2: milligram per square meter
TCDD: tetrachlorodibenzo(p)dioxin
PCDD/PCDF: polychlorinated dibenzo-p-dioxins/ polychlorinated dibenzofurans
PRG: Preliminary Remediation Goal

[1] Mercury emissions calculated based on BHP coal analysis data which assumes an average coal mercury content of 0.065 ppm. The 161 lb/year of mercury was estimated to distributed as follows: 26.8 lb/year of oxidized / particle bound mercury and 134.2 lb/year of elemental mercury. As discussed in Chapter 4 of the main text, due to its gaseous properties, only a small percentage of the elemental mercury vapor will settle out within 25 kilometers from the plant. Therefore, the deposition of mercury in the oxidized/particle bound form is considered in this evaluation.

[2] Concentrations in surface soil after 50 years of deposition were calculated as follows:

Concentration in soil	Csoil = [DR x AF x ED /(d x p)]		
		Value	Units
maximum total annual deposition rate	DR	Chemical-specific	mg/m^2-year
averaging factor	AF	0.5	unitless
exposure duration	ED	50	years
soil mixing zone	d	0.02	meters
soil density	p	1500	kg/m^3
Summary Factor [AF x ED /(d x p)] =		**0.833**	

2.4 MODELED CONCENTRATIONS OF CHEMICALS IN PLANTS

Metal uptake rates (i.e., vegetation bioconcentration factors [BCFs]) were calculated for each of the six metals of interest (see Section 2.1.3) in combination with each plant (five genera) and plant part (roots or stems/leaves), as discussed in Section 2.1.4.

$$\text{Original (2006) Concentrations: } BCF_{\text{Metal (2006)}} = C_{\text{Plant, Part (2006)}} / C_{\text{Soil (2006)}}$$

These site-specific and plant-specific dry-weight BCFs for each metal were then used to estimate concentrations in plants over 50 years when projected soil concentrations reach anticipated maximums due to aerial deposition of particulates on the soil.

$$\text{Projected (2056) Concentrations: } \quad C_{\text{Plant, Part (2056)}} = (BCF_{\text{Metal (2006)}}) \text{ x } (C_{\text{soil (2056)}})$$

The calculation of 50-year plant tissue concentrations for the specific chemicals selected as human health COPCs in plants is discussed in Section 3.2.4. Plant tissue concentrations used in the ecological risk assessment are provided in Section 4.2.

3.0 HUMAN HEALTH RISK ANALYSIS

The human health assessment includes a “screening” step where chemicals of potential concern (COPCs) are selected, followed by an analysis of health risks for these COPCs using site-specific information. The analysis was performed according to the four basic steps of USEPA risk assessment: 1) data evaluation and selection of chemicals of potential concern (COPCs), 2) evaluation of human exposure to the COPCs, 3) assessment of the toxicity of the COPCs, and 4) characterization of the health risks of the COPCs. The result of the risk assessment process are numerical estimates of health risk that are compared to target health risk goals established by government and public health agencies. These health goals are generally no more than a 1 in 10,000 (i.e., 1×10^{-4}) to a 1 in a million (i.e., 1×10^{-6}) risk of contracting cancer from exposure to carcinogenic chemicals or, in the case of chemicals with toxic effects other than cancer, the chemical dose from exposure to the COPCs must be equal to or less than the safe dose established by USEPA.

3.1 SCREENING

Typically, not all chemicals present at a site pose health risks or contribute significantly to overall site risks. USEPA guidelines (USEPA 1989) recommend focusing on a group of COPCs based on inherent toxicity, site concentration, and the behavior of the chemicals in the environment. To identify these COPCs, health-protective risk-based screening values are compared to site concentrations of chemicals. Health protective screening values are available for chemicals in air and soil. Issues involved in selecting COPCs for food chain exposures (i.e., chemicals in plants or animals eaten by people) are also discussed.

3.1.1 Selection of COPCs in Air

USEPA recommends evaluating airborne combustion emissions for both acute (short-term) and chronic (long-term) health effects (USEPA 2005a). Thus, chemicals in air are compared to both acute and chronic criteria. There are a number of available acute criteria and USEPA (USEPA 2005a) recommends selecting screening values using the following hierarchy:

1. Acute Reference Exposure Level (A-REL). The concentration in air at or below which no adverse health effects are anticipated in the general population, including sensitive individuals (CALEPA [California Environmental Protection Agency] 1999), http://www.oehha.ca.gov/air/pdf/acuterel.pdf

2. Level 1 acute inhalation exposure guidelines (AEGL-1). The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic non-sensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure (NOAA 2001, USEPA 2001). Values compiled from http://www.epa.gov/oppt/aegl/chemlist.htm

3. Level 1 emergency planning guidelines (ERPG-1). The maximum concentration in air below which it is believed nearly all individuals could be exposed for up to one hour without experiencing other than mild transient adverse health effects or perceiving a clearly defined objectionable odor (DOE 2001, SCAPA 2001a). Values compiled from http://www.aiha.org/committees/documents/erpglevels.pdf .

4. Level 1 temporary emergency exposure limits (TEEL-1). The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing other

than mild transient adverse health effects or perceiving a clearly defined objectionable odor (DOE 2001, SCAPA 2001b). Values compiled from http://www.eh.doe.gov/chem_safety//teel/TEELs_Rev21A-Table%203.pdf

If no A-REL value was available for a particular chemical, then AEGL-1 values were used, if no AEGL-1 value was found, then an ERPG-1 value was used, and so forth. If a chemical had no acute levels in any of the four sources listed above, the 24-hour acceptable concentration from the Arizona Ambient Air Quality Guidelines (AAQG) was selected as the screening value. The majority of the chemicals had either an A-REL (18 chemicals), a TEEL (21 chemicals), or an AAQG (12 chemicals). The selected screening values and the source of the values are shown on Table 3.1-1.Five chemicals (2-chloroacetophenone, ethyl chloride, isophorone, methyl tert butylether, and vinyl acetate) did not have any acute screening values. However, none of the 24-hour maximum air concentrations exceeded the chronic PRG, which is a lower, more conservative value than the acute screening values. Therefore, none of these 5 chemicals are a health concern for acute exposures.

For chronic exposures, modeled air concentrations from the proposed plant were compared to ambient air preliminary remediation goals (PRGs) established by USEPA Region 9 as concentrations a person (including sensitive sub-populations) could breath all day every day for 30 years without exceeding target health goals (USEPA 2004a, http://www.epa.gov/region09/waste/sfund/prg/index.html). Because of the concerns for lifetime exposure, acceptable chronic concentrations are much lower than acceptable acute exposure concentrations.

3.1.1.1 Results of Screening

The results of screening of chemicals in air are summarized on Table 3.1-1. Air concentrations estimated using 2003 meteorological data were used for screening because those concentrations were the highest for the three years of meteorological data evaluated. Predicted maximum 24-hour concentrations for each chemical were well below health-based concentrations; consequently, emissions of air toxic chemicals from the plant would not represent any short-term health risk.

Only one chemical, hexavalent chromium (chromium VI), was approximately equal to its long-term, or chronic, value. The maximum annual average concentration of chromium VI was 2.4×10^{-5} $\mu g/m^3$ and the PRG is 2.3×10^{-5} $\mu g/m^3$. Because ambient air PRGs do not take into account food chain exposures (only inhalation), or the possibility that toxic effects between chemicals could be additive, PRGs are sometimes divided by 10 (reduced by an order of magnitude) and then compared to emissions. If the air concentrations are compared to 1/10th their PRG, then three chemicals exceed their screening values: chromium VI, arsenic, and monomethyl hydrazine. These three chemicals that exceeded 1/10th of their PRGs are selected as COPCs for further risk analysis.

Exposures will occur to whatever total amount of chemicals are present in the air, not just those emitted from the plant. However, existing air concentration data were not located for any of the chemicals shown on Table 3.1-1. This is a source of uncertainty, but because modeled concentrations on Table 3.1-1 are likely overestimations, and most concentrations were orders of magnitude below health-based screening levels, this uncertainty is not likely to affect the conclusions of this risk analysis.

3.1.2 Selection of COPCs in Soil

USEPA recommends that chemicals in soil be evaluated for chronic exposures via incidental ingestion of soil that gets on hands and in the mouth, inhalation of chemicals emitted from soil as vapors or dusts, and dermal absorption of chemicals through the skin. As with the screening of chemicals in air, residential soil PRGs were selected as appropriate chronic screening values (USEPA 2004a). Residential soil PRGs

Table 3.1-1
Comparison of Modeled Air Concentrations From Proposed Plant with Health-Based Air Concentrations
(all concentrations in μg/m^3)

Analyte	Acute Exposures				Chronic Exposures			
	Maximum 24-hour	Health-Based Acute Concentration	Source of Health-based conc.	Maximum 24-hour Value Exceeds Risk-Based Acute Value?	Annual Average	Risk-Based Chronic Concentration (PRG)	Maximum Annual Average Value Exceeds Risk-Based Chronic Value?	Maximum Annual Average Value Exceeds 1/10th Risk-Based Chronic Value?
Acetaldehyde	5.8E-03	1.4E+03	AAQG	No	2.0E-04	8.7E-01	No	No
Acetophenone	1.5E-04	3.0E+04	TEEL	No	5.2E-06	2.1E-02 (1)	No	No
Acrolein	3.0E-03	1.9E-01	A-REL	No	1.0E-04	2.1E-02	No	No
Antimony and compounds	1.8E-04	1.5E+03	TEEL	No	6.2E-06	1.5E+00 (1)	No	No
Arsenic	4.2E-03	1.9E-01	A-REL	No	1.4E-04	4.5E-04	No	**Yes**
Benzene	1.3E-02	1.3E+03	A-REL	No	4.5E-04	2.5E-01	No	No
Benzyl chloride	7.2E-03	5.2E+03	ERPG	No	2.4E-04	4.0E-02	No	No
Beryllium and compounds	2.1E-04	1.6E-02	AAQG	No	7.2E-06	8.0E-04	No	No
1,1-Biphenyl	1.7E-05	3.9E+03	TEEL	No	5.9E-07	1.8E+02	No	No
Bis(2-ethylhexyl)phthalate	7.5E-04	1.0E+04	TEEL	No	2.5E-05	4.8E-01	No	No
Bromoform (tribromomethane)	4.0E-04	5.2E+03	TEEL	No	1.3E-05	1.7E+00	No	No
Cadmium and compounds	5.2E-04	1.1E-01	AAQG	No	1.8E-05	1.1E-03	No	No
Carbon disulfide	1.3E-03	6.2E+03	A-REL	No	4.5E-05	7.3E+02	No	No
2-Chloroacetophenone	7.2E-05	--	--	--	2.4E-06	3.1E-02	No	No
Chlorobenzene	2.3E-04	2.6E+03	AAQG	No	7.6E-06	6.2E+01	No	No
Chloroform	6.0E-04	1.5E+02	A-REL	No	2.0E-05	8.3E-02	No	No
Chromium (total)	2.7E-03	1.5E+03	TEEL	No	9.0E-05	1.6E-04 (2)	No	**Yes**
Chromium VI	8.1E-04	2.9E-02	AAQG	No	2.7E-05	2.3E-05	**Yes**	**Yes**
Cobalt	1.0E-03	1.0E+02	TEEL	No	3.5E-05	6.9E-04	No	No

Table 3.1-1

Comparison of Modeled Air Concentrations From Proposed Plant with Health-Based Air Concentrations

(all concentrations in µg/m^3)

Analyte	**Acute Exposures**				**Chronic Exposures**			
	Maximum 24-hour	**Health-Based Acute Concentration**	**Source of Health-based conc.**	**Maximum 24-hour Value Exceeds Risk-Based Acute Value?**	**Annual Average**	**Risk-Based Chronic Concentration (PRG)**	**Maximum Annual Average Value Exceeds Risk-Based Chronic Value?**	**Maximum Annual Average Value Exceeds 1/10th Risk-Based Chronic Value?**
Cumene (isopropylbenzene)	5.4E-05	2.5E+05	AEGL	No	1.8E-06	4.0E+02	No	No
Cyanide (hydrogen)	2.6E-02	3.4E+02	A-REL	No	8.6E-04	3.1E+00	No	No
1,2-Dibromoethane (EDB)	1.2E-05	2.4E-02	AAQG	No	4.1E-07	3.4E-03	No	No
2,4-Dinitrotoluene	2.9E-06	6.0E+02	TEEL	No	9.7E-08	7.3E+00	No	No
Ethylbenzene	9.6E-04	3.5E+03	AAQG	No	3.2E-05	1.1E+03	No	No
Ethyl chloride	4.3E-04	--	--	--	1.4E-05	2.3E+00	No	No
Formaldehyde	2.5E-03	9.4E+01	A-REL	No	8.3E-05	1.5E-01	No	No
n-Hexane	6.9E-04	1.4E+03	AAQG	No	2.3E-05	2.1E+02	No	No
Hydrazine, monomethyl	1.7E-03	3.8E+02	TEEL	No	5.9E-05	4.0E-04	No	**Yes**
Hydrogen Chloride	1.2E+01	2.1E+03	A-REL	No	4.1E-01	2.1E+01	No	No
Hydrogen fluoride	1.5E+00	8.2E+02	AEGL	No	5.2E-02	--	--	--
Isophorone	5.9E-03	--	--	--	2.0E-04	7.1E+00	No	No
Lead	4.3E-03	1.5E+02	TEEL	No	1.4E-04	--	--	--
Manganese and compounds	5.0E-03	8.0E+00	AAQG	No	1.7E-04	5.1E-02	No	No
Mercury (total)	8.5E-04	1.8E+00	A-REL	No	2.9E-05	3.1E-01	No	No
Methylene bromide	1.6E-03	1.5E+03	TEEL	No	5.5E-05	3.7E+01	No	No
Methylene chloride	3.0E-03	1.4E+04	A-REL	No	1.0E-04	4.1E+00	No	No
Methyl ethyl ketone (2-Butanone)	4.0E-03	1.3000E+04	A-REL	No	1.3E-04	5.1E+03	No	No
Methyl methacrylate	2.0E-04	7.0E+04	AEGL	No	6.9E-06	7.3E+02	No	No

Table 3.1-1

Comparison of Modeled Air Concentrations From Proposed Plant with Health-Based Air Concentrations

(all concentrations in μg/m^3)

Analyte	Acute Exposures				Chronic Exposures			
	Maximum 24-hour	**Health-Based Acute Concentration**	**Source of Health-based conc.**	**Maximum 24-hour Value Exceeds Risk-Based Acute Value?**	**Annual Average**	**Risk-Based Chronic Concentration (PRG)**	**Maximum Annual Average Value Exceeds Risk-Based Chronic Value?**	**Maximum Annual Average Value Exceeds 1/10th Risk-Based Chronic Value?**
Methyl tertbutyl ether (MTBE)	3.6E-04	--	--	--	1.2E-05	3.7E+00	No	No
Nickel	2.9E-03	6.0E+00	A-REL	No	9.7E-05	8.0E-03	No	No
Phenol	1.6E-04	5.8E+03	A-REL	No	5.5E-06	1.1E+03	No	No
Acenaphthene	5.2E-06	1.3E+03	TEEL	No	1.8E-07	2.2E+02	No	No
Anthracene	2.1E-06	4.0E+03	TEEL	No	7.2E-08	1.1E+03	No	No
Benz[a]anthracene	8.2E-07	3.0E+02	TEEL	No	2.8E-08	9.2E-03	No	No
Benzo[a]pyrene	3.9E-07	6.0E+02	TEEL	No	1.3E-08	9.2E-04	No	No
Chrysene	1.0E-06	6.0E+02	TEEL	No	3.5E-08	9.2E-01	No	No
Fluoranthene	7.3E-06	1.0E+01	TEEL	No	2.4E-07	1.5E+02	No	No
Fluorene	9.3E-06	2.5E+04	TEEL	No	3.1E-07	1.5E+02	No	No
Indeno[1,2,3-cd]pyrene	6.2E-07	5.0E+02	TEEL	No	2.1E-08	9.2E-03	No	No
Naphthalene	1.3E-04	4.0E+02	AAQG	No	4.5E-06	3.1E+00	No	No
Pyrene	3.4E-06	7.5E+03	TEEL	No	1.1E-07	1.1E+02	No	No
Selenium	1.3E-02	1.6E+00	AAQG	No	4.5E-04	1.8E+01 (1)	No	No
Styrene	2.6E-04	2.1E+04	A-REL	No	8.6E-06	1.1E+03	No	No
2,3,7,8-TCDD (dioxin)	1.5E-10	1.1E-02	AAQG	No	4.9E-12	4.5E-08	No	No
Total PCDD/PCDF	1.8E-08	--	--	--	6.1E-10	4.5E-08	No	No
Tetrachloroethylene (PCE)	4.4E-04	2.0E+04	A-REL	No	1.5E-05	3.2E-01	No	No
Toluene	2.5E-03	3.7E+04	A-REL	No	8.3E-05	4.0E+02	No	No

Table 3.1-1
Comparison of Modeled Air Concentrations From Proposed Plant with Health-Based Air Concentrations
(all concentrations in µg/m^3)

Analyte	Acute Exposures				Chronic Exposures			
	Maximum 24-hour	Health-Based Acute Concentration	Source of Health-based conc.	Maximum 24-hour Value Exceeds Risk-Based Acute Value?	Annual Average	Risk-Based Chronic Concentration (PRG)	Maximum Annual Average Value Exceeds Risk-Based Chronic Value?	Maximum Annual Average Value Exceeds 1/10th Risk-Based Chronic Value?
1,1,1-Trichloroethane	2.0E-04	6.8E+04	A-REL	No	6.9E-06	2.3E+03	No	No
Vinyl acetate	5.3E+01	--	--	No	7.7E-04	2.1E+02	No	No
Xylenes	3.8E-04	2.2E+04	A-REL	No	1.3E-05	1.1E+02	No	No

Notes
-- = not available or not applicable
ug/m^3 = microgram per cubic meter

AEGL = Level 1 acute inhalation exposure guidelines. The airborne concentration of a substance above which it is predicted that the general population, including susceptible individuals, could experience notable discomfort, irritation, or certain asymptomatic nonsensory effects. However, the effects are not disabling and are transient and reversible upon cessation of exposure (NOAA 2001, EPA 2001). Values compiled from http://www.epa.gov/oppt/aegl/chemlist.htm.

A-REL = Acute Reference Exposure Level. The concentration in air at or below which no adverse health effects are anticipated in the general population, including sensitive individuals (CALEPA [California Environmental Protection Agency] 1999, http://www.oehha.ca.gov/air/pdf/acuterel.pdf

ERPG = ERPG-1, level 1 emergency planning guidelines. The maximum concentration in air below which it is believed nearly all individuals could be exposed for up to one hour without experiencing other than mild transient adverse health effects of perceiving a clearly defined objectionable odor (DOE 2001, SCAPA 2001a). Values compiled from http://www.aiha.org/committees/documents/erpglevels.pdf.

TEEL = Level 1, Temporary emergency exposure limits. The maximum concentration in air below which it is believed nearly all individuals could be exposed without experiencing other than mild transient adverse health effects or perceiving a clearly defined odor (DOE 2001, SCAPA 2001b). Values compiled from http://www.eh.doe.gov/chem_safety//teel/TEELs_Rev21A-Table%203.pdf.

PRG = Preliminary Remediation Goal for residential exposures. US EPA Region 9, 2004 (http://www.epa.gov/region09/waste/sfund/prg/index.html)

(1) For these chemicals, no PRG was available, therefore, US EPA Region 3 RBCs were used, USEPA Region 3, 2006 (http://www.epa.gov/reg3hwmd/risk/human/index.htm)

(2) The PRG for total chromium assumes a ratio of 1:6 Cr VI to Cr III, an RBC value based on Cr III alone of 5,500 ug/m ^{3} is not exceeded.

are concentrations that will not result in health risks greater than target health goals if people are exposed to chemicals in soil every day at their home for 30 years.

3.1.2.1 Results of Screening

Of the chemicals shown on Table 2.3-1, only acrolein and arsenic have 50-year soil concentrations that exceed their respective PRGs; and benzene and benzyl chloride are the only volatile organic compounds that have 50-year soil concentrations within one order of magnitude of the PRG. However, for the volatile and semi-volatile organic compounds, 50-year soil concentrations are largely over-estimated because they do not take into account volatilization and biodegradation, both of which would reduce concentrations of these chemicals in the environment over time. Consequently, none of the volatile or semi-volatile organic compounds possibly emitted from the proposed Desert Rock plant would result in 50-year soil concentrations within an order of magnitude of the PRGs if these removal processes (e.g., volatilization) are considered in the calculation of 50-year soil concentrations. Therefore, VOCs and SVOCs are not likely to represent a health risk through the soil exposure pathways, and their selection as COPCs in soil was not warranted, with the possible exception of , monomethyl hydrazine and dioxins. Monomethyl hydrazine in soil was considered for further evaluation because it was selected as a COPC in air, and dioxins in soil was considered for further evaluation because of its potential to bioacculmulate. For the inorganic chemicals, where environmental losses might not be significant, and for monomethyl hydrazine and dioxins (semi-volatile organic compounds) screening of maximum concentrations (2003 meteorological conditions) was conducted against 1/10th of the residential PRGs.

The results of the screening for inorganic chemicals, monomethyl hydrazine, and dioxins are presented on Table 3.1-2. In this screening to select COPCs, baseline conditions were taken into consideration, where available, as presented on Table 3.1-2. Only arsenic and monomethyl hydrazine exceed 1/10th of their PRG (note that monomethyl hydrazine's 50-year soil concentration is overestimated because biodegradation and volatilization were not taken into account). Monomethyl hydrazine and arsenic were selected as COPCs in soil.

As discussed in Section 3.13.3.2 of the main text, arsenic is naturally occurring in soil. The USGS (1984) reported that the geometric mean, arithmetic mean, and range of naturally occurring arsenic (referred to as background concentration) in the western United States is 5.5, 7.0, and <0.1 to 97 mg/kg, respectively. The baseline soil concentration of arsenic in the vicinity of the proposed plant is 3.2 mg/kg, well within the range of naturally occurring arsenic concentrations of soil in the western United States. Plant emissions contribute to only about 28 percent of the 50-year soil concentration for arsenic (as indicated on Table 3.1-2). Over 50 years, the increase in arsenic concentration is small (arsenic concentration increased from 3.2 to 4.1 mg/kg), and cumulative arsenic concentrations in soil would still be within the range of natural background. While proposed facility operations are not expected to increase arsenic concentrations significantly above the concentrations of arsenic currently in the area, arsenic was selected as a COPC in soil. The incremental risk over background related to the deposition of arsenic due to the proposed plant is discussed in Section 3.4.

While the 50-year concentrations for the two bioaccumulative chemicals on Table 3.1-2, mercury and dioxins, are 1,000 times lower than their respective PRGs, they were further evaluated for possible selection as COPCs. As discussed in Section 3.13.3.2 of the main text, mercury, in the form of methyl mercury, has the potential to easily enter the aquatic food chain, and biomagnify on the order of 10,000 to 100,000 times the concentrations found in ambient waters, while mercury in soil is taken up to a lesser degree in terrestrial plants and animals. As shown on Table 3.1-2, the predicted 50-year soil concentration resulting from plant emissions could potentially double the baseline mercury concentration from 0.013 mg/kg to 0.026 mg/kg. In addition, the plant uptake data (presented in Section 2.1.4), indicates that mercury in plant tissues is approximately five to 14 times greater than the baseline mercury

Table 3.1-2

Comparison of Surface Soil Concentrations From Proposed Plant (after 50 years of deposition) with Health-Based Soil Concentrations

CHEMICAL	Baseline Concentration (1)	TOTAL DEPOSITION MAX RATE (2) (mg/m2-year)	Concentration in Surface Soil After 50 Years of Deposition (3) (mg/kg)	Region 9 Residential Soil PRG (mg/kg)	50-Year Soil Concentration Exceeds PRG?	50-Year Soil Concentration Exceeds 1/10th PRG?	50-year deposition as a % of baseline
Inorganic Compounds							
Antimony and compounds	na	4.68E-02	3.90E-02	3.13E+01	No	No	--
Arsenic	3.18E+00	1.07E+00	4.07E+00	3.90E-01	**Yes**	**Yes**	28%
Beryllium and compounds	na	5.47E-02	4.56E-02	1.54E+02	No	No	--
Cadmium and compounds	9.45E-02	1.33E-01	2.05E-01	3.70E+01	No	No	117%
Chromium III	5.89E+00 (4)	6.77E-01	6.45E+00	1.00E+05	No	No	10%
Chromium VI	3.10E-01 (4)	2.06E-01	4.82E-01	3.01E+01	No	No	55%
Cobalt	na	2.60E-01	2.17E-01	9.03E+02	No	No	--
Lead	7.43E+00	1.09E+00	8.34E+00	4.00E+02	No	No	12%
Manganese and compounds	na	1.28E+00	1.07E+00	1.76E+03	No	No	--
Mercury (oxidized/particle bound) (5)	1.33E-02	1.13E-02	2.27E-02	2.35E+01	No	No	71%
Nickel	na	7.29E-01	6.08E-01	1.56E+03	No	No	--
Selenium	3.88E-01	3.38E+00	3.20E+00	3.91E+02	No	No	726%
Semi-Volatile Organic Compounds							
Hydrazine, monomethyl	na	8.76E-02	7.30E-02	1.60E-01	No	**Yes**	--
2,3,7,8-TCDD (dioxin)	na	7.37E-09	6.14E-09	3.90E-06	No	No	--
Total PCDD/PCDF	na	9.07E-07	7.56E-07	--	--	--	--

Notes

(1) Baseline concentrations are the 95UCLs calculated for surface soil samples collected from all of the sampling investigation areas.

(2) Depostion rates are calculated using the highest deposition rates of the three years modeled (2001-2003).

(3) Concentration in soil after 50 years of deposition is calculated as follows. For those chemicals that have no baseline concentration available, baseline concentration is assumed to be 0.

Concentration in soil	Csoil = Cb + [DR x AF x ED /(d x p)]		
		Value	Units
maximum total annual deposition rate	DR	Chemical-specific	mg/m^2-year
averaging factor	AF	0.5	unitless
exposure duration	ED	50	years
soil mixing zone	d	0.02	meters
soil density	p	1500	kg/m^3
baseline soil concentration	Cb	Chemical-specific	mg/kg
Summary Factor [AF x ED /(d x p)] =		**0.833**	

(4) The baseline soil sample was analyzed for total chromium. In most soils, chromium VI represents at most a small percentage of total chromium (less than 5% and typically undetectable). Therefore, it was conservatively assumed that 5 percent of the baseline total chromium concentration in soil of 6.22 mg/kg is chromium VI (0.31 mg/kg), and the remaining concentration in soil (5.89 mg/kg) is chromium III.

(5) Mercury emissions calculated based on BHP coal analysis data which assumes an average coal mercury content of 0.065 ppm. The 161 lb/year of mercury was estimated to distributed as follows: 26.8 lb/year of oxidized / particle bound mercury and 134.2 lb/year of elemental mercury. As discussed in Chapter 4 of the main text, due to its gaseous properties, only a small percentage of the elemental mercury vapor will settle out within 25 kilometers from the plant. Therefore, the deposition of mercury in the oxidized/particle bound form is considered in this evaluation.

PRG: preliminary remediation goals for residential exposures. US EPA Region 9, 2004 (http://www.epa.gov/region09/waste/sfund/prg/index.html)

TCDD: tetrachlorodibenzo(p)dioxin

PCDD/PCDF: polychlorinated dibenzo-p-dioxins/polychlorinated dibenzofurans

mg/kg: milligram per kilogram

mg/m^2: milligram per square meter

kg/m^3: kilogram per cubic meter

N/A: not applicable

na: not available

concentration in soil. Therefore, because of the known bioaccumulation potential of mercury, the results of the baseline soil and plant investigation, and the community concern regarding the potential for mercury bioaccumulation, mercury was selected as a COPC in soil even though the 50-year soil concentration was 1,000 times lower than its PRG.

Dioxins are listed twice on Table 3.1-2, once as the single chemical, 2,3,7,8 tetrachloro- dibenzo(p)dioxin (TCDD), and also as total polychlorinated dibenzo-p-dioxins/polychlorinated dibenzofurans (PCDD/PCDF). The entire dioxin mixture of hundreds of chemicals is included in the total PCDD/PCDF value. However, only TCDD has toxicity information and a PRG is available only for TCDD. There are sixteen additional chemicals in the dioxin group (called congeners) that are considered to have a similar, but lesser, toxicity than TCDD. These 16 individual congeners, plus TCDD, and the amount by which their toxicity is less than TCDD ("toxicity equivalent factors") are shown on Table 3.1-3. The 16 congeners are separately "normalized" to a TCDD toxicity equivalency concentration by multiplying the mass-based analytical results for each of the 16 dioxin congeners by the USEPA's corresponding recommended toxicity equivalency factors (TEFs) (USEPA 2000a) to yield the toxicity equivalence concentrations (TECs) for each congener. Individual TECs are then summed to arrive at a TCDD "equivalent" concentration (TCDDeq). The TEFs established by the World Health Organization (WHO) in 1997 are the most commonly used to estimate TCDDeq concentrations. Because the majority of the 16 toxic congeners have toxicities that are one to four orders of magnitude less that TCDD, and the hundreds of dioxin congeners that do not have TEFs are not evaluated, the toxic concentration of total PCDD/PCDF will be much smaller than the total PCDD/PCDF concentration. Because the 50-year total PCDD/PCDF concentration shown on Table 3.1-2 is less than the PRG for TCDD and because the toxic portion of total PCDD/PCDF will be even smaller, total PCDD/PCDF is not considered a potential health concern even though a PRG is not available for total PCDD/PCDF, nor are individual congener results available to calculate a TCDDeq value. Dioxins are discussed further in the uncertainty section (Section 3.5).

3.1.3 Selection of COPCs in Food Chain Pathways

No screening values are readily available to select COPCs in food chain pathways (i.e., edible plants and livestock). Therefore, predicted 50-year plant tissue concentrations were not used to select COPCs in plants. However, mercury was selected as a COPC in food chain pathways, because of the potential for bioaccumulation, as described above. In addition, while arsenic does not bioaccumulate in the food chain (i.e., increase in concentration in plants and animals), arsenic was selected as a COPC in food chain pathways in the risk assessment to fully address cumulative effects.

