3.1 INTRODUCTION

This chapter summarizes readily available information concerning potential injuries to terrestrial resources and resource services in the UARB. It also provides a preliminary estimate of the magnitude of restoration project costs needed to offset these injuries. Consistent with existing analyses, this chapter presents information addressing the following terrestrial resources:

a) 11-Mile Reach: Irrigated Meadows;

b) 11-Mile Reach: Riparian Habitat;

c) 11-Mile Reach: Mine Waste Deposits in Fluvial Habitat;

d) California Gulch (OUs 4 and 8) Mine Waste Deposits in Fluvial Habitat; and

e) On-Site Mine Waste Rock Piles (OUs 4, 5, 7, 8, and 10).

This chapter focuses primarily on potential contamination-related injuries to vegetation resources (through phytotoxicity). While data suggest that injuries to wildlife and livestock (through food chain exposures and direct soil contact) may exist in the study area (e.g., hazard quotients in excess of 900 have been documented in fluvial tailings, based on ingestion of lead by birds (Weston *et al*. 1997, Appendix D-3)), in the Trustees' judgment insufficient wildlife data have been collected to allow evaluation of the potential extent, severity and duration of such injuries. Future assessment activities may include additional evaluation of wildlife (and vegetation) injuries, as well as potential injuries to agricultural, recreational and other human uses of contaminated terrestrial resources.

In addition, metals concentrations and pH in these geological resources also may be sufficient to contribute to injuries to surface water and groundwater resources within the study area; if so, such resources would be considered injured pursuant to DOI NRD regulations (43 CFR 11.62(e)(11)). Potential aquatic and ground and surface water injuries are addressed in Chapter 2 of this document.

The study area includes lands owned by a variety of private and public entities. The Trusteeship interest in private land occurs due to the potential injury to wildlife due to decreased forage, shelter and similar habitat services on private, undeveloped lands, and due to potential adverse effects from exposure to metals through soil ingestion and food chains. Impacts to livestock are relevant to Trustee NRD efforts to the extent livestock graze on land owned by the

government.[1] Further, contamination of many terrestrial areas resulted from the deposition of stream sediments during flood events. NRD regulations include sediments as surface water resources (43 CFR 11.14), and authorize Trustees to evaluate potential injuries to these resources.

3.2 IRRIGATED MEADOWS

The Trustees have identified 1,096 acres of meadows within the 11 Mile Reach 500-year floodplain affected by deposition of hazardous substances due to irrigation with water from California Gulch or the Upper Arkansas River (SCR 2002, p. ES-6). Contaminated water from California Gulch and the Upper Arkansas River is the source of elevated metals and low pH in soils in the irrigated meadows (ROD OU11 2005, Section 5.4.1). California Gulch was (and continues to be) the major source of metals to the Arkansas River, with concentrations of lead and cadmium negligible above the confluence (ROD OU1 1988, p. 5; CDOW 2006, p. 5).

3.2.1 Evidence of Injury

Soil and flora studies undertaken as part of the USEPA 2003 Ecological Risk Assessment Addendum evaluate the potential magnitude of contamination-related impairment of irrigated meadows in the Upper Arkansas River floodplain. More specifically, the 2003 ERA Addendum evaluated data collected in 2001-2002 to assess the potential for mine-waste related phytotoxicity as well as risks to herbivorous mammals that may feed in the area, and is the primary source of information cited in this subsection.[2] The addendum includes the following statement on ecological risks:

> An initial evaluation of risks to terrestrial receptors at the site (Weston et al. 1997) included a consideration of potential risks to a number of different taxa of terrestrial species, including birds, mammals, plants and soil-dwelling organisms. Based on the data available at the time, the risk assessment concluded that overall risks to raptors and game mammals were expected to be minimal, and risks to small mammals and birds were above a level of concern. Primary contributors to predicted risks for wildlife were arsenic, cadmium, lead and zinc. Predicted risks to plants and soil fauna were found to be above a level of concern across the entire site, with the highest risks in the riparian flood plains of California Gulch and the upper Arkansas River. Primary contributors to risks to plants included arsenic, copper, lead, manganese, selenium, silver, and zinc. At the time of the baseline risk assessment, only limited data were available on contaminant levels in the upper Arkansas River floodplain downstream of the confluence with California Gulch. Likewise, few data were available for contaminant

[1] Potential impacts to livestock grazing on privately owned land may be pursued by affected private parties.

[2] Data from the Ecological Risk Addendum were not available in time for inclusion in SCR 2002. Information in the ERA Addendum is included in the evaluation presented in the Restoration Alternatives Report (2003).

concentrations in plants in this area, so risks to herbivores did not include an estimation of risk from plant ingestion (USEPA 2003, p. ES-2).

The 2003 ERA Addendum study area encompasses terrestrial areas adjacent to the Arkansas River beginning at the confluence with California Gulch and extending to a distance approximately 11 miles downstream, including the 500 year floodplain plus areas outside the floodplain that are known to have been irrigated (USEPA 2003, p. ES-2). Portions of this analysis relevant to irrigated meadows were subsequently updated in the Record of Decision for OU11 (ROD OU11 2005). Key findings expected to be relevant to the determination of injury under natural resources damage regulations are summarized below. More detailed information can be found in the ERA Addendum and ROD.

