# 4.0 Baseline Risk Assessment Update

This section updates the human health and the ecological risk assessments that were originally presented in the 1998 RI (DOE 1998a). The impacts on the 1998 risk assessments are summarized in Section 2.9.

## 4.1 Human Health Risk Assessment

Several activities completed since 1998 have contributed to changes in surface water and ground water concentrations. Activities that have impacted, or likely impacted surface water and ground water concentrations are

- Millsite Excavation (Section 2.1)
- Remediation of Soil and Sediment Along Montezuma Creek (Section 2.3)
- Millsite Dewatering and Treatment (Section 2.5)
- PRB Treatability Study (Section 2.6)

Surface water and ground water monitoring data have been used to refine the list of COCs (Section 2.7.1). Recent monitoring data (October 2002) are used in this HHRA update to assign exposure point concentrations in surface water and ground water.

Other activities since 1998 have acted to ensure that 1998 assumptions about current and future use of the contaminated alluvial aquifer and building habitable structures in supplemental standard areas along Montezuma Creek are valid for this update. These activities include implementation of a Ground Water Management Policy (Section 2.4.1) and restrictive easements (Section 2.4.2).

Other data collection activities (Section 2.8) have provided input to the current ground water model, which is used to predict future exposure point concentrations in ground water (Section 3.0).

In addition to new surface water and ground water exposure point concentrations and changes in the COCs, this update to the HHRA incorporates changes in published toxicity values and a refined approach for estimating dose. This section focuses on each of these changes and the resulting risk estimates; more detailed assumptions, information, and references are presented in Volume VI, Baseline Human Health Risk Assessment, of the 1998 RI (DOE 1998a). The detailed calculations used to estimate risks presented in this update are included in Appendix F.

### 4.1.1 Contaminants of Concern

Section 2.7.1 summarizes changes to the COC list that were made during the IRA. Table 4–1 lists the COCs and shows changes in the COCs since the original baseline risk assessment (DOE 1998a).

*Table 4–1. Summary of Human Health Contaminants of Concern*

| Contaminants | Soils/Sediments | | Surface Water | | Ground Water | | Air | | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | 1998 BLRA | Updated COCs | 1998 BLRA | Updated COCs | 1998 BLRA | Updated COCs | 1998 BLRA | Updated COCs | |
| Arsenic | X | X | X | X | X | X | X | X | See DOE 1998a |
| Manganese | | | | | X | X | | | See DOE 1998a |
| Molybdenum | | | | | | X | | | Added for ground water because concentrations exceed an ARAR |
| Nitrate | | | | | | X | | | Added for ground water because of an increase in concentration during remediation |
| Selenium | | | | | X | X | | | See DOE 1998a |
| Sodium | | | a | a | a | a | | | See DOE 1998a |
| Sulfate | | | a | a | a | a | | | See DOE 1998a |
| Uranium | X | X | X | X | X | X | X | X | See DOE 1998a |
| Vanadium | | | | | X | X | | | See DOE 1998a |
| **Radionuclides** | | | | | | | | | |
| Lead-210 | X | | X | | X | | X | | Deleted as a ground water and surface water COC because it was not detected since 1996. Concentrations were significantly decreased from remediation. |
| Radium-226 | X | | X | | X | | X | | Deleted as a ground water and surface water COC because it was not detected since 1996. Concentrations were significantly decreased from remediation. |
| Radon-222 | | | | | X | | | | Deleted as a ground water COC because current concentrations result in a low risk using worst-case assumptions. |
| Thorium-230 | X | | | | | | X | | Deleted as a ground water and surface water COC because it was not detected since 1996. |
| Uranium-234 | X | X | | | X | X | X | X | See DOE 1998a |
| Uranium-235+D | X | X | | | X | X | X | X | See DOE 1998a |
| Uranium-238+D | X | X | | | X | X | X | X | See DOE 1998a |
| Gross alpha | | | a | a | | | | | See DOE 1998a |
| Gross beta | | | a | a | | | | | See DOE 1998a |
| External gamma | X | X | | | | | | | See DOE 1998a |

**Notes:** Air COCs and soils COCs are identical because exposure point concentrations in air are based on COC concentrations in soil (dust loading).
**Key:** "X" is included and quantified; "a" is included and not quantifiable; D = daughters (decay products); BLRA = baseline risk assessment.

In this update, exposure point concentrations for the soils and sediments were not altered from the original risk assessment. This was done to provide reasonable worst-case COC concentrations, because some contaminant mass removal occurred in the Upper and Lower Montezuma Creek as a result of the removal action. In addition, updated, comprehensive sampling data are not available throughout the soil and sediment area.

The COC concentrations in surface water and ground water have shown a decreasing trend since completion of the 1998 RI. However, concentrations increased somewhat in 2002; these increases are believed to be a result of the severe drought in southeast Utah. As a reasonable worst case, water concentrations from the October 2002 sampling event were used for surface water.

Two sets of exposure point concentrations were used for ground water. First, ground water data from alluvial well 92–11 (October 2002 sampling) were used to represent potential near-term future exposures, because sample concentrations from this well are elevated compared to those from other alluvial wells, and this well is located in an area where future exposures could occur. These exposure point concentrations are worst case; they are based on the assumptions that COC concentrations in the alluvial system do not decrease and that institutional controls (the Ground Water Management Policy) fail, allowing the near-term use of the contaminated ground water as a primary drinking water source.

Second, the highest uranium concentration predicted by the ground water model to exist in the alluvial ground water in 20 yr was coupled with estimated concentrations for the other COCs to represent future exposure point concentrations. In 20 yr, the area around well 92–09 is predicted to have the highest uranium concentrations. Only transport of uranium was considered in the ground water model because uranium is the only mobile COC with concentrations in off-site ground water greater than 1.5 times its PRG, and it is the risk driver. For other COCs, current concentrations in well 92–09 were used to represent future exposure point concentrations. This approach was used because COC concentrations have been stable at well 92–09 for over 10 yr, and coupled with the upgradient source removal, there is no reason to expect other COCs to migrate to this area in the future. Table 4–2 presents the exposure point concentrations used in the updated HHRA.

### 4.1.2 Exposure Assessment

Exposures are still expected to occur to the same populations identified in the 1998 risk assessment. In identifying the potentially exposed populations, DOE discussed current and future land use and planning with personnel from the city of Monticello, EPA, and UDEQ. On the basis of those discussions, the following populations are considered to be the most likely to be exposed to the OU III COCs:

- Current landowners and other nearby residents as agricultural workers and occasional recreational users.
- Other current residents of Monticello as occasional recreational users.

*Table 4–2. Exposure Point Concentrations*

| Exposure Point Concentrations in Soils and Sediments (mg/kg or pCi/g [gamma—μR/h]) | | | | | | |
|---|---|---|---|---|---|---|
| | mg/kg | | | | | |
| **Contaminant** | **Lower Canyon** | **Middle Canyon** | **Upper Canyon** | **Average** | **Reference** | **Notes** |
| Arsenic | 6.96 | 7.7 | 7.8 | 7.5 | 5.3 | Same data as original risk assessment |
| Uranium | 18.9 | 28.2 | 26.3 | 24.5 | 3.6 | Same data as original risk assessment |
| | pCi/g (gamma—μR/h) | | | | | |
| | **Lower Canyon** | **Middle Canyon** | **Upper Canyon** | **Average** | **Reference** | **Notes** |
| U-234 | 6.1 | 9.2 | 8.0 | 7.8 | 1.0 | Same data as original risk assessment |
| U-235 | 0.3 | 0.4 | 0.4 | 0.4 | 0.1 | Same data as original risk assessment |
| U-238 | 6.1 | 9.1 | 8.2 | 7.8 | 1.2 | Same data as original risk assessment |
| External gamma | 28.1 | 29.4 | 34.2 | 30.6 | 15.0 | Same data as original risk assessment |
| **Exposure Point Contaminant Concentrations in Surface Water (μg/L or pCi/L)** | | | | | | |
| | μg/L | | | | | |
| **Compound** | **Lower Canyon** | **Middle Canyon** | **Upper Canyon** | **Average** | **Reference** | **Notes** |
| Arsenic | 1.1 | 1.4 | 1.5 | 1.3 | 1.5 | Canyon data from October 2002 results; original reference area data |
| Uranium | 89.9 | 147.0 | 188.0 | 141.6 | 2.4 | Canyon data from October 2002 results; original reference area data |
| | pCi/L | | | | | |
| | **Lower Canyon** | **Middle Canyon** | **Upper Canyon** | **Average** | **Reference** | **Notes** |
| Uranium-234 | 27.6 | 45.6 | 58.7 | 44.0 | 2.3 | Estimated from total U based on the isotopic ratios |
| Uranium-235+D | 0.7 | 1.1 | 1.4 | 1.1 | 0.2 | Estimated from total U based on the isotopic ratios |
| Uranium-238+D | 32.3 | 52.4 | 69.1 | 51.3 | 1.1 | Estimated from total U based on the isotopic ratios |

| Exposure Point Contaminant Concentrations in Ground Water (μg/L or pCi/L) | | | | |
|---|---|---|---|---|
| **Contaminant** | **Near-Term Ground Water Concentration (μg/L)** | **20-year Ground Water Concentration (μg/L)** | **Background Concentration (μg/L)** | |
| Arsenic | 16.5 | 1.6 | 1.42 | Near-term: well 92-11 October 2002 results; 20-year: well 92–09; October 2002 results; original reference area data |
| Manganese (nonfood) | 1.3 | 218 | 30.4 | Near-term: well 92-11 October 2002 results; 20-year: well 92–09; October 2002 results; original reference area data |
| Molybdenum | 25 | <1.7 | 4.4 | Near-term: well 92-11 October 2002 results, 20-year: well 92–09; October 2002 results; original reference area data |
| Nitrate | 8668 | 54 | 4444 | Near-term: well 92-11 October 2002 results; 20-year: well 92–09; October 2002 results; original reference area data, converted to $NO_3$ by multiplying by 4.4 assuming the $NO_2$ +$NO_3$ is all $NO_3$; original reference area data |
| Selenium | 85 | <0.1 | 2.06 | Near-term: well 92-11 October 2002 results; 20-year: well 92–09; October 2002 results; original reference area data |
| Uranium | 317 | 249 | 4.78 | Near-term well 92-11, October 2002 results; 20-year: ground water model estimate; original reference area data |
| Vanadium | 562 | <0.3 | 2.83 | Near-term: well 92-11 October 2002 results; 20-year: well 92–09; October 2002 results; original reference area data |
| | **Ground Water Concentration (pCi/L)** | **pCi/L** | | **Notes** |
| U-234 | 91.6 | 72 | 3.09 | Estimated from total U based on the isotopic ratios; original reference area data |
| U-235 | 4.9 | 3.8 | 0.191 | Estimated from total U based on the isotopic ratios; original reference area data |
| U-238 | 105.9 | 83.2 | 1.7 | Estimated from total U based on the isotopic ratios; original reference area data |

- Future residents of Upper Montezuma Creek from potable use of water in the alluvial aquifer and as recreational users in an extended backyard scenario. Residential use of ground water as a drinking water source is not anticipated in Middle and Lower Montezuma Creek because there is very little source and because of the rough terrain and limited access. Also, contaminated alluvial ground water will not reach these areas because it is both discharged to Montezuma Creek and diluted by discharge from the Burro Canyon aquifer.
- Future landowners as agricultural workers and recreational users.
- Other future residents of Monticello as occasional recreational users.

For the identified populations, the following exposure pathways were evaluated:

*Exposure Pathways for Future Residents (adults and children aged 5 to 14)*

- Ingestion of soil and sediment
- Inhalation of soil and sediment (dust)
- Direct radiation exposure (gamma)
- Ingestion of surface water
- Ingestion of ground water

*Agricultural Workers (adults)*

- Ingestion of soil and sediment
- Inhalation of soil and sediment (dust)
- Direct radiation exposure (gamma)
- Ingestion of surface water

*Recreational Users (adults and children aged 5 to 14)*

- Ingestion of soil and sediment
- Inhalation of soil and sediment (dust)
- Direct radiation exposure (gamma)
- Ingestion of surface water

The ingestion of beef and game tissue (e.g., deer) was found to be insignificant in the original risk assessment and was not reevaluated in this update.

### 4.1.3 Exposure Assumptions

Pathway-specific intakes are estimated using exposure point concentrations and exposure assumptions specific to the activities of the receptor population. RME and CT are the two types of exposure assumptions used to provide a range of potential exposures. RME is defined as an exposure well above the average but still within the range of possible values. EPA guidance (EPA 1992b) suggests that RME is analogous to the high-end exposure estimates corresponding to an approximate 90th percentile of the population distribution. CT uses exposure assumptions that result in an average or best-estimate exposure to an individual (approximately 50th percentile of possible exposures). Although generally considered to be average exposure

estimates, CT estimates still tend to be somewhat conservative. CT provides additional information for risk management decisions by showing a plausible range of risks and by highlighting the sensitivity of the risk estimates to the exposure factors.