The other COPC in soil, monomethyl hydrazine, is a highly degradable chemical and very mobile in soil (ATSDR 1997). According to the ATSDR Toxicological Profile for Hydrazines (1997),

> "*The environmental fate of hydrazine and 1,1-dimethylhydrazine has been well defined (Atkinson and Carter 1984; EPA 1984a; Moliner and Street 1989a, 1989b; Ou and Street 1987a, 1987b; Stone 1989; WHO 1987). These chemicals are highly reactive and degrade readily in environmental media. Thus, they are not likely to be present in air or water and it is not likely that exposure to the general population is of concern.*"

Therefore, monomethyl hydrazine is not expected to remain in soil for any significant amount of time (ATSDR 1997). While monomethyl hydrazine in water may bioconcentrate in aquatic organisms to a moderate degree (ATSDR 1997), because of its high reactivity, the chemical is rapidly degraded in aquatic systems. This property, as well as the low octanol-water partition coefficient of hydrazine, makes food chain bioaccumulation unlikely (ATSDR 1997). Therefore, selection of monomethyl hydrazine as a COPC in food chain pathways is not warranted.

Table 3.1-3
Dioxin Congener Toxicity Equivalency Factors
(Table reproduced from USEPA, 2000a)

Congener	USEPA/87[a]	NATO/89[b]	WHO/97[c]
PCDDs			
2,3,7,8-TCDD	1	1	1
1,2,3,7,8-PeCDD	0.5	0.5	1
1,2,3,4,7,8-HxCDD	0.04	0.1	0.1
1,2,3,7,8,9-HxCDD	0.04	0.1	0.1
1,2,3,6,7,8-HxCDD	0.04	0.1	0.1
1,2,3,4,6,7,8-HpCDD	0.001	0.1	0.01
1,2,3,4,6,7,8,9-OCDD	0	0.001	0.0001
PCDFs			
2,3,7,8-TCDF	0.1	0.1	0.1
1,2,3,7,8-PeCDF	0.1	0.05	0.05
2,3,4,7,8-PeCDF	0.1	0.5	0.5
1,2,3,4,7,8-HxCDF	0.01	0.1	0.1
1,2,3,7,8,9-HxCDF	0.01	0.1	0.1
1,2,3,6,7,8-HxCDF	0.01	0.1	0.1
2,3,4,6,7,8-HxCDF	0.01	0.1	0.1
1,2,3,4,6,7,8-HpCDF	0.001	0.01	0.01
1,2,3,4,7,8,9-HpCDF	0.001	0.01	0.01
1,2,3,4,6,7,8,9-OCDF	0	0.001	0.0001

[a] USEPA, 1987 (from USEPA, 2000a).
[b] NATO/CCMS, 1989 (from USEPA, 2000a).
[c] Van den Berg et al., 1998.

CCMS = Committee on the Challenges of Modern Society
USEPA = United States Environmental Protection Agency
HpCB = heptachlorobiphenyl
HpCDD = heptachlorodibenzo-p-dioxin
HpCDF = heptachlorodibenzo-p-furan
HRA = health risk assessment
HxCB = hexachlorobiphenyl
HxCDD = hexachlorodibenzo-p-dioxin
HxCDF = hexachlorodibenzo-p-furan
IUPAC = International Union of Pure and Applied Chemistry
NATO = North Atlantic Treaty Organization
OCDD = octachlorodibenzo-p-dioxin
OCDF = octachlorodibenzo-p-furan
PCDD = polychlorinated dibenzodioxin
PeCB = pentachlorobiphenyl
PeCDD = pentachlorodibenzodioxin
PeCDF = pentachlorodibenzofuran
TCB = tetrachlorobiphenyl
TCDD = tetrachlorodibenzo-p-dioxin
TCDF = tetrachlorodibenzo-p-furan
WHO = World Health Organization

3.1.4 Summary of COPCs

A total of 4 chemicals were selected as COPCs and were quantitatively evaluated in the risk assessment in at least one media: chromium VI, arsenic, monomethyl hydrazine, and mercury. Only arsenic was selected in all media (air, soil, food chain). The following bullets summarize the rationale for the selection of each of the COPCs, as well as their associated health effects.

- Chromium VI was only selected in air because it readily reduces to trivalent chromium (chromium III), the less toxic valence state of chromium, once in the environment (ATSDR 2000). Therefore, chromium is not expected to remain in the hexavalent state for any significant period of time, and significant exposures to chromium VI in soil and plants are not expected. The predicted 50-year concentration of chromium VI in soil was less than 1/10th of the Region 9 PRG. Inhaling hexavalent chromium can cause irritation to the nose and over the long term may contribute to an increased risk of lung cancer.
- Arsenic was selected as a COPC in air, and was selected in both soil and vegetation. Predicted emissions of arsenic from the proposed plant result in a relatively small increase in existing

arsenic concentrations in soil over the next 50 years, from 3.2 mg/kg to 4.1 mg/kg; however, the existing (baseline) concentration is well above the screening level (this is typical of natural arsenic concentrations and natural concentrations of 3 mg/kg or more in soil are found throughout the U.S.). Thus, while proposed facility emissions would not increase arsenic concentrations in soil substantially above the baseline concentrations and therefore would not cause substantial cumulative impacts, levels are above risk-based screening levels and thus arsenic was selected as a COPC. In addition, while arsenic does not bioaccumulate in the food chain (i.e., increase in concentration in plants and animals), food chain pathways were included in the risk assessment to fully address cumulative effects. Low levels of arsenic can cause a darkening of the skin, and cause warts or corns to appear.

- Long term exposures to inorganic arsenic have been associated with an increased risk of lung cancer, skin cancer, and bladder cancer. Arsenic is considered a human carcinogen.
- Monomethyl hydrazine was selected as a COPC in air and soil, but not food chain pathways, because predicted concentrations were within one order of magnitude of the PRGs for air and soil. The chemical was not selected in food chain pathways because its half life in the environment is very short, and it is not expected to bioaccumulate. Monomethyl hydrazine exposure can result in damage to the liver and kidneys. The chemical is considered an animal carcinogen (benign tumors) with an unknown relevance to humans (i.e., there is no evidence of human carcinogenicity).
- Mercury was selected as a COPC in soil and food chain pathways. The predicted air concentrations of mercury from proposed facility emissions would be approximately 10,000 times below the ambient air PRG for mercury; thus mercury does not present a health risk from inhalation. Mercury was selected as a COPC in soil even though its predicted 50-year soil concentration was 1,000 times lower than the PRG, because of its potential to bioaccumulate. After absorption into living tissue it is metabolized to a more toxic form, methyl mercury. Therefore, mercury was also selected as a COPC in the food chain pathways. The toxic effects of mercury are damage to the brain, kidneys, and developing fetus. Children exposed to mercury in utero can be born with brain damage and older children can develop problems with their nervous and digestive systems, and have kidney damage if exposed to mercury concentrations in excess of safe levels.

Table 3.1-4 summarizes the results of the screening process to select COPCs.

Table 3.1-4
Summary of Chemicals of Potential Concern

Chemical of Potential Concern	Air	Soil	Food Chain
Chromium VI	X		
Arsenic	X	X	X
Mercury		X	X
Monomethyl Hydrazine	X	X	

3.2 EXPOSURE ANALYSIS

This section evaluates sources, pathways, receptors, exposure duration and frequency, and routes of exposure to assess total human exposure to the proposed plant emissions. The goal of this section is to calculate a dose of chemical that each receptor might contact for each COPC and exposure pathway combination. Three elements are required to calculate a dose: first, a CSM must be developed that identifies complete pathways for exposure of receptor populations to COPCs; second, estimates of media concentrations at the exposure point (the point of contact between the COPC and receptor) must be developed; and third, factors must be selected that quantify the amount of exposure. The combination of media concentrations and exposure factors result in the dose estimates for each chemical.

3.2.1 Conceptual Site Model

A CSM portrays the sources of chemicals at a site, their release and transfer through environmental media (e.g., soil and air), and the points and means by which human populations might contact the chemicals. The CSM was developed in Section 3.13.4 of the main text. This section refines the CSM discussed in Section 3.13.4 of the main text and provides a brief description of which environmental media have the potential to be impacted by plant emissions, a brief description of the site's land uses, and a characterization of the exposed populations under both current and future conditions, as is required by USEPA guidance (USEPA 1989).

The goal of the CSM is to provide an understanding of where the plant-related chemicals could be present, so that the populations that could encounter the chemicals can be identified. The pathways of exposure for these populations can then be selected for a quantitative evaluation of health risks. The sections that follow describe the CSM and identify exposure pathways.

3.2.1.1 Affected Media and Land Use

The following media have the potential to be affected by the proposed plant's emissions.

- Air
- Surface Soil
- Plants
- Livestock
- Surface Water/Sediment

As noted above, the proposed plant will emit chemicals directly into the air. In addition, airborne chemicals from plant emissions would be deposited on the soil in the surrounding area throughout the operational life of the plant. Plants growing in impacted soil have the potential to uptake chemicals directly from the soil into their root and leaf systems. Likewise, grazing animals could also be impacted because they could ingest the plants from these potentially impacted areas. Surface water and sediment could potentially be impacted via deposition and/or runoff; however, because of the ephemeral nature of the streams in the vicinity of the proposed plant (including Chaco River), the long distance to the nearest permanent water bodies, and the low amount of rainfall in the area, these media are not considered to be significantly impacted.

Section 3.13.4 of the main text detailed the current land use in the area of the proposed plant. The proposed power plant site and the majority of the land within 31 miles (50 km) is Navajo Indian Reservation land. Land use in the immediate vicinity of the proposed site is primarily open range used for the grazing of livestock (sheep, goats, cattle, and horses) (refer to Section 3.4 for land use within 0.5 mile of the proposed plant). The Navajo Nation and BIA have indicated that future land use in this vicinity will continue to be primarily grazing of domestic livestock. The nearest agricultural land to the proposed plant is land farmed by the NAPI. The nearest NAPI land is located approximately 2 miles east and slightly north of the proposed power plant site, and NAPI land extends in that direction to the San Juan River.

Morgan Lake (about 15 miles north of the proposed power plant site) is the nearest recreational area. Human development close to the proposed power plant is limited to a few scattered residences and dirt or gravel roads. Only about 75 people were identified as living within 7 miles of the site. The nearest residential area is the town of Burnham, home to about 50 families, located approximately 10 miles southeast of the proposed power plant.

The bulk of the population in the area is located north of the proposed plant site in the towns of Shiprock, Kirtland, Fruitland, and Farmington along U.S. Highway 64 approximately 20 to 35 miles (32 to 56 km) from the proposed plant. According to USEPA (USEPA 2005), the primary effects of emissions from power plants are generally limited to within 10 km of the plant. Therefore, the population of concern with regards to emissions from the proposed plant are people living within 10 km of the proposed facility.

At this site, there are no population centers, developed recreational areas, or major water resources (e.g., the San Juan River) within 10 km of the proposed plant site. However, two recreational fishing water bodies are present within the 50 km air quality study area: Morgan Lake and the San Juan River. Air concentrations from plant emissions and deposition rates decrease significantly with increasing distance from the proposed plant site. The San Juan River and Morgan Lake are located at distances greater than 10 km from the plant (28 km and 22 km, respectively). Therefore, water quality of Morgan Lake and the San Juan River are not expected to be significantly impacted by atmospheric deposition from the proposed plant operations and recreational fishers consuming fish caught from these water bodies were not selected as a population of concern.

Local mercury data are available for the San Juan River (see Table 3-9 of the main text). The maximum reported total mercury concentration in the San Juan River of 1.6 ug/L is below the Federal MCL for mercury of 2 ug/L, and the maximum dissolved mercury concentration in the San Juan River of 0.3 ug/L is below the chronic AWQC of 0.7 ug/L. As discussed in Section 4.2, it is estimated that the proposed power plant could release up to 161 pounds of mercury per year through air emissions.), of which approximately 26.8 pounds would be deposited within 25 kilometers of the site, the rest either removed from the emissions via control technologies or emitted as mercury vapor which would not deposit locally (see Section 4.1). Due to the uncertainties involved, it is not possible to estimate how much of the deposited mercury might reach the San Juan River through erosion and surface water runoff. However, due to the fact that the river is further away than 25 kilometers, and the majority of the deposition occurs within 1 kilometer of the plant, a significant contribution of mercury to the San Juan River is unlikely.

.According to information presented in *Methylmercury and Other Environmental Contaminants in Water and Fish Collected from Four Recreational Fishing Lakes on the Navajo Nation, 2004* (USFWS 2005), selenium concentrations in fish from Morgan Lake may pose health risks to people that consume a large amount of fish from the lake. However, the average dissolved selenium concentration measured in Morgan Lake was 1.0 μg/L (USFWS 2005). This is substantially lower than the USEPA chronic water quality criterion of 5.0 μg/L (total) (USEPA 2006) and lower than the Navajo Nation Aquatic Habitat Criterion of 2.0 μg/L as listed in USFWS (2005). Morgan Lake is located 22 km from the proposed plant; it is well beyond 1 km (where the maximum modeled deposition rates are expected) and beyond 10 km (where USEPA [2005a] states that the greatest impacts are expected). Because selenium concentrations in Morgan Lake are substantially lower than water quality criteria and Morgan Lake is located well outside the area where maximum particulate deposition is expected, impacts to selenium concentrations in the lake are expected to be insignificant.

In conclusion, no permanent surface water bodies in the vicinity of the proposed plant are expected to be impacted by deposition of particulates because these water bodies are at least 22 km away from the proposed plant and current concentrations of the metals of interest are well below chronic water quality criteria. Therefore, these water bodies are not expected be significantly impacted by the proposed plant site operations. While the water quality criteria do not specifically take into account the bioaccumulation potential of mercury in fish tissues, the San Juan River and Morgan Lake are currently under fish consumption advisories due to chemical contributions from other source areas unrelated to the proposed plant. The fish consumption advisories recommend that some consumers limit their intake of fish caught from these waters. The San Juan River fish consumption advisory was issued due to mercury contamination in fish tissues.

The Morgan Lake fish consumption advisory was issued due to selenium contamination in fish tissues. Based on the surface water evaluations (Sections 3.2 and 4.2 of the main text), contributions of selenium and mercury from the proposed plant to these two water bodies would be insignificant. Likewise, the subsequent potential uptake of mercury into fish tissues from the proposed plant operations would be additive but potentially insignificant relative to contributions from other source areas unrelated to the proposed plant.

3.2.1.2 Selected Populations

Based on the site's current and potential future land use, there are four categories of human populations that could encounter chemicals from the proposed facility. These four categories would be exposed to the same concentrations of chemicals but their duration of exposure would be different and they could be exposed to differing types of media (e.g., some people might just inhale chemicals in air while other could inhale chemicals in air and also eat local plants that contained chemicals). The four broad exposure categories are as follows:

- Occupational Exposures (adults only) – exposures to chemicals encountered by those who work within the study area boundaries but may live outside the boundaries;
- Residential Exposures (adults and children) – exposures to chemicals encountered by those who live within the study area boundaries;
- Recreational Exposures (adults and children) – exposures to chemicals encountered by those who are pursuing recreational activities within the study area boundaries but may live elsewhere; and
- Food Chain Exposures (adults and children) – exposures to chemicals in plants and animals harvested from within the study area.

3.2.1.3 Identification of Exposure Pathways

Several possible pathways of exposure may exist at this site. An exposure pathway is the mechanism by which a receptor (human) is exposed to chemicals from a source. The following four elements constitute a complete exposure pathway:

- A source and mechanism of chemical release;
- A retention or transport medium (e.g., soil);
- A point of potential human contact with the affected medium; and
- A means of entry into the body (e.g., ingestion) at the contact point.

Only complete pathways containing all four elements result in exposures. However, in some circumstances, an exposure pathway may be considered complete (i.e., meet all four of the elements) but insignificant. An exposure pathway is considered complete but insignificant if one or more of the following three conditions are met (USEPA 1989).

1. The exposure resulting from the pathway is much less than the exposure resulting from another pathway involving the same medium.
2. The potential magnitude of exposure from the pathway is low or of limited toxicological importance.
3. The probability of the exposure occurring is very low, and the risks associated with the occurrence are not high.

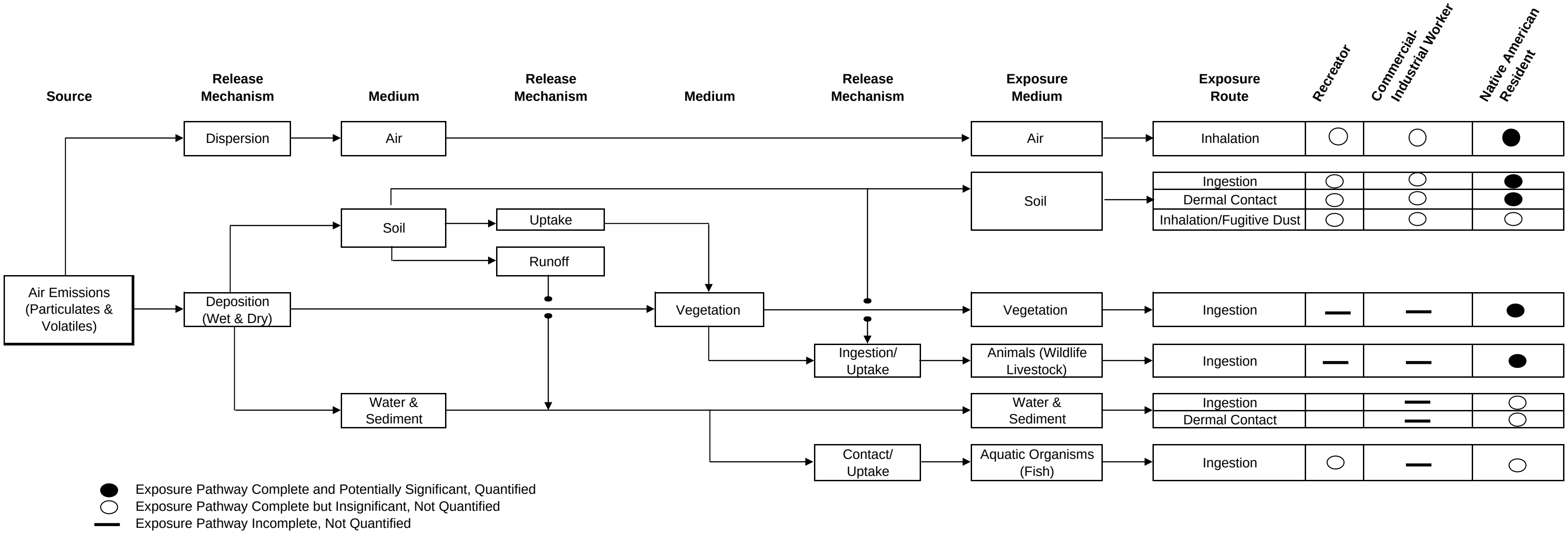
Only complete and significant pathways of exposure are quantitatively evaluated in this risk assessment. Complete but insignificant pathways of exposure generally do not require quantitative evaluation but are discussed qualitatively. The schematic CSM presented as Figure 3-19 of the main text was refined to show which complete pathways were evaluated quantitatively and which were addressed qualitatively. This revised CSM is presented as Figure 3.2-1.

Three current and future exposure pathways considered for characterization are discussed in more detail hereafter.

Inhalation of Airborne Contaminants and Contact with Soil by Workers. Adults who work within the study area boundary may be exposed to air toxics from proposed plant operations through inhalation of air toxics emitted directly from the plant or through contact with chemical deposition in surface soil. However, the USEPA's C*ombustion Risk Assessment Guidance* (USEPA 2005) states that the typical exposure area associated with power plant operations is generally within 10 km of the site, because the greatest impact from plant emissions would be expected to occur within 10 km of the site. There are currently no occupational populations within 10 km of the site, and none are expected in the future. In addition, as discussed in subsequent sections, residential exposures to airborne contaminants and impacted soil were evaluated in this assessment. Occupational activities typically occur 5 days per week for 25 years, and residential exposures were assumed to occur daily for an entire lifetime (70 years). Thus residential populations would have a much more intensive and longer contact with airborne contaminants and impacted soil. Therefore, evaluation of residential exposures is expected to yield a more conservative assessment of potential risks to human health resulting from the proposed plant operations, and evaluation of occupational exposures was not considered warranted. However, should risks and hazards calculated for residential exposures indicate a potential threat to human health, potential risks to occupational populations will be discussed in the uncertainty section of the risk assessment.

Contact with Surface Water, Sediments, and Fish by Recreational Populations. Child and adult populations could potentially come into contact with contamination related to the proposed plant's operations through recreational activities. However, no permanent surface water bodies in the vicinity of the proposed plant are expected to be impacted by deposition of particulates because these water bodies are at least 22 km away from the proposed plant and current concentrations of the metals of interest are well below chronic water quality criteria. Therefore, these water bodies are not expected be significantly impacted by the proposed plant site operations. While the water quality criteria do not specifically take into account the bioaccumulation potential of mercury in fish tissues, the San Juan River and Morgan Lake are currently under fish consumption advisories due to chemical contributions from other source areas unrelated to the proposed plant. The fish consumption advisories recommend that some consumers limit their intake of fish caught from these waters. The San Juan River fish consumption advisory was issued due to mercury contamination in fish tissues. The Morgan Lake fish consumption advisory was issued due to selenium contamination in fish tissues. Based on the surface water evaluations (Sections 3.2 and 4.2 of the main text), contributions of selenium and mercury from the proposed plant to these two water bodies would be insignificant. Likewise, the subsequent potential uptake of mercury into fish tissues from the proposed plant operations would be additive but potentially insignificant relative to contributions from other source areas unrelated to the proposed plant. Therefore, recreational exposures to site-related contamination is considered insignificant and will not be quantitatively evaluated.

Conceptual Site Model -- Air Emissions
Human Health Risk
Desert Rock EIS



Inhalation of Airborne Contaminants and Contact with Soil by Residential Populations. Human residential development close to the proposed power plant is limited to a few scattered residences served by dirt or gravel roads, located outside the area where the maximum air concentrations are predicted (approximately 0.3 km from the proposed plant fence line). For this small population, it was assumed that child and adults may be exposed to air toxics from the proposed plant operations through inhalation of air toxics emitted directly from the plant and through contact with chemical deposition in surface soil. Thus, residential exposure pathways to these media are both complete and potentially significant for inhalation of airborne air toxics and incidental ingestion and dermal contact with air toxics deposited in surface soil, and will be quantitatively evaluated in the risk assessment. The inhalation of re-suspended dust from soil, while a complete exposure route, is considered insignificant and will not be quantified. The dust re-suspension exposure route is insignificant for metals and SVOCs (the COPCs in soil) in comparison to the ingestion and dermal pathways (USEPA 2002a).

Ingestion of Plants and Livestock by Residential Populations. Land use in the immediate vicinity of the proposed plant is Navajo Indian Reservation land and is primarily open range (un-irrigated) used for the grazing of livestock (sheep, goats, cattle, and horses). The NAPI has approximately 68,000 acres of agricultural land in cultivation, at least half of which is within 31 miles (50 km) (NAPI 2006); however, only a small portion of this area is within 10 km of the proposed facility. Wheat, barley, small grains, alfalfa, potatoes and corn are grown by the NAPI. NAPI wheat from within the “wet deposition” area was sampled during the field investigation (locations WD-5 and WD-6 located approximately 16 km from the proposed facility, no crops were available for sampling within the 10 km range, see Figure 2-1). NAPI products are distributed throughout the country and are also found in local grocery stores.

In addition to agricultural crops, the Navajo people use some of the local native flora for foods, as well as for medicinal and ceremonial purposes. Air toxics emitted from the proposed plant could be deposited directly onto plants. In addition, plants growing in impacted soil have the potential to take up chemicals in soil through their root systems. Livestock grazing in the vicinity of the proposed plant have the potential to take up chemicals through the ingestion of contaminated plants and incidental ingestion of soil while grazing. Some cattle were observed grazing on NAPI wheat during the field investigation. Therefore, ingestion of plants and livestock by child and adult residential populations is considered a complete and potentially significant pathway, and will be quantitatively evaluated.

Ingestion of plants will be quantified for two separate scenarios: ingestion of cultivated wheat used for breads and cereals as a surrogate for all cultivated, irrigated plants (eaten as a regular part of the diet), and ingestion of local native plants used for medicinal purposes and during ceremonial activities.

3.2.2 Exposure Point Concentrations

An estimate must be made of the chemical concentration to which an individual may be exposed in order to calculate a cancer risk or a non-cancer hazard; that estimate is the exposure point concentration (EPC), and it is the chemical concentration in an environmental medium at the point of contact with a receptor. For this assessment, we are concerned with potential contamination that may result from the proposed plant operations. Therefore, the EPCs used to estimate the potential future risks and hazards to human health are based upon model predicted air emission and deposition data. The model results are conservative in their estimation, and err on the side of over-predicting rather than under-predicting actual plant emissions. Therefore, the EPCs used in this assessment are to be considered the maximum potential exposure a receptor would be expected to encounter and actually largely overestimate the actual concentrations that would result from the proposed plant. Section 2 of this appendix discussed the data available for use in the risk assessment. Section 2.2, Section 2.3 and Section 2.4 describe the methods used to model concentrations in air, soil, and plants, respectively.

The following subsections present the data used to calculate EPCs for each of the exposure medium. Table 3.2-1 summarizes the EPCs used in the risk calculations for each media.

3.2.2.1 Air

The proposed plant will emit chemicals directly into the air. Maximum annual average air concentrations estimated using 2003 meteorological data, as described in Section 2.2 above, were used for EPCs in air as those concentrations were the highest for the three years of meteorological data evaluated. According to the USEPA (1992a, 1997a, 2002b), the EPC should be an estimate of the average concentration to which an individual would be exposed over a significant part of a lifetime. Therefore, the maximum annual average air concentrations were used to assess daily exposures to air toxics in ambient air, rather than the maximum 24-hour air concentrations, because the maximum annual averages are the most reasonable maximum exposures residents could be expected to be encounter everyday for a lifetime of exposure. These predicted air concentrations are the maximum annual average concentrations of the air toxics that the plant is expected to emit, and are generally located in very close proximity to the proposed plant site. Therefore, they likely significantly overestimate the air concentrations for the majority of the residential populations in the area, because the nearest residential populations are located at greater distances from the proposed plant site. Table 3.2-1 summarizes the EPCs used for the COPCs selected in air.

Table 3.2-1
Summary of EPCs Used in the Human Health Risk Calculations

Chemical of Potential Concern in Surface Soil	Air EPC (ug/m^3)	Soil EPC (mg/kg)	Plant/Wheat EPC (mg/kg)	Beef EPC (mg/kg)
Chromium VI	2.4E-05	Not a COPC in this medium	Not a COPC in this medium	Not a COPC in this medium
Mercury	Not a COPC in this medium	0.023	0.17 / 0.041	0.0014
Arsenic	1.3E-04	4.07	1.1 / 0.017	3.2E-5
Monomethyl Hydrazine	5.2E-05	0.073	Not a COPC in this medium	Not a COPC in this medium

3.2.2.2 Surface Soil

Surface soil EPCs are the 50-year surface soil concentrations estimated using the predicted deposition rates for the air toxics, as described in Section 2.3 above. Baseline surface soil concentrations were added to the predicted 50-year surface soil concentration resulting from deposition for mercury, the only COPC in soil where baseline data are available. Table 3.1-2 details the calculation of the 50-year surface soil concentrations. Baseline surface soil concentrations were calculated using the 95 percent upper confidence limit (95UCL) of the combined surface soil data from all three of the areas for which baseline soil data were collected (See Section 2.1 and Attachment 2). Using a 95UCL of the mean ensures that the true mean is most likely to be less than the value used in the calculations, and baseline conditions are thereby health protective. This equation used to estimate the 50-year surface soil concentration largely overestimates the actual concentrations expected in surface soil, as described in Sections 2.1 and 2.3, above. See Table 3.2-1 for summaries of the EPCs used for the COPCs selected in surface soil.

3.2.2.3 Plants and Livestock

Concentrations of COPCs in soil have been estimated based on the predicted deposition rates. The concentrations in soil were used to estimate concentrations in plants and cattle beef via modeling using biouptake factors, as described below.

Plants. Section 2.4 described the process used to calculate plant concentrations using the baseline soil and plant concentrations to calculate a BCF and the 50-year soil concentrations, combined with the BCF to predict 50-year plant concentrations. BCFs were calculated for arsenic and mercury with each plant (five genera) and plant part (roots or stems/leaves), as described in Section 2.1.4. These BCFs were then combined with predicted 50-year soil concentrations to estimate the concentration of mercury in plant leaves and roots over 50-years, as summarized on Table 3.2-2. The 50-year soil concentrations used in these calculations were calculated in the same manner as described above in Section 3.2.3.2 except the undisturbed surface soil mixing depth default of 2 cm was adjusted as follows:

- For native/wild plants, a mixing depth of 10 cm was used because root uptake would be occurring at that depth.
- For cultivated plants (wheat used as the surrogate for cultivars), a mixing depth of 20 cm USEPA's default for tilled soils, was used (USEPA 2005).

Plant ingestion exposures are quantified for two different scenarios: ingestion of wheat, primarily as bread (surrogate for all cultivars in the NAPI area) and ingestion of other local flora used for medicinal or ceremonial purposes. Therefore, two separate EPCs were calculated, one for wheat and one for other plants. The BCF for mercury specific to wheat was used to calculate the EPC for mercury in wheat based on the 50-year concentration of mercury in soil (note that the 50-year soil concentration is based on the maximum wet deposition rate which occurs much closer to the proposed facility than the wheat field). Because both humans and livestock are only expected to consume the above-ground portion of the wheat plant, the EPC for wheat is based on the concentration calculated for the above-ground portion of the plant.

The EPC for plants other than wheat used for medicinal and ceremonial purposes was calculated using the 90th percentile of all the BCFs calculated for the four species of native plants sampled. As shown on Table 3.2-2, the 50-year concentrations estimated for mercury in plant roots is greater than the concentrations estimated for the above-ground portion of the plant. Therefore, the 50-year concentration for plant roots was conservatively selected as the EPCs for plants other than wheat, because according to the Navajo people, all parts of the plants have the potential to be used, whether as teas and spices, or for medicinal or ceremonial purposes.

Use of the BCFs as described in Section 2.1.4 results in plant tissue concentrations in dry weight. However, wet weight tissue concentrations are more appropriate for evaluating human exposures to the other plants, because it is assumed that the plants will not be dried before consumption. Therefore, the plant tissue concentrations were converted to wet weight using the measured percent moisture data, as shown on Table 3.2-2.