3.2.1.1 Phytotoxicity

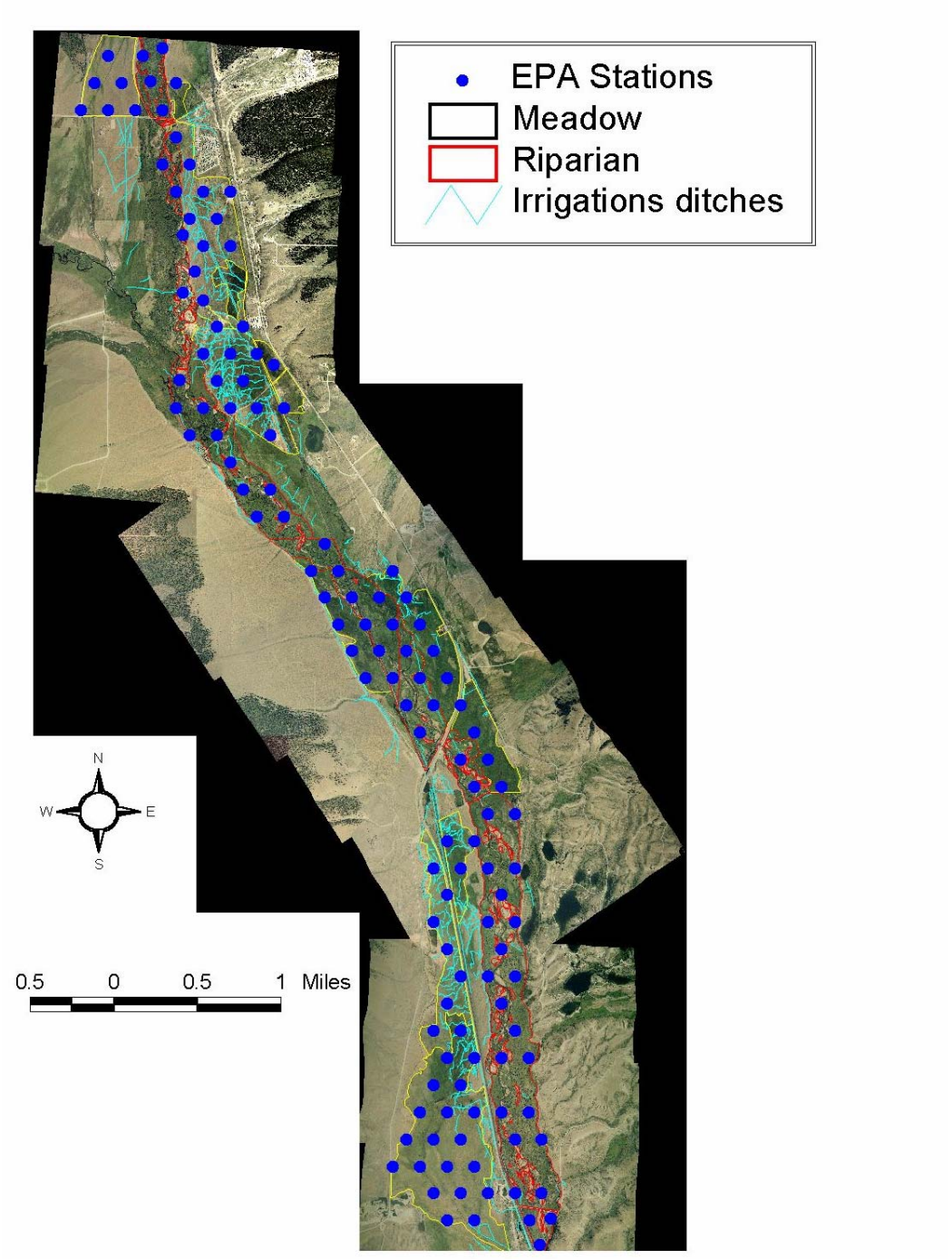
A total of 126 sites in the study area were sampled by EPA, including 71 from irrigated meadows (see Figure 3-1). A phytotoxicity model was developed from bulk soil chemistry and laboratory data including measurements of several plant growth endpoints (from plants grown in soils collected at 20 of these sites, including 11 from the irrigated meadows (see Figure 3-2).[3] Species diversity and plant density models were also constructed from field-based site observations and bulk soil chemistry. These results were extrapolated to give a mean phytotoxicity score (MPS) for the additional 106 sites in the study area where bulk soil chemistry data were collected, but not phytotoxicity or plant community data. Ranges in mean phytotoxicity scores were associated by EPA with differing degrees of potential phytotoxicity impairment, as indicated in Table 3-1. The results of EPA's phytotoxicity analysis are summarized visually in Figures 3-3 (predicted spatial pattern of phytotoxicity) and 3-4 (spatial patterns of primary contributors to predicted phytotoxicity). In terms of sample numbers, 43 of the 71 irrigated meadow sample locations were predicted to be non- or mildly phototoxic while 17, 8 and 3 sites were predicted to be moderately, highly and severely phytotoxic, respectively. Of the 28 irrigated meadow sites predicted to be moderately, highly or severely phytotoxic, metals were the primary contributor to toxicity at 17 locations. Metals and pH were both believed to be primary contributors at 4 locations, while calcium levels were the primary cause at 7 locations (USEPA 2003, pp. ES-5 and ES-6).

Subsequently, EPA expanded the calculations described above to include soil data from 28 additional sampling stations in the Irrigated Meadows (mainly in the upper portion of OU11). These results are presented in Table 3-2. As shown in the table, many sampling stations are predicted to exceed an MPS score of 0.5 (mild phytotoxicity). For irrigated meadows, the frequency of exceedances and mean MPS scores are highest in the upper portion of OU11, mainly in River Miles 1 and 2, although exceedances are found further downstream and maximum MPS scores don't exhibit a clear spatial trend.

[3] Suitable data for evaluation were collected at 19 of the 20 sites. Metals and metalloids included in the phytotoxicity studies are arsenic, cadmium, copper, lead, zinc, and mercury.

Figure 3-1

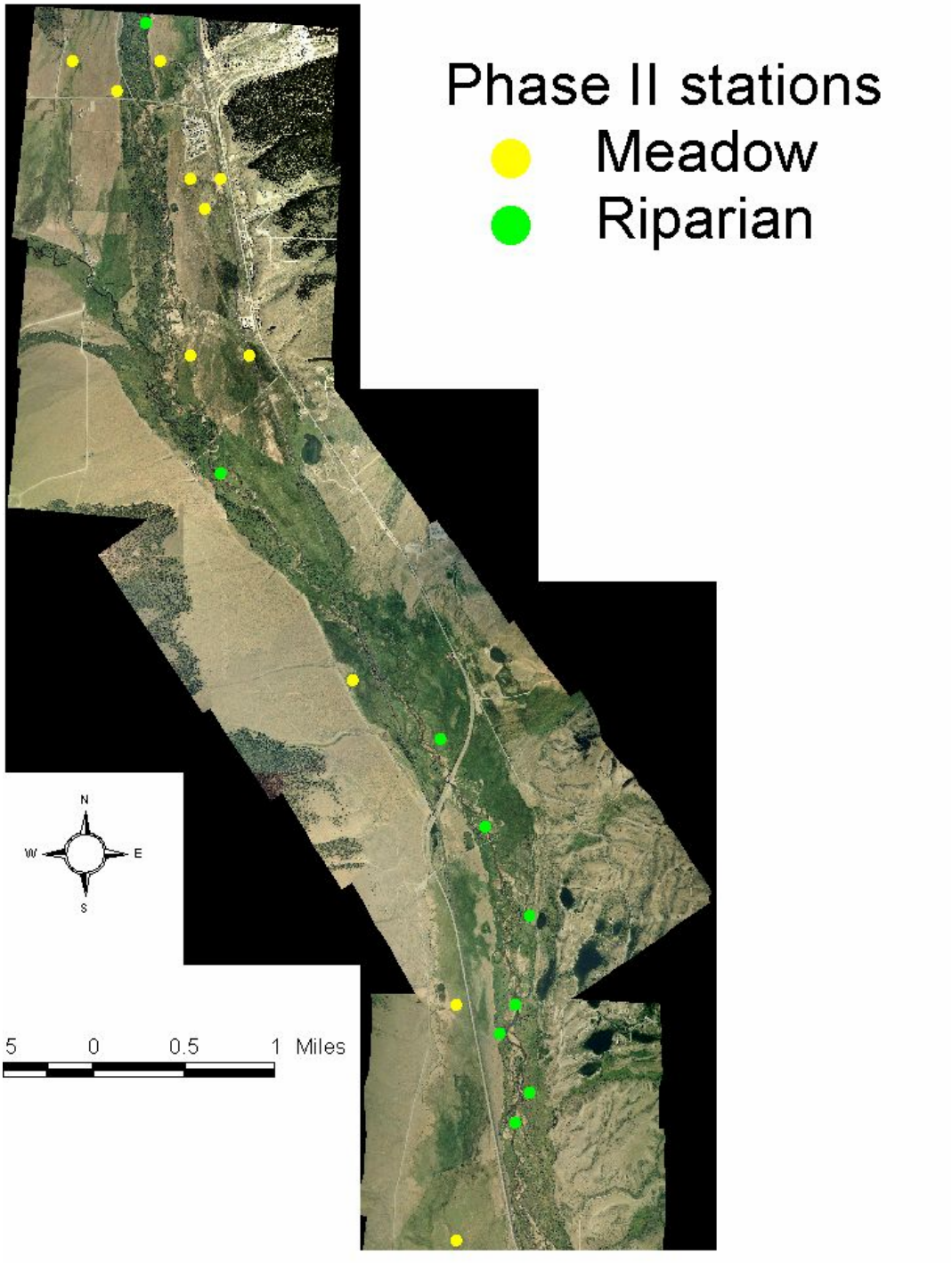
Phase I Sampling Stations
(N = 126)



Source: USEPA 2003.