As suggested in EPA risk assessment guidance (EPA 1989a), exposure assumptions based on site-specific data and conditions are used whenever possible to more accurately reflect actual exposures. Because several site-specific exposure scenarios are associated with the conditions at OU III, numerous site-specific exposure assumptions were used. Representatives from DOE, EPA, and UDEQ remedial project managers, and EPA and UDEQ risk assessors jointly developed the site-specific exposure factors. When site-specific data are not appropriate, standard EPA default assumptions for both RME and CT exposures were used according to EPA guidance (EPA 1989a, 1989b, 1991a). Information on the exposure assumptions has been organized by the exposure scenarios anticipated in each section of Montezuma Creek (Upper, Middle, and Lower), and the exposure assumptions associated with the potential ingestion of ground water for the potential future residential scenario are also presented. The same exposure factors used in the original risk assessment are still valid and were used in the update; they are summarized in Tables 4–3 through 4–6. These tables provide detailed remarks/references on the basis for the exposure factors; additional details are provided in the original risk assessment.

Since the completion of the original risk assessment, EPA has published information on PRGs for radionuclides, which includes some suggested exposure factors for agricultural scenarios (**http://epa-prgs.ornl.gov**). Most of the exposure pathways listed under the agricultural scenario (based on contaminated soil) do not apply; the three pathways that do apply are ingestion and inhalation of contaminated soil and direct radiation exposure. The exposure factors that can be directly compared are identical or similar for this risk assessment and the EPA reference. For ingestion risks, the weighted ingestion rate suggested by EPA for agricultural sources is 115 mg/day, and the RME used in this risk evaluation is 114 mg/kg. The same RME inhalation rate is used from both sources (20 cubic meters per day). The OU III risk assessment uses a direct measurement of waist-high gamma (in μR/h), which eliminates the need for gamma shielding factors suggested by EPA. The most significant issue in comparing the exposure factors from these two sources is the exposure frequency and exposure time in a contaminated area. These are very site-specific. The EPA agricultural scenarios suggest an exposure frequency of 350 days/yr; exposure time outdoors was 1.75 hours. A risk assessor would be required to reevaluate the exposure frequency, consider the amount of time exposure to contaminated areas may occur, or possibly use area-weighted exposure point concentrations to account for time spent in noncontaminated areas. The OU III risk evaluation uses RME assumptions of 175 days/yr and 0.75 hour/day of exposure in the Upper Montezuma Creek contaminated soil and sediment area; the assumptions for the upper canyon are the closest to a default agricultural use listed in the recent agricultural scenarios.

Nevertheless, an attempt was made to compare the default PRGs for the agricultural soil scenarios to the soil concentrations found at OU III. The PRGs were generated (**http://epa-prgs.ornl.gov**) using default values for ingestion of soil, external exposure, and inhalation of soil (the climatic zone was set as Salt Lake City, Utah, from the list of default cities). The other pathways that are not applicable to OU III (ingestion of produce, fish, beef, milk, swine, poultry, and eggs) were "turned off" by setting the ingestion rates to zero. The website calculation is based on a target risk of $1 \times 10^{-6}$; a PRG for a target risk of $1 \times 10^{-4}$ was added to present a range. The results are shown in Table 4–7. This table indicates that the range of the default PRGs

*Table 4–3. Upper Montezuma Creek Hypothetical Future-Use (Extended Backyard) Exposure Factors*

| Exposure Variable | | Upper Montezuma Creek | | Remark/Reference |
|---|---|---|---|---|
| | | Central Tendency | RME | **Exposure factors are based on the highest exposure subpopulation (child aged 5 to 14). Exposure factors for the current scenario are conservatively assumed to be equal to the future-use exposure factors.** |
| Daily soil and sediment ingestion rate (see Note 1) | milligrams per day | 59[a] | 114[b] | [a]Median (Thompson and Burnmaster 1991).<br>[b]Average child (6 years) and adult (24 years) for 30 years (EPA 1991a). |
| Period per day in Upper Montezuma Creek *affected* soil and sediments | hours per day | 0.5[c] | 0.75[d] | [c]Derived from Silvers et al. (1994). Assumes 25 percent of a child's outdoor at home activity time is spent in the *affected* portion of the floodplain.<br>Access into the Montezuma Creek floodplain near the beaver ponds is assumed to follow patterns similar to those identified by Silvers et al., including different seasonal availabilities on weekdays and weekends (e.g., school-age children and children supervised by adults) in an extended backyard scenario.<br>[d]RME is the central tendency plus 1 sigma from Silvers et al. The derived profile is based on Monticello weather and children's activity patterns from Silvers et al. |
| Days per year in Upper Montezuma Creek *affected* soil and sediment | days per year | 90[e] | 175[f] | [e]Access into the Upper Montezuma Creek floodplain (e.g., wetlands area) would be affected by local seasonal weather (e.g., 5 months when the average temperature is below 40°F and substantial snow cover is present).<br>[f]Upper end is central-tendency estimate plus a professional judgment 1-sigma estimate. |
| Exposure duration adjacent to floodplain | years | 9 | 30 | CT is based on professional judgment. RME is 90th percentile (EPA 1989a). Conservative to assume 30-year exposure when combined with the adolescent child contact rates. |
| Body weight | kilograms | 70 | 59 | CT is average adult body weight. RME is weighted average for a child and adult (EPA 1989a). |
| Averaging time, cancer | days | 25,550 | 25,550 | 70 years (EPA 1989a). |
| Averaging time, noncancer | days | 365 | 365 | Assumed chronic exposure, assessed on an annualized basis. |

Note 1: Intake rate modification by hours per day in floodplain divided by 24 incidental ingestion exposure hours available per day; e.g., 0.37/24. Ratio of time in floodplain to exposure hours available is analogous to the fraction ingested from the contaminated source factor in EPA guidance (EPA 1989a, Exhibit 6–14).

Note 2: Upper Montezuma Creek includes the area around the beaver ponds (i.e., wetlands area). In this exposure scenario, the Upper Montezuma Creek floodplain is considered an extended backyard adjacent to, but not legally within, a sizable (3 acres) rural residential plot. Surveys indicate that affected sediments in Upper Montezuma Creek are localized around the pond periphery, in overflow washes, and in depositional low points. Thus, only a portion of the potential exposure unit area is considered affected. Typical activities include walking, jogging, and child play.

*Table 4–4. Middle Montezuma Creek Hypothetical Future-Use (Recreational/Agricultural) Exposure Factors*

| Exposure Variable | | Middle Montezuma Creek | | Remark/Reference |
|---|---|---|---|---|
| | | Central Tendency | RME | **Exposure factors are based on the highest exposure subpopulation (child aged 5 to 14). Exposure factors for the current scenario are conservatively assumed to be equal to the future-use exposure factors.** |
| Daily soil and sediment ingestion rate (see Note 1) | milligrams per day | 59[a] | 114[b] | [a]Median (Thompson and Burmaster 1991).<br>[b]Average child (6 years) and adult (24 years) for 30 years (EPA 1991a). |
| Period per day in Middle Montezuma Creek *affected* soil and sediments | hours per day | 0.25[c] | 0.50[d] | [c]Professional judgment of typical pass-through time based on observation and actual walk-through of the approximately 0.5-mile segment east of the wetlands portion (3 miles per hour).<br>[d]RME estimate is conservatively estimated as twice the central tendency (i.e., rate is 1.5 miles per hour). |
| Days per year in Middle Montezuma Creek *affected* soil and sediment | days per year | 14 | 21 | Professional judgment based on experience and familiarity with terrain and alternative access routes to Lower Montezuma Creek. Linked to the lower canyon visitation rate; assumes two passages (trips per day [in and out]). One-half of the visits to the Lower Montezuma Creek segment occur through the Middle Montezuma Creek portal. |
| Exposure duration adjacent to floodplain | years | 9 | 30 | CT is based on professional judgment. RME is the 90th percentile (EPA 1989a). Conservative to assume 30-year exposure when combined with the adolescent child contact rates. |
| Body weight | kilograms | 70 | 59 | CT is average adult body weight. RME is a weighted average between an adult and child (EPA 1989a). |
| Averaging time, cancer | days | 25,550 | 25,550 | 70 years (EPA 1989a). |
| Averaging time, noncancer | days | 365 | 365 | Assumed chronic exposure, assessed on an annualized basis. |

Note 1: Intake rate modification by hours per day in floodplain divided by 24 exposure hours available per day; e.g., 0.25/24. Ratio of time in floodplain to exposure hours available is analogous to the fraction ingested from the contaminated source (FI) factor in EPA guidance (EPA 1989a, Exhibit 6–14).

Note 2: Less than 0.5 mile in length, Middle Montezuma Creek is restricted (due to rugged side terrain) and functions as a pass-through (i.e., a portal) between Upper and Lower Montezuma Creek. Typical activities include occasional hiking, observing nature, and photography while in transit between Upper and Lower Montezuma Creek. Lower Montezuma Creek has alternative access and egress routes that are generally less rigorous (e.g., draws and gentler slopes into the Lower Montezuma Creek). Thus, the Middle Montezuma Creek portal is but one of several access points into Lower Montezuma Creek.

*Table 4–5. Lower Montezuma Creek Hypothetical Future-Use (Recreational/Agricultural) Exposure Factors*

| Exposure Variable | | Lower Montezuma Creek | | Remark/Reference |
|---|---|---|---|---|
| | | **Central Tendency** | **RME** | **Exposure factors are based on the highest exposure subpopulation (child aged 5 to 14). Exposure factors for the current scenario are conservatively assumed to be equal to the future-use exposure factors.** |
| Daily soil and sediment ingestion rate (see Note 1) | milligrams per day | 59[a] | 114[b] | [a]Median (Thompson and Burnmaster 1991).<br>[b]Average child (6 years) and adult (24 years) for 30 years (EPA 1991a). |
| Period per day in Lower Montezuma Creek *affected* soil and sediments | hours per day | 0.7[c] | 1.0[d] | [c]Derived from Silvers et al. (1994). Conservatively assumes 25 percent of a child's outdoor away from home time is spent in the affected lower canyon soil and sediments. Access to Lower Montezuma Creek is likely to follow patterns similar to those identified by Silvers et al., which include different availabilities on weekdays and weekends (e.g., school-age children and children supervised by adults).<br>[d]RME estimate is the central tendency plus 1 sigma (Silvers et al. 1994). |
| Days per year in Lower Montezuma Creek *affected* soil and sediment | days per year | 14 | 21 | Professional judgment based on experience and familiarity with terrain, regional activity patterns, and discussion with local residents. |
| Exposure duration adjacent to floodplain | years | 9 | 30 | CT is based on professional judgment. RME is the 90th percentile (EPA 1989a). Conservative to assume 30-year exposure when combined with the adolescent child-contact rates. |
| Body weight | kilograms | 70 | 59 | Average adult body weight (EPA 1989a). |
| Averaging time, cancer | days | 25,550 | 25,550 | 70 years (EPA 1989a). |
| Averaging time, noncancer | days | 365 | 365 | Assumed chronic exposure, assessed on an annualized basis. |

Note 1: Intake rate modification by hours per day in floodplain divided by 24 exposure hours available per day; e.g., 0.68/24. Ratio of time in floodplain to exposure hours available is analogous to the fraction ingested from contaminated source (FI) factor in EPA guidance (EPA 1989a, Exhibit 6–14).

Note 2: Lower Montezuma Creek is considered a semirestricted (due to rugged terrain and distance from the residences) recreational visitor setting in the vicinity of a rural residential neighborhood. Although affected sediments may be anywhere in this segment, field surveys indicate that they are localized in depositional low spots.

*Table 4–6. Exposure Factors Associated With Ingestion of Alluvial Aquifer Ground Water*

| Exposure Variable | | OU III Alluvial Aquifer | | Remark/Reference |
|---|---|---|---|---|
| | | Central Tendency | RME | |
| Daily consumption of ground water | liters per day | 1.4 | 2.0 | EPA 1989a |
| Exposure frequency | days per year | 325 | 350 | Professional judgment consistent with other scenarios.<br>EPA 1991a (OSWER 9285.6-03) |
| Exposure duration | years | 9 | 30 | CT is based on professional judgment. RME is from EPA 1991a (OSWER 9285.6-03) |
| Body weight | kilograms | 70 | 59 | EPA 1991a (OSWER 9285.6-03) |
| Averaging time, cancer | days | 25,550 | 25,550 | 70 years (EPA 1989a) |
| Averaging time, noncancer | days | 365 | 365 | Assumed chronic exposure, assessed on an annualized basis. |

*Table 4–7. Comparison of EPA Agriculture Soil PRGs to Contaminant Concentrations at OU III*

| Contaminant | PRGs | | Contaminant Concentration Data (pCi/g) | | | | | Notes |
|---|---|---|---|---|---|---|---|---|
| | PRG $1 \times 10^{-6}$ | PRG $1 \times 10^{-4}$ | Lower Canyon | Middle Canyon | Upper Canyon | Average | Reference | |
| U-234 | 2.88 | 288 | 6.1 | 9.2 | 8.0 | 7.8 | 1.0 | Concentration data are from original risk assessment |
| U-235 | 0.155 | 15.5 | 0.3 | 0.4 | 0.4 | 0.4 | 0.1 | Concentration data are from original risk assessment |
| U-238 | 3.2 | 320 | 6.1 | 9.1 | 8.2 | 7.8 | 1.2 | Concentration data are from original risk assessment |

falls within the soil concentrations found at OU III (the concentrations listed in Table 4–7 were from soil samples taken before the OU III soil and sediment remediation).