Beef. For this site, the equations estimating beef concentrations from soil concentrations were obtained from Oak Ridge National Laboratory's (ORNL) online risk assessment database (http://risk.lsd.ornl.gov/prg/equations/ag_bef_bcs.shtml). The ORNL online database is part of the Toxicology and Risk Analysis Section, in the Life Sciences Division at ORNL. ORNL is a U.S. Department of Energy multi-program laboratory and its risk information database is routinely used on a wide variety of public and private sector risk assessment projects. Beef consumption should be considered a surrogate for other livestock (e.g., sheep and goats) that may be eaten. Beef is used because beef consumption is usually greater than for other livestock and because equations that model the chemical uptake in animals are primarily developed for cattle. The equations and equation inputs are presented on Table 3.2-3. The end result of the calculations on Table 3.2-3 is an estimate of the concentration in beef muscle tissue (generally only muscle tissue is consumed by humans).

Table 3.2-2
Calculation of 50-Year Plant Tissue Concentrations

CHEMICAL	TOTAL DEPOSITION MAX RATE (1) (mg/m2-year)	Baseline Concentration in Soil Column (0 to 10cm)	Concentration in Soil After 50 Years of Deposition (2) (mg/kg)	Current Plant Uptake Factor - Plant Uppers	Concentration in Plant Uppers After 50 Years of Deposition (3) (mg/kg)		Current Plant Uptake Factor - Plant Roots	Concentration in Plant Roots (wet weight) After 50 Years of Deposition (3) (mg/kg)	
					Dry weight	**Wet weight**		**Dry weight**	**Wet weight**
Plants other than wheat, Untilled Soil									
Arsenic (Cumulative 50 year concentration)	1.1E+00	3.90E+00	4.1E+00	0.34	1.4	0.55	0.79	3.22	1.84
Arsenic (50 year concentration due to deposition only)	1.1E+00	0.00E+00	1.8E-01	0.34	0.1	0.02	0.79	0.14	0.08
Mercury	1.13E-02	1.93E-02	2.12E-02	8.9	0.19	0.075	14	0.30	0.17
Wheat, Tilled Soil									
Arsenic (Cumulative 50 year concentration)	1.1E+00	3.90E+00	4.0E+00	0.024	0.10	0.038	na	na	na
Arsenic (50 year concentration due to deposition only)	1.1E+00	0.00E+00	8.9E-02	0.024	0.0021	0.00086	na	na	na
Mercury	1.13E-02	1.93E-02	2.02E-02	5.1	0.10	0.041	na	na	na

Notes

(1) Depostion rates are calculated using the highest deposition rates of the three years modeled (2001-2003). As discussed in Chapter 4 of the main text, due to its gaseous properties, only a small percentage of the elemental mercury vapor will settle out within 25 kilometers from the plant. Therefore, the deposition of mercury in the oxidized/particle bound form is considered in this evaluation.
(2) Concentration in soil after 50 years of deposition is calculated as follows.

Concentration in soil	Csoil	= Cb + [DR x AF x ED /(d x p)]	
		Value	Units
maximum total annual deposition rate	DR	Chemical-specific	mg/m^2-year
averaging factor	AF	0.5	unitless
exposure duration	ED	50	years
soil mixing zone (untilled soil)	d	0.1	meters
soil mixing zone (tilled soil	d	0.2	meters
soil density	p	1500	kg/m^3
baseline soil concentration	Cb	Chemical-specific	mg/kg
Summary Factor (untilled soil) [AF x ED /(d x p)] =		**0.167**	
Summary Factor (tilled soil) [AF x ED /(d x p)] =		**0.083**	

(3) Wet weight plant concentrations were calculated by applying the 90th percentile of the measured percent moisture (60% for plant uppers and 43% for plant roots) as follows:
Wet Weight = Dry Weight x [(100 - % moisture) /100)].

mg/kg: milligram per kilogram
mg/m^2: milligran per square meter
N/A: not applicable
na: not applicable

In general, ORNL default values were used for the beef parameters. The default values were developed for use in Department of Energy's PRGs and represent health-protective estimates of the amount of chemical that would end up in beef tissue. Four of the parameters were modified based on site-specific or the latest scientific knowledge of mercury as presented by USEPA. The three changes to ORNL defaults are:

- Fraction of year animal is on site. The ORNL default for this value is one year. However, pasturage would only occur when good forage is available. For this assessment, 6 months, or 0.5 of a year, was assumed, because wheat is not a plant that lives all year round. Therefore, during the months when wheat plants die back, cattle are expected to graze elsewhere.
- Soil-to-plant uptake. Plant uptake factors were calculated for the native vegetation in the area, as discussed in Section 2.1.4. The uptake factor calculated for mercury in the upper portion of the wheat plant (the only plant that cattle are expected to graze on) of 5.1 was used in the calculations.
- Concentration in Plant. The predicted concentration of mercury in above-ground wheat over 50-years of plant operations was used (Table 3.2-2). The wet weight mercury concentration in wheat was used, because cattle will be consuming the wheat straight from the field (See discussion for plant EPCs above).
- Soil ingestion rate by cattle. The ORNL default value for this rate is 1 kg/day; however, they acknowledged that an ingestion rate of 0.3 kg/day to 0.5 kg/day would be reasonable (http://rais.ornl.gov/homepage/bjcor27/appf.shtml). Two recent USEPA documents recommend a default value of 0.5 kg/day as an upper-bound soil ingestion rate for cattle (about 4% of their total intake; USEPA 2000b, 2005). Therefore, a soil ingestion rate of 0.5 kg/day was used in the calculations on Table 3.2-3.

Arsenic EPCs in Plant and Beef Tissue for Human Consumption. The concentrations of arsenic presented on Tables 3.2-2 and 3.2-3 in plants and beef tissue, respectively, were further adjusted in the derivation of the EPC for human consumption of plants and beef. The toxicity of arsenic is based primarily on inorganic arsenic; however, once in living tissue, some of the total arsenic is metabolized to relatively non-toxic organic forms. The estimate of the amount of total arsenic that is inorganic has been well studied in seafood where total arsenic concentrations may be orders of magnitude greater than the amount present in the inorganic form (USEPA 2003). Consequently, total arsenic concentrations in seafood are routinely adjusted downwards in risk assessment to avoid inappropriate overestimation of health risks (USEPA 2003). Terrestrial foods have been less studied than aquatic organisms, but the available data indicate that terrestrial foods may contain higher percentages of inorganic arsenic than seafood, depending on the types of food; however, for the majority of foods, the assumption of 100 percent of total arsenic in the inorganic form is an overestimate of inorganic arsenic in terrestrial foods (Schoof et al, 1999; Yost et al, 1998). A review of two papers found some produce having as little as 9 percent of its arsenic content in the inorganic form, and meats and dairy had even lower percentages (Schoof et al, 1999). In the absence of site-specific speciated arsenic data and acknowledging that the types and amounts of produce consumed will vary between individuals, the average amounts of inorganic arsenic found in grains, vegetables, and cattle of 45 percent, 60 percent, and 1 percent, respectively (from values presented in Schoof et al, 1999 and Yost et al, 1998) were used to adjust the total arsenic EPC values to represent the amount of arsenic in plants and animals that is inorganic. These adjusted EPCs are presented on Table 3.2-1 and were used in the risk calculations detailed in Attachment 3. The amount of inorganic arsenic in plants and animals is an area of uncertainty and amounts could vary from the percentages used here.

Table 3.2-3
Mercury Beef Tissue Modeling
(From Soil and Plant Concentrations to Beef)

Chemical	Cs (mg/kg)	Cp (mg/kg)	F (day/kg)	Cb (mg/kg)
Arsenic (Cumulative 50 year concentration)	4.07E+00	3.83E-02	2.00E-03	3.18E-03
Arsenic (50 year concentration due to deposition only)	8.92E-01	8.56E-04	2.00E-03	6.48E-04
Mercury	2.27E-02	4.13E-02	1.00E-02	1.42E-03

Notes:
All values, except site-specific data and the assumptions for soil ingestion, were obtained from Oak Ridge National Laboratory's (ORNL) online database;
web address: http://risk.lsd.ornl.gov/prg/equations/ag_bef_bcs.shtml. See equations and table below.

Equations from ORNL website:

Cb = F x [(Cp x Qp x fp x fs) + (Cs x Qs x fp)+(Cs x MLF)]

Factor	Definition	Units	Value	Source
Cb	chemical concentration in beef muscle tissue	mg/kg	calculated	ORNL
F	beef transfer coefficient	day/kg	chemical-specific	ORNL
Cp	chemical concentration in pasture plants	mg/kg	chemical-specific	site-specific
Qp	quantity of pasture ingested	kg/day	7.2	ORNL
fp	fraction of year animal on site	unitless	0.5	site-specific
fs	fraction of animal's food from site	unitless	0.9	ORNL
Cs	chemical concentration in soil	mg/kg	chemical-specific	site-specific
Qs	quantity of soil ingested	kg/day	0.5	USEPA 1998
MLF	plant mass loading factor	unitless	0.11	ORNL (default value for non-leafy plants)

3.2.3 Calculation of Chemical Dose

This section defines the magnitude, frequency, and duration of exposure for the populations and pathways selected for quantitative evaluation.. Doses were calculated using a combination of upperbound and average values that reflect exposures somewhere between the 90th and 98th percentile of the range of possible exposures that reasonably can be expected to occur at the site for a given population. The formulas and exposure factors that were used together with the EPC to quantify doses for the complete pathways at this site are presented in Table 3.2-4 through Table 3.2-7; the tables also indicate the sources of the factors.

Table 3.2-4

Exposure Assumptions And Intake Equations for Residential Exposures to Air

Equations:

$$\text{Chemical intake (mg/kg-day)} = CA \bullet SIF$$

$$SIF_{inh\text{-}nc} = \frac{InhRc \bullet EF \bullet EDc \bullet CF}{BWc \bullet ATnc}$$

$$SIF_{inh\text{-}ca} = \frac{[(InhRc \bullet EDc / BWc) + (InhRa \bullet EDa / BWa)] \bullet EF \bullet CF}{ATca}$$

Where:

$SIF_{inh\text{-}nc}$ (day^{-1}) = summary intake factor for inhalation from affected media-noncarcinogenic effects

$SIF_{inh\text{-}ca}$ (day^{-1}) = summary intake factor for inhalation from affected media-carcinogenic effects

Parameter	Definition	RME Value	Units	Source
ATca	Averaging time for carcinogenic effects	25,550	days	Default value (USEPA 1991,1993,2004a)
ATnc	Averaging time for noncarcinogenic effects	ED x 365 days/year	days	Default value (USEPA 1991,1993,2004a)
BWa	Body weight-adult	70	kg	Default value (USEPA 1991,1993,2004a)
BWc	Body weight-child	15	kg	Default value (USEPA 1991,1993,2004a)
CF	Conversion factor	1.00E-03	Mg/ug	Not applicable
CA	Chemical concentration in air	chemical-specific	ug/m^3	Modeled value
EDa	Exposure duration-adult	64	years	Site-specific
EDc	Exposure duration-child	6	years	Default value (USEPA 1991,1993,2004a)
EF	Exposure frequency	365	Days/year	Site-specific
InhRa	Inhalation rate - adult	20	m^3/day	Default value (USEPA 2004a)
InhRc	Inhalation rate -child	10	m^3/day	Default value (USEPA 2004a)

cm^2 = square centimeter
derm = dermal
ing = ingestion
inh = inhalation
kg = kilogram
L = liter
m^3 = cubic meter
mg = milligram
SIF = summary intake factor

Table 3.2-5

Exposure Assumptions and Intake Equations for Residential Exposures to Surface Soil

Equations:

$$\text{Chemical intake (mg/kg-day)} = CS \bullet SIF$$

$$SIF_{ing\text{-}nc} = \frac{IRc \bullet CF \bullet EF \bullet EDc}{BWc \bullet ATnc}$$

$$SIF_{ing\text{-}ca} = \frac{[(IRc \bullet EDc / BWc) + (IRa \bullet EDa / BWa)] \bullet EF \bullet CF}{ATca}$$

$$SIF_{derm\text{-}nc} = \frac{CF \bullet SAc \bullet AFc \bullet ABS \bullet EF \bullet EDc}{BWc \bullet ATnc}$$

$$SIF_{derm\text{-}ca} = \frac{[(SAc \bullet AFc \bullet EDc / BWc) + (SAa \bullet AFa \bullet Eda / BWa)] \bullet ABS \bullet EF \bullet CF}{Atca}$$

Where:

$SIF_{ing\text{-}nc}$ (day^{-1}) = summary intake factor for ingestion of sediment-noncarcinogenic effects
$SIF_{ing\text{-}ca}$ (day^{-1}) = summary intake factor for ingestion of sediment-carcinogenic effects
$SIF_{derm\text{-}nc}$ (day^{-1}) = summary intake factor for dermal contact with sediment-noncarcinogenic effects
$SIF_{derm\text{-}ca}$ (day^{-1}) = summary intake factor for dermal contact with sediment-carcinogenic effects

Parameter	Definition	RME Value	Units	Source
ABS	Absorption factor	chemical-specific	unitless	Exhibit 3-4 in USEPA, 2004b
AFa	Soil to skin adherence factor-adult	0.07	mg/cm^2-day	Default value (USEPA 2004a,b)
AFc	Soil to skin adherence factor-child	0.2	mg/cm^2-day	Default value (USEPA 2004a,b)
ATca	Averaging time for carcinogenic effects	25,550	days	Default value (USEPA 2004a,b)
ATnc	Averaging time for noncarcinogenic effects	ED x 365 days/year	days	Default value (USEPA 1991,1993,2004a)
BWa	Body weight-adult	70	kg	Default value (USEPA 1991,1993,2004a)
BWc	Body weight-child	15	kg	Default value (USEPA 1991,1993,2004a)
CF	Conversion factor	1.00E-06	kg/mg	Not applicable
CS	Chemical concentration in sediment	chemical-specific	mg/kg	Analytical data
EDa	Exposure duration-adult	64	years	Site-specific
EDc	Exposure duration-child	6	years	Default value (USEPA 1991,1993,2004a)
EF	Exposure frequency	365	days/year	Site-specific
IRa	Ingestion rate-adult	300	mg/day	Site-specific (USEPA 1998a)
IRc	Ingestion rate-child	300	mg/day	Site-specific (USEPA 1998a)
SAa	Surface area-adult	5,700	cm^2	Default value (USEPA 2004a,b)
SAc	Surface area-child	2,800	cm^2	Default value (USEPA 2004a,b)

cm^2 = square centimeter
DTSC = Department of Toxic Substances Control
derm = dermal
ing = ingestion
inh = inhalation
kg = kilogram
L = liter
m^3 = cubic meter
mg = milligram
OU = operable unit
PRG = preliminary remediation goal
RME = reasonable maximum exposure
SIF = summary intake factor

Table 3.2-6
Exposure Assumptions and Intake Equations for Subsistence Lifestyle Ingestion of Native and Cultivated Plants

Equations:

$$\text{Chemical intake (mg/kg-day)} = \text{CT} \bullet \text{SIF}$$

$$\text{SIF}_{\text{ing-nc}} = \frac{\text{IRc} \bullet \text{CF} \bullet \text{EF} \bullet \text{EDc} \bullet \text{FI}}{\text{BWch} \bullet \text{ATnc}}$$

$$\text{SIF}_{\text{ing-ca}} = \frac{[(\text{IRc} \bullet \text{EDc/BWch}) + (\text{IRa} \bullet \text{EDa/BWa})] \bullet \text{EF} \bullet \text{CF} \bullet \text{FI}}{\text{ATca}}$$

Where:

$\text{SIF}_{\text{ing-nc}}$ (day^{-1}) = summary intake factor for ingestion of tissue-noncarcinogenic effects
$\text{SIF}_{\text{ing-ca}}$ (day^{-1}) = summary intake factor for ingestion of tissue-carcinogenic effects

Parameter	Definition	RME Value	Units	Source
ATca	Averaging time for carcinogenic effects	25,550	days	Default value (USEPA 1991,1993,2004a)
ATnc	Averaging time for noncarcinogenic effects	ED x 365 days/year	days	Default value (USEPA 1991,1993,2004a)
CF	Conversion factor	1.00E-03	kg/g	Not applicable
CT	Chemical concentration in Tissue	chemical-specific	mg/kg	Modeled value
EDa	Exposure duration-adult	64	years	Site-specific
EDc	Exposure duration-child	6	years	Default value (USEPA 1991,1993,2004a)
BWa	Body weight-adult	70	kg	Default value (USEPA 1991,1993,2004a)
BWc	Body weight-child	15	kg	Default value (USEPA 1991,1993,2004a)
EF	Exposure frequency (wheat)	365	days/year	Site-specific
EF	Exposure frequency (plants other than wheat)	12	days/year	Site-specific
IRa	Ingestion rate – wheat (adult)	67	g/day	USEPA, 1997b
IRch	Ingestion rate – wheat (child)	47	g/day	USEPA, 1997b
FI	Fraction ingested from site – wheat only	0.1	unitless	Site-specific
IR	Ingestion rate – plant other than wheat	112	g/day	Site-specific

cm^2 = square centimeter
ing = ingestion
kg = kilogram
mg = milligram
SIF = summary intake factor

Table 3.2-7
Exposure Assumptions and Intake Equations for Subsistence Lifestyle Ingestion of Beef Tissue

Equations:

$$\text{Chemical intake (mg/kg-day)} = CT \bullet SIF$$

$$SIF_{ing\text{-}nc} = \frac{IRc \bullet CF \bullet EF \bullet EDc \bullet FI}{ATnc}$$

$$SIF_{ing\text{-}ca} = \frac{[(IRc \bullet EDc) + (IRa \bullet EDa)] \bullet EF \bullet CF \bullet FI}{ATca}$$

Where:

$SIF_{ing\text{-}nc}$ (day^{-1}) = summary intake factor for ingestion of tissue-noncarcinogenic effects
$SIF_{ing\text{-}ca}$ (day^{-1}) = summary intake factor for ingestion of tissue-carcinogenic effects

Parameter	Definition	RME Value	Units	Source
ATca	Averaging time for carcinogenic effects	25,550	days	Default value (USEPA 1991,1993,2004a)
ATnc	Averaging time for noncarcinogenic effects	ED x 365 days/year	days	Default value (USEPA 1991,1993,2004a)
CF	Conversion factor	1.00E-03	kg/g	Not applicable
CT	Chemical concentration in Tissue	chemical-specific	mg/kg	Modeled value
EDa	Exposure duration-adult	64	years	Site-specific
EDc	Exposure duration-child	6	years	Default value (USEPA 1991,1993,2004a)
EF	Exposure frequency	365	days/year	Site-specific
FI	Fraction ingestion from site	0.1	unitless	Site-specific
IR	Ingestion rate-beef	4	g/kg-day	USEPA, 1997

cm^2 = square centimeter
ing = ingestion
kg = kilogram
mg = milligram
SIF = summary intake factor

Exposure factors are generally developed using various guidance documents, including the Exposure Factors Handbook (USEPA 1997b); Risk Assessment Guidance for Superfund, Part A (USEPA 1989); “Standard Default Exposure Factors” (USEPA 1991); “Superfund Standard Default Exposure Factors for the Central Tendency and Reasonable Maximum Exposure” (USEPA 1993), Supplemental Guidance to RAGS. Dermal Risk Assessment. Final Guidance (USEPA 2004b), and User’s Guide and Background Technical Document for USEPA’s Region 9 PRGs Table (USEPA 2004a).

USEPA (1989) recommends the use of site-specific exposure factor values based on site-specific information and professional judgment in risk assessment. For this assessment, it is assumed that the residential populations living near the proposed plant would be living a subsistence lifestyle. Few default exposure factors for this scenario are available. Therefore, the exposure factors used were selected based on the best available information regarding the lifestyle of the Navajo Nation people. When site-specific information was not available, values were derived using USEPA guidance documents or standard USEPA default values were used.

The values are considered reasonable maximum exposures and may result in more conservative exposure potential at the Site than actual exposures. However, reasonable maximum exposures were adopted in order not to underestimate potential risk. Where site-specific exposure factors rather than accepted default values were used, the rationale for their selection is provided in the following discussions.

Exposure Frequency. The site-specific exposure frequency for all receptors is 365 days/year because Native American communities living a subsistence lifestyle generally do so year round.

Exposure Duration. The site-specific exposure duration for subsistence residents is equal to the USEPA default value for a lifetime of 70 years (USEPA 1989), because Native American communities living a subsistence lifestyle generally do so for their entire life. Exposure durations for specific subgroups is 6 years for children (0 to 6 years of age), and 64 years for adults.

Soil Ingestion Rate. The soil ingestion rate selected for this evaluation is 300 mg/day for both children and adults. This value was proposed by USEPA Region 10 for children and adults for contact intensive exposure scenarios of short duration such as camping (USEPA 1998a). It was assumed that the potential residents in the vicinity of the proposed power plant would be living under conditions similar to that of camping, as there is no readily available water supply to the area to use to rinse soil from bodies or foods.

Plant Ingestion Rate and Frequency. Two different plant ingestion scenarios were evaluated in this assessment: ingestion of wheat grown in the NAPI agricultural area by residential populations living near the proposed plant facility and ingestion of local native flora for medicinal and ceremonial purposes. Thus, different ingestion rates and ingestion frequencies were assumed for each scenario.

The NAPI is an agricultural industry owned and operated by the Navajo people. The NAPI cultivates several crops including wheat, oats, barley, corn, among others, and markets their products locally, nationally, as well as internationally for retail purposes, repackaging or for direct sale to customers (http://www.navajopride.com). The ingestion of wheat plants growing in the NAPI agricultural area was evaluated for residents living in the vicinity of the proposed plant site. To estimate an ingestion rate of wheat from NAPI by local residents, the USEPA's Exposure Factors Handbook (USEPA 1997b) was consulted. Table 12-18 of USEPA (1997b) contains the estimated per capita consumption rates of specific grains, including wheat, for different age groups along with the estimated lifetime average consumption rate in grams of wheat (dry weight) per day. The consumption rate of wheat for the 1 to 5 year old age group of 42 g/day was used to evaluate child exposures to wheat and the lifetime average consumption rate of 60 g/day was used to evaluate combined child/adult exposures. As indicated on Table 12-18 of USEPA (1997b), these consumption rates are dry weight intake rates. Therefore, as recommended in USEPA (1997b), they were converted to wet weight intake rates using the average moisture content in wheat products (Table 12-21 of USEPA [1997b]). The adjusted wet weight intake rates are 47 g/day and 67 g/day, for child and adults, respectively. These consumption rates are based on the total amount of wheat consumed by an individual. It is unlikely that a resident living in the vicinity of the proposed plant would receive all of its wheat grain from the site (i.e., some wheat is expected to come from store-bought products and/or other areas). Therefore, it was assumed that 10 percent of the local residents' wheat intake would come from wheat grown in the NAPI.

For native/wild plants ingested for medicinal purposes or during ceremonies, the ingestion rate and frequency is assumed to be much less than if the plants were being consumed as a regular part of the diet (e.g., as vegetables or wheat eaten daily or weekly). It was assumed that a 4 ounce portion size would be used during these activities, and that these activities would take place once per month. This equates to an ingestion rate of 112 grams per day for 12 days of the year. Note this is an average rate over 70 years, so shorter term exposures could be either more or less than the average.

Beef Ingestion Rate and Frequency. The NAPI also offers land for grazing of sheep and cattle, and there may be some livestock grazed within 10 km of the proposed facility that could be eaten by people. As discussed above for wheat, the ingestion of beef products from cattle grazing on NAPI land was evaluated for residents living in the vicinity of the proposed plant site. To estimate an ingestion rate of beef from cattle grazing in the NAPI by local residents, the USEPA's Exposure Factors Handbook (USEPA 1997b) was consulted. The 95th percentile of daily per capita beef ingestion rates of 2.327 g/kg-day was selected for use in the risk calculations. This value was obtained from Table 11-3 of USEPA (1997b). As discussed above for wheat, this consumption rate is based on the total amount of beef consumed by an individual. It is unlikely that a resident living in the vicinity of the proposed plant would receive all of its beef from cattle grazing at the NAPI (i.e., some beef is expected to come from store-bought products and/or other areas). Therefore, it was assumed that 10 percent of the local residents' beef intake would come from cattle grazing in the NAPI.

3.3 TOXICITY ANALYSIS

The purpose of the toxicity assessment is to weigh the available and relevant evidence regarding the potential for chemicals to cause adverse health effects in exposed individuals and to provide a quantitative estimate of the relationship between the magnitude of exposure and the likelihood of adverse effects (USEPA 1989). A fundamental principle of toxicology is that the dose determines the severity of the effect. Accordingly, the toxicity criteria describe the quantitative relationship between the dose of a chemical and the type and incidence of the toxic effect. This relationship is referred to as the dose-response. The types of toxicity criteria are described in the following subsections. Table 3.3-1 and Table 3.3-2 present toxicity criteria used in this assessment. Detailed discussions of the specific criteria and associated health effects for each COPC can be found on the USEPA's IRIS database (USEPA 2006). The following bullets summarize the health affects associated with each COPC:

- **Hexavalent Chromium**. Inhaling hexavalent chromium can cause irritation to the nose and over the long term may contribute to an increased risk of lung cancer.
- **Arsenic**. Low levels of arsenic can cause a darkening of the skin, and cause warts or corns to appear. Long term exposures to inorganic arsenic have been associated with an increased risk of lung cancer, skin cancer, and bladder cancer. Arsenic is considered a human carcinogen.
- **Monomethyl hydrazine**. Monomethyl hydrazine exposure can result in damage to the liver and kidneys. The chemical is considered an animal carcinogen (benign tumors) with an unknown relevance to humans (i.e., there is no evidence of human carcinogenicity)
- **Mercury**. The toxic effects of mercury are damage to the brain, kidneys, and developing fetus. Children exposed to mercury in utero can be born with brain damage and older children can develop problems with their nervous and digestive systems, and have kidney damage if exposed to mercury concentrations in excess of safe levels.

A dose-response evaluation is the process of quantitatively evaluating toxicity information and characterizing the relationship between the dose of the chemical and the incidence of adverse health effects in the exposed population. From this quantitative dose-response relationship, toxicity criteria are derived that can be used to estimate the potential for adverse health effects as a function of exposure to the chemical. Toxicity values are combined with the summary intake factors (SIFs) listed on Tables 3.2-4 through 3.2-7 and provide estimates of carcinogenic risks or indicate the potential for noncancer health effects for various exposure scenarios. Exposure to chemicals can result in cancer or noncancer effects, which are characterized separately. Essential dose-response criteria are the USEPA slope factor (SF) values for assessing cancer risks and the EPA-verified reference dose (RfD) values for evaluating noncancer effects. The following hierarchy is generally used to select toxicity criteria. The toxicity criteria selected for all of the COPCs evaluated in this assessment was obtained from USEPA's IRIS database.

3.3.1 Oral Toxicity Criteria

3.3.1.1 Cancer Effects

The cancer SF (expressed as $[\text{mg/kg-day}]^{-1}$) expresses excess cancer risk as a function of dose. The dose-response model is based on high- to low-dose extrapolation and assumes that there is no lower threshold for the initiation of toxic effects. Specifically, cancer effects observed at high doses in laboratory animals or from occupational or epidemiological studies are extrapolated, using mathematical models, to low doses common to environmental exposures. These models are essentially linear at low doses, so that no dose is without some risk of cancer. The cancer SFs for each of the COPCs are presented on Table 3.3-1.

3.3.1.2 Noncancer Effects

Chronic RfDs are defined as an estimate of a daily exposure level for the human population, including sensitive subpopulations, that are likely to be without appreciable risk of noncancer effects during a lifetime of exposure (USEPA 1989). Chronic RfDs are specifically developed to be protective for long-term exposure to a chemical and are generally used to evaluate the potential noncancer effects associated with exposure periods of 7 years to a lifetime. RfDs are expressed as mg/kg-day and are calculated using lifetime average body weight and intake assumptions. The noncancer toxicity criteria are presented in Table 3.3-2. RfD values are derived from experimental data on the no-observed-adverse-effect level (NOAEL) or the lowest-observed-adverse-effect level (LOAEL) in animals or humans. The NOAEL is the highest tested chemical dose given to animals or humans that has not been associated with any adverse health effects. The LOAEL is the lowest chemical dose at which health effects have been reported. RfDs are calculated by the USEPA by dividing the NOAEL or LOAEL by a total uncertainty factor, which represents a combination of individual factors for various sources of uncertainty associated with the database for a particular chemical or with the extrapolation of animal data to humans. IRIS also assigns a level of confidence in the RfD. The level of confidence is rated as high, medium, or low based on confidence in the study and confidence in the database.

RfDs for oral/ingestion exposures are expressed as mg/kg-day and are calculated using lifetime average body weight and intake assumptions.

3.3.2 Inhalation Toxicity Criteria

The criteria for inhalation are reference concentrations (RfCs) expressed in milligrams of chemical per cubic meter of air (mg/m^3) for noncarcinogens and unit risk factors (URFs) expressed in cubic meters of air per microgram of chemical (m^3/µg) for carcinogenic exposures. RfCs and URFs are developed in the same way as RfDs and SFs, except they include, as part of their development, a default inhalation rate assumption of 20 m^3 of air inhaled per day. Because the default inhalation rate is not applicable to all the receptors in this risk assessment, RfCs and URFs were converted into reference doses for inhalation (RfD$_i$) and inhalation slope factors (SF$_i$) according to the protocols presented by USEPA (1989, 2003a). The conversions are as follows:

$$\text{RfD}_i\ (\text{mg/kg-day}) = \text{RfC}\ (\text{mg/m}^3) \times 20\ (\text{m}^3/\text{day}) \times 1 / 70\ (\text{kg})$$

$$\text{SF}_i\ (\text{kg-day/mg}) = \text{URF}\ (\text{m}^3/\mu\text{g}) \times 1 / 20\ (\text{day/ m}^3) \times 70\ (\text{kg}) \times 10^3\ (\mu\text{g/mg})$$

3.3.3 Dermal Toxicity Criteria

Most oral RfDs and SFs are expressed as an administered dose (i.e., the amount of substance taken into the body by swallowing). In contrast, exposure estimates for the dermal route of exposure are expressed as an absorbed dose (i.e., the amount of chemical that is actually absorbed through the skin). Because dermal toxicity criteria are not readily available, oral toxicity values are used in conjunction with an absorption correction factor to adjust for the difference in administered to absorbed dose. The USEPA recommends absorption correction factors for a limited amount of inorganic chemicals in Exhibit 4-1 of the RAGS *Part E, Supplemental Guidance for Dermal Risk Assessment* (USEPA 2004b). For those chemicals that do not appear on the table, the recommendation is to assume 100% absorption (USEPA 2004b) (i.e., the dermal toxicity criteria would not differ from the oral toxicity criteria). For this assessment, no toxicity criteria for any chemical were adjusted for dermal exposures.