Figure 3-2

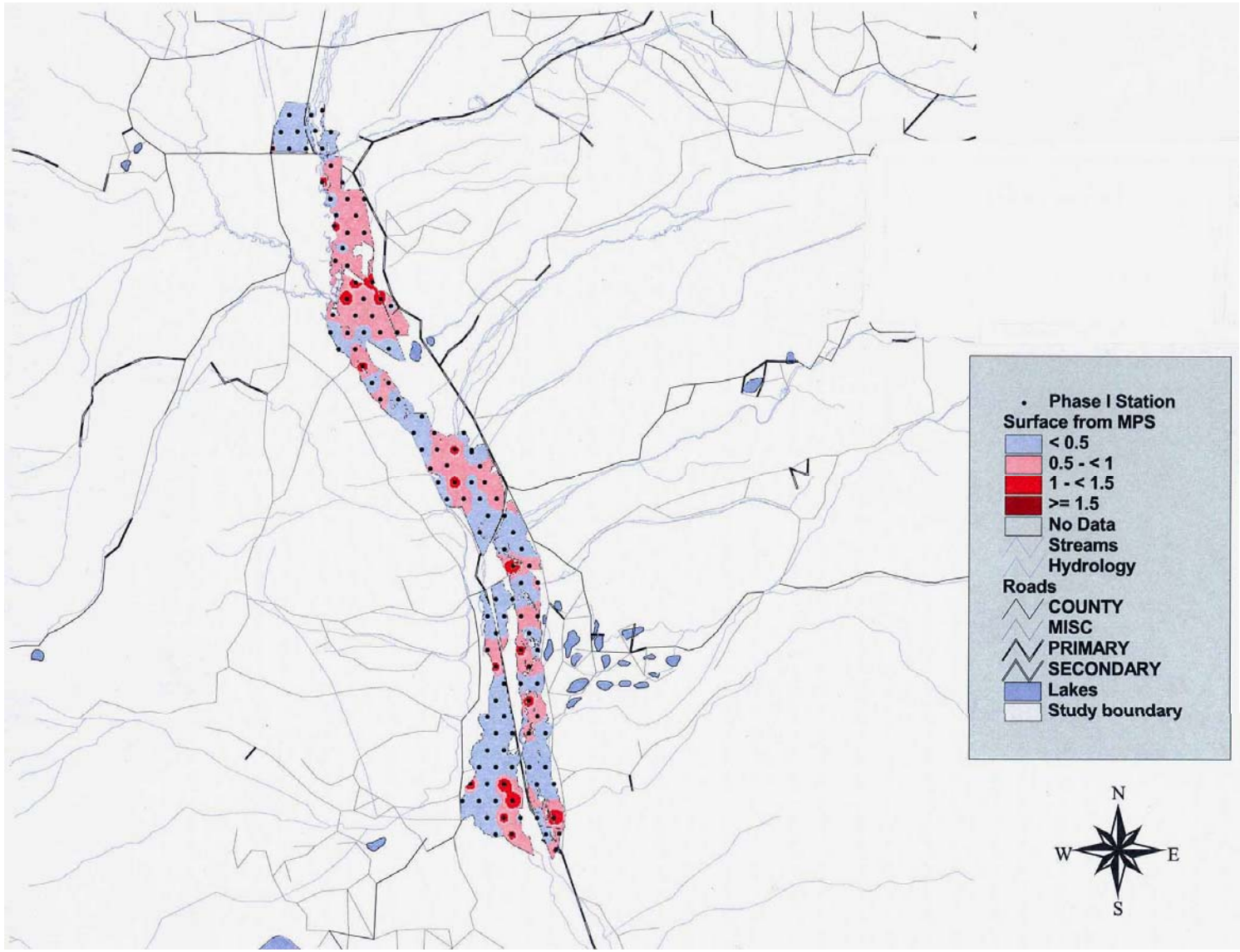
Phase II Sampling Stations
(N=20)



Source: USEPA 2003.

Figure 3-3

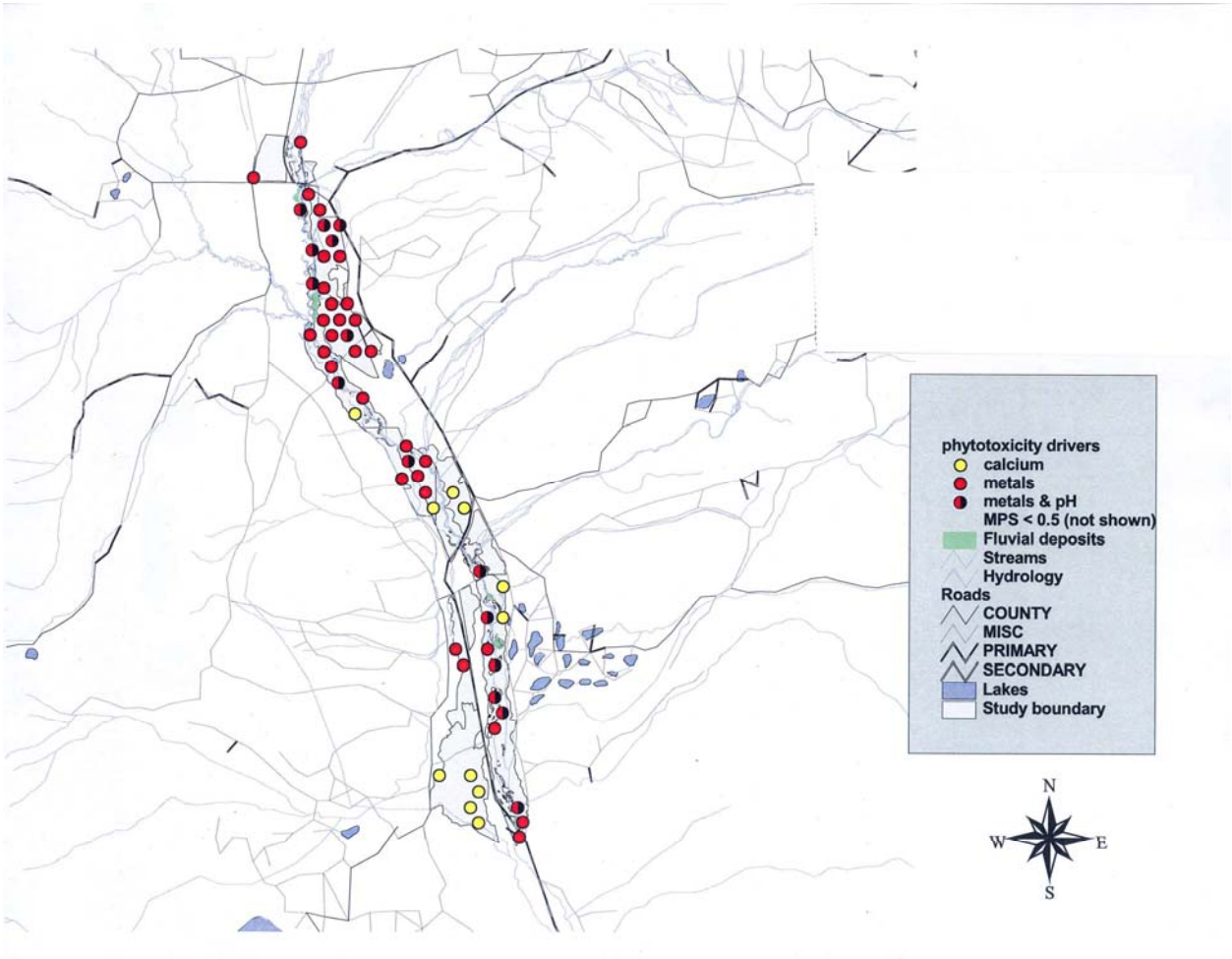
Predicted Spatial Pattern of Phytotoxicity



Source: USEPA 2003.