### 4.1.4 Toxicity Assessment

Table 4–8 presents the toxicity data used in the updated risk assessment. Most of the toxicity values did not change, with the exception of the data for the radionuclides (isotopes of uranium); in all cases, the toxicity data values increased (increased risk) from the original assessment. Specifically, the toxicity data for the uranium isotopes increased from 40 to 60 percent for water ingestion. In addition, the oral reference dose for manganese also changed from 0.14 mg/kg-day to 0.02 mg/kg-day; this change more accurately reflects exposures from ingestion of drinking water (instead of manganese in food). The conversion factor for external gamma was also revised from $5 \times 10^{-7}$ cancers/mrem to $8 \times 10^{-7}$ cancers/mrem based on an updated reference (ISCORS 2002).

The updated evaluation of dose was based on isotope-specific information. The original risk assessment used a tailings-specific dose conversion factor based on Ra-226 concentrations. As noted earlier, Ra-226 was eliminated as a COC. Therefore, isotope-specific conversion factors (in units of mrem/pCi) were used to estimate risk. This revised method should yield more accurate dose estimations.

### 4.1.5 Risk Characterization

The risk assessment summary tables (Recreational/Agricultural and Near-Term Residential) from the updated risk evaluation are presented for the CT and RME exposure factors in Tables 4–9 and 4–10, respectively. Tables 4–11 and 4–12 present a direct comparison between the near-term and 20-yr future residential scenarios for the CT and RME exposure factors, respectively. To better guide the reader, Figure 4–1 presents an overview of the exposure scenarios by time frame, complete pathways, and location of the risk results. The risks presented in the tables are organized by expected impacts. Added cancer risks are presented for nonradionuclides (arsenic) and radionuclides, noncarcinogenic hazard indices (negative impacts other than cancer such as loss of kidney function, liver disease, etc.), and dose from gamma radiation. The beef consumption pathway was eliminated from the updated evaluation because risks associated with this pathway are two to three orders of magnitude lower than the ground water ingestion pathway, and tissue sampling done by EPA confirmed the limited uptake of the COCs in cattle muscle tissue.

Risks are proportional to the exposure point concentrations; lower average contaminant concentrations result in reduced risks. Since the original assessment, risks have been reduced because of lower average contaminant concentrations.

#### Future Residential Scenarios

As described earlier, the future residential scenario was evaluated using two sets of exposure point concentrations. One estimation, near-term exposure, was based on worst-case, current concentrations in well 92–11; the other used the 20-yr modeled uranium concentration coupled with the current concentrations for the other COCs in well 92–09 as surrogates for future concentrations (i.e., only uranium concentrations are expected to increase in this area). The 20-yr estimates are expected to more accurately portray future conditions.

*Table 4–8. Toxicity Factors*

| Chemical Name | Oral SF (kg-day/mg) | Inhalation SF (kg-day/mg) | Oral RfD (mg/kg-day) | Inhalation RfD (mg/kg-day) | Critical Effects | Notes |
|---|---|---|---|---|---|---|
| Arsenic | 1.5 | 15 | 3.0E-04 | na | Cancer, hyperpigmentation, keratosis, vascular | IRIS, November 27, 2002; Inhalation is from the October 2002 RBC Table |
| Manganese (nonfood) | na | na | 2.0E-02 | 1.43E-05 | | RBC Table October 2002 |
| Molybdenum | na | na | 5.0E-03 | na | Increased uric acid | IRIS, November 27, 2002 |
| Nitrate | na | na | 1.6E+00 | na | Methemoglobinemia in infants | IRIS, November 27, 2002 |
| Selenium | na | na | 5.0E-03 | na | Selenosis | IRIS, November 27, 2002 |
| Sodium | na | na | NA | NA | | No toxicity information is available; risks are not quantified |
| Sulfate | na | na | NA | NA | | No toxicity information is available; risks are not quantified |
| Uranium | na | na | 3.0E-03 | na | Nephrotoxicity | IRIS October 3, 2002; Uranium, Soluble Salts |
| Vanadium | na | na | 7.0E-03 | na | | RBC Table October 2002, originally from HEAST |
| **Radionuclides** | | | | | | |
| | **Water Ingestion Risk/pCi** | **Food Ingestion Risk/pCi** | **Soil Ingestion Risk/pCi** | **Inhalation Risk/pCi** | **External Exposure Risk per Year pCi/g** | **Source** |
| Uranium-234 | 7.07E-11 | 9.55E-11 | 1.58E-10 | 1.14E-08 | 2.52E-10 | EPA 2001 |
| Uranium-235+D | 7.18E-11 | 9.76E-11 | 1.63E-10 | 1.01E-08 | 5.43E-07 | EPA 2001 |
| Uranium-238+D | 8.71E-11 | 1.21E-10 | 2.10E-10 | 9.35E-09 | 1.14E-07 | EPA 2001 |
| **Conversion Factors** | | | | | | |
| External gamma | 8E–07 CA/mrem | ISCORS Technical Report No. 1, July 2002 | | | | |
| | **Ingestion (mrem/pCi)** | **Inhalation (mrem/pCi)** | **Source** | | | |
| U-234 | 2.83E-04 | 0.132 | Federal Guidance Report No. 11 | | | |
| U-235 +D | 2.68E-04 | 1.23E-01 | Federal Guidance Report No. 11 | | | |
| U-238 +D | 2.85E-04 | 0.118 | Federal Guidance Report No. 11 | | | |

CA – cancers
D – daughters (decay products)
HEAST - Health Effects Summary Tables, U.S. Environmental Protection Agency
IRIS - Integrated Risk Information System
NA - not available
na – not applicable
RBC Table – EPA Region 3 Risk-Based Concentration Table, memo from Jennifer Hubbard, toxicologist, October 9, 2002.
RfD - reference dose
SF - slope factor

*Table 4–9. Risk Characterization Central Tendency (Near-Term)—Updated Summary*

**Added Cancer Risk**

**Nonradionuclides**

| Chemical | Upper Canyon | % | Middle Canyon | % | Lower Canyon | % | Residential Ground Water | % | Central Tendency: Current Use Recreational/Ag Pathways Combined | Compound Contribution % | Future Use Recreational/Ag Pathways Combined | Compound Contribution % | Future Use Residential All Pathways Combined | Compound Contribution % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 7.5E-09 | 0.0% | 5.8E-10 | 0.0% | 6.6E-10 | 0.0% | 5.7E-05 | 100.0% | 8.8E-09 | 100% | 8.8E-09 | 100% | 5.7E-05 | 100% |
| Summation | 7.5E-09 | 0.0% | 5.8E-10 | 0.0% | 6.6E-10 | 0.0% | 5.7E-05 | 100.0% | 8.8E-09 | 100% | 8.8E-09 | 100% | 5.7E-05 | 100% |

| Radionuclide | Upper Canyon | % | Middle Canyon | % | Lower Canyon | % | Residential Ground Water | % | Central Tendency: Current Use Recreational/Ag Pathways Combined | Compound Contribution % | Future Use Recreational/Ag Pathways Combined | Compound Contribution % | Future Use Residential All Pathways Combined | Compound Contribution % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Uranium-234 | 1.5E-08 | 0.0% | 9.4E-10 | 0.0% | 1.5E-09 | 0.0% | 2.7E-05 | 33.8% | 1.7E-08 | 0.1% | 1.7E-08 | 0.1% | 2.7E-05 | 33.8% |
| Uranium-235+D | 3.7E-10 | 0.0% | 2.5E-11 | 0.0% | 3.9E-11 | 0.0% | 1.4E-06 | 1.8% | 4.4E-10 | 0.0% | 4.4E-10 | 0.0% | 1.4E-06 | 1.8% |
| Uranium-238+D | 2.1E-08 | 0.0% | 1.3E-09 | 0.0% | 2.1E-09 | 0.0% | 3.8E-05 | 48.1% | 2.4E-08 | 0.2% | 2.4E-08 | 0.2% | 3.8E-05 | 48.1% |
| External gamma | 1.1E-05 | 14.1% | 7.4E-07 | 0.9% | 9.6E-07 | 1.2% | 0.0E+00 | 0.0% | 1.3E-05 | 99.7% | 1.3E-05 | 99.7% | 1.3E-05 | 16.3% |
| Summation | 1.1E-05 | 14.2% | 7.4E-07 | 0.9% | 9.7E-07 | 1.2% | 6.6E-05 | 83.7% | 1.3E-05 | 100.0% | 1.3E-05 | 100% | 7.9E-05 | 100.0% |

**Noncarcinogenic Hazard Indexes**

| Chemical | Upper Canyon | % | Middle Canyon | % | Lower Canyon | % | Residential Ground Water | % | Central Tendency: Current Use Recreational/Ag Pathways Combined | Compound Contribution % | Future Use Recreational/Ag Pathways Combined | Compound Contribution % | Future Use Residential All Pathways Combined | Compound Contribution % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 1.3E-04 | 0.0% | 9.7E-06 | 0.0% | 2.2E-05 | 0.0% | 0.98 | 20.5% | 1.6E-04 | 12.9% | 1.6E-04 | 12.9% | 1.0 | 20.5% |
| Manganese (nonfood) | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.00 | 0.0% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.0 | 0.0% |
| Molybdenum | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.09 | 1.9% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.1 | 1.9% |
| Nitrate | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.10 | 2.0% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.1 | 2.0% |
| Selenium | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.30 | 6.3% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.3 | 6.3% |
| Uranium | 9.4E-04 | 0.0% | 5.8E-05 | 0.0% | 9.6E-05 | 0.0% | 1.88 | 39.4% | 1.1E-03 | 87.1% | 1.1E-03 | 87.1% | 1.9 | 39.4% |
| Vanadium | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 1.43 | 29.9% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 1.4 | 29.9% |
| Summation | 1.1E-03 | 0.022% | 6.7E-05 | 0.001% | 1.2E-04 | 0.002% | 4.8E+00 | 100.0% | 0.00 | 100.0% | 0.00 | 100% | 4.8 | 100.0% |

**Dose Assessment**

| Effective Dose Equivalent | Upper Canyon | % | Middle Canyon | % | Lower Canyon | % | Residential Ground Water | % | Central Tendency: Current Use Recreational/Ag All Pathways Combined | Contribution % | Future Use Recreational/Ag All Pathways Combined | Contribution % | Future Use Residential All Pathways Combined | Contribution % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mrem/year | 1.6 | 6% | 0.1 | 0% | 0.1 | 0% | 26.1 | 94% | 1.8 | 100.0% | 1.8 | 100.0% | 27.9 | 100.0% |

*Table 4–10. Reasonable Maximum Exposure (Near-Term)—Updated Summary*

**Added Cancer Risk**

**Nonradionuclides**

| Chemical | Upper Canyon | % | Middle Canyon | % | Lower Canyon | % | Residential Ground Water | % | Current Use Recreational/Ag Pathways Combined | Compound Contribution % | Future Use Recreational/Ag Pathways Combined | Compound Contribution % | Future Use Residential All Pathways Combined | Compound Contribution % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 3.0E-07 | 0.1% | 2.3E-08 | 0.0% | 4.0E-08 | 0.0% | 3.4E-04 | 99.9% | 3.6E-07 | 100.0% | 3.6E-07 | 100.0% | 3.5E-04 | 100.0% |
| Summation | 3.0E-07 | 0.1% | 2.3E-08 | 0.0% | 4.0E-08 | 0.0% | 3.4E-04 | 99.9% | 3.6E-07 | 100.0% | 3.6E-07 | 100.0% | 3.5E-04 | 100.0% |