Table 3.3-1
Carcinogenic Toxicity Criteria for the Contaminants of Potential Concern

Chemical	Oral Cancer: Slope Factor $(mg/kg\text{-}day)^{-1}$	Inhalation Cancer: Slope Factor $(mg/kg\text{-}day)^{-1}$	Tumor Type	USEPA Cancer Classification[a]	Reference
Arsenic	1.5E+00	1.50E+01	Skin cancer (human) – oral Bladder and lung (human) - inhalation	A	IRIS (USEPA 2006)
Chromium VI	—	2.9E+02	Lung (human)	A	IRIS (USEPA 2006)
Mercury	—	—	—	C	IRIS (USEPA 2006)
Methylmercury	—	—	—	C	IRIS (USEPA 2006)
Monomethyl Hydrazine	3.0E+00	1.7E+01	Hepatoma (mouse) – oral Nasal cavity adenoma (rat) – inhalation	B2	IRIS (USEPA 2006)

[a] USEPA's Weight-of-Evidence Classification System:

Group A - human carcinogen (sufficient evidence in humans)
Group B1 - probable human carcinogen (limited human data available)
Group B2 - probable human carcinogen (sufficient evidence in animals, inadequate or no evidence in humans)
Group C - possible human carcinogen (limited evidence in animals)
Group D - not classifiable as to human carcinogenicity

USEPA = United States Environmental Protection Agency
IRIS = Integrated Risk Information System
mg/kg = milligrams per kilogram

Table 3.3-2
Noncarcinogenic Toxicity Criteria for the Contaminants of Potential Concern

Chemical	Chronic RfD (mg/kg-day)	Toxic Endpoint	Critical Study	Uncertainty Factor	RfD Source
Inhalation Exposures					
Arsenic	—	na	na	na	IRIS (USEPA 2006)
Chromium VI	3.00E-05	Lactate dehydrogenase in bronchialveolar lavage fluid	Rat subchronic study	300	IRIS (USEPA 2006)
Mercury	—	na	na	na	IRIS (USEPA 2006)
Methylmercury	—	na	na	na	IRIS (USEPA 2006a)
Monomethyl hydrazine	—	na	na	na	IRIS (USEPA 2006)
Oral Exposures					
Arsenic	3.0E-04	Hyperpigmemtation, keratosis	Human chronic oral exposures	3	IRIS (USEPA 2006)
Chromium VI	3.0E-03	None reported	1-year rat drinking water	300	IRIS (USEPA 2006)
Mercury	3.0E-04	Autoimmune effects	Rat Subchronic Feeding and Subcutaneous Studies	1000	IRIS (USEPA 2006)
Methyl-mercury	1.0E-04	Developmental neuropsychological impairment	Human epidemiological clinical studies	10	IRIS (USEPA 2006)
Monomethyl hydrazine	—	na	na	na	IRIS (USEPA 2006)

IRIS = Integrated Risk Information System
mg/kg = milligrams per kilogram
CrVI = hexavalent chromium
USEPA = United States Environmental Protection Agency
RfD = reference dose
na = not available

3.3.4 Toxicity Criteria for Mercury

The nature of mercury toxicity differs with the chemical form. Mercury has three valence states: metallic or elemental mercury, which readily vaporizes and is often in a gaseous state (Hg^0), mercurous mercury (Hg^{+1}), and mercuric mercury (Hg^{+2}) (ATSDR 1999). Mercury is predominantly released into the atmosphere as elemental mercury, where it is transformed into other forms of mercury before being deposited onto land and water surfaces. Mercuric mercury is the predominant form of mercury in soils where it binds to particulate matter to form various mercury complexes (e.g., mercuric chloride, mercuric sulfide, etc) (ATSDR 1999). Therefore, the toxicity criteria for inorganic mercury and its soluble salts (mercury and compounds) was used to assess exposures to mercury in soil. Once mercury is taken up by living organisms, mercury is transformed through methylation into organic mercury, most commonly methyl mercury (ATSDR 1999). Therefore, the toxicity criteria for methyl mercury was used to assess exposures through ingestion of plants and beef. The derivation of the toxicity criteria for inorganic mercury and methyl mercury are discussed in detail in USEPA's IRIS database (USEPA 2006).

3.4 RISK CHARACTERIZATION

Risk characterization is the summarizing step of risk assessment. In risk characterization, the toxicity values (RfDs and SFs) are applied, in conjunction with the concentrations of COPCs and summary intake assumptions, to estimate carcinogenic (cancer) risks and noncarcinogenic (non-cancer) health hazards. The following subsections describe the methods that are used to estimate risks and hazards and the health threshold levels that will be used to evaluate the results of the risk calculations for the site.

3.4.1 Methodology For Evaluating Noncarcinogenic Hazards

The potential for adverse health effects other than carcinogenic effects (i.e., noncarcinogenic effects) will be characterized by dividing estimated chemical intakes by chemical-specific RfDs. The resulting ratio is the hazard quotient (HQ), which is derived as follows:

$$\mathrm{HQ} = \frac{\text{Chemical Intake (mg/kg - day)}}{\text{RfD (mg/kg - day)}}$$

USEPA risk assessment guidelines (USEPA 1989) consider the additive effects associated with simultaneous exposure to several chemicals by specifying that all HQs initially must be summed across exposure pathways and chemicals to estimate the total hazard index (HI). This summation conservatively assumes that the toxic effects of all contaminants would be additive or, in other words, that all chemicals cause the same toxic effect and act by the same mechanism.

If the total HI is less than or equal to 1, multiple-pathway exposures to COPCs at the site will be considered unlikely to result in an adverse effect. If the total HI is greater than 1, further evaluation of exposure assumptions and toxicity, including consideration of specific affected target organs and the mechanisms of toxic actions of COPCs, will be conducted to ascertain whether the cumulative exposure would, in fact, be likely to harm exposed individuals.

3.4.2 Methodology For Evaluating Carcinogenic Risks

The potential for carcinogenic effects was evaluated by estimating the probability of developing cancer over a lifetime based on exposure assumptions and chemical-specific toxicity criteria. The increased likelihood of developing cancer from exposure to a particular chemical is defined as the excess cancer risk. (Excess cancer risk is the risk in excess of a background cancer risk of one chance in three [0.3, or

3×10^{-1}] for every American female and one chance in two [0.5, or 5×10^{-1}] for every American male, of eventually developing cancer [American Cancer Society, 2001].) Excess lifetime cancer risks were estimated by multiplying the estimated chemical intake by the cancer SF, as follows.

$$\text{Cancer Risk} = \text{Chemical Intake (mg/kg-day)} \times \text{SF (mg/kg-day)}^{-1}$$

This formula applies to cancer risks lower than 1×10^{-2} (1 in 100). All cancer risks in this assessment are lower than 1×10^{-2}.

The risks resulting from exposure to multiple carcinogens were assumed to be additive. The total carcinogenic risks were estimated by summing the estimated risks for each COPC and for each exposure pathway. USEPA's acceptable target risk range is 10^{-6} to 10^{-4}.

3.4.3 Summary Of Risk Results

All final risk and hazard estimates were presented to one significant figure only, as recommended by USEPA (USEPA 1989). Therefore, an HQ or HI of 1 could range between 0.95 and 1.4, and a risk of 2×10^{-5} could range between 1.5×10^{-5} and 2.4×10^{-5}. Details of the calculations, with risks and hazards presented to at least two significant figures, are included in Attachment 3. A summary of the risk and hazard results presented to one significant figure are shown on Tables 3.4-1 through 3.4-4.

Risks and hazards were evaluated for residents living in the vicinity of the proposed plant. Risks and hazards were calculated for children and adult exposures to COPCs emitted directly from the proposed plant, exposures to COPCs in soil resulting from deposition of proposed plant emissions, exposures to COPCs in plants and beef that may be affected from proposed plant operations. In addition to calculating and summing the risks and hazards per medium, cross-media risks and hazards were summed to yield total risks and hazards for residential populations by summing risks and hazards from exposures to contaminants in air, soil, plants and beef. This summing of risks and hazards across media assumes that a resident living a subsistence lifestyle could be exposed to contaminants resulting from proposed plant operations through all the pathways evaluated in this assessment.

Table 3.4-1 summarizes the risks and hazards associated with cumulative impacts to environmental media after 50 years of the proposed plant operations. As shown on Table 3.4-1, cumulative hazards are less than or equal to 1 for both child and lifetime (combined child/adult) exposures. The HI values for arsenic and mercury are not added together because the toxic effects of these chemicals do not affect the same target organ, therefore their toxic effects are not additive (see Table 3.3-2 and the discussion in

Table 3.4-1
Summary of Cumulative Risks and Hazards for Residential Populations Living Near the Proposed Facility

		Cumulative Total (Baseline + 50-years of Facility Operation)			**Incremental Risks from Arsenic After 50-years of Facility Operation**			**Baseline Arsenic Risks**		
Pathway of Exposure		**Child HI**	**Child/ Adult HI[a]**	**Child/ Adult CR[a]**	**Child HI**	**Child/ Adult HI[a]**	**Child/ Adult CR[a]**	**Child HI**	**Child/ Adult HI[a]**	**Child/ Adult CR[a]**
Inhalation of Air Toxics[c]		0.0005	0.0003	3E-06	NA	NA	NA			
Exposure to Soil[d]	Arsenic	0.3	0.08	4E-05	0.06	0.02	8.E-06	0.2	0.06	3.E-05
	Mercury	0.002	0.0004							
Ingestion of Wheat	Arsenic	0.03	0.01	3E-06	0.0006	0.0	6E-08	0.02	0.006	2.E-06
	Mercury	0.2	0.04							
Ceremonial and Medicinal Ingestion of Plants	Arsenic	0.9	0.3	1E-04	0.04	0.01	5E-06	0.9	0.24	1.E-04
	Mercury	0.4	0.1							
Ingestion of Beef	Arsenic	0.00002	0.00002	1E-08	0.000005	0.000005	2E-09	0.00002	0.00	9.E-09
	Mercury	0.003	0.003							
TOTAL Arsenic[e]	Arsenic	1	0.3	2E-04	0.1	0.03	1E-05	1	0.3	1E-04
TOTAL Mercury[e]	Mercury	0.6	0.2							
TOTAL Cancer Risks[e]				2E-04						

Section 3.4.1). Also shown on Table 3.4-1, the cumulative cancer risk of 2 x 10^{-4} is greater than USEPA's acceptable risk range of 10^{-6} to 10^{-4}. The majority of the cancer risk is driven by arsenic concentrations in soil and native plant tissues.

As discussed in Section 3.2 above and in Section 3.13.3.2 of the main text, arsenic is naturally occurring in soil. The baseline soil concentration of arsenic in the vicinity of the proposed plant is 3.2 mg/kg, well within the range of naturally occurring arsenic concentrations of soil in the western United States. Plant emissions contribute only about 28 percent to the 50-year soil concentration for arsenic (as indicated on Table 3.1-2). Over 50 years, the increase in arsenic concentration is small (arsenic concentration increased from 3.2 to 4.1 mg/kg), and cumulative arsenic concentrations in soil would still be within the range of natural background. The hazards and risks from baseline arsenic concentrations (i.e., the risks from exposure to 3.2 mg/kg of arsenic in soil) are also shown on Table 3.4.1 along with the incremental risk over background concentrations due to 50 years of operation of the proposed power plant. Increases in arsenic soil concentrations due to 50 years of plant operations do not increase arsenic's HI as shown by comparing baseline arsenic HI's with the cumulative HI totals. The increase in cancer risks is very slight, a change in risk from 1 x 10^{-4} at baseline to 2 x 10^{-4} after 50 years of plant operations (results rounded to one significant figure). Therefore, health risks from exposures to air toxics emitted from the plant are unlikely to be significant in comparison with current health risks.

The majority of the cancer risk is driven by the ingestion of native/wild plants through ceremonial and medicinal uses pathway, as well as the inhalation of air toxics and soil exposure pathways. The risks and hazards for the individual media and their contribution to total risks and hazards is discussed in the following subsections.

3.4.3.1 Inhalation of Air Toxics

Table 3.4-2 details the results of the risk and hazard calculations for the inhalation of air toxics pathway. Noncancer hazards calculated for this pathway of 0.0005 and 0.0003, for child and combined child/adult exposures, respectively, were well below the target health goal of 1. Therefore, COPCs in air do not present a health concern for noncancer effects. The cancer risk of 3 x 10^{-6} slightly exceeded USEPA's de minimis cancer risk level of 1 x10^{-6}, but is well within USEPA's acceptable risk range of 10^{-6} to 10^{-4}. Chromium VI was the greatest contributor to total cancer risk, contributing approximately 72 percent to the total cancer risk in air. However, modeled air concentrations based on the proposed facilities' estimated emission rates were used in the risk calculations. The model estimates resulted in the maximum concentration in air that is expected to be emitted from the plant and occurs in very close proximity to the proposed plant fence line (approximately 0.3 km of the proposed plant fence line). Chemical concentrations in air rapidly decrease with increasing distance from the site. No residential receptors are located within 0.3 km of the proposed plant fence line. Therefore, the concentrations of air toxics in air that an actual residential receptor would encounter is less than the concentrations used to estimate risks and hazards. In addition, chromium VI is not very stable in the environment and readily reduces to chromium III, an essential nutrient that is a much less toxic form of chromium (ATSDR 2000). Therefore, the actual concentration of chromium VI (as well as the other COPCs) that is likely to be present in the air and available for human exposure is expected to be less than the concentration used to estimate cancer risks. Therefore, the cancer risks calculated for chromium VI (as well as the other COPCs) exposures in air, are overestimated, and actual risks are likely to be below USEPA's de minimis cancer risk level of 1 x 10^{-6}.

3.4.3.2 Residential Exposures to Surface Soil

Table 3.4-3details the results of the risk and hazard calculations for the residential exposures to surface soil pathway. Noncancer hazards calculated for this pathway of 0.3 and 0.08 for child and combined child/adult exposures, respectively, were below the target health goal of 1. Therefore, no COPCs in surface soil present a health concern for noncancer effects. The cancer risk of 4×10^{-5} was within USEPA's acceptable risk range of 10^{-6} to 10^{-4}. Note that baseline arsenic contributions to soil risk are 3×10^{-5} (see Table 3.4-1). Because soil risks are within USEPA's acceptable risk range and proposed facility operations are not expected to increase arsenic concentrations significantly above the concentrations of arsenic currently in the area, no COPCs in surface soil present an unacceptable health concern for carcinogenic effects. In addition, as discussed for the inhalation of air toxics pathway above, modeled surface soil concentrations based on the proposed plants estimated emission and deposition rates were used in the risk calculations. Conservative assumptions, discussed in Section 2.3, were used in the process to calculate the surface soil EPCs that likely largely overestimate what actual soil concentrations in the vicinity of the proposed plan will be over 50 years of plant operations. Therefore, the risks and hazards calculated for residential exposures to surface soil, are overestimated, and actual risks and hazards are likely much lower.

Table 3.4-2
Summary of Risks and Hazards Resulting from Inhalation of Air Toxics Emitted Directly from the Proposed Plant

	Inhalation of Air Toxics		
COPC	**Child HI[b]**	**Child/Adult[a] HI**	**Child/Adult[a] CR**
Chromium VI	0.0005	0.0003	2E-06
Arsenic	--	--	6E-07
Monomethyl Hydrazine	--	--	3E-07
TOTAL	0.0005	0.0003	3E-06

[a] Risks are calculated for lifetime exposures

[b] Hazards are calculated separately for lifetime exposures (labeled "adult/child") and for exposures only during childhood (labeled "child")

HI = hazard index

CR = cancer risk

Table 3.4-3
Summary of Risks and Hazards Resulting from Exposures to Surface Soil

	Exposures To Surface Soil								
	Total			**Ingestion**			**Dermal**		
COPC	**Child[b] HI**	**Child/ Adult[a] HI**	**Child/ Adult CR**	**Child HI**	**Child/ Adult HI**	**Child/ Adult CR**	**Child HI**	**Child/ Adult HI**	**Child/ Adult CR**
Arsenic	0.3	0.08	4E-05	0.3	0.08	3E-05	0.02	0.003	2E-06
Monomethyl Hydrazine	--	--	1E-06	--	--	1E-06	--	--	2E-07
Mercury and Compounds	0.002	0.0004	--	0.002	0.0004	--	--	--	--
TOTAL	--[c]	--[c]	4E-05	--[c]	--[c]	4E-05	0.02	0.003	2E-06

[a] Risks are calculated for lifetime exposures

[b] Hazards are calculated separately for lifetime exposures (labeled “adult/child”) and for exposures only during childhood (labeled “child”)

[c] Health hazards for arsenic and mercury are not additive – the chemicals affect different organ systems and have different toxic endpoints; therefore, their hazards are not added together. Total cancer risks are always assumed to be additive.

-- = chemical not associated with noncarcinogenic or carcinogenic affect
HI = hazard index
CR = cancer risk

3.4.3.3 Ingestion of Plants and Beef

Methyl mercury was selected as a COPC in the food chain pathways because of its potential to bioaccumulate. In addition, while arsenic does not bioaccumulate in the food chain (i.e., increase in concentration in plants and animals), arsenic was selected as a COPC in the food chain pathways to fully address cumulative effects. Two different plant ingestion scenarios were evaluated in this assessment: ingestion of wheat grown in the NAPI agricultural area by residential populations living near the proposed plant facility and ingestion of the local native flora used for medicinal and ceremonial purposes. In addition, hazards were calculated for ingestion of beef from cattle grazing on irrigated wheat grown in the NAPI agricultural area. Table 3.4-4 summarizes the results for the food chain pathways. As shown on Table 3.4-4, noncancer hazards for child exposures through food do not exceed USEPA’s target health goal of 1. The combined child/adult cancer risk of 1 x 10^{-4} is equal to USEPA’s maximum acceptable cancer risk, and is due entirely to arsenic. The ceremonial and medicinal scenario is the greatest contributor of all the foodchain pathways. As shown on Table 3.4-1, food pathway risks due to arsenic are nearly all due to the amount of arsenic already present in the soil without contributions from the proposed power plant (i.e., baseline arsenic health risks are the same as cumulative risks).

Table 3.4-4
Summary of Risks and Hazards Resulting from Food Chain Exposures

	COPC	Child HQ[b]	Child/Adult HQ[b]	Child/Adult CR[a]
Ingestion of Wheat	Arsenic	0.03	0.006	3E-06
	Methyl Mercury	0.2	0.04	--
	Total	--[c]	--[c]	3E-06
Cermonial and Medicinal Ingestion of Plants	Arsenic	0.9	0.3	1E-04
	Methyl Mercury	0.4	0.1	--
	Total	--[c]	--[c]	1E-04
Ingestion of Beef	Arsenic	0.00002	0.00002	1E-08
	Methyl Mercury	0.003	0.003	--
	Total	--[c]	--[c]	1E-08
Total from Food Chain Pathways				
	Total	--[c]	--[c]	1.E-04

[a] Risks are calculated for lifetime exposures

[b] Hazards are calculated separately for lifetime exposures (labeled "adult/child") and for exposures only during childhood (labeled "child")

[c] Health hazards for arsenic and mercury are not additive – the chemicals affect different organ systems and have different toxic endpoints; therefore, their hazards are not added together. Total cancer risks are always assumed to be additive.

HQ = hazard quotient
CR = cancer risk

Because the majority of arsenic's hazards and risks are due to background concentrations, methyl mercury is the greatest contributor to the noncancer hazards for the foodchain pathways due to plant operations, a more likely scenario given the bioaccumulative potential of methyl mercury. The following bullets summarize the contribution of methyl mercury to the total noncancer hazard for each scenario:

- Methyl mercury hazards from ingestion of wheat growing in the NAPI were 0.2 and 0.04, for child and combined child/adult exposures, respectively, which are each below USEPA's target health goal of 1.
- Methyl mercury hazards from ingestion of wild/native plants used medicinally and in ceremonies were 0.4 and 0.1 for child and combined child/adult exposures, respectively. Young children were assumed to have as much exposure to native plants as adults, which may be an overestimate for child exposures.
- Methyl mercury hazards from ingestion of beef grazing in the NAPI were 0.003 for both child and combined child/adult exposures, well below USEPA's target health goal of 1. The EPC for methyl mercury in beef was estimated using a conservative model developed by the ORNL, that is designed to over-estimate rather than under-estimate the concentration of a chemical in beef tissue.

Modeled surface soil concentrations based on the proposed plants estimated emission and deposition rates were used in the plant and beef tissue concentration calculations for the risk calculations. Conservative assumptions, discussed in Section 2.3, were used in the process to calculate the surface soil EPCs that likely largely overestimate what actual soil concentrations in the vicinity of the proposed plan will be over 50 years of plant operations. Therefore, the risks and hazards calculated for the foodchain pathways, are overestimated, and actual risks and hazards are likely much lower.

3.4.3.4 Summary of Risk Characterization Results

Risk and hazards were estimated for residential exposures to air toxics emitted from the plant through both direct pathways of exposure (inhalation of air toxics) and indirect pathways of exposure (residential contact with soil, ingestion of wheat, native plants, and beef). Baseline concentrations of inorganic chemicals were included in the evaluation for the indirect pathways of exposure. No baseline concentrations of air toxics in air were available. The total hazards, including the contribution from background sources, meet USEPA's target health goal of HI's less than or equal to 1. The cumulative cancer risk of 2 x 10^{-4} is greater than USEPA's acceptable risk range of 10^{-6} to 10^{-4}; however, nearly all of that risk is due to existing concentrations of arsenic and the contribution of arsenic from the operation of the facility is slight.

The majority of the noncancer hazard for mercury is driven by the ingestion of wheat and the ingestion of native/wild plants through ceremonial and medicinal uses pathways, while for arsenic, the ingestion of ceremonial and medicinal plants is the largest contributor of non-cancer health hazards. The majority of the cancer risk for arsenic is also driven by the ingestion of native/wild plants through ceremonial and medicinal uses pathway. As previously discussed, arsenic is naturally occurring in soil. The baseline soil concentration of arsenic in the vicinity of the proposed plant is 3.2 mg/kg, well within the range of naturally occurring arsenic concentrations of soil in the western United States. Plant emissions contribute only about 28 percent to the 50-year soil concentration for arsenic (as indicated on Table 3.1-2). Over 50 years, the increase in arsenic concentration is small (arsenic concentration increased from 3.2 to 4.1 mg/kg). Because of the toxicity of arsenic background concentrations of arsenic commonly result in health risks in excess of USEPA's target health goals. Because proposed facility operations are not expected to increase arsenic concentrations significantly above the concentrations of arsenic currently in the area, the total risk without including the contribution from baseline arsenic concentrations was also considered in this evaluation in order to estimate whether the increase in arsenic concentrations would result in a significant increase in health risks. A comparison of baseline arsenic risks with the cumulative risks after 50-years of facility operations and risks due only to the contributions from the facility, indicates that the facility contributions are insignificant. Arsenic's non-cancer health hazards do not change due to plant operations and cancer health risks increase only slightly, from 1 x 10^{-4} to 2 x 10^{-4}.

These risks and hazards are at or below noncancer target health goals and at the upper limit of the acceptable cancer risk range even if it was assumed that a resident would have exposures through all these pathways simultaneously for their entire 70 year lifetime. Additional health-protective assumptions were used in the calculation of risks and hazards in order to over-estimate rather than under-estimate actual exposure conditions.

The residential exposure scenario quantified in this assessment has the highest amount of exposures of any potential exposure scenario. Therefore, when risks and hazards do not exceed target health goals under a residential scenario, they are not expected to be exceeded under other scenarios, including commercial and industrial scenarios.

This risk analysis was conducted assuming that a resident receptor lives in very close proximity to the proposed plant fenceline (less than 1 km), where maximum air concentrations and soil deposition are predicted to occur. Proposed facility emissions (thus, air concentrations and soil concentrations) decrease with increasing distance from the proposed site. There are no residences located less than 1 km from the proposed facility fenceline. Thus, exposures to the nearest residential communities are likely to be less than those estimated in this analysis. The results of this analysis indicate that there are not likely to be public health concerns from exposure to air toxics resulting from the operations of the proposed facility, even over 50 years of operation.

3.5 UNCERTAINTIES IN HUMAN HEALTH RISK ANALYSIS

The purpose of this risk analysis is to identify potential risks and hazards from potential exposure to chemicals emitted from the proposed plant facility within the overall study area. Estimating and evaluating health risk from exposure to environmental contaminants is a complex process with inherent uncertainties. Uncertainty reflects limitations in knowledge, and simplifying assumptions must be made to quantify health risks.

In this assessment, uncertainties relate to the selection of COPCs and the development of media concentrations to which people may be exposed; the assumptions about exposure and toxicity; and the characterization of health risks. Uncertainty in the development of media concentrations results from the modeling required to predict the level of chemical contamination that could result from plant operations. Because plant operations have not yet begun, it is not possible to know what actual concentrations resulting from the proposed plant are. Instead, we rely on the use of modeling to predict those concentrations. A modeler must make certain assumptions in order to most accurately predict what concentrations in environmental media could be. In general, these assumptions are designed to prevent underestimation of media concentrations, thus avoiding an underestimation of the risks to public health.

There are uncertainties regarding the quantification of health risks in terms of several assumptions about exposure and toxicity, including site-specific and general uncertainties. Based on anticipation of uncertainty when quantifying exposure and toxicity, the health risks and hazards presented in this risk assessment are more likely to overestimate risk.

Uncertainty in the risk assessment produces the potential for two kinds of errors. A Type I error is the identification of a specific contaminant, area, or activity as a health concern when, in fact, it is not a concern (false positive conclusion). A Type II error is the elimination of a contaminant, area, or activity from further consideration when, in fact, there should be a concern (false negative conclusion). In the risk assessment, uncertainties were handled conservatively (i.e., health protective choices were made preferentially). This strategy is more likely to produce false positive errors than false negative errors. The following sections provide additional detail regarding uncertainties in the estimations of health risks.

3.5.1 Uncertainties Related to Media Concentrations and the Selection of COPCs

The data evaluation process addresses whether contaminants may be present in various environmental media at levels of health concern and whether data is sufficient to fully characterize each exposure pathway. For this risk analysis, the concern is cumulative health effects from a facility that has not yet been built. Thus, modeling was required to estimate future concentrations of chemicals in the media of concern: air, soil, plants, and cattle. Models are necessarily simplifications of reality because the modeled processes are generally too complex and contain too many variables where there is insufficient data to accurately quantify the particular variable.

Consequently, health protective assumptions were made (such as no loss of chemical from soil due to environmental processes, the use of default emission rates of chemicals from the proposed facility that tend to over-estimate actual emissions, and the use of concentrations in roots only for the plant pathways) in order that media concentrations would not be underestimated. For a number of metals, sampling data on current concentrations was obtained from soil and plants that reduced some of the uncertainties associated with modeling; however, there remains uncertainty regarding what actual concentrations would be 50 years in the future.

Modeled soil concentrations were calculated assuming maximum emission and deposition rates would occur throughout the 10 km study area. However, the maximum concentrations are driven by wet deposition and these would actually occur only very close to the plant, and concentrations in soil (and thus other media) farther away from the facility where residences are located would be lower than the concentrations used in this risk assessment. Table 3.5-1 shows the model predictions for the location of the maximum deposition of chemicals. Although maximum dry deposition rates occur at locations further from the plant than maximum wet deposition rates, the dry deposition rates are several orders of magnitude smaller than wet deposition rates (see Tables 2.2-1 through 2.2-3).

Modeled plant concentrations were based on the 50-year predicted soil concentration rate and the soil-to-plant uptake factors, which were calculated using the baseline soil and plant data. The 90th percentile uptake factor for all the plants and soil data was used in the risk calculations for native plants. Uptake factors will vary depending on the species; however, use of the 90th percentile value over-estimates uptake for the majority of the plant species, adding a layer of protectiveness to plant modeling.

Modeling did not include possible concentration increases due to rain splash and air deposition on plants which could contribute to underestimation concentrations. This is unlikely to be an issue for wheat because wheat will be washed and processed prior to consumption, but it could contribute to an underestimation of concentrations in native plants. For human consumption of the above-ground portions of native plants, some washing of the plant is typical which would reduce the soil layer on the plants from rain splash and air deposition. In particular, rain splash is anticipated to be insignificant because of the low rainfall in the area. While direct air deposition onto plants was not included, all the native plant concentrations used in the risk calculations were based on mercury concentrations in the root, which is higher than the concentrations in the above-ground portion of the plant. Table 3.2.-2 presents the uptake factors for above-ground and root plant parts. The root factor is higher than the above-ground factor by at least 40% (8.9 vs 14, see Table 3.2-2). The increase in above-ground plant concentrations due to air deposition is modeled by multiplying deposition rates by a factor that is less than 1 because not all the chemical will deposit on the plant, some will reach the ground (USEPA 2005). Therefore, use of the root concentration as a surrogate for concentrations in the above-ground native plant parts is likely sufficiently protective to account for some slight increase in above-ground plant concentrations due to air deposition. Note that use of the unwashed root concentrations for the above-ground native plant portions will over-estimate concentrations if the plants are washed.

Table 3.5-1
Highest Modeled Impact and Location Relative to the Main Stack(1)

Modeled Parameter	**Averaging Period**	**Conc./ Flux Units**	**2001**			**2002**			**2003**		
			Conc./Flux	**Dist. (km)**	**Bering (deg)**	**Conc./Flux**	**Dist. (km)**	**Bering (deg)**	**Conc./Flux**	**Dist. (km)**	**Bering (deg)**
Ground Level Concentration	Annual	mg/m^3	3.37E-03	1.44	7	3.5E-03	5.3	124	3.4E-03	1.14	314
Wet Deposition	Annual	mg/m^2/s	8.28E-05	0.26	32	4.5E-05	0.8	37	1.3E-04	0.26	32
Dry Deposition	Annual	mg/m^2/s	3.42E-07	5.33	124	3.9E-07	5.3	124	3.1E-07	2.80	302
Total Deposition	Annual	mg/m^2/s	8.29E-05	0.26	32	4.5E-05	0.8	37	1.3E-04	0.26	32
Main Stack Location(2)											
x	127.25	Km									
y	54.998	Km									

Note: The main stack was modeled as a dual flue stack representing stack parameters for both boiler flues at 100% load for short-term and annual.

(1) Highest modeled impacts are based on a 1 g/s emissions rate for the main stack only.

(2) Coordinates reflect a Lambert conformal coordinate system used for the CALPUFF modeling and units are km.

Modeled **concentrations of chromium VI in air** likely overestimate the amount of chromium VI that a person would actually inhale. Chromium VI is not stable in air, but will be rapidly reduced to the less toxic chromium III compound in the atmosphere, with a half-life in air in the range of 16 hours to five days (ATSDR 2000). Therefore, chromium VI concentrations directly emitted from the plant are likely over-estimated in this risk assessment.