Figure 3-4

Spatial Patterns of Primary Contributors to Predicted Phytotoxicity



Source: USEPA 2003

Table 3-1

Index Values for Phytotoxicity Scores

Magnitude of Endpoint Response (as % Control)	% Reduction in Ecological Services	Phytotoxicity Score (for Species)	Mean Phytotoxicity Score (for Station)	Description
>90%	0%	0	0.00-0.24	Non-phytotoxic
>75-90%	11-25%	0.5	0.25-0.50	Mildly phytotoxic
>50-75%	26-50%	1.0	0.51-1.00	Moderately phytotoxic
>25-50%	51-75%	2.0	1.01-2.00	Highly phytotoxic
0-25%	75%	4.0	>2.00	Severely phytotoxic

Source: USEPA 2003, p. 4-4.

Table 3-2

Phytotoxicity Model Results

Station Type	River Mile	Number of Stations with MPS > 0.5	Mean MPS	Max MPS
Meadow	Upstream	1	0.16	0.62
	1	7	0.63	0.99
	2	10	0.70	1.34
	3	0	-0.07	0.20
	4	3	0.33	1.02
	5	0	0.17	0.45
	6	2	0.24	0.93
	7	5	0.33	1.71
Riparian	Upstream	1	0.30	0.92
	1	3	0.89	1.36
	2	3	0.34	0.66
	3	4	0.52	0.99
	4	5	0.65	1.40
	5	3	0.59	1.55
	6	4	0.59	1.34
	7	4	0.37	1.46

Source: Data from USEPA 2003

For natural resource damage purposes, Figure 3-5 summarizes the Trustee's preliminary characterization of the level of toxicity for each station (and the area associated with that station), separated into riparian and non-riparian (irrigated meadows) areas.[4] Based on this preliminary evaluation, mild, moderate and high risks of phytotoxicity are predicted for 234, 408 and 40 irrigated meadow acres, respectively. EPA analysis suggests that the remaining 414 acres are non-phytotoxic.

Thus, readily available data suggest that metals concentrations in irrigated meadows are sufficient to adversely affect vegetation. More specifically, EPA's phytotoxicity model is focused on potential growth impacts, although species diversity and plant density also may be affected. For PED purposes, preliminary estimates of service loss reflect expected reductions in vegetative cover, based on modeled Mean Phytotoxicity Scores, field observations and Trustee judgment. Preliminary, quantitative estimates of service loss and recovery time for this potential irrigated meadow resource injury are addressed in the final section of this chapter.

3.2.1.2 Risks to Herbivores and Other Wildlife

As noted previously, irrigated meadow resources may be affected by contamination in other ways (e.g., through a compromised ability to support wildlife communities, due to the transfer of contaminants at levels sufficient to harm such receptors). Any such injuries would be in addition to the potential phytotoxicity impacts discussed above. Readily available information concerning potential risks to herbivores is summarized below, although in the Trustees' judgment insufficient data have been collected to allow evaluation of the potential extent, severity and duration of injuries to herbivores or other wildlife exposed to contaminated soils and/or vegetation directly or indirectly through prey.

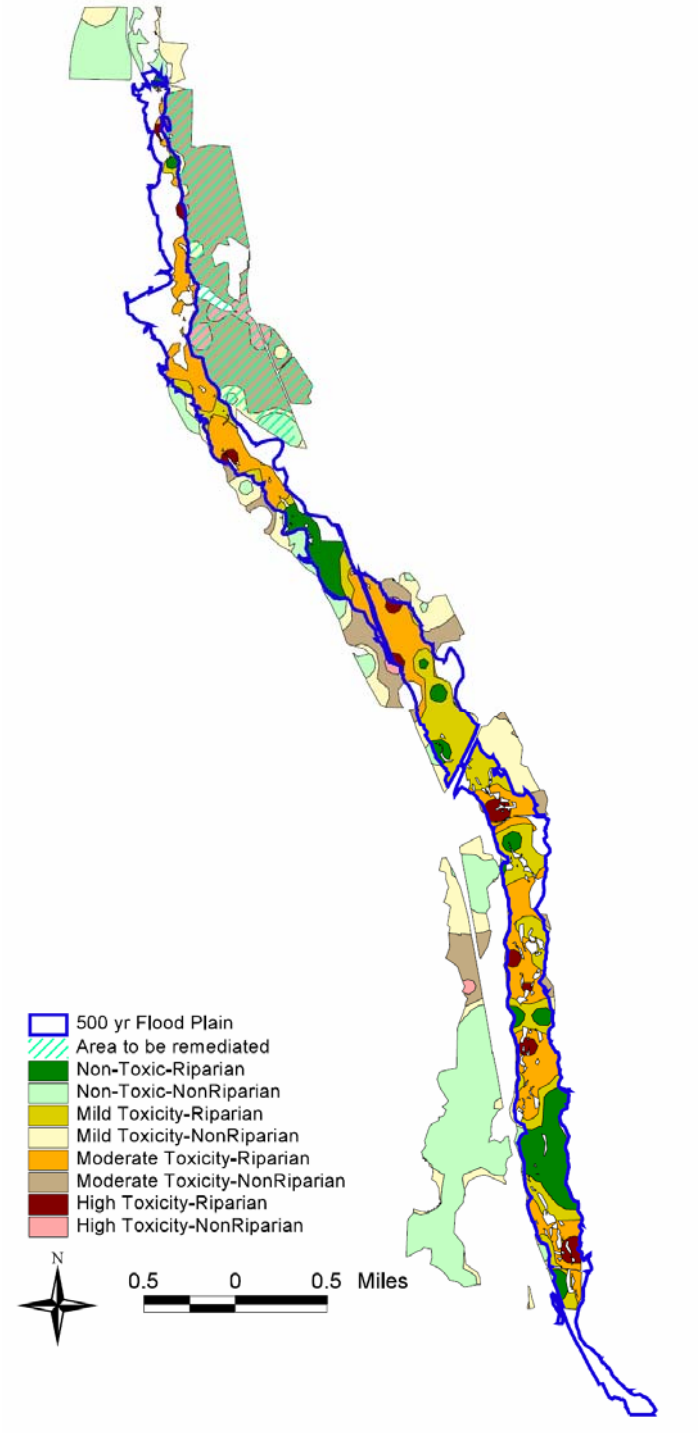
Risks to herbivores in the floodplain of the 11-Mile Reach also are evaluated in the 2003 ERA Addendum. Risks were estimated for a number of different herbivorous receptors, including horses, cattle, deer, and vole. Estimated risks are based on a model of metal uptake in plants using soil chemistry and phytotoxicity studies in the Upper Arkansas 500-year floodplain and expected doses from plant and soil ingestion (USEPA 2003, executive summary). Toxicity reference values were derived from published toxicity studies.

Model results are summarized in Tables 3-3 and 3-4. As indicated in Table 3-3, at most stations HQ values are below a level of concern for all chemicals and all receptors (i.e., HQ $\leq$ 1). However, at 11 sampling locations, HQ values are above 1 for one or more receptors, with values ranging from 2 to 20. These stations are located mainly in River Mile 1 and 2.

[4] The stations for which calcium is identified as the primary contributor to phytotoxicity are omitted from Figure 3-5.