**Radionuclides**

| Radionuclide | Upper Canyon | % | Middle Canyon | % | Lower Canyon | % | Residential Ground Water | % | Recreational/Ag Pathways Combined | Compound Contribution % | Pathways Combined | Compound Contribution % | Residential All Pathways Combined | Compound Contribution % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Uranium-234 | 4.2E-07 | 0.1% | 2.7E-08 | 0.0% | 3.3E-08 | 0.0% | 1.4E-04 | 29.1% | 4.8E-07 | 0.4% | 4.8E-07 | 0.4% | 1.4E-04 | 29.2% |
| Uranium-235+D | 1.1E-08 | 0.0% | 6.8E-10 | 0.0% | 9.0E-10 | 0.0% | 7.4E-06 | 1.6% | 1.2E-08 | 0.0% | 1.2E-08 | 0.0% | 7.4E-06 | 1.6% |
| Uranium-238+D | 6.1E-07 | 0.1% | 3.7E-08 | 0.0% | 4.8E-08 | 0.0% | 1.9E-04 | 41.4% | 6.9E-07 | 0.5% | 6.9E-07 | 0.5% | 1.9E-04 | 41.5% |
| External gamma | 1.1E-04 | 23.0% | 7.4E-06 | 1.6% | 1.5E-05 | 3.1% | 0.0E+00 | 0.0% | 1.3E-04 | 99.1% | 1.3E-04 | 99.1% | 1.3E-04 | 27.7% |
| Summation | 1.1E-04 | 23.2% | 7.5E-06 | 1.6% | 1.5E-05 | 3.1% | 3.4E-04 | 72.0% | 1.3E-04 | 100.0% | 1.3E-04 | 100.0% | 4.7E-04 | 100.0% |

**Noncarcinogen Hazard Indexes**

| Chemical | Upper Canyon | % | Middle Canyon | % | Lower Canyon | % | Residential Ground Water | % | Recreational/Ag Pathways Combined | Compound Contribution % | Recreational/Ag Pathways Combined | Compound Contribution % | Residential All Pathways Combined | Compound Contribution % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Arsenic | 1.5E-03 | 0.0% | 1.2E-04 | 0.0% | 2.0E-04 | 0.0% | 1.788 | 20.5% | 1.8E-03 | 14.1% | 1.8E-03 | 14.1% | 1.8 | 20.5% |
| Manganese (nonfood) | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.002 | 0.0% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.0 | 0.0% |
| Molybdenum | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.163 | 1.9% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.2 | 1.9% |
| Nitrate | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.176 | 2.0% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.2 | 2.0% |
| Selenium | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.553 | 6.3% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.6 | 6.3% |
| Uranium | 9.8E-03 | 0.1% | 6.2E-04 | 0.0% | 7.8E-04 | 0.0% | 3.435 | 39.3% | 1.1E-02 | 85.9% | 1.1E-02 | 85.9% | 3.4 | 39.4% |
| Vanadium | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 2.610 | 29.9% | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 2.6 | 29.9% |
| Summation | 1.1E-02 | 0.13% | 7.4E-04 | 0.01% | 9.9E-04 | 0.01% | 8.7 | 99.9% | 0.01 | 100.0% | 0.01 | 100.0% | 8.7 | 100.0% |

**Dose Assessment**

| Effective Dose Equivalent | Upper Canyon | % | Middle Canyon | % | Lower Canyon | % | Residential Ground Water | % | Current Use Recreational/Ag Pathways Combined | Compound Contribution % | Future Use Recreational/Ag Pathways Combined | Compound Contribution % | Future Use Residential All Pathways Combined | Compound Contribution % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| mrem/year | 4.6 | 10.1% | 0.3 | 0.7% | 0.6 | 1.4% | 40.2 | 87.9% | 5.5 | 100.0% | 5.5 | 100.0% | 45.7 | 100.0% |

*Table 4–11. Comparison of Future Use Residential Scenario for Near-Term and Long-Term Ground Water CT Exposure Assumptions*

**Added Cancer Risk**

| Chemical | Near Term (Well 92–11) Residential Ground Water | Near Term (Well 92–11) Compound Contribution % | 20-Year (Well 92–09) Residential Ground Water | 20-Year (Well 92–09) Compound Contribution % | Future Use Recreational/Ag Near Term All Pathways Combined | Future Use Recreational/Ag Near Term Compound Contribution % | Future Use Residential 20-Year All Pathways Combined | Future Use Residential 20-Year Compound Contribution % |
|---|---|---|---|---|---|---|---|---|
| Arsenic | 5.7E-05 | 100.0% | 5.5E-06 | 99.8% | 8.8E-09 | 100% | 5.5E-06 | 100% |
| Summation | 5.7E-05 | 100.0% | 5.5E-06 | 99.8% | 8.8E-09 | 100% | 5.5E-06 | 100% |

| Radionuclide | Residential Ground Water | Compound Contribution % | Residential Ground Water | Compound Contribution % | Future Use Recreational/Ag All Pathways Combined | Future Use Recreational/Ag Compound Contribution % | Future Use Residential All Pathways Combined | Future Use Residential Compound Contribution % |
|---|---|---|---|---|---|---|---|---|
| Uranium-234 | 2.7E-05 | 33.8% | 2.1E-05 | 32.3% | 1.7E-08 | 0.1% | 2.1E-05 | 32.4% |
| Uranium-235+D | 1.4E-06 | 1.8% | 1.1E-06 | 1.7% | 4.4E-10 | 0.0% | 1.1E-06 | 1.7% |
| Uranium-238+D | 3.8E-05 | 48.1% | 3.0E-05 | 46.0% | 2.4E-08 | 0.2% | 3.0E-05 | 46.1% |
| External gamma | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 1.3E-05 | 99.7% | 1.3E-05 | 19.8% |
| Summation | 6.6E-05 | 83.7% | 5.2E-05 | 80.1% | 1.3E-05 | 100% | 6.4E-05 | 100.0% |

**Noncarcinogenic Hazard Indexes**

| Chemical | Residential Ground Water | Compound Contribution % | Residential Ground Water | Compound Contribution % | Future Use Recreational/Ag All Pathways Combined | Future Use Recreational/Ag Compound Contribution % | Future Use Residential All Pathways Combined | Future Use Residential Compound Contribution % |
|---|---|---|---|---|---|---|---|---|
| Arsenic | 0.98 | 20.5% | 0.09 | 5.3% | 1.6E-04 | 12.9% | 0.1 | 5.4% |
| Manganese (nonfood) | 0.00 | 0.0% | 0.19 | 10.9% | 0.0E+00 | 0.0% | 0.2 | 10.9% |
| Molybdenum | 0.09 | 1.9% | 0.01 | 0.3% | 0.0E+00 | 0.0% | 0.0 | 0.3% |
| Nitrate | 0.10 | 2.0% | 0.00 | 0.0% | 0.0E+00 | 0.0% | 0.0 | 0.0% |
| Selenium | 0.30 | 6.3% | 0.00 | 0.0% | 0.0E+00 | 0.0% | 0.0 | 0.0% |
| Uranium | 1.88 | 39.4% | 1.48 | 83.2% | 1.1E-03 | 87.1% | 1.5 | 83.3% |
| Vanadium | 1.43 | 29.9% | 0.00 | 0.0% | 0.0E+00 | 0.0% | 0.0 | 0.0% |
| Summation | 4.8E+00 | 100.0% | 1.8 | 99.9% | 0.00 | 100% | 1.8 | 100.0% |

**Dose Assessment**

| Effective Dose Equivalent | Residential Ground Water | % | Residential Ground Water | % | Future Use Recreational/Ag All Pathways Combined | Future Use Recreational/Ag Contribution % | Future Use Residential All Pathways Combined | Future Use Residential Contribution % |
|---|---|---|---|---|---|---|---|---|
| mrem/year | 26.1 | 94% | 20.5 | 92% | 1.8 | 100.0% | 22.3 | 100.0% |

*Table 4–12. Comparison of Future Use Residential Scenario for Near-Term and Long-Term Ground Water RME Exposure Assumptions*

**Added Cancer Risk**

| Nonradionuclides | Near-Term (Well 92–11) | | 20-Year (Well 92–09) | | Future Use Recreational/Ag Near-Term | | Future Use Residential 20-Year | |
|---|---|---|---|---|---|---|---|---|
| Chemical | Residential Ground Water | Compound Contribution % | Residential Ground Water | Compound Contribution % | Pathways Combined | Compound Contribution % | All Pathways Combined | Compound Contribution % |
| Arsenic | 3.4E-04 | 99.9% | 3.3E-05 | 98.9% | 3.6E-07 | 100.0% | 3.4E-05 | 100.0% |
| Summation | 3.4E-04 | 99.9% | 3.3E-05 | 98.9% | 3.6E-07 | 100.0% | 3.4E-05 | 100.0% |

| Radionuclides | | | | | | | Residential | |
|---|---|---|---|---|---|---|---|---|
| Radionuclide | Residential Ground Water | Compound Contribution % | Residential Ground Water | Compound Contribution % | Pathways Combined | Compound Contribution % | All Pathways Combined | Compound Contribution % |
| Uranium-234 | 1.4E-04 | 29.1% | 1.1E-04 | 27.0% | 4.8E-07 | 0.4% | 1.1E-04 | 27.1% |
| Uranium-235+D | 7.4E-06 | 1.6% | 5.7E-06 | 1.4% | 1.2E-08 | 0.0% | 5.7E-06 | 1.5% |
| Uranium-238+D | 1.9E-04 | 41.4% | 1.5E-04 | 38.5% | 6.9E-07 | 0.5% | 1.5E-04 | 38.6% |
| External gamma | 0.0E+00 | 0.0% | 0.0E+00 | 0.0% | 1.3E-04 | 99.1% | 1.3E-04 | 32.8% |
| Summation | 3.4E-04 | 72.0% | 2.6E-04 | 66.9% | 1.3E-04 | 100.0% | 4.0E-04 | 100.0% |

**Noncarcinogenic Hazard Indexes**

| | | | | | Recreational/Ag | | Residential | |
|---|---|---|---|---|---|---|---|---|
| Chemical | Residential Ground Water | Compound Contribution % | Residential Ground Water | Compound Contribution % | Pathways Combined | Compound Contribution % | All Pathways Combined | Compound Contribution % |
| Arsenic | 1.788 | 20.5% | 0.173 | 5.3% | 1.8E-03 | 14.1% | 0.2 | 5.4% |
| Manganese (nonfood) | 0.002 | 0.0% | 0.354 | 10.9% | 0.0E+00 | 0.0% | 0.4 | 10.9% |
| Molybdenum | 0.163 | 1.9% | 0.011 | 0.3% | 0.0E+00 | 0.0% | 0.0 | 0.3% |
| Nitrate | 0.176 | 2.0% | 0.001 | 0.0% | 0.0E+00 | 0.0% | 0.0 | 0.0% |
| Selenium | 0.553 | 6.3% | 0.001 | 0.0% | 0.0E+00 | 0.0% | 0.0 | 0.0% |
| Uranium | 3.435 | 39.3% | 2.698 | 82.9% | 1.1E-02 | 85.9% | 2.7 | 83.3% |
| Vanadium | 2.610 | 29.9% | 0.001 | 0.0% | 0.0E+00 | 0.0% | 0.0 | 0.0% |
| Summation | 8.7 | 99.9% | 3.2 | 99.6% | 0.01 | 100.0% | 3.3 | 100.0% |

**Dose Assessment**

| | | | | | Future Use Recreational/Ag | | Future Use Residential | |
|---|---|---|---|---|---|---|---|---|
| Effective Dose Equivalent | Residential Ground Water | % | Residential Ground Water | % | Pathways Combined | Contribution % | All Pathways Combined | Contribution % |
| mrem/year | 40.2 | 87.9% | 31.6 | 85.0% | 5.5 | 100.0% | 37.1 | 100.0% |

| | Current Exposure | Future Exposure | | | |
|---|---|---|---|---|---|
| | | Near-Term | | 20-Year | |
| Exposure Scenarios | Agricultural/Recreational | Agricultural/Recreational | Residential | Agricultural/Recreational | Residential |
| Complete Pathways | Ingestion of soil and sediment<br>Inhalation of soil and sediment (dust)<br>Direct radiation exposure (gamma)<br>Ingestion of surface water | Ingestion of soil and sediment<br>Inhalation of soil and sediment (dust)<br>Direct radiation exposure (gamma)<br>Ingestion of surface water | Ingestion of soil and sediment<br>Inhalation of soil and sediment (dust)<br>Direct radiation exposure (gamma)<br>Ingestion of surface water<br>Ingestion of ground water | Ingestion of soil and sediment<br>Inhalation of soil and sediment (dust)<br>Direct radiation exposure (gamma)<br>Ingestion of surface water | Ingestion of soil and sediment<br>Inhalation of soil and sediment (dust)<br>Direct radiation exposure (gamma)<br>Ingestion of surface water<br>Ingestion of ground water |
| **Location of Results** | | | | | |
| —Central Tendency: | Table 4–9 | Table 4–9 | Table 4–9 | Tables 4–9 and 4–11 | Table 4–11 |
| —Reasonable Maximum Exposure: | Table 4–10 | Table 4–10 | Table 4–10 | Tables 4–10 and 4–12 | Table 4–12 |

Notes: Details on how risks were calculated are presented in Appendix F.
The only change for the 20-yr estimates is for the residential scenario (ground water ingestion). The 20-yr estimate uses the ground water modeling results for uranium and data from a different well (well 92–09 for 20 yr opposed to well 92–11 for near term).