Dioxins were not selected as a COPC because they were not a concern by the air pathway due to very low predicted air concentrations and the predicted 50-year soil concentration for 2,3,7,8 –TCDD was approximately three order of magnitude (1,000 times) lower than the residential soil PRG. However, dioxins can bioaccumulate in the environment to some degree and not selecting dioxins as a COPC in plants and cattle could contribute to a slight underestimation of health risks. USEPA notes that the amount of dioxins in above-ground plants are virtually zero, and there is almost no movement of dioxins from roots to the above ground portions of plants (USEPA 2000a, 2003b). Even in roots, the root concentration of dioxins is lower than the soil dioxin concentration (USEPA 2003b); therefore, because the predicted 50-year soil concentration is 1,000 times lower than the PRG (protective of direct, daily, soil contact), dioxin concentrations in roots are very unlikely to present a health concern to those eating the roots as often as once a month. Because cattle do not eat roots, their source of dioxins would be from air deposition onto plants that they eat and direct ingestion of soil. Like roots, concentrations of dioxins in beef are lower than those in soil (USEPA 2003b); consequently, dioxin concentrations in beef are very unlikely to present a health concern.

3.5.2 Uncertainties Related to Exposure Assumptions

Wheat and beef consumption rates used in the risk calculations are based on “per capita” ingestion rates, rates from the entire US population as a whole, including consumers and non-consumers. Therefore, consumption rates that are considered “consumers only” could be higher. However, with wheat and beef, there is only a small percentage of the population that does not consume these foods (over 90% consume for the US as a whole, about 80% consume for Native American populations; USEPA 1997b). In addition, these foods are produced on NAPI land and their products are distributed throughout the US as part of an agricultural business; thus, local “home-grown” exposure rates are not applicable and it was assumed that only 10 percent of a person’s wheat or beef intake would come from this single source. For people generally buying their food supplies from grocery stores and other regular retail outlets, 10 percent is likely to overestimate the amount of beef and wheat they would consume from one particular agricultural field. Even if a person buys a sack of wheat flower from the NAPI, it is unlikely that foods prepared using the wheat flower from the NAPI would account for more than 10 percent of a persons’ total intake of wheat. Thus, exposures to methyl mercury from ingestion of wheat grown in the NAPI is not expected to be a health concern, even over 50 years of plant operation and use of per capita rates are appropriate to model exposure.

We note that for beef, mercury’s HQ was 0.003, almost three full orders of magnitude below a level that might be a health concern. Consequently, beef could be consumed at a rate 300 times greater than that assumed by the risk calculations, a level much higher than reported in any empirical study (or alternatively, a person could get all their beef from this one source and still not have mercury-related health impacts). In addition, the formula from ORNL used to estimate methyl mercury concentrations in beef is health protective in that it is designed to over-estimate rather than under-estimate the concentration of a chemical in beef tissue.

The **ceremonial/medicinal consumption rate** for native plants has a large degree of uncertainty due to the lack of available information regarding consumption rates for these types of activities and potential individual variability in consumption rates. Actual consumption rates for native plants within 10 km of the proposed facility could be either more or less than the rate assumed in the risk calculations. Consumption of these plants accounted for the highest mercury hazard, an HQ of 0.4 for children aged 0 to 6 years, which is still below the health threshold level of an HQ greater than 1.

The risk calculations assumed that children aged 0 to 6 years would participate in the medicinal/ceremonial uses of native and wild plants using the same ingestion rate as adults, which potentially overestimates a child's actual exposure under this scenario. Therefore, while hazards for child exposures predicted in the risk assessment are already less than half of the target health goal, actual hazards are likely even lower. For the combined child/adult scenario, it was assumed that adults would participate in the ceremonial uses of native and wild plants every month for their entire 70 year lifetime. Hazards for combined child/adult exposures are already an order of magnitude less than the target health goal, and actual hazards are potentially even lower.

Another area of uncertainty relates to the amount of native plants that might be collected from the potentially impacted area. The area surrounding the proposed plant is high desert, with little rainfall and relatively little vegetation. Thus, any individual who regularly gathers local plants would have to range over a large area in order to routinely gather plants and still maintain a healthy local plant population. Because the risk calculations used maximum deposition rates as the basis for predicting plant concentrations, plants within 1 km will have the highest concentrations and plants farther away than this will have lower concentrations, and thus lower health risks, than those assumed for the risk calculations.

The 300 mg **soil ingestion rate** is based on high-end (i.e., approximating the 90th percentile) estimates from soil tracer studies in young children in a camping scenario (van Wijnen et al. 1990). Because this soil ingestion rate represents a high-end value obtained from a soil tracer study, it is likely to be protective as applied to a lifetime of exposure, assuming that young children, on average, ingest more soil on a daily basis than adults. While it is possible that the rate may be exceeded on an occasional basis, on average it is less likely to be exceeded over the course of a 70-year exposure. For comparison, mean soil ingestion rates recommended in the USEPA Exposure Factors Handbook are 100 mg/day for children and 50 mg/day for adults (USEPA 1997b). Superfund RME default ingestion rates are 200 and 100 mg/day for children and adults, respectively (USEPA 1991). These ingestion rates are applicable to long-term (i.e., chronic) exposures arising from inadvertent soil ingestion and would not be appropriate for intentional soil ingestion (Simon 1998). A similar approach has been taken by Massachusetts Department of Environmental Protection which recently lowered its recommendation for an adult high-contact soil scenario from 500 to 100 mg per day (Friedmann, 2002).

The **365 day per year exposure frequency** is an upper bound value that is likely to overestimate risks for people who travel, attend school, work in locations outside of the 10 km study area for the proposed facility, or otherwise are not within 10 km of the proposed facility every day of the year. USEPA's default exposure frequency for residential exposure scenarios is 350 days per year based on a two week vacation and travel from the site (rounded to 15 days) (USEPA 1991). Increasing the frequency to 365 increased risks by about 4% above the default value.

There are currently no **occupational populations** within 10 km of the site, and none are expected in the future. In addition, as discussed in previous sections, residential exposures to airborne contaminants and impacted soil were evaluated in this assessment. Occupational activities typically occur 5 days per week for 25 years, and residential exposures were assumed to occur daily for an entire lifetime (70 years). Therefore, even if a resident of the area lived and worked within the assumed exposure area, the assumptions used to calculate risks and hazards in this evaluation are considered to be protective. However, the risks and hazards presented in this evaluation are overestimated for occupational populations who live at distances greater than 10 km from the site. Using USEPA (1989, 1991, 1993, and 1997) default exposure assumptions for occupational/industrial exposures, risks and hazards for future occupational populations are 7×10^{-7} for inhalation of airborne air toxics and 1×10^{-6} for exposures to soil through the ingestion and dermal pathways, below or equal to USEPA's de minimus cancer risk level of 1×10^{-6}.

3.5.3 Uncertainties Related to Toxicity

Toxicity values have been developed by the USEPA from the available toxicological data. These values frequently involve high-to-low-dose extrapolations and are often derived from animal rather than human data. In addition, few studies may be available for a particular contaminant. As the unknowns regarding toxicity increase, the uncertainty of the toxicity value increases. Uncertainty is addressed by reducing RfDs using uncertainty factors and by deriving SFs using a conservative model. The greater the uncertainty, the greater the uncertainty factors and tendency to overestimate the toxicity to ensure health-protective analyses.

The highest cancer risks in this risk analysis are due to **inhalation of chromium VI**. The cancer slope factor for chromium is based on a 1975 evaluation of workers who were exposed between 1931 and 1937 while working in a chromate plant (USEPA 1998b). Smoking rates for the plant workers were assumed to be the same as for the general population but the proportion of smokers is higher for the industrial working populations, thus that assumption may have resulted in an overestimation of the cancer potency of chromium VI. The cancer associated with chromium VI exposure is lung cancer and lung cancer rates are significantly affected by smoking.

3.5.4 Summary

Every aspect of a risk assessment contains multiple sources of uncertainty. Simplifying assumptions are often made so that health risks can be estimated quantitatively. Because the uncertainty cannot be quantified precisely, the risk assessment is intended to overestimate, rather than underestimate, probable risk. The results of this assessment are therefore likely to be protective of health, despite the inherent uncertainties in the process.

3.6 SUMMARY AND CONCLUSIONS

This risk analysis evaluated potential human health risks from chemicals other than the criteria pollutants (referred to as "air toxics") that could be emitted from the proposed Desert Rock power plant in northwestern New Mexico. There are approximately 60 chemicals that could be emitted, based on USEPA evaluations of bituminous coal combustion (USEPA 1998c), including volatile organic compounds (VOCs), semi-volatile organic compounds (SVOC) (e.g., dioxins/furans), and metals (e.g., mercury, arsenic, chromium VI). Not all of these chemicals will necessarily be emitted from the proposed Desert Rock plant in the predicted concentrations because of plant-to-plant variations that are the result of the specific type of coal and combustion processes used, and specific control technologies that will be employed at the proposed facility. However, the risk assessment evaluated the full list, using USEPA's default emission factors (which tend to overestimate emission rates) in order to assess whether emissions of any of the possible chemicals could potentially result in adverse health effects.

Four chemicals were selected as COPCs and were quantitatively evaluated in the risk assessment in at least one media, chromium VI, arsenic, monomethyl hydrazine, and mercury. Only arsenic was selected in all media (air, soil, food chain). The following bullets summarize the rationale for the selection of each of the COPCs, as well as their associated health effects.

- Chromium VI was only selected in air because it readily reduces to trivalent chromium (chromium III), the less toxic valence state of chromium, once in the environment (ATSDR 2000). Therefore, chromium is not expected to remain in the hexavalent state for any significant period of time, and significant exposures to chromium VI in soil and plants are not expected. The predicted 50-year concentration of chromium VI in soil was less than 1/10th of the Region 9 PRG.

- Arsenic was selected as a COPC in air, and was selected in both soil and vegetation. Predicted emissions of arsenic from the proposed plant result in a relatively small increase in existing arsenic concentrations in soil over the next 50 years, from 3.2 mg/kg to 4.1 mg/kg; however, the existing (baseline) concentration is well above the screening level (this is typical of natural arsenic concentrations and natural concentrations of 3 - 10 mg/kg or more in soil are found throughout the U.S.). Thus, while proposed facility emissions would not increase arsenic concentrations in soil substantially above the baseline concentrations and therefore would not cause substantial cumulative impacts, levels are above risk-based screening levels and thus arsenic was selected as a COPC. In addition, while arsenic does not bioaccumulate in the food chain (i.e., increase in concentration in plants and animals), food chain pathways were included in the risk assessment to fully address cumulative effects.

- Monomethyl hydrazine was selected as a COPC in air and soil, but not food chain pathways, because predicted concentrations were within one order of magnitude of the PRGs for air and soil. The chemical was not selected in food chain pathways because its half life in the environment is very short, and it is not expected to bioaccumulate.

- Mercury was selected as a COPC in soil and food chain pathways. The predicted air concentrations of mercury from proposed facility emissions would be approximately 10,000 times below the ambient air PRG for mercury; thus mercury does not present a health risk from inhalation. Mercury was selected as a COPC in soil even though its predicted 50-year soil concentration was 1,000 times lower than the PRG, because of its potential to bioaccumulate. After absorption into living tissue it is metabolized to a more toxic form, methyl mercury. Therefore, mercury was also selected as a COPC in the food chain pathways.

Potential risks to humans from the proposed plant's chemical emissions were evaluated in combination with the concentrations of these chemicals already present in the environment, to the extent that existing conditions are known. Risks were calculated using predicted air concentrations and deposition rates for the proposed plant plus baseline data from soil and plant tissue. Baseline data was available for eight metals (including arsenic, chromium, and mercury) but not any organic compounds. Because predicted air emissions of the air toxics were much lower than health-based screening values for the majority of the chemicals being emitted from the proposed facility (except those selected as COPCs), health impacts from air toxics being emitted from neighboring power plants combined with the proposed facility emissions are unlikely to be significant. In addition, maximum predicted air concentrations generally occur quite close to the emitting facility; thus there is less potential for cumulative effects from different facilities.

Risk and hazards were estimated for residents living in the area who could be exposed to air toxics emitted from the plant through both direct pathways of exposure (inhalation of arsenic, monomethyl hydrazine, and chromium VI) and indirect pathways of exposure (ingestion and dermal contact with arsenic, mercury and monomethyl hydrazine in soil, and ingestion of arsenic and mercury in wheat, native plants, and beef). Two different plant ingestion scenarios were evaluated to fully assess mercury exposures from plants: 1) ingestion of cultivated plants that were a regular part of the diet (wheat grown in the NAPI area was used to evaluate this plant pathway) and 2) ingestion of wild plants that were used less frequently, but still on a regular basis, for medicinal and ceremonial purposes.

The beef ingestion scenario evaluated health risks from ingestion of beef from cattle grazing on wheat grown in the NAPI agricultural area (beef was used as a surrogate for other domestic or wild animals that might graze in the area surrounding the proposed facility). The total cumulative noncancer hazards met USEPA's target non-cancer health goal of an HI less than or equal to 1. Cumulative cancer risks slightly exceeded USEPA's target health goal of cancer risks of 10^{-4}, with cumulative risks of 2 x 10^{-4}. However, the majority of the cancer risk was driven almost entirely by arsenic concentrations in soil and plant tissues, and the risk is overwhelmingly due to the existing, baseline concentrations of arsenic in soil. Arsenic is naturally occurring in soil. The baseline soil concentration of arsenic in the vicinity of the proposed plant is 3.2 mg/kg and after 50 years the increase in arsenic concentration is small (increase from 3.2 to 4.1 mg/kg). Background concentrations of arsenic commonly result in health risks in excess of USEPA's target health goals because of the toxicity of the chemical. Because proposed facility operations are not expected to increase arsenic concentrations significantly above the concentrations of arsenic currently in the area, the total risk without including the contribution from baseline arsenic concentrations was also considered in this evaluation in order to estimate whether the increase in arsenic concentrations would result in a significant increase in health risks. A comparison of baseline arsenic risks with the cumulative risks after 50-years of facility operations and risks due only to the contributions from the facility, indicates that the facility contributions are insignificant. Arsenic's non-cancer health hazards do not change due to plant operations and cancer health risks increase only slightly, from 1 x 10^{-4} to 2 x 10^{-4}.

There are currently no occupational populations within 10 km of the site, and none are expected in the future. Occupational activities typically occur 5 days per week for 25 years, and residential exposures were assumed to occur daily for an entire lifetime (70 years). Therefore, even if a resident of the area lived and worked within the assumed exposure area, the assumptions used to calculate risks and hazards in this evaluation are considered to be protective. However, the risks and hazards presented in this evaluation are overestimated for occupational populations who live at distances greater than 10 km from the site. Using USEPA default exposure assumptions for occupational/industrial exposures, risks and hazards for future occupational populations are 7 x 10^{-7} for inhalation of airborne air toxics and 1 x 10^{-6} for exposures to soil through the ingestion and dermal pathways, below or equal to USEPA's de minimus cancer risk level of 1 x 10^{-6}.

While there is uncertainty in these estimates due to the use of modeling to predict environmental concentrations 50 years from now and due to uncertainties regarding exposure, the process is designed to over-estimate, rather than under-estimate health risks. Thus, because the results of the risk analysis indicate health risks are at or below public health goals and risks from plant operations do not significantly increase health risks in the area, there is confidence in the conclusion that there are unlikely to be public health concerns from exposure to air toxics resulting from the operations of the proposed facility, even over 50 years of operation.

4.0 ECOLOGICAL RISK

The ecological assessment includes a screening process where COPECs are selected and the subsequent risk-based assessment where site-specific risks and impacts are evaluated.

4.1 SCREENING

The ecological screening phase is a conservative evaluation used to select COPECs. The goal of the screening process is not to provide an indication of potential for risk, but rather to identify chemicals that may warrant further evaluation using more detailed procedures.

4.1.1 Soil Screening

Sources for soil (terrestrial) ecological screening levels (ESLs) for metals include: USEPA's *Ecological Soil Screening Levels* (2005) and the Los Alamos National Laboratory (LANL) Ecorisk Database Release 2.2 (2005). The priority for selection of the ESLs for each soil analyte is:

- USEPA's Eco SSLs (lowest of the available soil screening levels for plants, soil invertebrates, birds, or mammals), or if an Eco SSL is not available from USEPA (2005b), then;
- LANL ecological screening levels (lowest of the four ESLs for plants, soil invertebrates, birds, or mammals).

The list of available terrestrial ESLs from USEPA (2005) and LANL (2005) is provided in Table 4.1-1. The selected ESL for each metal is shown in the last column of the table.

To select COPECs, the estimated 50-year soil concentrations of the metals in surface soil and the soil column are compared with the selected chemical-specific ESL for that metal. The assumed mixing zones for the surface soil and soil column are 0-2 and 0-10 cm, respectively. If the 50-year soil concentration in either soil depth exceeds the ESL, the metal is retained as a COPEC for the risk-based assessment (Section 4.2). If a metal is retained as a COPEC for further assessment, it is assessed for all terrestrial receptors – soil invertebrates, plants, birds, and mammals.

Results of the screening are shown in Table 4.1-2. Concentrations shown are the sum of concentrations in soil due to deposition (see Table 2.3-1) plus baseline (see Tables 2.1-1 and 2.1-3). Two metals (selenium and mercury) have estimated 50-year concentrations that exceed ESLs and are therefore considered COPECs. Estimated concentrations of the COPECs in both the 0-2 and 0-10 cm depth profiles exceed the respective ESLs. The higher of these two soil estimates for each metal are used as exposure point concentrations (EPCs) as these two metals are carried forward into the risk-based assessment (Section 4.2).

The estimated 2056 concentration of bis(2-ethylhexyl)phthalate in soil as seen in Table 2.3-1 (3.13E-02 mg/kg) also exceeds a conservative ESL from LANL (2005) for birds (2.0E-02 mg/kg). It does not exceed the ESL for mammals (5.9E-01). Bis(2-ethylhexyl)phthalate is not carried forward into the risk-based assessment, however, because the modeled soil concentration does not take into account the several conservative factors discussed in Section 2.3 that act preferentially on organic compounds. These factors act to reduce the concentrations of organics in air, reduce deposition rates, and ultimately, concentrations in soil. The primary environmental process that is not considered is volatilization. Because the modeled concentration of bis(2-ethylhexyl)phthalate in soil does not consider the many ameliorating factors, the

Table 4.1-1
Ecological Screening Levels (ESLs) for Soil

Analyte	**Plant Eco SSLs (mg/kg) (USEPA 2005)**	**Invertebrate Eco SSLs (mg/kg) (USEPA 2005)**	**Bird Eco SSLs (mg/kg) (USEPA 2005)**	**Mammal Eco SSLs (mg/kg) (USEPA 2005)**	**Earthworm Soil ESLs (mg/kg) (LANL 2005)**	**Plant Soil ESLs (mg/kg) (LANL 2005)**	**Bird Soil ESLs (mg/kg) (LANL 2005)**	**Mammal Soil ESLs (mg/kg) (LANL 2005)**	**Selected ESL (mg/kg)**
Arsenic	18	-	43	46	6.8	18	18	15	18
Cadmium	32	140	0.77	0.36	140	32	0.29	0.27	0.36
Chromium	-	-	26	34 (Cr III) 81 (Cr VI)	2.3 (Cr III) 0.34 (Cr VI)	2.4 Cr total) 0.35 (Cr VI)	830 (Cr total) 190 (Cr VI)	750 (Cr total) 170 (Cr VI)	26
Lead	120	1700	11	56	1700	120	14	72	11
Mercury	-	-	-	-	0.05	34	0.012	1.7	0.012
Selenium	-	-	-	-	7.7	0.1	1.1	0.92	0.1

ESLs for chromium are shown for total chromium (Cr total), trivalent chromium (Cr III), and hexavalent chromium (Cr VI).

The selected ESL is the lowest of the USEPA (2005) Eco SSLs, if available. If no Eco SSL is available from USEPA (2005), the selected ESL is the lowest of the LANL (2005) ESLs.

U.S. Environmental Protection Agency (USEPA). 2005. Ecological Soil Screening Levels (Eco SSLs). Office of Solid Waste and Emergency Response. Available at: http://www.epa.gov/ecotox/ecossl/ Last updated May.

Los Alamos National Laboratory (LANL). 2005. Ecorisk Database (Release 2.2). Prepared by Environmental Health Associates, Inc. Albuquerque, NM. September.

ESL = Ecological Screening Level
mg/kg = milligrams per kilogram
SSL = Soil Screening Level

Table 4.1-2
Ecological Screening Results for Soil

Analyte	**Concentration in Soil After 50 Years of Deposition (mg/kg)**	**ESL**	**COPEC?**
Surface Soil (0-2cm)(1)			
Arsenic	4.07E+00	1.8E+01	No
Cadmium	2.05E-01	3.6E-01	No
Chromium III	6.45E+00	2.6E+01	No
Chromium IV	4.82E-01	2.6E+01	No
Lead	8.34E+00	1.1E+01	No
Mercury	**2.41E-02**	1.2E-02	**Yes**
Selenium	**3.20E+00**	1.0E-01	**Yes**
Soil Column (0-10cm)(2)			
Arsenic	4.08E+00	1.8E+01	No
Cadmium	1.19E-01	3.6E-01	No
Chromium III	6.80E+00	2.6E+01	No
Chromium IV	3.86E-01	2.6E+01	No
Lead	8.22E+00	1.1E+01	No
Mercury	2.15E-02	1.2E-02	**Yes**
Selenium	9.98E-01	1.0E-01	**Yes**

(1) Deposition assumed to mix into 0-2 cm soil.
(2) Deposition assumed to mix into 0-10 cm soil.

Mercury and selenium concentrations in 0-2 cm soil (bold) exceed concentrations in 0-10 cm soil and are used as exposure point concentrations in the risk-based assessment of these COPECs (Section 4.2).

cm = centimeter
COPEC = Chemical of Potential Ecological Concern
ESL = Ecological Screening Level. See Table 4.1-1.
mg/kg = milligrams per kilogram

modeled soil concentration over-states the concentration and therefore, is not expected to exceed the conservative ESL for birds from LANL (2005). Consequently, bis(2-ethylhexyl)phthalate is not considered further.

4.1.2 AQUATIC SCREENING

Surface water and sediment also could be impacted by the deposition of particulates or by runoff from areas impacted by deposition. However, most streams in the vicinity of the proposed plant, including the Chaco River, are ephemeral. The closest permanent water bodies are Morgan Lake (approximately 22 km) northwest of the proposed Plant and the San Juan River (approximately 28 km) north of the plant. Based on site-specific modeling and general guidance from USEPA (2005), the greatest impacts from plant emissions are expected to occur within 10 km (6 miles) of the power plant.

As discussed in Section 2.1.2, maximum modeled deposition rates using meteorological data from years 2001–2003 are located in the wet deposition area, and the maximum deposition areas within the wet deposition area is located less than 1 km (0.26 to 0.81 km) from the proposed plant (Conners, pers. comm. 2006). Deposition rates further away are much lower. The close proximity of highest deposition rates is confirmed by the USEPA in its *Human Health Risk Assessment Guidance for Hazardous Waste Combustion Facilities* (USEPA 2005) where it states that the greatest impacts are expected to occur within 10 km of a power plant or other combustion emission source.

According to the USEPA (2006), approximately 10% of total mercury that is emitted to the atmosphere is actually deposited on land and water within 25 kilometers of a facility. As discussed in more detail in Section 3.3.4, mercury is predominantly released into the atmosphere as elemental mercury (Hg^0) in a gaseous state but readily transforms into mercurous mercury (Hg^{+1}). Mercuric mercury (Hg^{+2}) is the predominant form of mercury in soils where it binds to particulate matter, and organic mercury, most commonly methyl mercury, is formed when mercury is taken up by organisms (ATSDR 1999).

As shown in Table 3-9 (page 3-20 of the EIS), mercury concentrations (dissolved) in the San Juan River at Shiprock Bridge over the period of 1994-2001 ranged from 0.1 to 0.3 µg/L (average of 0.1 µg/L). The federal chronic ambient water quality criterion (AWQC) for dissolved mercury is 0.77 µg/L (protection of aquatic organisms) (USEPA 2006). Given that the recent mercury concentrations of mercury in the San Juan river are, at most, less than half the criterion and that deposition rates at a distance of 28 km from the proposed plant are expected to be minimal, the water quality criterion for mercury is unlikely to be exceeded by aerial deposition from the stacks. Similarly for selenium, the AWQC for total selenium is 5.0 µg/L, and the mean concentration of total selenium during the period of 1994 –2001 is only 0.73 µg/L – 15% of the criterion.

Based on the results of air toxics modeling, it is estimated that the proposed power plant would release a maximum of 161 pounds of mercury per year through air emissions. The emitted mercury would consist of both particulates and vapors. Some particulate mercury could be deposited both near to and far from the proposed plant site. Some portion of the mercury would be carried away by the atmosphere and would not be deposited in the region at all. It is estimated that about 19 pounds of mercury per year would be deposited within 25 km of the plant. The San Juan River is about 28 km from the power plant site. The actual quantity of mercury deposition that could eventually enter the San Juan River system or Morgan Lake directly or via runoff is difficult to quantify due to the large number of unknown parameters in the mercury hydrogeologic cycle. As shown in Table 3-9 of the EIS, existing mercury concentrations (dissolved) in the San Juan River at Shiprock Bridge during the period 1994-2001 ranged from 0.1 to 0.3 µg/L (average of 0.1 µg/L) – below the Federal chronic ambient water quality criterion (AWQC) of 0.77 µg/L for dissolved mercury (USEPA 2006).

According to information presented in *Methylmercury and Other Environmental Contaminants in Water and Fish Collected from Four Recreational Fishing Lakes on the Navajo Nation, 2004* (USFWS 2005), selenium concentrations in fish from Morgan Lake may pose health risks to people and wildlife that consume a large amount of fish from the lake.

Catfish and bass collected from Morgan Lake had a selenium concentration in filets of 3.4 mg/kg dry weight, and ecologically significant risks have been reported by others for piscivorous wildlife and fish where-whole body selenium concentrations exceeded 3 and 4 mg/kg dry weight, respectively. While multiple sources of selenium to the fish in Morgan Lake are possible, USFWS (2005) recommends that the sources of selenium to the fish should be identified and controlled, if possible.

In contrast to the elevated levels of selenium in fish, the average dissolved selenium concentration measured in Morgan Lake (1.0 μg/L) is substantially lower than the USEPA chronic AWQC of 5.0 μg/L (total) (USEPA 2006) and lower than the Navajo Nation Aquatic Habitat Criterion of 2.0 μg/L as listed in USFWS (2005). Morgan Lake is located approximately 22 km from the proposed plant; it is well beyond 1 km (where the maximum modeled annual deposition rates are expected) and beyond 10 km (where USEPA [2005] states that the greatest impacts are expected). Based on the air quality modeling results presented in Section 4.1 of the EIS, the maximum total deposition rate (particle mass weighted) at Morgan Lake (22 km from the stack at a bearing of 84 degrees) is 2.97E-02 ųg/m^2/year. Based on conservative assumptions, the concentration of selenium in Morgan Lake is estimated to increase by 1.64E-04 ųg/L after 50 years of plant operation. Because current selenium concentrations in Morgan Lake are 4 ųg/L lower than the criterion and the increase after 50 years would be only 1.64E-04 ųg/L, additive impacts to selenium concentrations in the lake are expected to be insignificant.

In conclusion, no permanent surface water bodies in the vicinity of the proposed plant are expected to experience exceedances in established water quality standards due to deposition of particulates because these water bodies are at least 22 km away from the proposed plant and current concentrations of the metals of interest are well below chronic water quality criteria. This is true for the two terrestrial COPECs, mercury and selenium, and for all other chemicals considered in the ecological risk evaluation.

4.2 RISK-BASED ASSESSMENT

The risk-based assessment includes five steps: Problem Formulation, Exposure Analysis, Ecological Effects of Chemicals, Risk Estimates, and Risk Descriptions.

4.2.1 Problem Formulation

Three key aspects of the Problem Formulation are assessment endpoints, and associated testable hypotheses and measurement endpoints to determine whether a potential risk to the assessment endpoint exists. An assessment endpoints is “explicit expression of the environmental value that is to be protected” (USEPA 1992). Testable hypotheses are specific risk questions that are based on assessment endpoints and COPECs. A measurement endpoint is then selected to evaluate each hypothesis. Measurement endpoints, or measures of effect, are measurable ecological characteristics related to the valued characteristic chosen as the assessment endpoint (USEPA 1998).

The general strategies used to evaluate ecological risks (i.e., the measurement endpoints) are:
1) comparisons of the exposure concentration in soil with a toxicity reference value (TRV) for plants or soil invertebrates; or 2) comparisons of the dietary dose for a wildlife receptor with a dietary TRV. In the evaluation, TRVs are selected based on both no effect (e.g., no observed adverse effect level [NOAEL]), and low effect (e.g., lowest observed adverse effect level [LOAEL]) concentrations or doses to provide a

range in the potential for effects. However, in the ecological screening, comparisons are with NOAEL values only.

A summary of assessment endpoints (in bold type) and associated testable hypotheses and measurement endpoints is presented below. All of the wildlife species listed as receptors are known to occur in the site area.

Viability and Function of the Plant Community

Testable Hypothesis 1 – Are the concentrations of COPECs in soils sufficient to impair the viability and function of the plant community?

Measurement Endpoint 1 –Conservative exposure concentrations of COPECs in soil are compared with plant TRV concentrations available for screening and risk assessment.

Viability and Function of the Soil Invertebrate Community

Testable Hypothesis 2 – Are the concentrations of COPECs in soils sufficient to impair the viability and function of the soil invertebrate community?
Measurement Endpoint 2 – Conservative exposure concentrations of COPECs in soil are compared with invertebrate TRV concentrations available for screening and risk assessment.

Survival, Growth, and Reproduction of Birds and Mammals (Herbivores)

Testable Hypothesis 3 – Are the concentrations of COPECs in the upper portions of plants sufficient to impair the survival, growth, and reproduction of birds and mammals described as herbivores?

Measurement Endpoint 3 – To evaluate this assessment endpoint in the evaluation, the dietary dose that a wildlife receptor receives from plants and soils is compared with TRVs from the literature. TRVs for each soil COPEC representing NOAEL and LOAEL doses are selected or developed to provide a range in potential effects in the evaluation. The herbivorous receptors used in the assessment are the horned lark (*Eremophila alpestris*) and the black-tailed jackrabbit (*Lepus californicus*). Both receptors are assumed to ingest upper portions of plants.

Survival, Growth, and Reproduction of Birds and Mammals (Insectivores)

Testable Hypothesis 4 – Are the concentrations of COPECs in soils sufficient to impair the survival, growth, and reproduction of birds and mammals described as insectivores (a subset of carnivores)?