Figure 3-5

Upper Arkansas River 500-year Floodplain: Regions of Phytotoxicity



Source: Trustee Analysis of USEPA 2003 results

Table 3-3
Risks to Herbivores

Receptor	Location	Count of Maximum HQ Values					
		Max HQ ≤ 1		Max HQ = 2 -4		Max HQ ≥ 5	
		Count	%	Count	%	Count	%
Horse	Riparian	49 / 55	89%	6 / 55	11%	0 / 55	0%
	Meadow	66 / 71	93%	4 / 71	6%	1 / 71	1%
	Total	115 / 126	91%	10 / 126	8%	1 / 126	1%
Cattle	Riparian	53 / 55	96%	2 / 55	4%	0 / 55	0%
	Meadow	68 / 71	96%	2 / 71	3%	1 / 71	1%
	Total	121 / 126	96%	4 / 126	3%	1 / 126	1%
Deer	Riparian	54 / 55	98%	1 / 55	2%	0 / 55	0%
	Meadow	69 / 71	97%	1 / 71	1%	1 / 71	1%
	Total	123 / 126	98%	2 / 126	2%	1 / 126	1%
Vole	Riparian	55 / 55	100%	0 / 55	0%	0 / 55	0%
	Meadow	67 / 71	94%	2 / 71	3%	2 / 71	3%
	Total	122 / 126	97%	2 / 126	2%	2 / 126	2%
Overall	Riparian	50 / 55	91%	3 / 55	5%	2 / 55	4%
	Meadow	65 / 71	92%	6 / 71	8%	0 / 71	0%
	Total	115 / 126	91%	9 / 126	7%	2 / 126	2%

Max HQ = maximum of the chemical-specific HQs within a station
(the chemical-specific HQ at a station includes both soil and plant ingestion exposures)

Table 3-4

Predicted Risks for Large Home Range Receptors Based on Average Exposure Across River Miles

Station Type	River Mile	Hazard Quotient (HQ)		
		Cattle	Horse	Deer
Meadow	upstream	9.6E-02	2.4E-01	1.4E-01
	1	1.6E-01	4.0E-01	2.3E-01
	2	4.0E-01	8.4E-01	8.6E-01
	3	6.5E-02	1.3E-01	8.4E-02
	4	6.6E-02	1.2E-01	9.2E-02
	5	7.1E-02	1.6E-01	9.5E-02
	6	1.2E-01	3.0E-01	1.8E-01
	7+	6.7E-02	7.4E-02	9.7E-02
Riparian	upstream	1.1E-01	2.8E-01	1.6E-01
	1	5.9E-01	1.2E+00	9.4E-01
	2	9.0E-02	2.1E-01	1.4E-01
	3	1.6E-01	3.6E-01	2.1E-01
	4	2.2E-01	5.8E-01	3.3E-01
	5	2.9E-01	6.0E-01	3.5E-01
	6	2.8E-01	6.3E-01	3.6E-01
	7+	2.7E-01	6.2E-01	3.6E-01

HQ = maximum (across chemicals) of the average chemical-specific HQ (across stations)

EPA HQ calculations assume a home range of one mile for herbivore receptors. The Trustees have concerns that this simplifying assumption may not accurately characterize contaminant exposure to these receptors. Additional consideration of this issue, as well as more precise delineation of contaminated areas that may result in injuries to Trustee resources will be conducted during design and implementation of the OU 11 remedy. In the absence of more complete data, the PED relies on literature and professional judgment that indicates metal concentrations are at levels that may harm ecological receptors, and adopts the simplified assumption that risks to herbivores and other wildlife track phytotoxicity.

3.3 RIPARIAN HABITAT

The Trustees have identified approximately 700 acres of riparian areas potentially affected by metals contamination within the 11 Mile Reach 500 year floodplain, based on the USEPA 2003 Ecological Risk Assessment Addendum. California Gulch was (and continues to be) the major source of metals to the Arkansas River, with concentrations of lead and cadmium negligible above the confluence (ROD OU1 1988, p. 5; CDOW 2006, p. 5). Elevated metals concentrations in floodplain sediment deposits may impact soil function and contribute to

phytotoxicity. Reduced vegetative productivity of riparian areas also reduces habitat suitability through loss of shade and increased bank erosion (SCR 2002, p. ES-4). Fluvial mine waste deposits in the 11-mile reach, which resulted from historic mining and mineral processing activities upstream, in particular from the Leadville Mining District, continue to affect the riparian habitat (ROD OU11 1995, Section 5.4.2). Floodplain soils peripheral to the mine-waste deposits have elevated metals concentrations, due to transport during flood events (SCR 2002, p. ES-6).

3.3.1 Evidence of Injury

Soil and flora studies undertaken as part of the USEPA 2003 Ecological Risk Assessment Addendum provide evidence of injury to riparian areas in the Upper Arkansas River 500-year floodplain. As noted above, the 2003 ERA Addendum evaluates data collected in 2001-2002 and is the primary source of information cited in this subsection, along with the Record of Decision for OU11 (ROD OU11 2005). Key findings expected to be relevant to the determination of injury under natural resources damage regulations are summarized below. More detailed information can be found in the ERA Addendum and ROD.

3.3.1.1 Phytotoxicity

EPA uses the same phytotoxicity model described for irrigated meadows to evaluate ecological impacts in study area riparian zones. The study area includes 126 sites, including 55 from riparian areas (see Figure 3-1). The results of EPA's phytotoxicity analysis are summarized in Figures 3-3 (predicted spatial pattern of phytotoxicity) and 3-4 (spatial patterns of primary contributors to predicted phytotoxicity). In terms of sample numbers, 27 of the 55 riparian sample locations were predicted to be non- or mildly phytotoxic while 16, 10 and 2 sites were predicted to be moderately, highly and severely phytotoxic, respectively. As shown in Table 3-2, the frequency with which riparian sampling stations exceed an MPS score of 0.5 (mild phytotoxicity) is relatively constant along the length of OU11. Maximum MPS scores also are relatively consistent spatially. Mean MPS scores are highest along River Mile 1.

For natural resource damage purposes, Figure 3-5 summarizes the Trustee's preliminary characterization of the level of toxicity for each station (and the area associated with that station), separated into riparian and non-riparian (irrigated meadows) areas.[5] Based on this preliminary evaluation, mild, moderate and high risks of phytotoxicity are predicted for 209, 305 and 39 riparian acres, respectively. EPA analysis suggests that the remaining 146 acres are non-phytotoxic.

Thus, readily available data suggest that metals concentrations in riparian habitat are sufficient to adversely affect vegetation. As previously noted, EPA's phytotoxicity model is focused on potential growth impacts, although species diversity and plant density also may be affected. Reduced vegetative growth and cover in turn will lead to reduced forage, shelter and similar services provided to the wildlife and livestock communities dependent on this habitat.

[5] The stations for which calcium is identified as the primary contributor to phytotoxicity are omitted from Figure 3-5.

For PED purposes, preliminary estimates of service loss reflect expected reductions in vegetative cover, based on modeled Mean Phytotoxicity Scores, field observations and Trustee judgment. Preliminary, quantitative estimates of service loss and recovery time for this potential riparian habitat injury are addressed in the final section of this chapter.

3.3.1.2 Risks to Herbivores and Other Wildlife

Irrigated meadow resources also may be affected by contamination in other ways (e.g., through a compromised ability to support wildlife communities, due to the transfer of contaminants at levels sufficient to harm such receptors). Any such injuries would be in addition to the potential phytotoxicity impacts discussed above. However, in the Trustees' judgment insufficient data have been collected to allow evaluation of the potential extent, severity and duration of injuries to herbivores or other wildlife exposed to contaminated soils and/or vegetation directly or indirectly through prey. In the absence of more complete data, the PED relies on literature and professional judgment that indicates metal concentrations are at levels that may harm ecological receptors, and adopts the simplified assumption that risks to herbivores and other wildlife track phytotoxicity.