*Figure 4–1. Overview of the Exposure Scenarios, Complete Pathways, and Location of the Risk Results*

### Near-Term Scenario

Compared to risk estimates in the 1998 RI, the updated carcinogenic risks from nonradionuclides are lower because of the lower arsenic concentration in ground water; consumption of ground water accounts for over 99 percent of this type of risk. Elimination of the radionuclide COCs (mostly Pb-210, which has a high toxicity) and lower contaminant concentrations reduced cancer risks from radionuclides. However, this was somewhat offset by increased toxicity values for the uranium isotopes. Although ground water is the predominant pathway for these contaminants, gamma exposure in the upper canyon accounts for over 20 percent of the total risks for the RME residential scenario. Noncarcinogenic risks were also reduced because of decreasing contaminant concentrations; only a small increase in risks occurred from adding molybdenum and nitrate as COCs. The predominant contributors to noncarcinogenic risk (HI) are uranium, vanadium, and arsenic.

Carcinogenic risks for both chemicals (arsenic) and radionuclides (isotopes of uranium) are within EPA's risk range of $10^{-4}$ to $10^{-6}$, assuming RME and CT exposure factors. The HI exceeds the benchmark of 1 for the RME and CT scenarios. The EDE ranges from 26 to 40 mrem/yr for the ground water ingestion pathway.

### 20-Year Scenario

Risks estimated with these exposure point concentrations have decreased compared to the near-term future residential estimates because of the decreased COC concentrations in ground water; all other exposures are the same as those presented for the near-term future residential scenario. Arsenic risks have decreased by an order of magnitude; carcinogenic risks from radionuclides have decreased by nearly 15 percent because of the lower uranium concentrations for ground water ingestion (the contribution from gamma exposure is unchanged). The hazard indices have been reduced by over 60 percent; the predominant contributors to the HI are uranium and manganese (manganese concentrations in the area of well 92–09 are likely elevated because of a natural contribution from the Burro Canyon aquifer). The dose assessment reflects the lower uranium concentrations in ground water; dose for future residential risk is approximately 37 mrem/yr for RME (Table 4–12) and approximately 22 mrem/yr using the CT assumptions (Table 4–11).

The 20-yr future residential risk estimate for CT (Table 4–11) shows no areas of concern except for an HI of 1.8. The RME estimates for future use residential (Table 4–12) show an added cancer risk for radionuclides of $4.0 \times 10^{-4}$ and an HI of 3.3.

Overall, the unlikely exposure scenario of the future use of alluvial ground water as the primary drinking water source dominates the estimated risks for the residential scenario. Two sets of ground water exposure point concentrations (near-term and 20-yr) were evaluated, assuming the ground water ingestion pathway is complete in the future and two types of exposure assumptions (CT and RME) were used to provide risk managers a range of outcomes.

### Recreational/Agricultural Scenarios

For the more likely recreational/agricultural scenario, carcinogenic risks (chemical and total radiological risks) are typically 1.5 to 3 times greater than risks expected from background concentrations (see Table 4–13 for a comparison of incremental risks [site-related risks minus risks estimated using background concentrations] using RME assumptions. Risks for the agricultural scenarios are nearly 20 times background for noncarcinogens; however, the site-related HI is much less than one. The EDE ranges from 1.8 to 5.5 mrem/yr (see Tables 4–9 and 4–10). The risk driver for this scenario is gamma exposure, which was based on the survey data before the soil and sediment in Montezuma Creek was remediated. Therefore, the risks associated with external gamma exposures are likely lower than estimated because some of the contamination was removed and the weighted average waist-high gamma values have probably been reduced.

### 4.1.6 Assessment of Uncertainties

The major uncertainties associated with this risk assessment have not changed since the original risk assessment was completed. These include the representativeness of the spatial sampling, the exposure assumptions regarding potential future use, and the accuracy of the toxicological data used to evaluate risks. Each of these sources of uncertainty is discussed thoroughly in the 1998 RI (DOE 1998a). The discussion in the 1998 RI includes a semiquantitative uncertainty analysis, the relative uncertainty among the areas of uncertainty, and the uncertainty effects. The overall conclusion is that the assumptions used in the original risk assessment likely overestimate the risks.

Two new major areas of uncertainty were introduced as part of the updated risk assessment: (1) representativeness of data from wells 92–09 and 92–11 as an indicator for future exposure point concentrations in ground water, and (2) the use of soil/sediment data from the original risk assessment even though remediation occurred in Upper and Lower Montezuma Creek.

(1) *Representativeness of ground water concentration data from wells 92–09 and 92–11*—To approximate potential near-term risk, recent (October 2002) ground water concentration data from well 92–11 were used as the exposure point concentrations. This assumption probably overestimates risk because concentrations will likely have decreased because of natural attenuation when exposure actually occurs (assumed to be 5 to 15 yr). In addition, recent drought conditions likely overestimate risks for exposures assumed to last up to 30 yr (the drought could worsen in the short-term; however, average concentrations over an extended exposure period would likely be lower than those used to estimate risks).

Longer-term (20 yr) future residential exposures are assumed to occur in the vicinity of well 92–09. This area was selected because the ground water model predicts uranium concentrations (the risk driver) will be the highest in this area in 20 yr. Although the model results are assumed to be the most accurate predictor of future ground water concentrations, assuming exposure would occur in the area with the highest concentrations likely overestimates risks.

*Table 4–13. Incremental Risk Comparison for the Residential and Recreational/Agricultural Scenario*

| | | | | | | Current Use Residential | Future Use Recreational/Ag |
|---|---|---|---|---|---|---|---|
| **Carcinogens** | **Chemicals** | **Upper Canyon** | **Middle Canyon** | **Lower Canyon** | **Residential Ground Water** | **Pathways Combined** | **Pathways Combined** |
| Chemical RME with Background | Arsenic | 9.8E-08 | 8.0E-09 | 1.7E-08 | 3.0E-05 | 1.2E-07 | 1.2E-07 |
| Chemical RME with OU III Concentrations | | 3.0E-07 | 2.3E-08 | 4.0E-08 | 3.4E-04 | 3.6E-07 | 3.6E-07 |
| Incremental Risk—Absolute | | 2.0E-07 | 1.5E-08 | 2.3E-08 | 3.2E-04 | 2.3E-07 | 2.3E-07 |
| Incremental as % > Background | | 200% | 183% | 139% | 1062% | 191% | 191% |
| Radionuclides RME with Background | Uranium Isotopes Only | 4.1E-09 | 3.2E-10 | 6.7E-10 | 8.0E-06 | 5.0E-09 | 5.0E-09 |
| Radionuclides RME with OU III Concentrations | | 1.0E-06 | 6.5E-08 | 8.2E-08 | 3.4E-04 | 1.2E-06 | 1.2E-06 |
| Incremental Risk—Absolute | | 1.0E-06 | 6.4E-08 | 8.1E-08 | 3.3E-04 | 1.2E-06 | 1.2E-06 |
| Incremental as % > Background | | 25,613% | 19,869% | 12,168% | 4,121% | 23,464% | 23,464% |
| External Gamma with Background | Gamma Only | 3.0E-05 | 2.4E-06 | 4.9E-06 | 0.0E+00 | 3.7E-05 | 3.7E-05 |
| External Gamma with OU III Values | | 1.1E-04 | 7.4E-06 | 1.5E-05 | 0.0E+00 | 1.3E-04 | 1.3E-04 |
| Incremental Risk—Absolute | | 7.8E-05 | 5.0E-06 | 9.7E-06 | 0.0E+00 | 9.3E-05 | 9.3E-05 |
| Incremental as % > Background | | 265% | 214% | 200% | NA | 253% | 253% |
| Total Radiological Risk with Background | Uranium Isotopes & Gamma | 3.0E-05 | 2.4E-06 | 4.9E-06 | 8.0E-06 | 3.7E-05 | 3.7E-05 |
| Total Radiological Risk with OU III | | 1.1E-04 | 7.5E-06 | 1.5E-05 | 3.4E-04 | 1.3E-04 | 1.3E-04 |
| Incremental Risk—Absolute | | 7.9E-05 | 5.1E-06 | 9.8E-06 | 3.3E-04 | 9.4E-05 | 9.4E-05 |
| Incremental as % > Background | | 268% | 216% | 201% | 4121% | 256% | 256% |
| **Noncarcinogens** | | | | | | | |
| Hazard Index with Background | Seven Chemicals | 5.4E-04 | 4.4E-05 | 9.0E-05 | 0.4 | 6.8E-04 | 6.8E-04 |
| Hazard Index with OU III Concentrations | | 1.1E-02 | 7.4E-04 | 9.9E-04 | 8.7 | 1.3E-02 | 1.3E-02 |
| Incremental Risk—Absolute | | 1.1E-02 | 6.9E-04 | 9.0E-04 | 8.3 | 1.2E-02 | 1.2E-02 |
| Incremental as % > Background | | 1,978% | 1,588% | 998% | 2,079% | 1,823% | 1,823% |

Note: Incremental risk = RME OU III risks – RME risks using background concentrations



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The current concentrations for the other COCs were used as indicators of future exposure point concentrations near well 92–09. The impacts on the risk estimates are expected to be minimal because concentrations for all COCs other than uranium have been stable in this area over the last 10 yr.

(2) *Use of soil/sediment data from the original risk assessment*—As noted earlier the 1998 RI was completed with data collected prior to soil and sediment remediation. Although resampling would likely yield lower concentrations in this area, a comprehensive resampling was not done, and this updated risk assessment used concentrations of samples collected before remediation. These values are likely to overestimate risks associated with exposures to contaminated soils and sediments.

The most significant area of uncertainty is whether the residential ground water ingestion pathway (the most significant exposure pathway) will be complete. Institutional controls are in place to prevent the use of contaminated ground water as a drinking water source. In addition; municipal water lines are nearby and could be extended for use in this area.

### 4.1.7 Human Health Risk Assessment Synopsis

Risk characterization results were presented in Section 4.1.5; the following paragraph presents an overall synopsis of the risk assessment results.

The improbable future use of alluvial ground water as the primary source of drinking water would cause the most significant risks of all exposure pathways evaluated for the HHRA. Use of this water as drinking water is not likely because of the availability of city of Monticello water, the low yield from the alluvial aquifer, and the shallow depth of the water, which could become contaminated from nearby animal feed locations. The current recreational/agricultural scenario does not exceed risk-based concentrations using CT exposure assumptions.

## 4.2 Ecological Risk Assessment

In preparation of this document, surface water data collected since the 1998 RI were viewed by the ETAG as the only type of data that required aspects of the 1998 ERA to be updated. Receptors, exposure pathways, and toxicity benchmarks used in the 1998 ERA were considered to still be appropriate or viewed as not having changed enough to alter the final conclusion of the 1998 ERA. It was noted that some evaluation of the benthic community might be considered in the future to demonstrate a successful remedy (Hoff 2000).

It was also noted by the ETAG that continued monitoring of selenium concentrations in surface water and ground water was prudent because of the increase in selenium concentrations (that began in 1999) to levels above those evaluated in the 1998 ERA. The ETAG felt that continued surface water and ground water monitoring was the appropriate course of action because it was reasoned that weathering of bedrock and bedrock-derived soil naturally abundant in selenium released selenium to surface water and ground water. These materials are present as carbonaceous marine shale that were freshly exposed during remediation beneath the alluvial aquifer on the east half of the Millsite. Selenium leaching from the bedrock was expected to decrease once the effect of exposing the bedrock and then covering with backfill material and restoration of the Millsite was complete.

DOE, EPA, and UDEQ also made the decision to look for other possible sources of selenium and explanations for the increase in its concentration. This additional investigation led to the identification of seeps on the Millsite with high selenium concentrations. High concentrations of selenium in samples from those seeps are considered the result of weathering of similar, off-site bedrock and bedrock residuum. An example of surface water that contains high selenium concentrations from the weathering of off-site materials is seep 3, which is channeled to Montezuma Creek and provides some recharge and selenium contamination to the alluvial system a short distance upstream of Wetland 3. Therefore, the increase in selenium in Montezuma Creek and the constructed wetlands (primarily Wetland 3) since source removal is currently believed to be the result of (1) the discharge of alluvial ground water on the Millsite that contains selenium at currently observed concentrations and (2) seeps that are not related to the alluvial system (separate sources) but enter the creek and wetlands from the north margin of the Millsite (e.g., seep 3).

During preparation of this ERA update, there was ongoing discussion with the ETAG about the scope of the update. It was decided that a new review of the results of the 1998 ERA (Table 1–6 presents a summary) was necessary given the following changes: (1) the progressing establishment of wetlands on the Millsite and (2) the selenium surface water data which show that selenium concentrations in Millsite surface water have increased more than in surface water downstream of the Millsite (Plate 8).