Measurement Endpoint 4 – To evaluate this assessment endpoint in the evaluation, the dietary dose that a receptor receives from soils and soil invertebrates is compared with TRVs from the literature. TRVs for each soil COPEC representing NOAEL and LOAEL doses are selected from the literature to provide a range in potential effects. The insectivorous receptors used in the assessment are the western meadowlark (*Sturnella neglecta*) and the deer mouse (*Peromyscus maniculatus*). It is assumed that the deer mouse eats primarily insects, although it also reportedly eats seeds and some green vegetation (USEPA 1993).

Survival, Growth, and Reproduction of Birds and Mammals (Carnivores)

Testable Hypothesis 5 – Are the concentrations of COPECs in soils sufficient to impair the survival, growth, and reproduction of higher tropic level carnivorous birds and mammals?

Measurement Endpoint 5 – To evaluate this assessment endpoint in the evaluation, the dietary dose that a receptor receives from soil and from small mammalian prey is compared with TRVs from the literature. For the assessment, TRVs for each COPEC representing a NOAEL and LOAEL are selected from the literature. The carnivorous receptors used in the assessment are the red-tailed hawk (*Buteo jamaicensis*) and the kit fox (*Vulpes macrotis*).

4.2.2 Exposure Analysis

Exposure of receptors can be through direct contact (i.e., direct exposure) or through the ingestion pathway. For both types of exposure, the EPC of each COPEC must be estimated. As noted in Section 4.1, the metals concentrations from the 0-2 cm assumed mixing depth profile are used as EPCs.

Exposure of the receptors is illustrated in the conceptual site model (CSM) diagram in Figure 4.2-1. The principal release mechanism is Deposition – Wet, Dry, and in the direction of the Prevailing Winds. Exposure pathways expected to be complete are shown with a "C" under each receptor. These exposures are quantified in the subsequent section of the risk analysis. Other exposures of receptors are either incomplete ("I"), not applicable ("NA"), or not quantifiable ("NQ"). Inhalation and direct contact by the wildlife receptors are not quantified because these exposure pathways are expected to be minor compared with ingestion and the quantification methods have substantial associated uncertainties.

Direct Exposure of Plants and Soil Invertebrates to Soil. Plants and soil invertebrates are in direct contact with COPECs in soils.

Exposure of Wildlife Receptors through Ingestion. Concentrations of COPECs in soil are applied directly in estimating direct exposures, and are necessary to estimate ingestion exposure concentrations in wildlife receptors. Meaningful inferences about the potential hazards of ingesting COPECs require an understanding of the relationship between exposures, expressed as concentrations or doses (i.e., mass of COPEC/unit of receptor body weight/unit of time), and responses. Doses are estimated using:

- The measured and projected concentrations of each COPEC in media known or assumed to be ingested (mg/kg in soil and in food)
- Estimates of the mass of each media ingested each day
- Estimates of the mass of each COPEC consumed per day, obtained by multiplying the concentration (mg/kg) in each medium by the amount of that medium (kg) assumed to be ingested by an individual in the population of the receptor species and expressed in terms of the mass (body weight) of the receptor (mg/kg-bw/day)

Ingestion-pathway exposures of the vertebrate ROIs are estimated as average daily doses (ADDs) using the approach outlined in USEPA (1993) as follows:

For food and soil:

$$ADD = [(IRf*Cf) + (IRs*Cs)] * BA*AUF/bw$$

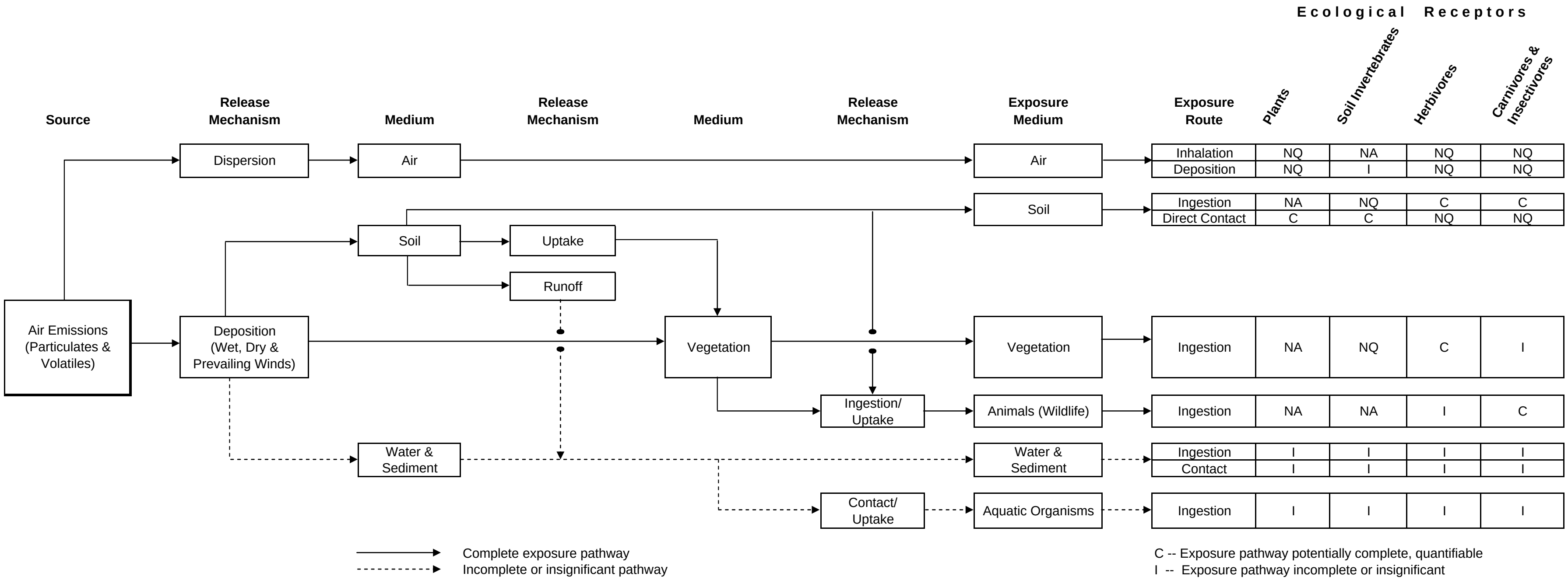
where:

IRf = Ingestion rate of food (kg/day)

IRs = Ingestion rate (incidental) of soil/sediment (kg/day)

Cf = Concentration of COPEC in food (mg/kg)

Figure 4.2-1
Conceptual Site Model -- Air Emissions
Ecological Risk
Desert Rock EIS



Exposure Medium	Exposure Route	Plants	Soil Invertebrates	Herbivores	Carnivores & Insectivores
Air	Inhalation	NQ	NA	NQ	NQ
	Deposition	NQ	I	NQ	NQ
Soil	Ingestion	NA	NQ	C	C
	Direct Contact	C	C	NQ	NQ
Vegetation	Ingestion	NA	NQ	C	I
Animals (Wildlife)	Ingestion	NA	NA	I	C
Water & Sediment	Ingestion	I	I	I	I
	Contact	I	I	I	I
Aquatic Organisms	Ingestion	I	I	I	I

C -- Exposure pathway potentially complete, quantifiable
I -- Exposure pathway incomplete or insignificant
NA -- Not applicable
NQ -- Exposure pathway potentially complete, but not quantifiable

Cs = Concentration of COPEC in soil (mg/kg)

BA = Bioavailability of COPEC in soil and food (assumed to be 1.0)

AUF = Area use factor (assumed to be 1.0)

bw = Body weight of the receptor (kg)

Relatively few empirical measurements of these attributes in wildlife species are available, and those that are available are often based on captive specimens. Uncertainty regarding exposure attributes can never be totally eliminated, but prudent application of well-documented information about the behavior and physiology of the receptors minimizes uncertainty. Generally accepted principles and qualified professional judgment are used to derive assumptions from relevant literature (mainly *Wildlife Exposure Factors Handbook* [USEPA 1993] and primary sources cited therein) that can be applied to the Desert Rock Site. Exposure factors specific for all terrestrial receptors are presented in Table 4.2-1.

Area Use

To account for the fraction of ingested media derived from an exposure area, behavioral information from the literature (such as home ranges or feeding territories) is considered in light of the relevant site dimensions. The AUF is the fraction of the exposure area over which a receptor may forage and can theoretically range from near 0.0 to 1.0 (100 %). Home ranges of the ecological receptors, which are shown in Table 4.2-1, range from 0.27 acre for the deer mouse to 4,370 acres for the red-tailed hawk. However, because the air quality study area is extremely large (25-km radius or over 1,900 km^2), area use factors for all receptors are set at 1.0. Even the bald eagle (*Halianeetus leucocephalus*), which according to Craig et al (1988) can have a foraging radius of 7 km (area of 38,000 acres), would be protected by the assumed AUF of 1.0.

Dietary Composition

Diets identified for the receptors in Table 4.2-1 are based on available literature and consider the feeding patterns and the way food habits are commonly described. For the purpose of this evaluation, the typical diets are conservatively modified so that each receptor is described as being a strict herbivore, insectivore, or carnivore. Actual dietary exposure may be overestimated because of this adjustment in diet. The effect of these narrow interpretations of diet on exposure and risk to the wildlife receptors is evaluated and discussed in the uncertainty section of the evaluation.

Food Ingestion Rate (IR_f)

There are three general sources of food ingestion rates for wildlife:

- Expressions based on a percentage of body weight, derived from collective experience (including some empirical measurements) of researchers familiar with the types of animals in question (e.g., Nagy 1987)
- Empirical measurements, usually obtained from a relatively small "sample" of animals fed *ad libitum* in captivity
- Allometric equations based on a combination of empirical measurements from a wide variety of representatives of categories of animals and bioenergetic principles and theory (e.g., Nagy 1987; also see USEPA 1993)

Table 4.2-1
Exposure Factors For Terrestrial Wildlife Receptors

Representative Species			Body Weight (bw)			Food Ingestion Rate (IR_f)			Composition of Diet (%)					Soil Ingestion Rate (IR_s)			Water Ingestion Rate (IR_w)			Home Range		
Food-web classification	**Common Name**	**Scientific Name**	**kg**	**Comment**	**Reference**	**kg/day ww**	**Comment**	**Reference**	**Plants**	**Inverte-brates**	**Small Mammals**	**Comment**	**Reference**	**kg/day**	**Comment**	**Reference**	**L/day**	**Comment**	**Reference**	**Acres**	**Comment**	**Reference**
Birds																						
Herbivore	Horned lark	*Eremophila alpestris*	0.032	32 g	NatureServe 2006	0.0084	Based on equation for passerines (0.0076 kg dw); Assuming 10% moisture in seeds	USEPA 1993	100%	0%	0%		Assumed for evaluation	0.00015	No data; assumed soil comprises 2% of diet (dw)		0.0059	$= 0.059*bw^{0.67}$(kg) for all birds (L/day)	USEPA 1993	17	Based on range of 0.3 - 14 ha in Colorado shortgrass prairie	NatureServe 2006
Carnivore	Red-tailed hawk	*Buteo jamaicensis*	1.22		Sample et al. 1996	0.121		Sample et al. 1996	0%	0%	100%		Efroymson et al. 1997	0.0008		Efroymson et al. 1997	0.064		Sample et al. 1996	4370	Based on range of 2,365-6,090 acres in Colorado uplands	USEPA 1993
Insectivore/ Invertivore	Western meadowlark	*Sturnella neglecta*	0.103	Average of values	Sample et al. 1997	0.0061	Based on 2.37g /day dw and 61% moisture	Sample et al. 1997	0%	100%	0%	Modified from Rotenberry, 1980	Sample et al. 1997	0.0001	2% of dw food ingestion rate; measure of conservatism		0.013	$= 0.059*bw^{0.67}$(kg) for all birds (L/day)	USEPA 1993	18	Based on home ranges of 1.2 to 13 ha (average of 7.1 ha)	Sample et al. 1997
Mammals																						
Herbivore	Black-tailed jackrabbit	*Lepus californicus*	2.1	Goodwin and Currie 1965	Sample et al. 1997	0.114	Based on range of 61 to 145 g/day (avg. = 103 g/day dw)and 10% moisture	Sample et al. 1997	100%	0%	0%		Sample et al. 1997	0.0072	6.3% of diet (dw); Arthur and Gates 1988	USEPA 1993	0.19	$= 0.099*bw^{0.9}$(kg) for all mammals (L/day)	USEPA 1993	40	Based on home range of 16.2 ha in Idaho.	Sample et al. 1997
Insectivore/ Invertivore	Deer mouse	*Peromyscus maniculatus*	0.021	Average of adult male and female means; North	USEPA 1993	0.0063	Average of adult female nonbreeding and lactating means; Canada (0.3 g/g-day ww)	USEPA 1993	0%	100%	0%		Assumed for evaluation	0.0000252	Assumed same as white-footed mouse (<2% of dw diet)	USEPA 1993	0.004	0.19 g/g-day; two laboratory studies	USEPA 1993	0.27	Based on average adult home range of 0.11 ha in Oregon Ponderosa pines	USEPA 1993
Carnivore	Kit fox	*Vulpes macrotis*	2.25	Based on average adult weight range 1.5 - 3 kg	Sample et al. 1997	0.175	Average of captive adults (175 g/day ww)	Sample et al. 1997	0%	0%	100%		Assumed for evaluation	0.0049	Assumed same as red fox (2.8% of dw diet) Beyer et al. 1994	Sample et al. 1997	0	Appear to obtain adequate moisture from prey	Sample et al. 1997	2770	Based on average home range of 1120 ha in western Arizona	Sample et al. 1997

Efroymson, R.A., G.W. Suter II, B.E. Sample and D.S. Jones. 1997. Preliminary Remediation Goals for Ecological Endpoints. Prepared for the U.S. Department of Energy. ES/ER/TM-162/R2. (Table 5).
NatureServe. 2006. Comprehensive Report Species - Eremophila alpestris. NatureServe website accessed June 23 at http://www.natureserve.org.
Sample, B.E., M.S. Aplin, R.A. Efroymson, G.W. Suter II and C.J.E. Welsh. 1997. Methods and Tools for Estimation of the Exposure of Terrestrial Wildlife to Contaminants. Oak Ridge National Laboratory, TN. Prepared for U.S. Department of Energy. ORNL/TM-13391.
Sample, B.E., D.M. Opresko and G.W. Suter II. 1996. Toxicological Benchmarks for Wildlife: 1996 Revision. Risk Assessment Program, Oak Ridge National Laboratory, Oak Ridge, TN. Prepared for U.S. Department of Energy. ES/ER/TM-86/R3. (Table B.1).
U.S. Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook, Volume 1. Office of Research and Development. EPA/600/R-93/187a.

dw = dry weight
g = gram
g/day = grams per day
g/g-day = grams per grams per day
ha = hectares
kg = kilogram
L/day = liters per day
ww = wet weight

Most of the food ingestion rates in Table 4.2-1 are based on allometric relationships developed by Nagy (1987) and are reproduced in USEPA (1993). In the absence of empirical measurements specific to the selected receptors, use of the allometric equations is appropriate because these are widely accepted, empirically derived relationships. Food ingestion rates are presented in units of wet weight in Table 4.2-1. This is because ingestion rates and estimates of concentrations of chemicals in dietary items (biological tissue) are usually reported in units of wet (fresh) weight.

Soil Ingestion Rates (IR_s)

Many higher vertebrates are known to ingest sediment or soil, usually incidentally to feeding or grooming (USEPA 1993; Beyer et al. 1994). The quantities are often a function of the animal's feeding habits; for example, some small mammals that feed extensively on soil invertebrates ingest relatively high amounts of soil. The rate is normally estimated as a percentage of the overall diet and then converted to kg/day.

Water Ingestion Rates (IR_w) and Water Concentration (C_w)

For the purpose of evaluating potential risk to wildlife exposed to metals accumulated in soil and vegetation, it was assumed that the wildlife received most or all of the needed water from the metabolic processes of digesting food and from the water in the vegetation or other food ingested. Ephemeral water sources may also be used as they are available. As a result of obtaining water primarily through the diet, rather than through direct ingestion of water, the factors IR_w and C_w, which are otherwise included in the exposure equation, are not included.

Body Weight (bw)

Body weight is an important factor because doses are quantified in terms of body weight. Body weight is also often used in calculating other exposure assumptions when realistic direct measurements are not available (e.g., food ingestion rates). Estimated body weights for the wildlife receptors are presented in Table 4.2-1.

Ecological Exposure Concentrations

Concentrations of COPECs (i.e., the EPC) in each environmental medium (soil, plants, or prey) that receptors may contact must be estimated to determine the magnitude of potential exposure. Soil concentrations (C_s) for mercury and selenium were discussed in Section 4.1 and provided in Table 4.1-2.

Concentrations of COPECs in plants or prey organisms ingested by terrestrial wildlife in 2056 are estimated by the application of a BCF or bioaccumulation factor (BAF) to the calculated soil EPC for the COPEC:

$$C_f = BCF*C_s \text{ or}$$

$$C_f = BAF*C_s$$

As described above, BCFs for plants and the six metals of interest were calculated from site-specific data for subsurface soil and plant upper portions (leaves and stems). These site-specific BCFs were then applied to 50-year soil column (0-10 cm) concentrations to estimate metals concentrations in plants over 50 years when projected soil concentrations reach anticipated maximums due to aerial deposition of particulates. BCFs from the literature are used with 50-year soil (0-10 cm) concentrations to estimate metals concentrations in soil invertebrates. BAFs are used with 50-year surface soil (0-2 cm) concentrations to estimate concentrations in small birds or mammals (prey organisms). The primary source of literature-based BCFs and BAFs is the Ecosystem Database in LANL (2005).

Dry-weight BCFs and BAFs were converted to wet-weight factors by multiplying the dry-weight factors by the site-specific percent solids for plant upper portions and assumed percent solids in the tissues of soil invertebrates and small birds/mammals as per USEPA (1993). These percent solids, are: 74% – plants, 39% – soil invertebrates, and 32% – small birds/mammals. All BCFs and BAFs are shown in Table 4.2-2.

4.2.3 Ecological Effects of Contaminants

The effects of contaminants on ecological receptors can be based on direct comparisons of TRVs with measured concentrations in the abiotic exposure media expressed as mg/kg or mg/L, or effects can be based on comparisons of the reference doses with estimated doses that a wildlife receptor receives from the environment. Doses are expressed as mg/kg-body weight/day.

4.2.3.1 Direct Exposure TRVs

As discussed above, conservative ESLs used in the screening for plants and soil invertebrates exposed to COPECs in soil were compiled from USEPA (2005) and LANL (2005). To evaluate potential risks to plants and soil invertebrates, comparisons of EPCs are made with 10 x ESLs, used to represent lowest observed effect concentrations (LOECs).

4.2.3.2 Ingestion Pathway TRVs

In accordance with assessment endpoints involving survival, reproduction, development, and/or growth for the terrestrial-feeding wildlife, appropriate dietary toxicological endpoints for COPECs are reviewed for application in the evaluation. These endpoints may include the NOAEL, LOAEL, and lethal dose. The NOAEL is the highest dose where there is no statistically significant difference from the control response. The LOAEL is the lowest dose that results in a statistically significant effect compared to a control. The lethal dose (i.e., the LD_{50}) is the dose lethal to 50% of the test organisms over a specific exposure period.

Both LOAEL and NOAEL values are applied in the evaluation to provide a range of risk assessment results for wildlife. However, the LOAEL dose is the appropriate TRV for evaluating risk at the population level for common species that serve as wildlife receptors. The primary source for all ingestion pathway TRVs is the LANL Ecorisk Database (Release 2.2) (2005). Other sources of TRVs include USEPA (1999, 2005), and Sample et al. (1996), among others. The general strategy for selecting (or deriving) a single LOAEL and NOAEL value as TRVs from among the many values reported in the literature is as follows:

- Preference is given to studies that are chronic or subchronic exposures versus single event or acute exposures. Where data are available for more than one dosing regime, chronic is selected first, subchronic second, and acute only if no other data are available. Critical life-stage tests also carry significant weight.

- Studies are considered based on the dosing regime. Intraperitoneal or intravenous studies are not used if results based on other dosing methods are available. Studies using gavage or oral intubation are not used when food studies are available.

Table 4.2-2
Bioconcentration/Bioaccumulation Factors for Soils

	BCFs				BAFs	
	Plants		Soil Invertebrates		Small Birds/Mammals	
Analytes	**(dw)**	**(ww)**	**(dw)**	**(ww)**	**(dw)**	**(ww)**
Mercury	8.9E+00	6.6E+00	3.9E+00	1.5E+00	6.5E-01	2.1E-01
Selenium	6.3E+00	4.7E+00	9.9E-01	3.9E-01	9.9E-03	3.2E-03

Dry weight BCF/BAF values provided for plants, invertebrates, and small birds/mammals were adjusted to wet weight values by multiplying by the assumed percent solids in each exposure medium. Percent solids are: 74% - plants (site-specific 90th percentile), 39% - soil invertebrates, and 32% - small birds/mammals (USEPA 1993).
Plant BCFs were calculated for subsurface soil uptake to plant upper stems and leaves. All other BCFs and BAFs are from Los Alamos National Laboratory (LANL). 2005. Ecorisk Database (Release 2.2). Prepared by Environmental Health Associates, Inc. Albuquerque, NM. January.
U.S. Environmental Protection Agency (USEPA). 1993. Wildlife Exposure Factors Handbook, Volume 1. Office of Research and Development. EPA/600/R-93/187a.

BAF = bioaccumulation factor
BCF = bioconcentration factor
dw = dry weight
ww = wet weight

- Where literature values are identified for the specific ROI, the lowest LOAEL representing the assessment endpoint (survival, reproduction, development, and/or growth) is selected. For the NOAEL scenario, the highest NOAEL that does not exceed the lowest LOAEL is selected.
- Where values are not available for a specific ROI (which is characteristic of the vast majority of literature values), values from taxonomically close surrogate receptors are selected.
- In cases where NOAELs are reported for a chemical, but LOAELs are not identified, the highest reported NOAEL value is used for deriving TRVs. In such an instance, a LOAEL is derived based on ten times the NOAEL unless a different LOAEL/NOAEL ratio is specified for a similar chemical. If only a LOAEL value is available, the NOAEL is based on one-tenth the LOAEL value.
- If no LOAEL and/or NOAEL data are available for a chemical, but lethal dose data are reported, an uncertainty factor (division) of 10 is applied to the lowest acute lethal dose to derive a LOAEL, and an additional uncertainty factor of 10 applied to the LOAEL to derive a NOAEL. LD_{10}s are selected preferably over LD_{50}s. Lethal dose values are used only in the absence of LOAEL and NOAEL information.

Measures of effect considered include survival, growth, development, and/or reproduction. Endpoints specifically related to survival, growth and reproduction such as fetotoxicity or infertility are considered. Effects such as carcinogenesis, liver damage, kidney function, sperm mobility, enzyme induction, and blood pressure are generally not considered appropriate endpoints for use in assessing the potential for ecologically significant effects. The severity of effect for these toxicological endpoints must be evaluated on a chemical-by-chemical basis to determine applicability in the evaluation. Both NOAEL and LOAEL TRVs for mercury and selenium are found in Tables 4.2-3 and 4.2-4 for birds and mammals, respectively.

4.2.4 Risk Characterization

The final two steps of the evaluation include: (1) Risk Estimates – use of the results from exposure and effects characterization to develop an "estimate" of the risks posed to the assessment endpoints; and (2) Risk Descriptions – description/interpretation of that estimate in the context of ecological significance (relevance) and uncertainty. COPECs that are found to present unacceptable risk to ecological receptors when considering the risk estimate (HQ estimate [Section 4.2.1.4]), risk description (Section 4.2.4.2), and uncertainties associated with the risk assessment process (Section 4.2.5) are termed chemicals of ecological concern (COECs).

4.2.4.1 Risk Estimates

Risk estimates, expressed in terms of HQs (based on both NOAELs and LOAELs or equivalent benchmarks) were calculated for each of the appropriate receptor groups for the Site.

Estimate Methods

The assessment and measurement endpoints, together with analytical data for the various exposure media, form the foundation for the risk characterization. Measurement endpoints selected for the evaluation are based on comparison of the EPC or dietary dose to TRVs from the literature. This comparison is portrayed in a ratio termed the hazard quotient:

$$HQ = EPC \text{ or } Dose / TRV$$

Table 4.2-3
Toxicity Reference Values for Birds

COPECs	Source of Toxicity Data	Form	Test Species	Exposure Duration	Exposure Route	Endpoint(s)	Chronic LOAEL TRV (mg/kg-bw/d)	Chronic NOAEL TRV (mg/kg-bw/d)	Comments
Mercury	LANL 2005	mercuric chloride	Japanese quail	20 weeks	Oral	reproduction	0.19	0.019	Chronic NOAEL = 0.1(Chronic LOAEL)
Selenium	LANL 2005	--	screech owl	13.7 weeks	Oral	reproduction	1.5	0.44	

Los Alamos National Laboratory (LANL). 2005. ECORISK Database (Release 2.2), ER package # 186. Risk Reduction and Environmental Stewardship Remediation Services Project. Los Alamos, NM. ER ID 87386. LA-UR-04-7304. September.

LOAEL = lowest observed adverse effects level
NOAEL = no observed adverse effects level
TRV = toxicity reference value

Table 4.2-4
Toxicity Reference Values for Mammals

Analyte	Source of Toxicity Data	Form	Test Species	Exposure Duration	Exposure Route	Endpoint(s)	Chronic LOAEL TRV (mg/kg-bw/d)	Chronic NOAEL TRV (mg/kg-bw/d)	Comments
Mercury	LANL 2005	--	mink	5 months	Oral	reproduction, develolpment and growth	14.1	1.41	LOAEL = 10(NOAEL)
Selenium	LANL 2005	--	rat	1 year	Oral	reproduction	0.33	0.2	

Los Alamos National Laboratory (LANL). 2005. ECORISK Database (Release 2.2), ER package # 186. Risk Reduction and Environmental Stewardship Remediation Services Project. Los Alamos, NM. ER ID 87386. LA-UR-04-7304. September.

LOAEL = lowest observed adverse effects level
NOAEL = no observed adverse effects level
TRV = toxicity reference value

TRVs based on both no effects (e.g., NOAELs) and low effects (e.g., LOAELs) are used to provide a range of predicted outcomes. The HQs are interpreted as follows:

- HQ_{NOAEL} <1 suggests no risk.
- HQ_{NOAEL} >1 but HQ_{LOAEL} <1 suggests potential risks, and the uncertainty associated with this conclusion must be evaluated further.
- HQ_{LOAEL} >1 suggests potential risks. In this scenario, additional information collection and further evaluation may be warranted, or steps may be taken to initiate evaluation of corrective measures.

For wildlife receptors, the HQ is based on the daily dose per kilogram of body weight that over a chronic exposure period results in: (1) no adverse effects (based on the NOAEL); or (2) represents the lowest dose (level) at which an adverse effect might occur (based on the LOAEL).

The use, validity, and understanding of laboratory-based NOAELs and LOAELs lie in their experimental definitions. Experimentally, these values are determined statistically and are biased by the experimental design, specifically the statistical power of the test design. The NOAEL shows no statistically significant adverse effects when compared to control values, and the LOAEL is the lowest dose/concentration tested that produces statistically significant adverse effects when compared to a control. Statistical significance does not automatically relate to biological significance.

Although the HQ is not a definitive measure, it can be used to estimate the potential level at which the measured or predicted exposure (EPC or Dose) relates to known levels at which adverse effects have been observed in laboratory toxicological studies or found not to be statistically significant (the LOAEL and NOAEL, respectively).

Nevertheless, these HQs contribute to the “line-of-evidence” for interpreting the potential for ecological risks. Additionally, they are easily communicated to and understood by the public and other stakeholders. In the context of this evaluation and specific to their use herein, HQs are estimated for the explicit purpose of evaluating ecological groups within the Desert Rock site that may be adversely affected by exposure to COPECs. The HQ tool as applied in the evaluation should not be construed as an accurate “measure” of risk, but rather as an “indication” of the potential for risk.

Risk Estimate Results

Results of the risk estimation process in terms of HQs for ecological receptors exposed to soils after 50 years of power plant operation are provided in the following tables:

Table 4.2-5:Plants and Soil Invertebrates
Table 4.2-6:Avian Wildlife Receptors
Table 4.2-7:Mammalian Wildlife Receptors
Table 4.2-8:Summary of HQs for Wildlife

Based on the results shown in these tables for the COPECs of mercury and selenium, maximum selenium concentrations in soil after 50 years present a possible risk (HQ = 3.2) to plants (Table 4.2.5).