3.4 MINE WASTE DEPOSITS IN 11 MILE REACH FLUVIAL HABITAT

The Trustees have identified approximately 65 acres of fluvial mine waste deposits within the 11-Mile Reach 500-year floodplain (see Figures 3-6, 3-7 and 3-8). Over 150 deposits resulted from historic mining and mineral processing activities upstream, in particular from the Leadville Mining District (ROD OU11 2005, p. DS-11), including erosion from tailings and waste rock piles along California and Oregon Gulch. Fluvial habitat mine waste deposits have low pH (3 or below), are highly mineralized, and can be significant sources of metals to surrounding habitats.

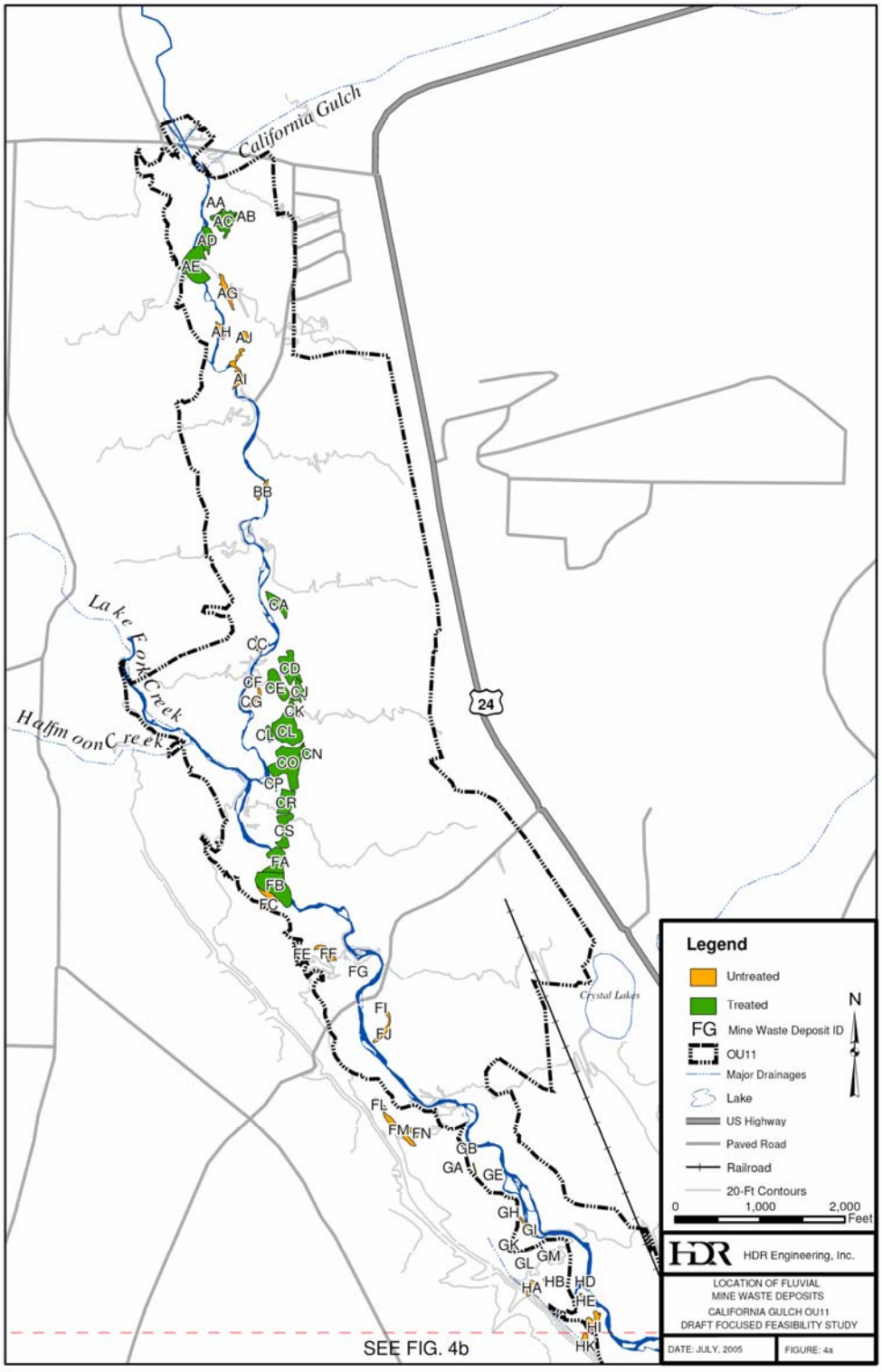
3.4.1 Evidence of Injury

Readily available data suggest the potential for injuries to Trustee resources resulting from mine waste deposits. The SCR and the ROD for OU11 compile and evaluate key data available through 2003. Key findings are summarized below. More detailed information can be found in the source documents.

Removal actions have been implemented at some of these locations. Descriptions of these actions are provided in subsequent sections of this chapter. Because natural resource damage regulations allow Trustees to pursue damages for past injuries to natural resources and/or resource services, characterization of conditions prior to remediation is appropriate for natural resource damage assessment purposes. Preliminary damage estimates presented at the end of this chapter account for improvements in resource condition over time due to remedial activities and natural recovery processes.