In 1998, the risk-driving pathways were ingestion of invertebrates, soil/sediment, and grass; COCs were arsenic, copper, vanadium, uranium, and selenium (Table 1–6). The receptors with pathways and COCs exceeding an HQ of 1 were the deer mouse, muskrat, spotted bat, and southwestern willow flycatcher. It was concluded in 1998 that even though some pathways and COCs resulted in HQs greater than 1, the conservative nature of assumptions used in the assessment probably overestimated risks and that actual risks were likely to be lower. It was noted that benthic macroinvertebrates did show some uptake of arsenic, molybdenum, uranium, and vanadium; however, effects of these uptakes were not apparent with respect to the benthic organisms themselves. The concentration range of selenium in benthic macroinvertebrate samples from reference areas (nondetect to 1.78 mg/kg) and from Montezuma Creek (nondetect to 1.72 mg/kg) were similar (see 1998 RI, Volume VII, Appendix C, page C1-7). Surface water exposure point concentrations for benthic macroinvertebrates did not exceed ambient water quality criteria.

After considering that selenium concentrations have increased in surface water and that concentrations are greatest in surface water near Wetland 3 created on the Millsite, the ETAG suggested focusing this update on potential risks to the spotted bat and southwestern willow flycatcher. These receptors are of particular concern because of their status as state and federal endangered species, respectively. They are also the only receptors for which selenium was identified as a risk-driving COC; the risk-driving exposure pathway associated with selenium was invertebrate ingestion. Benthic macroinvertebrates were included because results of the earlier ERA were inconclusive and those organisms are in direct contact with surface water.

During the process of updating the evaluation of risk to the spotted bat, the southwestern willow flycatcher, and benthic macroinvertebrates, it became evident that data gaps existed. Although 238 surface soil samples were collected from the Millsite during verification and 17 samples

were collected of wetland subgrade sediments[1], the entire Millsite was covered with 6 inches of loess-derived soil subsequent to sampling and so the prior data are not representative of exposure point concentrations in the future. The loess-derived soil placed on the hillside of the restored Millsite and in the wetlands is not expected to be a current significant source of selenium. Possibly, selenium may accumulate in the loess-derived soils and the subgrade soil/sediment (primarily in the wetlands and in those areas with seeps) because of the elevated concentrations in surface water and ground water passing through those materials.

Besides the lack of current sediment data, no benthic macroinvertebrate samples have been collected for chemical analysis since the 1998 ERA. Macroinvertebrate data are not relevant to the task of updating risk to the spotted bat or southwestern willow flycatcher as they are not a food item in either animal's diet; however, aquatic invertebrates are a pathway of concern as a primary food chain item for new receptors that may frequent the constructed wetlands. Data necessary to fill the data gaps and complete the analysis of risk to new ecological receptors (in particular waterfowl exposure to aquatic vertebrates) cannot be collected until a definitive trend in selenium concentrations has been established and development of the wetlands on the Millsite has progressed to the state where they are a high quality habitat. At the present stage of development, Wetland 3 is relatively small and does not contain any open water or a shrub mid-story component. As such, it does not serve as higher quality habitat for avian species such as waterfowl or shorebirds. However, if Wetland 3 develops as designed, there is a potential risk to waterfowl if high selenium concentrations are present in the wetland. The scope of additional data collection efforts is the subject of continued discussion for the ETAG. A preliminary outline of the types of data that will be collected and the areas where collection efforts will be focused is given in Section 4.2.4. The scope of additional data collection (which will begin in 2004) and routine monitoring will be described in the OU III Proposed Plan and ROD.

### 4.2.1 Data Review

Consistent with ETAG discussions prior to preparation of this document, no additional analyses of grasses, invertebrates, soil and sediment needed to be performed since completion of the 1998 ERA. In general, decreases of COC concentrations in surface water, ground water, soil, and sediment should also result in concentration decreases for those same constituents in grasses and invertebrates, although for contaminants that bioaccumulate (e.g., selenium), concentrations may have increased.

Surface water and ground water monitoring have been ongoing since completion of the 1998 ERA. As described in Section 2.7.1, cobalt, copper, lead, and zinc were eliminated as COCs for ecological risk; they will not be considered further here. Table 4–14 presents a comparison of recent surface water analyses with concentrations used in the 1998 ERA for the current ecological COCs. Concentrations of all constituents except selenium have decreased. Because the original source of ground water and surface water contamination (mill tailings) has been removed, concentrations of all COC (except, perhaps, selenium in the short term) will continue to decrease from present levels in surface water and ground water as the contaminant plume dissipates.

[1] Soil and subgrade sediment data are sufficient to conclude that COC concentrations in those materials are at background levels and should not be a source of surface water and ground water contamination. The average selenium concentration in surface soil samples was approximately 0.4 mg/kg; the average selenium concentration in subgrade sediment samples was 0.8 mg/kg.

*Table 4–14. Montezuma Creek Surface Water Concentrations (µg/L)*

| Analyte | Upper Montezuma Creek | | | Upper and Middle | Middle Montezuma Creek | | Lower Montezuma Creek | | All Sections |
|---|---|---|---|---|---|---|---|---|---|
| | 1995 | 1995 and 1996 Combined | 2001 and 2002 Combined; Sorenson and SW00–04 | 1996 | 1995 and 1996 Combined | 2001 and 2002 Combined; SW92–08 | 1995 | 2001 and 2002 Combined; SW94–01 | 1995 and 1996 Combined |
| Arsenic | 3.21[a] | 2.83[a] | 1.5[a] | 2.69[a] | 2.7[b] | 1.4[b] | 4.6[a] | 1.1[b] | 3.55[a] |
| Molybdenum | 28.9U | 17.2[a] | 13.3[a] | 18.6[a] | 16.3[b] | 13.7[b] | 28.9U | 11.6[b] | 16.3[a] |
| $NO_3 + NO_2$ as N | 538[a] | 538[a] | 517[c] | – | – | 325[a] | 1,140[b] | 61.9[b] | 899[a] |
| Selenium | 2.23[a] | 2.19[a] | 9.9[a] | 2.33[a] | 2.0[b] | 7.5[b] | 2.2U | 6.3[b] | 1.82[a] |
| Uranium | – | 159[a] | 120[a] | 159 | 140[b] | 139[a] | – | 93.7[b] | 159[b] |
| Vanadium | 13.6[a] | 10.5[a] | 9.7[a] | 10.9[a] | 7.7U | 4.3[a] | 9.1[b] | 3.0[b] | 8.42[a] |

U = Not detected; value is the sample detection limit.
– = No data.
[a]95 percent upper confidence limit.
[b]Maximum detected.
[c]Average concentration.

For the purposes of characterizing the range of selenium concentrations in surface water at the MMTS, surface water sampling locations can be divided into three groups: (1) Montezuma Creek locations, (2) wetland (pond) locations, and (3) seep locations. In Montezuma Creek, selenium concentrations have increased from about 2 µg/L to about 8 to 10 µg/L (Table 4–14 and Plate 8).

Surface water in Wetlands 1 and 2 has not been sampled directly, but samples collected from the outflow of the wetlands into Montezuma Creek (locations SW01-02 and SW-01-03, respectively) have ranged from nondetect to 2 µg/L. Selenium concentrations in Wetland 3 on the Millsite ranged from 10 to 69.3 µg/L in 2002; the extent of open water was approximately half the design size shown on Plate 8. During a site visit in August 2003, no open water was present at Wetland 3. Downstream of the Millsite surface water, concentrations at the sediment pond that exists where the canyon narrows and the cliffs begin, ranged from 2.5 to 7.4 µg/L as measured at the outflow of the pond (location SW00-04).

On the Millsite, concentrations of selenium at seep 1 ranged from 5.9 to 9.9 µg/L (Appendix C, page C2–21), at seep 2 from 2 to 97.3 µg/L (Appendix C, page C2–25), and at seep 3 from 112 to 129 µg/L (Appendix C, page C2–19). Seeps in the western half of the Millsite ranged from 5.9 to 15.5 µg/L (Plate 8). Selenium concentrations in surface water in 2002 are greater than, or at least representative of, concentrations measured since the 1998 ERA.

Wetland 3 and Montezuma Creek capture most of the ground water flow on the Millsite. Some water captured by the wetlands and creek leaks back into the aquifer at the eastern margin of the Millsite. COC concentrations currently measured in Wetland 3 are similar to ground water concentrations in the area as a result of ground water discharge to the wetland. COC concentrations in Montezuma Creek are less because of mixing of relatively clean upstream surface water with the contaminated ground water that is discharged to the creek near Wetland 3. The interaction between surface water and ground water has been established on the restored Millsite, and the effect of ground water concentrations on surface water is fully accounted for in the surface water quality data, including the effect of any other features such as the riprap channel near Deer Draw and the PRB. Therefore, direct exposure to ground water is still a negligible exposure pathway for OU III receptors of concern.

As weathering of the bedrock on the Millsite progresses, the amount of selenium that is mobilized is expected to decrease because the bedrock will be exposed to less oxidizing conditions. Also, it is believed that the transient nitrate plume, which resulted from fertilization efforts during revegetation of the Millsite, may have enhanced the mobility of selenium. The nitrate plume, which reached concentrations as high as 65 mg/L in some areas of the alluvial ground water on the Millsite, has now dissipated to concentrations less than 10 mg/L and generally to concentrations less than 2 mg/L. Unlike selenium released from Millsite bedrock, off-site sources of selenium that enter the Millsite along the north margin of the Millsite may continue. For further discussion of selenium concentrations see page 2–31 of Section 2.7.3, "Ground Water Results."

### 4.2.2 Ecological Risk Assessment Update

Although a determination of risk to the environment from increases in selenium concentrations in surface water cannot be completed for the Millsite for the reasons discussed in the

introduction to this section, surface water monitoring data are available to complete an update to the evaluation of risk to the receptors identified in 1998 downstream of the Millsite.

For this update, the receptors evaluated are those identified in the previous RI/FS—the spotted bat and willow flycatcher. Effects on changed site conditions relevant to those receptors are discussed. It is important to note, however, that in preparing this addendum, a need was identified to reevaluate relevant site receptors because both the spotted bat and southwestern willow flycatcher prey on terrestrial invertebrates and not the aquatic invertebrates that are expected to be more profoundly affected by increased levels of selenium in surface water. Waterfowl were subsequently identified as the most likely receptors of greatest concern in the future. Data are not presently available to characterize risk to waterfowl. However, appropriate data to assess potential risks to those receptors will be collected as part of the site monitoring for the CERCLA 5-year review process (see Section 4.2.4).

Except for selenium, the decreases in COC concentrations in surface water, ground water, soil, and sediment should result in concentration decreases for those same constituents in grasses and invertebrates. Because selenium tends to bioaccumulate, concentrations may have increased in these media. Therefore, it is assumed that risks to the ecological receptors identified in 1998 associated with all ecological COCs except selenium have been reduced by remedial action and that the conclusions reached in the 1998 ERA remain valid (i.e., no significant current ecological risks are present). The reevaluation of risks to the 1998 ecological receptors of concern presented in the following section focuses on changes in selenium concentrations.

**Reevaluation of Risks Associated with Surface Water Ingestion**

In the 1998 ERA, the risks calculated for selenium via surface water ingestion by the spotted bat and flycatcher were very low—maximum HQs approached 0.002. Exposure point selenium concentrations used for those calculations were approximately 2.0 µg/L. Recent (2001 and 2002) surface water data show that selenium concentrations in Upper Montezuma Creek average 8.6 µg/L. In Middle and Lower Montezuma Creek, the maximum concentrations detected were 7.5 and 6.3 µg/L, respectively. The Utah Aquatic Wildlife Criteria is 5 µg/L. Data from 2002 are favored for use in this update because (1) they are the most current; (2) Millsite restoration was not completed until August 31, 2001; and (3) concentration trends resulting from Millsite excavation (source removal) and restoration have stabilized (see Section 2.7). Selenium concentrations are greatest in seeps on the Millsite, where the maximum concentration measured in 2002 was 129 µg/L (Plate 8). Concentrations in seeps are not representative of the surface water system downstream of the Millsite where concentrations in 2003 ranged from 0.95 to 10 µg/L. Although the best current habitat for the spotted bat and willow flycatcher is near the sediment pond at the beginning of the narrows, the seeps do represent worst-case concentrations for surface water ingestion. If these worst-case values were used with the same exposure parameters and assumptions as those in the 1998 ERA, the resulting risks for the spotted bat and flycatcher would be two orders of magnitude higher than those in the 1998 ERA—on the order of 0.1 for maximum HQs. These risks are still well below the threshold value of 1.0, which is used to signal a potential for concern.