Table 4.2-5
Hazard Quotients for Plants and Soil Invertebrates Exposed to Soil

Analyte	Concentration in Soil After 50 Years of Deposition (mg/kg)	Plant Surrogate LOEC (mg/kg)	Plant HQ	Soil Invertebrate Surrogate LOEC (mg/kg)	Soil Invertebrate HQ
Surface Soil (0-2 cm)					
Mercury	2.41E-02	340	7.09E-05	0.5	4.82E-02
Selenium	3.20E+00	1	**3.20E+00**	77	4.16E-02
Soil Column (0-10 cm)					
Mercury	2.15E-02	340	6.32E-05	0.5	4.30E-02
Selenium	9.98E-01	1	9.98E-01	77	1.30E-02

Hazard Quotients exceeding 1.0 are shown in bold.

cm = centimeters
ESL = Ecological Screening Level. See LANL (2005) in Table 4.1-1
HQ = hazard quotient; concentration in soil/ESL
LANL = Los Alamos National Laboratory
LOEC = lowest observed effect concentration; estimated at 10 X ESL
mg/kg = milligrams per kilogram
SSL = Soil Screening Level

Table 4.2-6
Calculations of NOAEL and LOAEL Risk-Based Hazard Quotients (HQs) for Avian Wildlife Receptors

Analyte	Surface Soil EPC (mg/kg)	Plant BCF	Invertebrate BCF	Mammal BAF	Estimated Plant Conc. (mg/kg)	Estimated Invertebrate Conc. (mg/kg)	Estimated Mammal Conc. (mg/kg)	Body Wt (kg)	Plant Ingestion Rate (kg/d)	Invertebrate Ingestion Rate (kg/d)	Mammal Ingestion Rate (kg/d)	Soil Ingestion Rate (kg/d)	Plant Exposure (mg/d)	Invertebrate Exposure (mg/d)	Mammal Exposure (mg/d)	Soil Exposure (mg/d)	BA	AUF	ADD (mg/kg-bw/d)	Chronic NOAEL or LOAEL Dose (mg/kg-bw/d)	HQ
Horned lark (NOAEL)																					
Mercury	2.4E-02	6.6E+00	1.5E+00	2.1E-01	1.4E-01	3.3E-02	5.0E-03	3.20E-02	8.4E-03	0.0E+00	0.0E+00	1.5E-04	1.2E-03	0.0E+00	0.0E+00	3.7E-06	1.0E+00	1.0E+00	3.7E-02	1.9E-02	**2.0E+00**
Selenium	3.2E+00	4.7E+00	3.9E-01	3.2E-03	4.7E+00	3.9E-01	1.0E-02	3.20E-02	8.4E-03	0.0E+00	0.0E+00	1.5E-04	3.9E-02	0.0E+00	0.0E+00	4.9E-04	1.0E+00	1.0E+00	1.2E+00	4.4E-01	**2.8E+00**
Horned lark (LOAEL)																					
Mercury	2.4E-02	6.6E+00	1.5E+00	2.1E-01	1.4E-01	3.3E-02	5.0E-03	3.20E-02	8.4E-03	0.0E+00	0.0E+00	1.5E-04	1.2E-03	0.0E+00	0.0E+00	3.7E-06	1.0E+00	1.0E+00	3.7E-02	1.9E-01	2.0E-01
Selenium	3.2E+00	4.7E+00	3.9E-01	3.2E-03	4.7E+00	3.9E-01	1.0E-02	3.20E-02	8.4E-03	0.0E+00	0.0E+00	1.5E-04	3.9E-02	0.0E+00	0.0E+00	4.9E-04	1.0E+00	1.0E+00	1.2E+00	1.5E+00	8.3E-01
Red-tailed hawk (NOAEL)																					
Mercury	2.4E-02	6.6E+00	1.5E+00	2.1E-01	1.4E-01	3.3E-02	5.0E-03	1.22E+00	0.0E+00	0.0E+00	1.2E-01	8.0E-04	0.0E+00	0.0E+00	6.1E-04	1.9E-05	1.0E+00	1.0E+00	5.1E-04	1.9E-02	2.7E-02
Selenium	3.2E+00	4.7E+00	3.9E-01	3.2E-03	4.7E+00	3.9E-01	1.0E-02	1.22E+00	0.0E+00	0.0E+00	1.2E-01	8.0E-04	0.0E+00	0.0E+00	1.2E-03	2.6E-03	1.0E+00	1.0E+00	3.1E-03	4.4E-01	7.1E-03
Red-tailed hawk (LOAEL)																					
Mercury	2.4E-02	6.6E+00	1.5E+00	2.1E-01	1.4E-01	3.3E-02	5.0E-03	1.22E+00	0.0E+00	0.0E+00	1.2E-01	8.0E-04	0.0E+00	0.0E+00	6.1E-04	1.9E-05	1.0E+00	1.0E+00	5.1E-04	1.9E-01	2.7E-03
Selenium	3.2E+00	4.7E+00	3.9E-01	3.2E-03	4.7E+00	3.9E-01	1.0E-02	1.22E+00	0.0E+00	0.0E+00	1.2E-01	8.0E-04	0.0E+00	0.0E+00	1.2E-03	2.6E-03	1.0E+00	1.0E+00	3.1E-03	1.5E+00	2.1E-03
Western meadowlark (NOAEL)																					
Mercury	2.4E-02	6.6E+00	1.5E+00	2.1E-01	1.4E-01	3.3E-02	5.0E-03	1.03E-01	0.0E+00	6.1E-03	0.0E+00	1.2E-04	0.0E+00	2.0E-04	0.0E+00	2.9E-06	1.0E+00	1.0E+00	2.0E-03	1.9E-02	1.0E-01
Selenium	3.2E+00	4.7E+00	3.9E-01	3.2E-03	4.7E+00	3.9E-01	1.0E-02	1.03E-01	0.0E+00	6.1E-03	0.0E+00	1.2E-04	0.0E+00	2.4E-03	0.0E+00	3.9E-04	1.0E+00	1.0E+00	2.7E-02	4.4E-01	6.0E-02
Western meadowlark (LOAEL)																					
Mercury	2.4E-02	6.6E+00	1.5E+00	2.1E-01	1.4E-01	3.3E-02	5.0E-03	1.03E-01	0.0E+00	6.1E-03	0.0E+00	1.2E-04	0.0E+00	2.0E-04	0.0E+00	2.9E-06	1.0E+00	1.0E+00	2.0E-03	1.9E-01	1.0E-02
Selenium	3.2E+00	4.7E+00	3.9E-01	3.2E-03	4.7E+00	3.9E-01	1.0E-02	1.03E-01	0.0E+00	6.1E-03	0.0E+00	1.2E-04	0.0E+00	2.4E-03	0.0E+00	3.9E-04	1.0E+00	1.0E+00	2.7E-02	1.5E+00	1.8E-02

HQ = ADD / TRV

where: HQ = Hazard Quotient; ADD = Average Daily Dose (see below); and TRV = Chronic NOAEL or LOAEL Dose

ADD = [(IRf*Cf) + (IRs*Cs)] * BA*AUF/bw

where: IRf = Ingestion rate of food (kg/day); IRs = Ingestion rate (incidental) of soil (kg/day); Cf = Concentration of COPEC in food (mg/kg)(see below); Cs = Concentration of COPEC in soil (mg/kg); BA = Bioavailability of COPEC in soil and food (assumed to be 1.0); AUF = Area use factor (decimal fraction); and bw = Body weight of the receptor (kg).

Cf = BCF*Cs or Cf = BAF*Cs

where: BCF = bioconcentration factor (ww) and BAF = bioaccumulation factor (ww)

Note: BCFs for plants and invertebrates were applied to 50-year soil column (0-10cm) concentrations to estimate metals concentrations in plants and invertebrates after 50 years. BAFs were used with 50-year surface soil (0-2 cm) concentrations to estimate concentrations in small birds or mammals (prey organisms) based on concentrations in soil.

ADD = average daily dose
AUF = area use factor
BA = bioavailability
BAF = bioaccumulation factor
BCF = bioconcentration factor
EPC = exposure point concentration
kg = kilogram
kg/d = kilograms per day
LOAEL = lowest observed adverse effects level
mg/d = milligrams per day
mg/kg = milligrams per kilogram
mg/kg-bw/d = milligrams per kilogram of body weight per day
NOAEL = no observed adverse effects level
TRV = toxicity reference value
ww = wet weight

Table 4.2-7
Calculations of NOAEL and LOAEL Risk-Based Hazard Quotients (HQs) for Mammalian Wildlife Receptors

Analyte	Surface Soil EPC (mg/kg)	Plant BCF	Invertebrate BCF	Mammal BAF	Estimated Plant Conc. (mg/kg)	Estimated Invertebrate Conc. (mg/kg)	Estimated Mammal Conc. (mg/kg)	Body Wt (kg)	Plant Ingestion Rate (kg/d)	Invertebrate Ingestion Rate (kg/d)	Mammal Ingestion Rate (kg/d)	Soil Ingestion Rate (kg/d)	Plant Exposure (mg/d)	Invertebrate Exposure (mg/d)	Mammal Exposure (mg/d)	Soil Exposure (mg/d)	BA	AUF	ADD (mg/kg-bw/d)	Chronic NOAEL or LOAEL Dose (mg/kg-bw/d)	HQ
Black-tailed jackrabbit (NOAEL)																					
Mercury	2.4E-02	6.6E+00	1.5E+00	2.1E-01	1.4E-01	3.3E-02	5.0E-03	2.10E+00	1.1E-01	0.0E+00	0.0E+00	7.2E-03	1.6E-02	0.0E+00	0.0E+00	1.7E-04	1.0E+00	1.0E+00	7.8E-03	1.4E+00	5.5E-03
Selenium	3.2E+00	4.7E+00	3.9E-01	3.2E-03	4.7E+00	3.9E-01	1.0E-02	2.10E+00	1.1E-01	0.0E+00	0.0E+00	7.2E-03	5.3E-01	0.0E+00	0.0E+00	2.3E-02	1.0E+00	1.0E+00	2.6E-01	2.0E-01	**1.3E+00**
Black-tailed jackrabbit (LOAEL)																					
Mercury	2.4E-02	6.6E+00	1.5E+00	2.1E-01	1.4E-01	3.3E-02	5.0E-03	2.10E+00	1.1E-01	0.0E+00	0.0E+00	7.2E-03	1.6E-02	0.0E+00	0.0E+00	1.7E-04	1.0E+00	1.0E+00	7.8E-03	1.4E+01	5.5E-04
Selenium	3.2E+00	4.7E+00	3.9E-01	3.2E-03	4.7E+00	3.9E-01	1.0E-02	2.10E+00	1.1E-01	0.0E+00	0.0E+00	7.2E-03	5.3E-01	0.0E+00	0.0E+00	2.3E-02	1.0E+00	1.0E+00	2.6E-01	3.3E-01	8.0E-01
Deer mouse (NOAEL)																					
Mercury	2.4E-02	6.6E+00	1.5E+00	2.1E-01	1.4E-01	3.3E-02	5.0E-03	2.10E-02	0.0E+00	6.3E-03	0.0E+00	2.5E-05	0.0E+00	2.1E-04	0.0E+00	6.1E-07	1.0E+00	1.0E+00	9.9E-03	1.4E+00	7.0E-03
Selenium	3.2E+00	4.7E+00	3.9E-01	3.2E-03	4.7E+00	3.9E-01	1.0E-02	2.10E-02	0.0E+00	6.3E-03	0.0E+00	2.5E-05	0.0E+00	2.4E-03	0.0E+00	8.1E-05	1.0E+00	1.0E+00	1.2E-01	2.0E-01	6.0E-01
Deer mouse (LOAEL)																					
Mercury	2.4E-02	6.6E+00	1.5E+00	2.1E-01	1.4E-01	3.3E-02	5.0E-03	2.10E-02	0.0E+00	6.3E-03	0.0E+00	2.5E-05	0.0E+00	2.1E-04	0.0E+00	6.1E-07	1.0E+00	1.0E+00	9.9E-03	1.4E+01	7.0E-04
Selenium	3.2E+00	4.7E+00	3.9E-01	3.2E-03	4.7E+00	3.9E-01	1.0E-02	2.10E-02	0.0E+00	6.3E-03	0.0E+00	2.5E-05	0.0E+00	2.4E-03	0.0E+00	8.1E-05	1.0E+00	1.0E+00	1.2E-01	3.3E-01	3.6E-01
Kit fox (NOAEL)																					
Mercury	2.4E-02	6.6E+00	1.5E+00	2.1E-01	1.4E-01	3.3E-02	5.0E-03	2.25E+00	0.0E+00	0.0E+00	1.8E-01	4.9E-03	0.0E+00	0.0E+00	8.8E-04	1.2E-04	1.0E+00	1.0E+00	4.4E-04	1.4E+00	3.1E-04
Selenium	3.2E+00	4.7E+00	3.9E-01	3.2E-03	4.7E+00	3.9E-01	1.0E-02	2.25E+00	0.0E+00	0.0E+00	1.8E-01	4.9E-03	0.0E+00	0.0E+00	1.8E-03	1.6E-02	1.0E+00	1.0E+00	7.8E-03	2.0E-01	3.9E-02
Kit fox (LOAEL)																					
Mercury	2.4E-02	6.6E+00	1.5E+00	2.1E-01	1.4E-01	3.3E-02	5.0E-03	2.25E+00	0.0E+00	0.0E+00	1.8E-01	4.9E-03	0.0E+00	0.0E+00	8.8E-04	1.2E-04	1.0E+00	1.0E+00	4.4E-04	1.4E+01	3.1E-05
Selenium	3.2E+00	4.7E+00	3.9E-01	3.2E-03	1.5E+01	1.2E+00	1.0E-02	2.25E+00	0.0E+00	0.0E+00	1.8E-01	4.9E-03	0.0E+00	0.0E+00	1.8E-03	1.6E-02	1.0E+00	1.0E+00	7.8E-03	3.3E-01	2.4E-02

HQ = ADD / TRV
where: HQ = Hazard Quotient; ADD = Average Daily Dose (see below); and TRV = Chronic NOAEL or LOAEL Dose
ADD = [(IRf*Cf) + (IRs*Cs)] * BA*AUF/bw
where: IRf = Ingestion rate of food (kg/day); IRs = Ingestion rate (incidental) of soil (kg/day); Cf = Concentration of COPEC in food (mg/kg)(see below); Cs = Concentration of COPEC in soil (mg/kg); BA = Bioavailability of COPEC in soil and food (assumed to be 1.0); AUF = Area use factor (decimal fraction); and bw = Body weight of the receptor (kg).
Cf = BCF*Cs or Cf = BAF*Cs
where: BCF = bioconcentration factor (ww) and BAF = bioaccumulation factor (ww)
Note: BCFs for plants and invertebrates were applied to 50-year soil column (0-10cm) concentrations to estimate metals concentrations in plants and invertebrates after 50 years. BAFs were used with 50-year surface soil (0-2 cm) concentrations to estimate concentrations in small birds or mammals (prey organisms) based on concentrations in soil.

ADD = average daily dose
AUF = area use factor
BA = bioavailability
BAF = bioaccumulation factor
BCF = bioconcentration factor
EPC = exposure point concentration
kg = kilogram
kg/d = kilograms per day
LOAEL = lowest observed adverse effects level
mg/d = milligrams per day
mg/kg = milligrams per kilogram
mg/kg-bw/d = milligrams per kilogram of body weight per day
NOAEL = no observed adverse effects level
TRV = toxicity reference value
ww = wet weight

Table 4.2-8
Summary of NOAEL- and LOAEL-Based Hazard Quotients for Wildlife Exposed to Soil

	Avian Herbivore Horned Lark		Avian Carnivore Red-tailed Hawk		Avian Insectivore Western Meadowlark	
COPECs	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**
Mercury	**2.0E+00**	2.0E-01	2.7E-02	2.7E-03	1.0E-01	1.0E-02
Selenium	**2.8E+00**	8.3E-01	7.1E-03	2.1E-03	6.0E-02	1.8E-02

	Mammalian Herbivore Black-tailed Jackrabbit		Mammalian Insectivore Deer Mouse		Mammalian Carnivore Kit Fox	
COPECs	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**	**NOAEL**	**LOAEL**
Mercury	5.5E-03	5.5E-04	7.0E-03	7.0E-04	3.1E-04	3.1E-05
Selenium	**1.3E+00**	8.0E-01	6.0E-01	3.6E-01	3.9E-02	2.4E-02

Hazard Quotients exceeding 1.0 are shown in bold.

COPECs = chemicals of potential ecological concern
LOAEL = lowest observed adverse effects level
NOAEL = no observed advsere effects level

Based on LOAELs, none of the wildlife species, which represent herbivores, insectivores, and carnivores, are at risk from mercury or selenium deposited on soils (Tables 4.2-6, 4.2-7, and 4.2-8). HQs (LOAEL-based) for wildlife range from 3.1E-05 to 8.3E-01. The highest HQs are for the horned lark (avian herbivore) and the black-tailed jackrabbit (mammalian herbivore) exposed to selenium. The sensitivity of these two receptors to selenium (and to mercury) is seen in the NOAEL-based HQs that are greater than 1.0. However, NOAEL-based HQs are applicable only for assessing risk to protected species.

Risk Description

The calculated HQ for plants exposed to selenium is overly conservative due to conservative estimates of exposure and toxicological benchmarks. The selenium HQ of 3.2 is based on estimated surface soil (0-2 cm) concentrations; however, soil column (0-10 cm) concentrations in contact with plant root zones do not exceed the plant LOEC, and the HQ is lower than 1.0. Also, the ESL for plants exposed to selenium (0.1 mg/kg) in LANL (2005) is overly conservative compared with screening benchmark from Efroymson et al. (1997). In conclusion, plants likely are not at risk from selenium deposited on the soils over the 50 years of power plant operation.

The calculated HQs for the horned lark and the black-tailed jackrabbit are, by design, very conservative, because the majority of uncertainties discussed below contribute to an overestimate of exposure and risk (see Section 4.2.5). The only HQs exceeding 1.0 are based on NOAEL dose TRVs. In the context of assessing risk to common species, LOAELs are the more appropriate TRVs because an impact at the population level is the threshold for significance. The HQs calculated using LOAEL TRVs are all lower than 1.0. As described above, an $HQ_{NOAEL} > 1$ but $HQ_{LOAEL} < 1$ suggests potential risks, but the uncertainties associated with this conclusion must be evaluated further. Therefore, no risk to population levels of avian herbivores mammalian herbivores, or other wildlife receptors is expected for the 50-year deposition of particulates on the soils surrounding the proposed plant.

In conclusion, the ecological risk evaluation indicates that emissions from the proposed Desert Rock power plant will not pose unacceptable risks to plants or, at the population level, to wildlife receptors.

4.2.5 Uncertainties

Within many steps of the risk assessment process, assumptions were made due to a lack of absolute scientific knowledge. Every assumption introduces some degree of uncertainty into the risk evaluation process; however, regulatory risk evaluation methodology requires that conservative assumptions be made wherever possible to ensure that the ecological risks are not underestimated. The primary sources of uncertainty in the evaluation are discussed below together with the estimated effect of the assumption. Uncertainties are discussed with respect to exposure and ecological effects of contaminants.

4.2.5.1 Exposure Analysis

- Calculations of soil concentrations do not take into account any of the many processes (e.g., biotic and abiotic degradation, volatilization) that would reduce soil concentrations – Overestimates exposure.
- Calculated uptake rates (BCFs) used in estimating plant concentrations of metals are based on the 90th percentile of the combined data – Likely overestimates exposure to metals in plants.
- Particulates falling on plant surfaces are not included in the 2056 exposure estimates – May underestimate total concentrations of metals ingested by herbivorous receptors.

- Calculations of deposition and soil concentrations assume continuous (100%) power plant operations (24/7 for 50 years); more reasonable operations would be 85% of the time over a 50-year period – Overestimates deposition and exposure.
- Bioavailability equal to 1 – It is unlikely that 100% of a measured chemical (e.g., see Gustafsson et al. 2003) is available for uptake and absorption – Overestimates exposure and risk.
- Area use factor equal to 1 – given the poor habitat quality in many portions of the study area, literature-based home ranges may not be large enough and the area use factor may not be equal to 1 – May overestimate exposure in many areas due to low overall habitat quality.
- Uptake factor for prey items – An uptake factor typically based on literature-derived equilibrium assumptions assumes that the measured concentrations of contaminants are constantly available to the receptors. It does not consider that only a finite mass of each contaminant is available for the receptors – May overestimate exposure and risk.
- Uncertainties in the estimation of EPCs in the site characterization – Numbers of samples in the exposure area(s) may not be adequate to describe exposure concentrations. May overestimate or underestimate exposure and risk.
- Environmentally conservative values (95% UCLs) were used to estimate initial soil concentrations – May overestimate long-term average exposure and risk.

4.2.5.2 Ecological Effects of Contaminants

- Extrapolation of toxicological data from laboratory test species to wildlife receptor species – species differ with respect to absorption, metabolism, distribution, and excretion of chemicals – May overestimate or underestimate risk to wildlife species.
- The ESL for plants exposed to selenium (0.1 mg/kg) in LANL (2005) is overly conservative. In *Toxicological Benchmarks for Screening Contaminants of Potential Concern for Effects on Terrestrial Plants: 1997 Revision* (Efroymson et al., 1997), the screening benchmark for selenium is 1.0 mg/kg (an order of magnitude higher than the ESL). This soil concentration benchmark in Efroymson et al. (1997) is the closest to the 10th percentile of 14 phytotoxicity results considered – Use of the selenium ESL and Surrogate LOEC overestimates risk to plants.
- Use of the NOAEL TRVs for wildlife overestimates the potential for toxic effects of metals. – Overestimates risk at the population level for common receptor species.

5.0 REFERENCES

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ATTACHMENT 1
Soil and Plant Chemical Data

Table 1-1
Desert Rock
Data Summary for Sample Location PW-1

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	6.4	J	6.1	J	0.48	J	0.41	J
Barium	mg/kg	270		320		53		47	
Cadmium	mg/kg	0.11		0.063	J	0.034	J	0.044	J
Chromium	mg/kg	10		12		1.9		2	
Lead	mg/kg	11		10		0.44		0.78	
Mercury	mg/kg	0.02	J	0.024	J	0.0073	J	0.0068	J
Selenium	mg/kg	0.69	J	0.65	J	0.38	J	0.19	J
Percent Moisture	%	1.3		2.4		33		28	
pH	Std. Units	NA		7.0		NA		NA	
Total Organic Carbon	g/kg	3.3		2.5		NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 18 cm.
Species sampled: Shad scale
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable

Table 1-2
Desert Rock
Data Summary for Sample Location PW-2

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	3.4	J	4	J	0.59	J	0.92	
Barium	mg/kg	61		130		7.4		19	
Cadmium	mg/kg	0.12		0.078	J	0.057	J	0.12	J
Chromium	mg/kg	10		12		2		3.3	
Lead	mg/kg	7.6		7.4		0.45		1.5	
Mercury	mg/kg	0.017	J	0.013	J	0.012	J	ND (0.0037)	U
Selenium	mg/kg	0.51	J	0.55	J	1.2		0.5	J
Percent Moisture	%	0.75		2.6		43		25	
pH	Std. Units	NA		7.1		NA		NA	
Total Organic Carbon	g/kg	2.9		3.8		NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 20 cm.
Species sampled: Shad scale
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable

Table 1-3
Desert Rock
Data Summary for Sample Location PW-3

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	1.1	J	1.3	J	0.64	J	0.11	J
Barium	mg/kg	33		49		9.2		5	
Cadmium	mg/kg	0.039	J	0.062	J	0.035	J	0.15	
Chromium	mg/kg	3.7		5.6		1.9		1.4	
Lead	mg/kg	3.4		4.5		0.34		0.13	J
Mercury	mg/kg	ND (0.0028)	U	0.0042	J	0.009	J	ND (0.004)	U
Selenium	mg/kg	0.18	J	0.23	J	0.81	J	0.18	J
Percent Moisture	%	0.62		1.9		47		29	
pH	Std. Units	NA		6.9		NA		NA	
Total Organic Carbon	g/kg	1.1	J	1.8	J	NA		NA	

*Metals concentrations in terms of dry weight.

S1 = surface soil

S24 = subsurface soil. Sampling depth of 25 cm.

Species sampled: 4-winged saltbush

PU = plant upper (leaves and stems)

PL = plant lower (roots)

Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.

ND = not detected; method detection limit in parentheses

NA = not applicable

Table 1-4
Desert Rock
Data Summary for Sample Location PW-4

Analyte	Units*	S1	S1-Flag	S4	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	3.1	J	2.5	J	0.24	J	0.89	
Barium	mg/kg	69		60		9.5		22	
Cadmium	mg/kg	0.17		0.12		0.022	J	0.12	J
Chromium	mg/kg	11		9.4		2		3.4	
Lead	mg/kg	7.5		6.1		0.48		1.9	
Mercury	mg/kg	0.014	J	0.0099	J	0.019	J	0.025	J
Selenium	mg/kg	0.53	J	0.44	J	0.17	J	0.23	J
Percent Moisture	%	2.5		8.9		28		24	
pH	Std. Units	NA		7.3		NA		NA	
Total Organic Carbon	g/kg	7		2.3		NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 13 cm.
Species sampled: Alkalai saccaton
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable

Table 1-5
Desert Rock
Data Summary for Sample Location PW-5

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	2.3	J	6.7	J	0.38	J	0.36	J
Barium	mg/kg	65		130		37		33	
Cadmium	mg/kg	0.051	J	0.055	J	0.04	J	0.04	J
Chromium	mg/kg	4.3		8.9		2.2		1.6	
Lead	mg/kg	4.8		8.9		0.72		0.33	
Mercury	mg/kg	ND (0.0028)	U	0.024	J	0.0051	J	0.012	J
Selenium	mg/kg	0.22	J	0.34	J	0.3	J	0.1	J
Percent Moisture	%	0.4		2.2	(DUP 2.2)	27		21	
pH	Std. Units	NA		6.9		NA		NA	
Total Organic Carbon	g/kg	3.6		2.9					

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 13 cm.
Species sampled: Broom snakeweed
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable
NA = not applicable

Table 1-6
Desert Rock
Data Summary for Sample Location PW-6

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	2.1	J	2.5	J	0.094	J	2.2	
Barium	mg/kg	93		100		11		68	
Cadmium	mg/kg	0.06	J	0.055	J	0.028	J	0.065	J
Chromium	mg/kg	4.5	J	5.2		1.6		4.4	
Lead	mg/kg	7.9	J	9.5		0.26		7	
Mercury	mg/kg	0.0075	J	0.0063	J	0.013	J	0.024	J
Selenium	mg/kg	0.31	J	0.4	J	ND (0.11)	U	0.31	J
Percent Moisture	%	0.98		9.7		30		17	
pH	Std. Units	NA		7.2		NA		NA	
Total Organic Carbon	g/kg	9.8		2.8					

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 15 cm.
Species sampled: Alkalai saccaton
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable

Table 1-7
Desert Rock
Data Summary for Sample Location PW-7

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	3.7	J	4.7	J	0.76	J	0.87	
Barium	mg/kg	260		900		23		130	
Cadmium	mg/kg	0.11		0.086	J	0.036	J	0.14	
Chromium	mg/kg	8		7.5		1.9		3	
Lead	mg/kg	11		11		0.44		1.9	
Mercury	mg/kg	0.015	J	0.01	J	0.015	J	0.0066	J
Selenium	mg/kg	0.48	J	0.63	J	0.85		0.43	J
Percent Moisture	%	0.73		2.8		41		24	
pH	Std. Units	NA		7.4		NA		NA	
Total Organic Carbon	g/kg	3.8		2	J				

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 13 cm.
Species sampled: NM saltbush
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable

Table 1-8
Desert Rock
Data Summary for Sample Location PW-8

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	3.5	J	4.3	J	0.2	J	1	
Barium	mg/kg	170		240		16		48	
Cadmium	mg/kg	0.092	J	0.11		0.018	J	0.066	J
Chromium	mg/kg	6.7		7.3		1.7		2.8	
Lead	mg/kg	9.1		10		0.42		1.9	
Mercury	mg/kg	0.011	J	0.013	J	0.016	J	0.012	J
Selenium	mg/kg	0.39	J	0.41	J	0.091	J	0.17	J
Percent Moisture	%	0.8	(DUP 0.72)	2.3		9.9		6	
pH	Std. Units	NA		7.3		NA		NA	
Total Organic Carbon	g/kg	2.4		2.5		NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 13 cm.
Species sampled: Alkalai saccaton
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable
NA = not applicable

Table 1-9
Desert Rock
Data Summary for Sample Location DD-1

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	2.8	J	4.7	J	0.36	J	2.8	
Barium	mg/kg	140		230		63		100	
Cadmium	mg/kg	0.11		0.1		0.093	J	0.14	J
Chromium	mg/kg	5.6		7.7		1.4		4.8	
Lead	mg/kg	8.7		8.8		0.4		5	
Mercury	mg/kg	0.026	J	0.058		0.026	J	0.025	J
Selenium	mg/kg	0.36	J	0.62	J	0.38	J	0.4	J
Percent Moisture	%	0.53		2.3		58		44	
pH	Std. Units	NA		6.9		NA		NA	
Total Organic Carbon	g/kg	4.7		3.4		NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 13 cm.
Species sampled: Shad scale
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable
NA = not applicable

Table 1-10
Desert Rock
Data Summary for Sample Location DD-2

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	2	J	2.3	J	0.13		0.56	J
Barium	mg/kg	95		98		38		50	
Cadmium	mg/kg	0.058	J	0.05	J	0.035	J	0.16	
Chromium	mg/kg	3.1		3.1		1.7		1.8	
Lead	mg/kg	4.8		4.8		0.36		0.47	
Mercury	mg/kg	0.012	J	0.0091	J	0.02	J	0.017	J
Selenium	mg/kg	0.22	J	0.24	J	0.2	J	0.25	J
Percent Moisture	%	0.3		1.1		53		34	
pH	Std. Units	NA		6.9		NA		NA	
Total Organic Carbon	g/kg	3.2		1	J	NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 13 cm.
Species sampled: Broom snakeweed
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable
NA = not applicable

Table 1-11
Desert Rock
Data Summary for Sample Location DD-3

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	4.2	J	3.9	J	0.44	J	5.1	
Barium	mg/kg	460		430		36		280	
Cadmium	mg/kg	0.066	J	0.034	J	0.035	J	0.13	J
Chromium	mg/kg	4.5		3.4		1.7		3.8	
Lead	mg/kg	6.1		4.6		0.47		4.4	
Mercury	mg/kg	0.02	J	0.022	J	0.029	J	0.12	
Selenium	mg/kg	0.37	J	0.39	J	5.3		1.5	
Percent Moisture	%	0.55		1.5		60		31	
pH	Std. Units	NA		6.9		NA		NA	
Total Organic Carbon	g/kg	2.3		0.61	J	NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 20 cm.
Species sampled: Shad scale
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable
NA = not applicable

Table 1-12
Desert Rock
Data Summary for Sample Location DD-4

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	2.2	J	1.7	J	0.17	J	0.12	J
Barium	mg/kg	78		140		33		34	
Cadmium	mg/kg	0.048	J	0.028	J	0.039	J	0.13	J
Chromium	mg/kg	2.5		2.8		1.9		1.6	
Lead	mg/kg	4.5	J	3.4		0.25	J	0.39	
Mercury	mg/kg	0.0054	J	0.0048	J	0.012	J	0.012	J
Selenium	mg/kg	0.15	J	0.19	J	0.62	J	0.34	J
Percent Moisture	%	0.69		1.6		42		27	
pH	Std. Units	NA		6.6		NA		NA	
Total Organic Carbon	g/kg	1.6	J	1.2	J	NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 15 cm.
Species sampled: 4-winged saltbush
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable
NA = not applicable

Table 1-13
Desert Rock
Data Summary for Sample Location DD-5

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	2.4	J	2.2	J	0.19	J	0.065	J
Barium	mg/kg	290		340		140		140	
Cadmium	mg/kg	0.065	J	0.035	J	0.095	J	0.047	J
Chromium	mg/kg	3.7		3.7		1.8		1.5	
Lead	mg/kg	5.7		4.4		0.35		0.16	J
Mercury	mg/kg	0.008	J	0.0049	J	0.0066	J	0.011	J
Selenium	mg/kg	0.25	J	0.22	J	0.17	J	0.14	J
Percent Moisture	%	1.1		2.5		32		37	
pH	Std. Units	NA		6.6		NA		NA	
Total Organic Carbon	g/kg	3.1		1.5	J	NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 20 cm.
Species sampled: Torrey's ephedra
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable
NA = not applicable

Table 1-14
Desert Rock
Data Summary for Sample Location DD-6

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	1.7	J	1.3	J	0.32	J	0.26	J
Barium	mg/kg	100		70		19		28	
Cadmium	mg/kg	0.044	J	0.029	J	0.1	J	0.22	
Chromium	mg/kg	3.9		2.6		2.4		1.5	
Lead	mg/kg	4.9		3.4		0.5		0.49	
Mercury	mg/kg	0.007	J	0.0068	J	0.017	J	0.0072	J
Selenium	mg/kg	0.23	J	0.19	J	1.3		3.2	
Percent Moisture	%	3		2.9		46		38	
pH	Std. Units	NA		6.6		NA		NA	
Total Organic Carbon	g/kg	1.9	J	1.8	J	NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 15 cm.
Species sampled: Broom snakeweed
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable
NA = not applicable

Table 1-15
Desert Rock
Data Summary for Sample Location DD-7

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	2	J	1.6	J	0.07	J	0.08	J
Barium	mg/kg	41		65		130		49	
Cadmium	mg/kg	0.033	J	0.041	J	0.072	J	0.13	J
Chromium	mg/kg	1.2		2.6		1.4		1.4	
Lead	mg/kg	2.9		3.7		0.088	J	0.19	J
Mercury	mg/kg	0.0036	J	ND (0.0028)	U	0.013	J	0.014	J
Selenium	mg/kg	0.13	J	0.17	J	0.17	J	0.14	J
Percent Moisture	%	1.2		1.6		40		35	
pH	Std. Units	NA		6.9		NA		NA	
Total Organic Carbon	g/kg	ND (0.44)	U	0.73	J	NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 15 cm.
Species sampled: Torrey's ephedra
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable
NA = not applicable

Table 1-16
Desert Rock
Data Summary for Sample Location DD-8

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	2.1	J	4.8	J	0.13	J	0.54	J
Barium	mg/kg	110		100		19		19	
Cadmium	mg/kg	0.04	J	0.045	J	0.1	J	0.031	J
Chromium	mg/kg	3.1		3		1.7		2	
Lead	mg/kg	4.4		4.6		0.24		0.26	J
Mercury	mg/kg	0.005	J	0.0034	J	0.0074	J	0.013	J
Selenium	mg/kg	0.2	J	0.28	J	0.42	J	1.4	
Percent Moisture	%	1.7 (DUP 1.6)		1.9		32		59	
pH	Std. Units	NA		6.8		NA		NA	
Total Organic Carbon	g/kg	1.7	J	1.3	J	NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 18 cm.
Species sampled: 4-winged saltbush
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable
NA = not applicable

Table 1-17
Desert Rock
Data Summary for Sample Location WD-1

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	2.2	J	2	J	1.2	J	0.47	J
Barium	mg/kg	120		210		59		83	
Cadmium	mg/kg	0.07	J	0.032	J	0.14	J	0.11	J
Chromium	mg/kg	3.7		2.9		2.2		1.9	
Lead	mg/kg	5.8		3.8		0.33	J	1.2	
Mercury	mg/kg	ND (0.0028)		ND (0.0028)		0.017	J	0.013	J
Selenium	mg/kg	0.27	J	0.25	J	1.8		0.36	J
Percent Moisture	%	0.43		1.6		68		51	
pH	Std. Units	NA		7.1		NA		NA	
Total Organic Carbon	g/kg	2.2		0.45	J	NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 38 cm.
Species sampled: Shad scale
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable
NA = not applicable

Table 1-18
Desert Rock
Data Summary for Sample Location WD-2

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	4.3	J	3.5	J	0.28	J	2.3	
Barium	mg/kg	180		88		7.6		45	
Cadmium	mg/kg	0.041	J	0.042	J	0.74		0.29	
Chromium	mg/kg	5		4.9		1.9		2.1	
Lead	mg/kg	13		15		0.44		2.8	
Mercury	mg/kg	0.03	J	0.051		0.02	J	0.039	J
Selenium	mg/kg	0.69	J	0.59	J	0.14	J	0.41	J
Percent Moisture	%	2.7		13		25		40	
pH	Std. Units	NA		7.2		NA		NA	
Total Organic Carbon	g/kg	ND (0.45)		16		NA		NA	

*Metals concentrations in terms of dry weight.