Figure 3-6

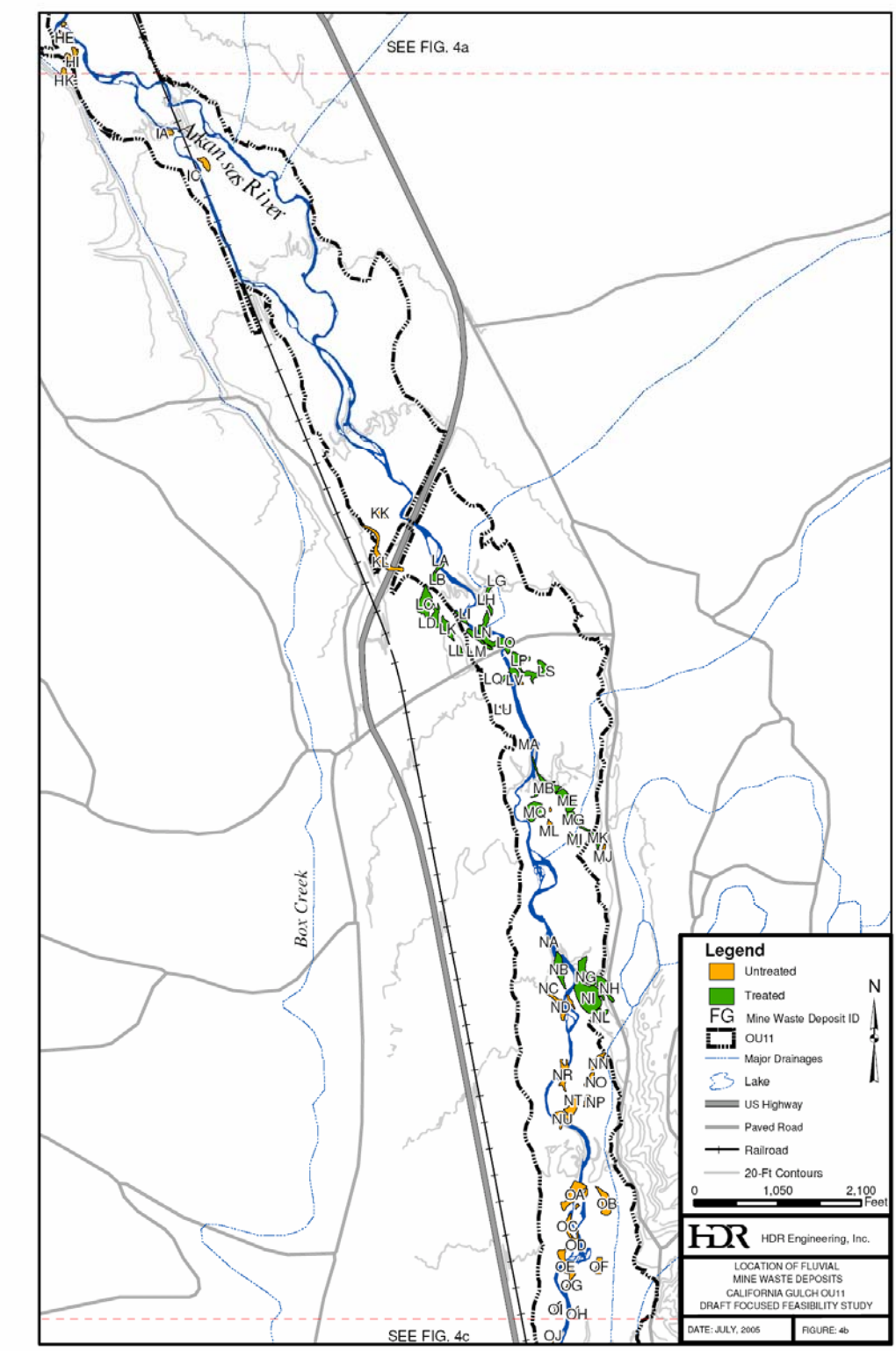
Location of Fluvial Mine Waste Deposits



Source: ROD OU11 2005

Figure 3-7

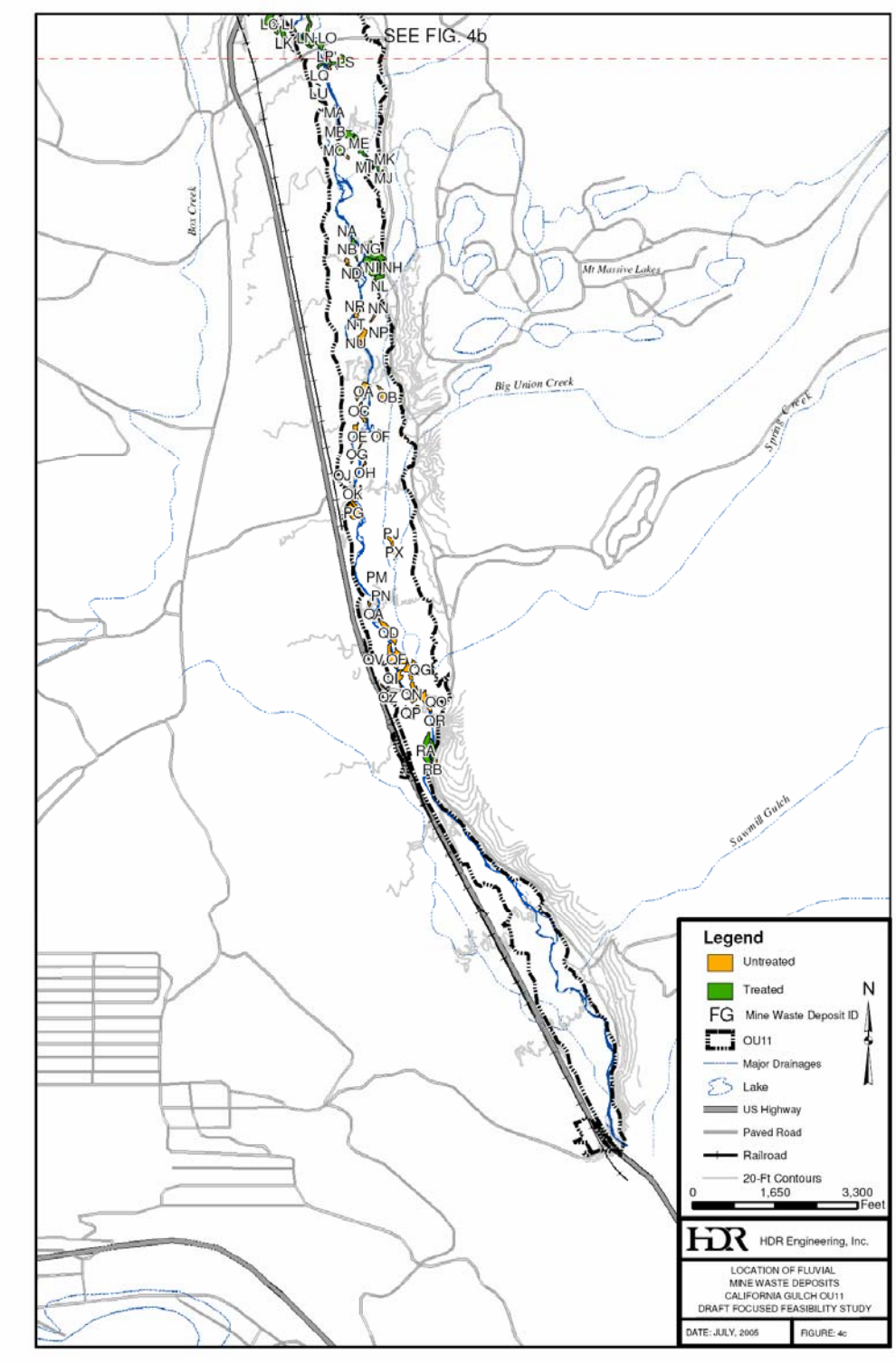
Location of Fluvial Mine Waste Deposits



Source: ROD OU11 2005

Figure 3-8

Location of Fluvial Mine Waste Deposits



Source: ROD OU11 2005

3.4.1.1 Phytotoxicity

Low pH, elevated metal concentrations, and poor substrate result in decreased vegetative cover and consequent impaired habitat in the areas of mine waste deposits. More specifically, for Reaches 1, 2 and 3 the SCR states that "soils where mine-waste deposits occur are considered to be injured. Total metal concentrations exceed toxicity thresholds and plant growth has been substantially impacted on most sites where mine-waste deposits have been identified" (SCR 2002, Chapter 3 Summary Matrix pp. 20-22). For Reach 4, the SCR states that "with respect to mine-waste deposits, not enough information exists to draw direct conclusions about injury. However, only a few small barren or sparsely vegetated areas consistent with mine-waste deposits could be identified. It is inferred that soils in those small areas are injured due to the presence of mine-waste" (SCR 2002, Chapter 3 Summary Matrix p. 23).

The 2003 ERA Addendum study does not predict phytotoxicity potential for fluvial mine waste deposits because the conditions in these deposits are significantly different than in irrigated meadow and riparian area soils, and the phytotoxicity model is not calibrated to be reliable for this type of medium. However, EPA notes that "it is evident that the Fluvial Mine Waste deposits are phytotoxic, since Fluvial Mine Wastes are characterized by sparse or absent plant growth" (ROD OU11 2005, p. DS-16). Table 3-5 shows mine waste deposits by reach, with number, area, and vegetative coverage. Cover is determined from aerial photographs of the region (SCR 2002, Appendix H). Just over four acres of the 65 have good vegetative cover (>50 percent).