Because selenium concentrations exceed the Utah Aquatic Wildlife Criteria, concentrations could be of some concern for aquatic organisms, specifically benthic macroinvertebrates. No new data are available for COC concentrations in invertebrates or on the benthic

macroinvertebrate community. Data reported by the U.S. Department of Interior (DOI), states that the lowest threshold for chronic toxicity for selenite or selenate occurs at approximately 25 to 100 µg/L and no clear community-level effects were apparent at concentrations of 25 µg/L. Using the DOI data as criteria, risks to the benthic community in Montezuma Creek are probably low because the highest concentration of selenium measured in Montezuma Creek during 2001 and 2002 was 12.1 µg/L. Risks to the benthic community are not likely to be a major concern and these organisms should continue to provide a viable food source for higher level organisms. However, as discussed in the next section, concentrations of selenium in macroinvertebrates, in general, may be of concern for higher trophic level organisms because they are a primary food chain item. The appropriateness of benthic macroinvertebrates, specifically (i.e., aquatic organisms), as assessment endpoints will be discussed with the ETAG and the need for additional sampling will be addressed in the OU III Proposed Plan and ROD.

**Reevaluation of Risks to Spotted Bat and Southwestern Willow Flycatcher Associated with Terrestrial Invertebrate Ingestion**

*Summary of 1998 ERA Results*

According to the 1998 ERA, the highest potential risks posed to the flycatcher and spotted bat were due to concentrations of selenium in terrestrial invertebrates that make up the major portions of their diets. Ninety-nine percent and 95 percent of dietary intake for the spotted bat and southwestern willow flycatcher, respectively, were assumed to be terrestrial invertebrates. Selenium concentrations analyzed in samples of terrestrial invertebrates from the site ranged from 0.33 to 2.9 mg/kg and averaged 1.2 mg/kg. Reference area concentrations were as high as 1.5 mg/kg and averaged about 0.5 mg/kg, based on data presented in Appendix H of the 1998 RI (DOE 1998a). Selenium results from the 1998 ERA for the various sampling media are presented in Table 4–15.

A summary of HQs calculated for the flycatcher and bat via terrestrial invertebrate ingestion is presented in Table 4–16 for Upper Montezuma Creek, Upper and Middle Montezuma Creek, and the reference area for the site (Verdure Creek). In selecting numerical benchmarks that were used to calculate HQs, an attempt was made to identify benchmarks representing both the "no observed adverse effects level" (NOAEL) and "lowest observed adverse effects level"(LOAEL).

At the time of the 1998 ERA, site-related HQs calculated for intakes of selenium through ingestion of terrestrial invertebrates were within the range calculated for the Verdure Creek reference area, despite the higher concentrations of selenium in Montezuma Creek surface water. This suggested that terrestrial invertebrate concentrations may not have been directly related to surface water concentrations and that selenium levels in terrestrial invertebrates from OU III did not differ significantly from background.

*Table 4–15.1998 RI Co-Located Sample Data for Selenium*

| Media | Location | Detection Frequency | Minimum[a] Detected | Maximum[a] Detected | Average[b] | Upper Confidence Limit (Spotted Bat)[c] | Upper Confidence Limit (Southwestern Willow Flycatcher)[c] |
|---|---|---|---|---|---|---|---|
| Surface Water | Reference | 0/7 | 0.85 | 1.1 | 0.98 | 1.1[d] (1995)<br>0.85[a] (1996) | 1.1[d] (1995)<br>0.85[a] (1996) |
| | Upper Montezuma Creek | 5/8 | 1.8 | 2.5 | 1.8 | 2.23 (1995) | 2.23 (1995) |
| | Middle Montezuma Creek | 1/2 | 2.0 | 2.0 | 1.43 | | |
| | Lower Montezuma Creek | 0/4 | 1.1 | 1.1 | 1.1 | | |
| | Upper/Middle Montezuma Creek | | | | | 2.33 (1996) | 2.33 (1996) |
| Soil | Reference | 12/14 | 0.29 | 1.4 | 0.61 | 0.491[e] (1995)<br>1.34 (1996) | 0.491[e] (1995)<br>1.34 (1996) |
| | Upper Montezuma Creek | 16/16 | 0.39 | 4.1 | 1.23 | 1.21 (1995) | 1.21 (1995) |
| | Middle Montezuma Creek | 4/4 | 1.3 | 3.6 | 2.23 | | |
| | Lower Montezuma Creek | 8/8 | 0.49 | 0.86 | 0.652 | | |
| | Upper/Middle Montezuma Creek | | | | | 3.62 (1996) | 3.62 (1996) |
| Sediment | Reference | 10/11 | 0.22 | 5.3 | 1.4 | | |
| | Upper Montezuma Creek | 26/32 | 0.28 | 6.8 | 1.43 | | |
| | Middle Montezuma Creek | 4/4 | 0.5 | 6.3 | 1.69 | | |
| | Lower Montezuma Creek | 2/4 | 0.15 | 3.6 | 0.72 | | |
| Cliff Swallow | Reference | 3/3 | 1.1 | 1.3 | 1.2 | | |
| | Upper Montezuma Creek | 3/3 | 1.3 | 1.8 | 1.6 | | |
| Terrestrial Invertebrates | Reference | 6/7 | 0.1 | 1.5 | 0.65 | 0.3[e] (1995)<br>1.5 (1996) | 0.3[e] (1995)<br>1.5 (1996) |
| | Upper/Middle/Lower Montezuma Creek | 15/15 | 0.33 | 2.9 | 1.2 | | |
| | Upper Montezuma Creek | | | | | 1.26 (1995) | 1.26 (1995) |
| | Upper/Middle Montezuma Creek | | | | | 1.1 (1996) | 1.1 (1996) |
| Shrubs | Reference | 3/6 | 0.27 | 0.41 | 0.19 | | 0.41[e] (1995)<br>0.06 (1996) |
| | Upper Montezuma Creek | 7/8 | 0.22 | 0.72 | 0.37 | | 0.61 (1995) |
| | Middle Montezuma Creek | 2/2 | 0.25 | 0.33 | 0.29 | | |
| | Lower Montezuma Creek | 4/4 | 0.27 | 0.76 | 0.45 | | |
| | Upper/Middle Montezuma Creek | | | | | | 0.33 (1996) |

[a]Minimum and maximum detected are actual values detected and not 1/2 the detection limit unless the frequency of detection was zero in which case 1/2 the detection limit is reported.
[b]Averages were calculated assuming 1/2 the detection limit for samples with of non-detect results.
[c]Values are the 95% lognormal upper confidence limit used in the exposure assessment for the identified receptor.
[d]Value is less than minimum detection limit.
[e]Maximum value detected. 95% UCL was greater than maximum.

*Table 4–16. Selenium HQs for Terrestrial Invertebrate Ingestion at Monticello OU III—1998 ERA Results*

| Receptor/Location | $HQ–CT_{NOAEL}$ | $HQ–RME_{NOAEL}$ | $HQ–CT_{LOAEL}$ | $HQ–RME_{LOAEL}$ |
|---|---|---|---|---|
| Spotted Bat—U | 1.28 | 1.36 | 0.73 | 0.78 |
| Spotted Bat—UM | 1.12 | 1.19 | 0.64 | 0.68 |
| Reference Area Range | 0.30–1.5 | 0.32–1.62 | 0.17–0.87 | 0.19–0.93 |
| Flycatcher—U | 1.63 | 2.92 | 0.82 | 1.5 |
| Flycatcher—UM | 1.43 | 2.55 | 0.71 | 1.3 |
| Reference Area Range | 0.39–1.94 | 0.70–3.48 | 0.19–0.97 | 0.35–1.74 |

U = Upper Montezuma Creek.
UM = Upper and Middle Montezuma Creek.

## *Ecotoxicological Effects of Selenium*

DOI (1998) summarized potential effects of different levels of selenium in various media based on a review of the ecotoxicological literature. Results of the DOI evaluation pertinent for comparison to OU III are presented in Table 4–17.

*Table 4–17. Summary of the Ecotoxicity of Selenium (from DOI 1998)*

| Medium | Concentration | Effect |
|---|---|---|
| Water | 1–3 µg/L | LOAELs in fish and wildlife through bioaccumulation |
| Terrestrial invertebrates | 0.1–2.5 mg/kg | Background invertebrate concentrations (typically <1.5 mg/kg) |
| Aquatic invertebrates | 0.4–4.5 mg/kg | Background invertebrate concentrations (typically <2.0 mg/kg) |
| Aquatic invertebrates | 2.5–15 mg/kg | Experimental LOAEL for subacute (growth) effects in invertebrates |
| Avian dietary intakes (e.g., invertebrates) | 3–8 mg/kg | Threshold for reproductive impairment |
| Bird, whole body | <2 mg/kg | Typical background |
| Dietary intakes, rats | 3 mg/kg (dry wt.) | LOAEL, reproductive selenosis |
| Dietary intakes, dogs | 7 mg/kg | Sublethal effects, LOAEL |
| Sediment | 2.5 mg/kg | EC 10 (effective concentration) for fish and birds |

Selenium ecotoxicity summarized in Table 4–17 indicates that concentrations of selenium detected in surface water since the 1998 ERA are within the range reportedly associated with adverse effects to fish and wildlife. Dietary exposure calculations using invertebrate tissue concentrations collected prior to 1998 (thus not affected by the recently increased concentrations in surface water) also suggested a potential risk to avian insectivores and mammals. However, it is also noted that those calculations were performed using conservative assumptions which likely overestimated average exposures.

As indicated by the DOI (1998) report, selenium is much less toxic to most plants and invertebrate animals than to vertebrate animals, and the most notable feature of selenium ecotoxicology is the very narrow margin between nutritionally optimal and potentially toxic dietary exposures for vertebrate animals. Current concentrations of selenium in sediment and terrestrial or benthic macroinvertebrate tissue have not been measured since the increased concentrations in surface water have occurred. Due to the nature of selenium to bioaccumulate,

there is a potential for dietary selenium to be within the threshold reported for reproductive impairment in avian receptors.

Selenium ecotoxicity data in Table 4–17 also indicates that concentrations of selenium measured in OU III terrestrial invertebrates (average 1.2 mg/kg) are within the range of measured background terrestrial invertebrate concentrations (0.2 to 1.5 mg/kg), indicating that risks to the terrestrial invertebrate community are probably low. Concentrations of selenium measured in cliff swallow carcasses for OU III (less than 1.8 mg/kg, see Volume VII, Appendix H, page H-67 of the1998 RI) were within the range identified as background for avian whole-body concentrations (Table 4−17). Slightly elevated risks were calculated for ingestion of invertebrates by the spotted bat and southwestern willow flycatcher at OU III (Table 4−16), despite the fact that that selenium concentrations measured in OU III terrestrial invertebrates were within the range of background. However, on the basis of a threshold range of 3 to 8 mg/kg for reproductive impairment in birds and a threshold of 3 mg/kg for mammals (rats; Table 4−17), average OU III terrestrial invertebrate concentrations (1.2 mg/kg) would need to increase by a factor of at least 3 (and perhaps as large as 8) over those observed through previous sampling and analysis to fall within this range. There is no reason to believe that changed site conditions downstream of the Millsite would have produced such changes in terrestrial invertebrate concentrations, so this pathway is probably of little concern for the spotted bat and southwestern willow flycatcher.

Increases in selenium in seeps and surface water since completion of Millsite excavation does raise the issue of potential effects on benthic invertebrate concentrations and implications for corresponding higher trophic level receptors (i.e., waterfowl). Benthic invertebrate concentrations probably are related to surface water concentrations and may be affected by selenium increases at the site. Because wetlands were created at the site to attract waterfowl, which feed on benthic invertebrates, it is possible that these receptors could be at increased risk due to changes in selenium concentration associated with the site. The future monitoring and evaluation planned for the site will address these issues (see Section 4.2.4).

**Reevaluation of Exposure Assumptions**

Risks associated with dietary exposure to representative insectivorous avian and mammal receptors remain a primary concern for the site. Terrestrial invertebrate tissue account for 99 percent and 95 percent of the dietary intakes of the spotted bat and flycatcher, respectively. Tables 4–18 through 4–21 provide exposure parameters and calculated exposure factors used in the 1998 ERA risk calculations for the spotted bat and southwestern willow flycatcher. The assumptions made regarding intakes of site-related (and presumably contaminated) invertebrates are critical in calculating potential risks; uncertainties in the assumptions must be considered in interpreting resulting calculated risks. As previously noted, no new monitoring data have been obtained for OU III-specific invertebrates during the recovery period since completion of the 1998 ERA, so it is not possible to recalculate those HQs based on current site conditions. However, selenium does tend to bioaccumulate, and the effects increased concentrations in surface water will have on terrestrial invertebrate concentrations are unknown.