S1 = surface soil

S24 = subsurface soil. Sampling depth of 13 cm.

Species sampled: Broom snakeweed

PU = plant upper (leaves and stems)

PL = plant lower (roots)

Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.

ND = not detected; method detection limit in parentheses

NA = not applicable

NA = not applicable

Table 1-19
Desert Rock
Data Summary for Sample Location WD-3

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	2.1	J	2.3	J	0.031	J	1.2	
Barium	mg/kg	73		84		22		93	
Cadmium	mg/kg	0.044	J	0.044	J	0.034	J	0.11	J
Chromium	mg/kg	2.2		3.1		1.3		2	
Lead	mg/kg	4		4.2		ND (0.087)		1.9	
Mercury	mg/kg	ND (0.0028)		ND (0.0028)		0.011	J	0.026	J
Selenium	mg/kg	0.26	J	0.31	J	0.25	J	0.41	J
Percent Moisture	%	0.24		1.7		43		23	
pH	Std. Units	NA		6.8		NA		NA	
Total Organic Carbon	g/kg	0.92	J	1.4	J	NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 30 cm.
Species sampled: Torrey's ephedra
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable
NA = not applicable

Table 1-20
Desert Rock
Data Summary for Sample Location WD-4

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	1.4	J	1.3	J	0.49	J	0.22	J
Barium	mg/kg	59		47		16		9.7	
Cadmium	mg/kg	0.048	J	0.028	J	0.048	J	0.52	
Chromium	mg/kg	2.9		2.8		2.1		1.5	
Lead	mg/kg	3.8		2.9		0.44		0.34	
Mercury	mg/kg	ND (0.0028)		ND (0.0028)		0.02	J	0.0068	J
Selenium	mg/kg	0.21	J	0.18	J	0.92	J	0.24	J
Percent Moisture	%	0.35		1.2		59		34	
pH	Std. Units	NA		6.7		NA		NA	
Total Organic Carbon	g/kg	4.3		1.3	J	NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 41 cm.
Species sampled: 4-winged saltbush
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable
NA = not applicable

Table 1-21
Desert Rock
Data Summary for Sample Location WD-5

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	1.8	J	1.6	J	ND (0.028)		1.3	
Barium	mg/kg	78		75	J	27		86	
Cadmium	mg/kg	0.076	J	0.073	J	0.041	J	0.33	
Chromium	mg/kg	4		3.7		1.6		4.8	
Lead	mg/kg	4.3		3.9		ND (0.097)	U	2.6	
Mercury	mg/kg	ND (0.0028)		ND (0.0029)		0.0081	J	0.023	J
Selenium	mg/kg	0.23	J	0.17	J	ND (0.15)		0.28	J
Percent Moisture	%	0.98		3.3		48		22	
pH	Std. Units	NA		6.5		NA		NA	
Total Organic Carbon	g/kg	6.3		4.3		NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 10 cm.
Species sampled: Common wheat
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable
NA = not applicable

Table 1-22
Desert Rock
Data Summary for Sample Location WD-6

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	1.8	J	1.6	J	ND (0.028)		1.4	
Barium	mg/kg	78		75	J	27		120	
Cadmium	mg/kg	0.076	J	0.073	J	0.041	J	0.43	
Chromium	mg/kg	4		3.7		1.6		5.8	
Lead	mg/kg	4.3		3.9		ND (0.097)	U	4.5	
Mercury	mg/kg	ND (0.0028)		ND (0.0029)		0.0081	J	0.17	J
Selenium	mg/kg	0.23	J	0.17	J	ND (0.15)		0.27	J
Percent Moisture	%	0.98		3.3		48		29	
pH	Std. Units	NA		6.8		NA		NA	
Total Organic Carbon	g/kg	6.3		4.3		NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 10 cm.
Species sampled: Common wheat
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable

Table 1-23
Desert Rock
Data Summary for Sample Location WD-7

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	4.9	J	6.3	J	0.67	J	1.4	
Barium	mg/kg	150		150		42		37	
Cadmium	mg/kg	0.14		0.1		0.046	J	0.046	J
Chromium	mg/kg	9.4		10		2.6		2.8	
Lead	mg/kg	8.4		8		0.96		1.1	
Mercury	mg/kg	0.006	J	0.014	J	0.0079	J	0.015	J
Selenium	mg/kg	0.49	J	0.48	J	0.35	J	0.23	J
Percent Moisture	%	0.51		1.7		26		30	
pH	Std. Units	NA		6.9		NA		NA	
Total Organic Carbon	g/kg	3.2		3.8		NA		NA	

*Metals concentrations in terms of dry weight.
S1 = surface soil
S24 = subsurface soil. Sampling depth of 13 cm.
Species sampled: Broom snakeweed
PU = plant upper (leaves and stems)
PL = plant lower (roots)
Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.
ND = not detected; method detection limit in parentheses
NA = not applicable
NA = not applicable

Table 1-24
Desert Rock
Data Summary for Sample Location WD-8

Analyte	Units*	S1	S1-Flag	S24	S24-Flag	PU	PU-Flag	PL	PL-Flag
Arsenic	mg/kg	2.2	J	2.2	J	ND (0.025)		0.21	J
Barium	mg/kg	180		140		49		94	
Cadmium	mg/kg	0.09	J	0.037	J	0.016	J	0.053	J
Chromium	mg/kg	4.1		3.9		1.4		1.5	
Lead	mg/kg	5.2		4.9		ND (0.084)	U	ND (0.07)	U
Mercury	mg/kg	0.0053	J	ND (0.0029)		0.0093	J	0.03	J
Selenium	mg/kg	0.21	J	0.26	J	0.37	J	0.41	J
Percent Moisture	%	0.23		2.4 (DUP 2.6)		40		29	
pH	Std. Units	NA		7.1		NA		NA	
Total Organic Carbon	g/kg	1.7	J	1.9	J	NA		NA	

*Metals concentrations in terms of dry weight.

S1 = surface soil

S24 = subsurface soil. Sampling depth of 48 cm.

Species sampled: Torrey's ephedra

PU = plant upper (leaves and stems)

PL = plant lower (roots)

Flag = J: The number is an estimated concentration because something in the sample interfered with the analysis. U: The contaminant was not detected at a concentration greater than the detection limit.

ND = not detected; method detection limit in parentheses

NA = not applicable

NA = not applicable

ATTACHMENT 2
Estimating the 95% UCL for Exposure Point Concentrations

ATTACHMENT 2
ESTIMATING THE 95% UCL FOR EXPOSURE POINT CONCENTRATIONS

For sampled media/exposure where the number of samples is adequate, the exposure point concentration (EPC), a conservative estimate of the average chemical concentration in an environmental medium, was estimated using the 95% upper confidence limit (UCL) (USEPA 2002).

The main steps of calculating 95% UCL are as follows:

- Perform exploratory data analysis (EDA).
- Test for data distributional assumption.
- Calculate the 95% upper confidence limit (UCL).

A brief description of each step follows.

- Perform exploratory data analysis.

The objective of EDA is to discover trends in the data so that appropriate approaches and limitations in using the datasets could be identified. Both numerical and graphical methods of EDA may be used. Non-detects were replaced with half of the corresponding detection limit in this analysis. In addition, the maximum concentration among the duplicates was used as a single data point to ensure the data were reasonably independent. If more than one sample were taken over time in a single location, the average of these sample results was used in the statistical evaluation.

The numerical methods included a table of basic summary statistics, such as mean, standard deviation, minimum, and maximum, for both raw values and natural log-transformed values. These statistics can be used to make inferences concerning the population from which the sample data were drawn. Graphical methods may include histograms, box-and-whisker plots, and normal probability plots. These plots were used to assess the shape and skewness of the data distribution, as well as to inspect any potential outliers (extreme values).

- Test for data distributional assumption.

The purpose of this step is to check whether the data (raw or log-transformed) could be assumed to be normally distributed. Based on the results of this evaluation, an appropriate probability distribution can be assumed for the data for use in the calculation of 95% UCL in the next step.

The Shapiro-Wilk W test was used to test the normality of the dataset at a 5% significance level, as described in the US Environmental Protection Agency (USEPA) Guidance Document (USEPA 2004a). The test was first applied to raw data. If this data set passed the normality test, the raw data were assumed to be normally distributed. If the raw data did not pass the normality test, the test would then be applied to the log-transformed data. If the log-transformed data passed the normality test, the data were assumed to be lognormally distributed. If the data failed both tests, the data were assumed to be non-parametric.

- Calculate the 95% upper confidence limit.

If the data were determined to be normally distributed, the 95% UCL was calculated as follows (USEPA 2002):

$$UCL = \bar{x} + t_{1-\alpha,n-1} \frac{s}{\sqrt{n}}$$

where:

$\bar{x}$ = sample mean

t = the Student t value at α significance level, with n-1 degree of freedom

α = 0.05 (one-tailed)

n = sample size

s = sample standard deviation

Otherwise, if the data were determined to be lognormally distributed, the 95% UCL was calculated based on one of the following methods:

(a) H-statistic based UCL.
(b) Chebychev Inequality method on the estimation of minimum variance unbiased estimator (MVUE) of a lognormal mean, at a 95% confidence level.
(c) Chebychev Inequality method using the sample mean and standard deviation, at a 99% confidence level.

The choice of method depends on the sample size and sample skewness (measured by the standard deviation of log-transformed data), as illustrated and recommended by USEPA (2004b). The detailed statistical steps of these methods are documented in the USEPA's guidance document, and the calculation of MVUE of a lognormal mean is documented in Gilbert's *Statistical Methods for Environmental Pollution Monitoring* (1987).

If the data distribution was neither normal nor lognormal based on the result of Shapiro-Wilk W test in Step 2, the 95% UCL was calculated based on one of the following methods:

(a) Chebychev Inequality method using the sample mean and standard deviation, at a 95% confidence level.
(b) Hall's bootstrap method.

Similar to the lognormal distribution, the choice of method depends on the sample size and sample skewness. These methods do not require any parametric assumption on the data and are recommended by USEPA (2004b).

References

Gilbert, Richard O. 1987. *Statistical Methods for Environmental Pollution Monitoring*. Van Nostrand Reinhold, New York.

US Environmental Protection Agency (USEPA). 2002. *Calculating Upper Confidence Limits for Exposure Point Concentrations at Hazardous Waste Sites.* Office of Emergency and Remedial Response, U.S. Environmental Protection Agency, Report No. OSWER 9285.6-10.

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ATTACHMENT 3
Detailed Human Health Risk Calculations

Table 1
Inhalation of Outdoor Air
Future

Exposure Medium: Air	Noncancer Hazard = CS x SIFnc / RfD
Receptor Population: Resident	Cancer Risk = CS x SIFc x CSF
Receptor Age: Adult and Child	
Exposure Point: Outdoor Air	

Parameter	Units	RME Child	 Adult
Chemical Concentration in Indoor Air (Cair)	ug/m^3	chem-specific	
Inhalation Rate of Air (Inh)	m^3/day	10	20
Exposure Frequency (EF)	days/year	365	
Exposure Duration (ED)	years	6	64
Conversion Factor (CF)	mg/ug	1.0E-03	
Body Weight (BW)	kg	15	70
Averaging Time (noncancer) (ATnc)	days	2190	25550
Averaging Time (cancer) (ATc)	days	25550	
SIFnc (child) = ((Inh-ch*EF* EDch* CF) /(BWch*ATnc-ch))		6.67E-04	
InhFadj (Inhalation Adjusted Factor)= (Inh-ch*EDch/BWch) + (Inh-a*EDa/BWa)		2.23E+01	
SIFnc (child/adult) = ((InhFadj*EF*CF)/(ATnc))		3.18E-04	
SIFc = ((InhFadj*EF*CF)/(ATc))		3.18E-04	

Chemical	RfDi (mg/kg-d)	CSFi $(mg/kg\text{-}d)^{-1}$
Chromium VI	3.0E-05	2.9E+02
Arsenic	--	1.5E+01
Monomethyl Hydrazine	--	1.7E+01
Mercury and Compounds	--	--
Methyl Mercury	--	--

Reasonable Maximum Exposure

Office Buildings	Cair (a) (ug/m3)	Intake nc Child (mg/kg-d)	Intake nc Child/Adult (mg/kg-d)	Intake c Child/Adult (mg/kg-d)	Hazard Quotient Child	Hazard Quotient Child/Adult	Cancer Risk Child/Adult
Chemical							
Chromium VI	2.70E-05	1.80E-08	8.60E-09	8.60E-09	0.00060	0.00029	2.5E-06
Arsenic	1.40E-04	9.33E-08	4.46E-08	4.46E-08	--	--	6.7E-07
Monomethyl Hydrazine	5.90E-05	3.93E-08	1.88E-08	1.88E-08	--	--	3.2E-07
TOTAL					0.00060	0.00029	3.5E-06

SIF - Summary Intake Factor

Table 2

Incidental Ingestion of Surface Soil

Future

Exposure Medium: Surface Soil
Exposure Point: Yard Soil
Receptor Population: Residents
Receptor Age: Adults and Children

Noncancer Hazard (child) = CS x SIFnc(child) / RfD
Noncancer Hazard (child/adult) = CS x SIFnc(child/adult) / RfD
Cancer Risk (child/adult) = CS x SIFc(child/adult) x CSF

Parameter	Units	RME Adult	 Child
Chemical Concentration in Soil (CS)	mg/kg	chem-specific	chem-specific
Ingestion Rate of Soil (IRS)	mg/day	300	300
Exposure Frequency (EF)	days/year	365	365
Exposure Duration (ED)	years	64	6
Conversion Factor (CF)	kg/mg	1.0E-06	1.0E-06
Body Weight (BW)	kg	70	15
Averaging Time (noncancer-child) (ATnc-ch)	days		2,190
Averaging Time (noncancer) (ATnc)	days	25,550	
Averaging Time (cancer) (ATc)	days	25,550	
SIFnc(child) = ((IRS*EF*EDch*CF)/(BWch*ATnc)			2.00E-05
IngFadj (Ingestion Adjusted Factor)= (IRSch*EDch/BWch)+(IRSa*EDa/BWa)		394.3	
SIFnc(child/adult) = (IngFadj*EF*CF)/ATnc		5.63E-06	
SIFc(child/adult) = (IngFadj*EF*CF)/ATc		5.63E-06	

Chemical	RfD-O (mg/kg-d)	CSF-O $(mg/kg\text{-}d)^{-1}$	ABSo unitless
Chromium VI	3.0E-03	--	1
Arsenic	3.0E-04	1.5E+00	1
Monomethyl Hydrazi	--	3.0E+00	1
Mercury and Compou	3.0E-04	--	1
Methyl Mercury	1.0E-04	--	1

	Reasonable Maximum Exposure						
Yard Soil Chemical	**CS** **(mg/kg)**	**$Intake_{nc}$** **child** **(mg/kg-d)**	**$Intake_{nc}$** **child/adult** **(mg/kg-d)**	**$Intake_{c}$** **child/adult** **(mg/kg-d)**	**HQ** **child**	**HQ** **child/adult**	**Risk** **child/adult**
Monomethyl Hydrazine	0.058	1.16E-06	3.27E-07	3.3E-07	--	--	9.80E-07
Mercury and Compounds	0.026943218	5.39E-07	1.52E-07	1.5E-07	0.0018	0.00051	--
Total					0.0018	0.00051	9.8E-07

SIF - Summary Intake Factor

Table 3
Dermal Contact with Surface Soil
Future

Exposure Medium: Surface Soil
Exposure Point: Yard Soil
Receptor Population: Residents
Receptor Age: Adults and Children

Noncancer Hazard (child) = CS x SIFnc(child) x Absd / RfD
Noncancer Hazard (child/adult) = CS x SIFnc(child/adult) x Absd / RfD
Cancer Risk (child/adult) = CS x SIFc(child/adult) x Absd x CSF

		RME	
Parameter	**Units**	**Adult**	**Child**
Chemical Concentration in Soil (CS)	mg/kg	chem-specific	chem-specific
Exposure Frequency (EF)	events/year	365	365
Exposure Duration (ED)	years	64	6
Surface Area Available for Contact (SA)	cm^2	5,700	2,800
Adherence Factor (AF)	mg/cm^2-event	0.07	0.2
Conversion Factor (CF)	kg/mg	1.0E-06	1.0E-06
Dermal Absorption (Absd)	unitless	chem-specific	chem-specific
Body Weight (BW)	kg	70	15
Averaging Time (noncancer - child) (ATnc-ch)	days		2,190
Averaging Time (noncancer) (ATnc)	days	25,550	
Averaging Time (cancer) (ATc)	days	25,550	
SIFnc(child) = ((EF*EDch*SAch*AFch*CF)/(BWch*ATnc-ch))			3.73E-05
DFadj (Dermal Adjusted Factor) = (EDch*SAch*AFch /BWch)+(EDa*SAa*AFa/BWa)		588.8	
SIFnc(child/adult) = (DFadj*EF*CF)/ATnc		8.41E-06	
SIFc(child/adult) = (DFadj*EF*CF)/ATc		8.41E-06	

Chemical	**RfD** (mg/kg-d)	**CSF** $(mg/kg\text{-}d)^{-1}$	**Absd** unitless
Chromium VI	7.5E-05	--	--
Arsenic	3.0E-04	1.5E+00	3.0E-02
Monomethyl Hydrazine	--	3.0E+00	1.0E-01
Mercury and Compounds	2.1E-05	--	--
Methyl Mercury	1.0E-04	--	1.0E-01

	Reasonable Maximum Exposure						
Yard Soil Chemical	**CS** (mg/kg)	**Intake$_{nc}$ child** (mg/kg-d)	**Intake$_{nc}$ child/adult** (mg/kg-d)	**Intake$_{c}$ child/adult** (mg/kg-d)	**HQ child**	**HQ child/adult**	**Cancer Risk child/adult**
Monomethyl Hydrazine	0.058	2.17E-07	4.88E-08	4.9E-08	--	--	1.5E-07
Mercury and Compounds	0.0269432	--	--	--	--	--	--
Total					--	--	1.5E-07

SIF - Summary Intake Factor

Table 4
Ingestion of Plants during Medicinal and Spiritual Ceremonies
Future

Exposure Medium:Plant
Exposure Point: Plants
Receptor Population: Residents
Receptor Age: Adults and Children

Noncancer Hazard (child) = CP x SIFnc(child) / RfD
Noncancer Hazard (child/adult) = CP x SIFnc(child/adult) / RfD
Cancer Risk (child/adult) = CP x SIFc(child/adult) x CSF

		RME	
Parameter	**Units**	**Adult**	**Child**
Chemical Concentration in Plant (CP)	mg/kg	chem-specific	chem-specific
Ingestion Rate of Plant (IRP)	g/day	112	112
Exposure Frequency (EF)	days/year	12	12
Exposure Duration (ED)	years	64	6
Conversion Factor (CF)	kg/g	1.0E-03	1.0E-03
Body Weight (BW)	kg	70	15
Averaging Time (noncancer-child) (ATnc-ch)	days		2,190
Averaging Time (noncancer) (ATnc)	days	25,550	
Averaging Time (cancer) (ATc)	days	25,550	
SIFnc(child) = ((IRP*EF*EDch*CF)/(ATnc)			2.45E-04
IngFadj (Ingestion Adjusted Factor)= (IRPch*EDch/BWch)+(IRPa*EDa/BWa)		147.2	
SIFnc(child/adult) = (IngFadj*EF*CF)/ATnc		6.91E-05	
SIFc(child/adult) = (IngFadj*EF*CF)/ATc		6.91E-05	

Chemical	**RfD-O** (mg/kg-d)	**CSF-O** (mg/kg-d)$^{-1}$	**ABSo** unitless
Chromium VI	--	--	1
Arsenic	3.0E-04	1.5E+00	1
Monomethyl Hydrazine	--	3.0E+00	1
Mercury and Compounds	3.0E-04	--	1
Methyl Mercury	1.0E-04	--	1

	Reasonable Maximum Exposure						
Yard Soil		**Intake$_{nc}$**	**Intake$_{nc}$**	**Intake$_{c}$**			
Chemical	**CP (mg/kg)**	**child (mg/kg-d)**	**child/adult (mg/kg-d)**	**child/adult (mg/kg-d)**	**HQ child**	**HQ child/adult**	**Risk child/adult**
Methyl Mercury	0.18	4.42E-05	1.24E-05	1.2E-05	0.44	0.12	--
Total					0.44	0.12	--

SIF - Summary Intake Factor

Table 5
Ingestion of Wheat from NAPI
Future

Exposure Medium:Plant	**Noncancer Hazard (child) = CP x SIFnc(child) / RfD**
Exposure Point: Plants	**Noncancer Hazard (child/adult) = CP x SIFnc(child/adult) / RfD**
Receptor Population: Residents	**Cancer Risk (child/adult) = CP x SIFc(child/adult) x CSF**
Receptor Age: Adults and Children	

Parameter	Units	RME Adult	 Child
Chemical Concentration in Plant (CP)	mg/kg	chem-specific	chem-specific
Ingestion Rate of Plant (IRP)	g/day	47	67
Exposure Frequency (EF)	days/year	365	365
Exposure Duration (ED)	years	64	6
Conversion Factor (CF)	kg/g	1.0E-03	1.0E-03
Body Weight (BW)	kg	70	15
Fraction ingested from Site (FI)	unitless	0.1	0.1
Averaging Time (noncancer-child) (ATnc-ch)	days		2,190
Averaging Time (noncancer) (ATnc)	days	25,550	
Averaging Time (cancer) (ATc)	days	25,550	
SIFnc(child) = ((IRP*EF*EDch*CF*FI)/(ATnc/BWch)			4.44E-04
IngFadj (Ingestion Adjusted Factor)= (IRPch*EDch/BWch)+(IRPa*EDa/BWa)		69.3	
SIFnc(child/adult) = (IngFadj*EF*CF*FI)/ATnc		9.90E-05	
SIFc(child/adult) = (IngFadj*EF*CF*FI)/ATc		9.90E-05	

Chemical	**RfD-O** (mg/kg-d)	**CSF-O** $(mg/kg-d)^{-1}$	**ABSo** unitless
Chromium VI	--	--	1
Arsenic	3.0E-04	1.5E+00	1
Monomethyl Hydrazine	--	3.0E+00	1
Mercury and Compounds	3.0E-04	--	1
Methyl Mercury	1.0E-04	--	1

	Reasonable Maximum Exposure						
Yard Soil Chemical	**CP** **(mg/kg)**	**$Intake_{nc}$** **child** **(mg/kg-d)**	**$Intake_{nc}$** **child/adult** **(mg/kg-d)**	**$Intake_{c}$** **child/adult** **(mg/kg-d)**	**HQ** **child**	**HQ** **child/adult**	**Risk** **child/adult**
Methyl Mercury	0.042	1.87E-05	4.16E-06	4.2E-06	0.19	0.04	--
Total					0.19	0.04	--

SIF - Summary Intake Factor

Table 6
Ingestion of Beef from NAPI
Future

Exposure Medium: Beef
Exposure Point: Beef
Receptor Population: Residents
Receptor Age: Adults and Children

Noncancer Hazard (child) = CB x SIFnc(child) / RfD
Noncancer Hazard (child/adult) = CB x SIFnc(child/adult) / RfD
Cancer Risk (child/adult) = CB x SIFc(child/adult) x CSF

Parameter	Units	RME Adult	 Child
Chemical Concentration in Beef (CB)	mg/kg	chem-specific	chem-specific
Ingestion Rate of Beef (IRB)	g/kg-day	2.327	2.327
Exposure Frequency (EF)	days/year	365	365
Exposure Duration (ED)	years	64	6
Conversion Factor (CF)	kg/g	1.0E-03	1.0E-03
Fraction ingested from Site (FI)	unitless	0.1	0.1
Averaging Time (noncancer-child) (ATnc-ch)	days		2,190
Averaging Time (noncancer) (ATnc)	days	25,550	
Averaging Time (cancer) (ATc)	days	25,550	
SIFnc(child) = (IRB*EF*EDch*CF*FI)/ATnc			2.33E-04
IngFadj (Ingestion Adjusted Factor)= (IRBch*EDch)+(IRBa*EDa)		162.9	
SIFnc(child/adult) = (IngFadj*EF*CF*FI)/ATnc		2.33E-04	
SIFc(child/adult) = (IngFadj*EF*CF*FI)/ATc		2.33E-04	

Chemical	RfD-O (mg/kg-d)	CSF-O $(mg/kg\text{-}d)^{-1}$	ABSo unitless
Chromium VI	--	--	1
Arsenic	3.0E-04	1.5E+00	1
Monomethyl Hydrazine	--	3.0E+00	1
Mercury and Compounds	3.0E-04	--	1
Methyl Mercury	1.0E-04	--	1

	Reasonable Maximum Exposure						
Yard Soil Chemical	CB (mg/kg)	$Intake_{nc}$ child (mg/kg-d)	$Intake_{nc}$ child/adult (mg/kg-d)	$Intake_c$ child/adult (mg/kg-d)	HQ child	HQ child/adult	Risk child/adult
Methyl Mercury	0.00144	3.35E-07	3.35E-07	3.4E-07	0.003	0.003	--
Total					0.003	0.003	--

SIF - Summary Intake Factor

Pathway of Exposure to Methyl Mercury	HQ Child	HQ Child/Adult
Ingestion of Wheat	0.19	0.042
Cermonial and Medicinal Ingestion of Plants	0.44	0.12
Ingestion of Beef	0.0034	0.0034
TOTAL	0.63	0.17

	Air ug/m3	Surface Soil mg/kg	Plant not wheat mg/kg	Wheat mg/kg	Beef mg/kg
Chromium VI	2.70E-05	--	--	--	--
Arsenic	1.40E-04	--	--	--	--
Monomethyl Hydrazine	5.90E-05	0.058	--	--	--
Mercury and Compounds	--	0.0269	--	--	--
Methyl Mercury	--	--	0.18	0.042	1.44E-03

Toxicity Values

	RfD-I	RfD-O	RfD-D	SF-I	SF-O	SF-D	ABSd
Chromium VI	3.00E-05	3.00E-03	7.50E-05	2.90E+02	--	--	--
Arsenic	--	3.00E-04	3.00E-04	1.50E+01	1.50E+00	1.50E+00	3.00E-02
Monomethyl Hydrazine	--	--	--	1.70E+01	3.00E+00	3.00E+00	1.00E-01
Mercury and Compounds	--	3.00E-04	2.10E-05	--	--	--	--
Methyl Mercury	--	1.00E-04	0.0001	--	--	--	0.1