*Table 4–18. Spotted-Bat Exposure Parameters*

| Parameter | Units | CT Value[a] | RME Value[b] | Source |
|---|---|---|---|---|
| $DF_{soil}$—Diet fraction of soil | percent | 1.00 | 1.00 | Assumed |
| $DF_{invertebrates}$—Det fraction of invertebrates | percent | 99.00 | 99.00 | Poche 1981 |
| $IR_{solids}$—Ingestion rate of solids | g/g-day | 0.12 | 0.13 | Poche 1981 |
| $IR_{water}$—Ingestion rate of water | g/g-day | 0.09 | 0.09 | Poche 1981 |
| BW—Body weight | g | 13.70 | 14.50 | Poche 1981 |
| HR—Home range | hectares | — | — | Not Available |
| CA—Contaminated area | hectares | 15.10 | 15.10 | Measured |
| ED—Exposure days | days | 365.00 | 365.00 | Assumed |

[a]Median value of the reported range.
[b]Maximum value of the reported range.

*Table 4–19. Calculated Exposure Factors for the Spotted Bat*

| Exposure Factor | Units | CT Value[a] | RME Value[b] | Equation |
|---|---|---|---|---|
| $I_{ts}$—Ingestion total for solids | g/day | 1.69 | 1.90 | $I_{ts} = IR_{solids} \times BW$ |
| $I_{soil}$—Ingestion of soil | g/day | 0.02 | 0.02 | $I_{soil} = I_{ts} \times DF_{soil}/100$ |
| $I_{invertebrates}$—Ingestion of invertebrates | g/day | 1.67 | 1.88 | $I_{invertebrates} = I_{ts} \times DF_{invertebrates}/100$ |
| $I_{tw}$—Ingestion total for water | g/day | 1.21 | 1.35 | $I_{tw} = IR_{water} \times BW$ |
| EF—Exposure frequency | unitless | 1.00 | 1.00 | EF = ED/365 |
| $AUF_{ca}$—Area use factor for contaminated area | unitless | 1.00 | 1.00 | $AUF_{ca} = CA/HR$ |

[a]Calculated from CT values, Table 4–17.
[b]Calculated from RME values, Table 4–17.

*Table 4–20. Southwestern Willow Flycatcher Exposure Parameters*

| Parameter | Units | CT Value[a] | RME Value[b] | Source |
|---|---|---|---|---|
| $DF_{soil}$—Diet fraction of soil | percent | 1.00 | 1.00 | Assumed |
| $DF_{shrubs}$—Diet fraction of shrubs | percent | 4.00 | 4.00 | Bent 1963 |
| $DF_{invertebrates}$—Diet fraction of invertebrates | percent | 95.00 | 95.00 | EPA 1993 |
| $IR_{solids}$—Ingestion rate of solids | g/g-day | 0.83 | 0.99 | EPA 1993 |
| $IR_{water}$—Ingestion rate of water | g/g-day | 0.27 | 0.28 | EPA 1993 |
| BW—Body weight | g | 13.80 | 14.60 | King 1955, USFWS 1996 |
| HR—Home range | hectares | 0.26 | 0.06 | Bent 1963 |
| CA—Contaminated area | hectares | 15.10 | 15.10 | Measured |
| ED—Exposure days | days | 120.00 | 180.00 | Assumed |

[a]Median value of the reported range.
[b]Maximum or minimum value of the reported range.

*Table 4–21. Calculated Exposure Factors for the Southwestern Willow Flycatcher*

| Exposure Factor | Units | CT Value[a] | RME Value[b] | Equation |
|---|---|---|---|---|
| $I_{ts}$—Ingestion total for solids | g/day | 11.45 | 14.45 | $I_{ts} = IR_{solids} \times BW$ |
| $I_{soil}$—Ingestion of soil | g/day | 0.11 | 0.14 | $I_{soil} = I_{ts} \times DF_{soil}/100$ |
| $I_{shrubs}$—Ingestion of shrubs | g/day | 0.46 | 0.58 | $I_{shrubs} = I_{ts} \times DF_{shrubs}/100$ |
| $I_{invertebrates}$—Ingestion of invertebrates | g/day | 10.88 | 13.73 | $I_{invertebrates} = I_{ts} \times DF_{invertebrates}/100$ |
| $I_{tw}$—Ingestion total for water | g/day | 3.73 | 4.09 | $I_{tw} = IR_{water} \times BW$ |
| EF—Exposure frequency | unitless | 0.33 | 0.49 | EF = ED/365 |
| $AUF_{ca}$—Area use factor for contaminated area | unitless | 1.00 | 1.00 | $AUF_{ca} = CA/HR$ |

[a]Calculated from CT values, Table 4–19.
[b]Calculated from RME values, Table 4–19.

The assumptions used in the 1998 ERA were purposely selected to represent a range of conservative estimates to ensure that risks were not underestimated. Effects of elevated selenium concentrations, if any, would probably be localized based on OU III selenium distributions in surface water, sediment, and terrestrial invertebrate tissue. For example, it is conservative to assume that spotted bats will spend 100 percent of their time feeding in the contaminated area, when it is known that they will travel up to 10 kilometers from their roost to forage (University of Michigan website at http://animaldiversity.ummz.umich.edu/accounts/euderma/e.maculatum$narrative.html). The most likely bat roosting habitat is in the narrow portion of the canyon near surface water sampling locations SW92-07/SW00-04, and SW92-08. At SW92-07 and SW00-04, selenium concentrations averaged 3.7 µg/L from November 1992 through December 1996 (Appendix C, page C2–41) and 7.0 µg/L during 2001 and 2002 (Appendix C, page C2–42). At SW92-08, concentrations averaged 2.4 µg/L in November 1992 through December 1996 and 5.1 µg/L during 2001 and 2002 (Appendix C, page C2–47). Feeding habits indicate that spotted bats drink shortly after leaving their roosts and then forage for several hours. It is possible that most of the bats' diet would then consist of terrestrial invertebrates from outside the small fraction of area that is affected by selenium.

As for the southwestern willow flycatcher, it is likely that not all the suitable flycatcher-nesting habitat at OU III has elevated levels of selenium in soil or surface water. Birds selecting nesting locations outside the selenium-contaminated area would not have elevated risks for ingestion of selenium in invertebrates. Also, although flycatchers maintain well-defined territories, which are typically no larger than the size of the area with elevated levels of selenium, flycatchers are known to leave their territories even during the nesting stage to gather food for their nestlings (USFWS 2002). Birds that are not nesting are also known to travel to areas outside their territories (USFWS 2002). As such, the assumption that 100 percent of dietary terrestrial invertebrates is from the contaminated area likely contributes to an overestimation of site-related selenium intake for the southwestern willow flycatcher. For the spotted bat and the southwestern willow flycatcher, it is probable that the exposure assumptions used in the 1998 ERA are conservative and not likely realistic for existing site conditions.

### 4.2.3 Summary of the ERA Update

Current concentrations of selenium in surface water in the Millsite wetlands reflect, in part, perturbations from remediation activities and are not likely to represent long-term concentrations

in those media. While it is anticipated that concentrations in surface water and ground water may decrease as the bedrock surface weathers and less selenium is available for leaching, the tendency for selenium to accumulate in the environment will have the opposite effect on concentrations measured. Also, in their present state (i.e., newly established and in a drought regime), the wetlands on the Millsite are not a long-term representation of their value as habitat or their potential for risks to ecological receptors.

For COCs other than selenium, the decreases in COC concentrations in surface water, ground water, soil, and sediment should result in concentration decreases for those same constituents in biotic media. Therefore, it is assumed that risks to the ecological receptors identified in 1998 associated with all ecological COCs except selenium have been reduced by remedial action and that the conclusions reached in the 1998 ERA remain valid (i.e., no significant ecological risks). However, increased concentrations of selenium detected in surface water at the site may be of potential concern to new ecological receptors (i.e., waterfowl through ingestion of aquatic invertebrates) because of high selenium toxicity and its tendency to bioaccumulate. It is probable that the observed increase in selenium concentrations is partly the result of remediation to and exposure of bedrock.

The best habitat for the spotted bat and southwestern willow flycatcher is in an area where concentrations of selenium in the creek average between 5.1 and 7.0 µg/L and hot-spot remediation of contaminated soil and sediment has occurred. Although the surface water concentrations are above Utah Water Quality standards and in the range for dietary effects to wildlife, it is unlikely that the spotted bat or southwestern willow flycatcher are using the Millsite wetlands as a primary habitat. The data necessary to evaluate effects due to potentially increased dietary ingestion of selenium are not available at this time, though it is unlikely that these receptors are currently at significant risk from selenium. Selenium concentrations in surface water in Montezuma Creek are unlikely to be a significant risk to benthic macroinvertebrates in the short term or the long term. However, bioaccumulation of selenium in benthic macroinvertebrates could be of concern for higher trophic level receptors.

The analysis presented in this update supports the conclusions reached in the 1998 ERA that there is not a current significant risk to the receptors chosen for evaluation in 1998 and that no alternatives need to be developed in the focused feasibility study (Section 5.0) to mitigate environmental risk. However, because current conditions are not an adequate representation of future conditions, especially on the Millsite, a long-term monitoring plan will be developed that includes biomonitoring. Data needs and the scope of potential monitoring are outlined in the following section and will be included in the OU III ROD. If an evaluation of the data collected under the OU III long-term monitoring plan indicates that risks from selenium exposure are a concern, the ETAG will be consulted as to the appropriate steps to take.

### 4.2.4 Uncertainties and Continued Monitoring and Data Collection

Future risks to ecological receptors from exposure to selenium cannot be addressed at this time and are considered an uncertainty. If Wetland 3 develops as designed, there is a potential risk to ecological receptors, in particular waterfowl, because of the presence of selenium. A post-remediation monitoring plan will be developed to address potential uncertainties with regard to the ecological health of wetlands on the Millsite due to selenium. Results of the data collection

effort dictated by the post-remedial monitoring plan will be evaluated as recommended by the ETAG before the next CERCLA 5-year review scheduled to be completed during year 2007.

During preparation and review of this ERA update, the ETAG identified potential data gaps that require resolution. All the potential data gaps relate to the observation that selenium concentrations have increased significantly in Millsite surface water relative to concentrations evaluated in the 1998 ERA. The increase in selenium concentrations was first identified in 1999 and has been the subject of numerous discussions since that time. Possible sources of selenium were evaluated, and it is accepted that the most probably source is the mobilization of selenium from carbonaceous marine shale present in the area during remediation activities and not tailings-related contamination that was not remediated. Concentrations in surface water are expected to attenuate with time, making the current increase temporary or transient. The rate and degree to which they might decrease cannot yet be predicted.

The ETAG has accepted these observations and the decision was made to continue to monitor selenium concentrations in water as the drought eases and the hydrologic conditions designed for the Millsite are established. While the specific sampling goals and design will be in the OU III Proposed Plan, ROD, and LTS&M Plan, ground water monitoring is expected to continue in the vicinity of Wetland 3 and downgradient of the Millsite. Surface water monitoring is expected to continue at

- SW00-02 near the outlet of Wetland 3 at the eastern boundary of the Millsite,
- Seeps along the north side of the Millsite,
- SW01-02 near the outlet of Wetland 1, which is near the western boundary of the Millsite,
- SW01-03 near the outlet of Wetland 2 near the mid-portion of the Millsite, and
- Downstream of the Millsite at locations SW01-01, Sorenson, and SW00-04.

The lack of updated selenium concentration data in sediment prevents the meaningful evaluation of potential exposure and risk associated with current selenium concentrations at the site. Sediment sampling will be conducted in the wetlands and at the pond near surface water location SW00-04, at a minimum, as part of the long-term monitoring.

Before finalizing other components of the long-term monitoring plan, the list of ecological receptors will be reviewed to determine the adequacy of those receptors to reflect potential current and future concerns at the site, given the habitat that is expected to develop on the Millsite. For example, although a site-specific evaluation of the benthic macroinvertebrate community has been suggested, benthic macroinvertebrates are probably more important as a food source to other wildlife. It is well documented that benthic macroinvertebrates may bioaccumulate concentrations of selenium higher than those in the water in which they live. It is anticipated that an aquatic bird species that uses wetland habitats for breeding might be added as a receptor of concern. DOE may request that U.S. Fish and Wildlife Service technical staff perform field surveys of threatened and endangered species within the vicinity of OU III.

Other components of long-term monitoring that are being considered by the ETAG include

- Collection of data necessary to model exposure point concentrations for risk-driving pathway (aquatic invertebrates) or direct measurement of those concentrations in aquatic invertebrates. If the ETAG determines that these data are appropriate, the data will be collected in the near future to establish baseline concentrations in aquatic invertebrates.
- Collection of waterfowl eggs to evaluate impairment of clutch viability.

Additional types of monitoring will be conducted on an as-needed basis if certain "trigger levels" are exceeded. The establishment of these decision points will be done in conjunction with the ETAG. The scope of long-term monitoring will be outlined in the OU III Proposed Plan and ROD and will be explicitly stated in a long-term monitoring plan that will be reviewed by and receive concurrence from EPA, UDEQ, and other members of the ETAG. Prior to the reevaluation of risk to the environment that will be presented in the 2007 CERCLA 5-year review, information on selenium fate and transport and ecological toxicity will be updated to evaluate risk to the receptor(s) of concern.

End of current text