Table 3-5

11-Mile Reach Fluvial Deposits (OU11)
Mine Waste Deposit Size and Vegetative Cover

	No. of Deposits	Volume (cy)	Area (acres)	Past Remediation (Acres)	Future Remediation Plans (Acres)	Number of Deposits with Specified Vegetative Cover (and acreage)	
						Poor to Fair (10-50%)	Good (>50%)
Reach 1	24	32,844	18.01	15.3	2.71	23 (17.91)	1 (0.1)
Reach 2	35	8,644	9.32	0	5.1	21 (7.2)	14 (2.1)
Reach 3	94	58,456	37.62	16.8	15	82 (35.67)	12 (1.95)
Total	**153**	**99,944**	**64.95**	**32.1**	**22.81**	**126 (60.78)**	**27 (4.15)**

Note: A small number of uncatalogued mine waste deposits are also present in Reach 4, constituting an estimated two acres. Trustees assume remediation of these sites in Reach 4.
Source: RAR 2003

Thus, readily available data suggest that metals concentrations in 11 Mile Reach fluvial habitat are sufficient to adversely affect the ability of vegetation to establish and sustain itself as would be expected in the absence of such contamination. For PED purposes, preliminary estimates of service loss reflect expected reductions in vegetative cover, based on field observations and Trustee judgment. Preliminary, quantitative estimates of service loss and recovery time for this potential irrigated meadow resource injury are addressed in the final section of this chapter.

3.4.1.2 Risks to Livestock and Wildlife

Readily available data do not address potential risks to livestock and wildlife arising from mine waste deposits in fluvial habitat. The Trustees may further assess such potential injuries as part of future natural resource damage assessment activities.

3.5 FLUVIAL MINE WASTE DEPOSITS IN CALIFORNIA GULCH (OUS 4 AND 8)[6]

Fluvial mine waste deposits also are prevalent in the 500-year floodplain of the California Gulch. In the Upper and Lower California Gulch (OUs 4 and 8), where Resurrection is the Remediation Lead, roughly 70 acres of mine waste deposits were identified and considered for remediation under Superfund authorities. More specifically, the deposits were divided into six fluvial tailing sites, one in OU4 (FTS4) and five in OU8 (FTS1, FTS2, FTS3, FTS6, and FTS8). The fluvial tailing waste volume in OU4 was estimated at 102,000 cubic yards over 10 acres, extending from 20 to 100 feet out across the valley floor, along 1.5 miles of the Upper California Gulch (ROD OU 4 1998, p. DS-1). In OU8, the five sites encompass an estimated 60.6 acres with 71,100 cubic yards of tailings (ROD OU8 2000, pp. DS-10 to DS-12). Table 3-6 provides additional detail on the area, depth, and volume of each FTS.

Table 3-6

Fluvial Mine Waste Deposits in OU4 and OU8

	Location	Volume (cy)	Area (acres)	Average Depth (ft)	Unvegetated Portion of Site	Vegetation on Remaining Site
FTS 1	OU8	5,500	3.4	1	65%	Grasses
FTS 2	OU8	5,200	3.2	1	Most	Isolated grasses
FTS 3	OU8	38,800	4.8	5	75%	Sagebrush, grasses, marshy near channel
FTS 4	OU4	102,000	10	6	75%	Grasses and lodgepole pine
FTS 6	OU8	3,400	4.2	0.5	60%	Sparse grasses with isolated pine trees
FTS 8	OU8	18,200	45	0.25	<80%	20% is well vegetated with dense grasses and shrubs.
TOTAL		**173,100**	**70.6**	**1.5**	**74%**	

Note: FTS8 extends beyond the 500-year floodplain of California Gulch, outside OU8. Overall the tailings encompass 115 acres at a depth of 4 inches, for roughly 46,000 cubic yards of material (ROD OU8 2000, p. DS-12). For total unvegetated calculation, used 90% for FTS 2 and 75% for FTS 8.

Remedial actions have been implemented at some of these locations. Descriptions of these actions are provided in subsequent sections of this chapter. Because natural resource damage regulations allow Trustees to pursue damages for past injuries to natural resources and/or resource services, characterization of conditions prior to remediation is appropriate for natural resource damage assessment purposes. Preliminary damage estimates presented at the end of this chapter account for improvements in resource condition over time due to remedial activities and natural recovery processes.

[6] Fluvial mine waste deposits also are present in other OUs, although readily available information is insufficient to include them in the analysis presented below.

3.5.1 Evidence of Injury

Vegetation is severely limited throughout the tailings sites. Between the six fluvial tailings sites in OU4 and OU8, nearly 75 percent of the surface area is completely unvegetated (Table 3-6). Elevated levels of arsenic, cadmium, lead, and zinc are prevalent throughout the tailing deposits at potentially phytotoxic levels (Table 3-7). The Record of Decision for OU8 provides the following summary of the pre-remediation condition of vegetation at fluvial tailing subsites:

- Fluvial Tailing Site 1 - Vegetation is variable with no vegetation over approximately 65% of the site. The remaining 35% of FTS1 is vegetated with grasses (ROD OU8 2000, p. DS-10);

- Fluvial Tailing Site 2 - Portions of FTS2 are devoid of vegetation with only isolated grasses on the tailing deposit. Dense vegetation is present in the area immediately adjacent to the channel (ROD OU8 2000, p. DS-10);

- Fluvial Tailing Site 3 - Approximately 25% of FTS3 is vegetated with sagebush, grasses and marshy areas near the channel. Tailing deposits and areas containing recently deposited fill are generally devoid of vegetation (ROD OU8 2000, p. DS-11);

- Fluvial Tailing Site 6 - Vegetation in FTS6 ranges from sparse grasses with isolated pine trees to unvegetated (approximately 60% of the site) (ROD OU8 2000, p. DS-11); and

- Fluvial Tailing Site 8 - Vegetation in FTS8 ranges from non-existent to dense grasses and shrubs located adjacent to the California Gulch channel. Approximately 20% of FTS8 is well vegetated (ROD OU8 2000, p. DS-12).

Thus, readily available data suggest that metals concentrations in OU 4 and 8 fluvial habitat are sufficient to adversely affect the ability of vegetation to establish and sustain itself as would be expected in the absence of such contamination. For PED purposes, preliminary estimates of service loss reflect expected reductions in vegetative cover, based on field observations and Trustee judgment. Preliminary, quantitative estimates of service loss and recovery time for this potential irrigated meadow resource injury are addressed in the final section of this chapter.

Table 3-7 Metal Concentrations in FTS and Waste Rock Piles in OU4 and OU8					
Site	**Arsenic (mg/kg)**	**Cadmium (mg/kg)**	**Copper (mg/kg)**	**Lead (mg/kg)**	**Zinc (mg/kg)**
FTS1	214	12.7	250	5780	2,290
FTS2	NA	19.5	NA	NA	NA
FTS3	172	17.4	437	3,220	4,170
FTS4	248	516	271	13,200	11,300
FTS6	108	45.9	263	3,250	6,710
FTS8	193	55	344	7,750	6,320
Source: ROD OU4 1998, ROD OU8 2000.					

3.6 ON-SITE MINE WASTE ROCK PILES (OUs 4, 5, 7, 8, AND 10)

Tailing impoundments, smelter waste, and waste rock piles are distributed throughout the Site. The piles are the waste products from various mining operations throughout the history of the Leadville Mining District. Trustee analysis of maps of the Superfund Site indicate a total of 145 acres of waste rock distributed in various sized parcels among OUs 4, 5, 7, 8, and 10 (see Figure 3-9). OU4 contains the greatest portion, with 86.8 acres of waste rock, primarily in evergreen forest areas.

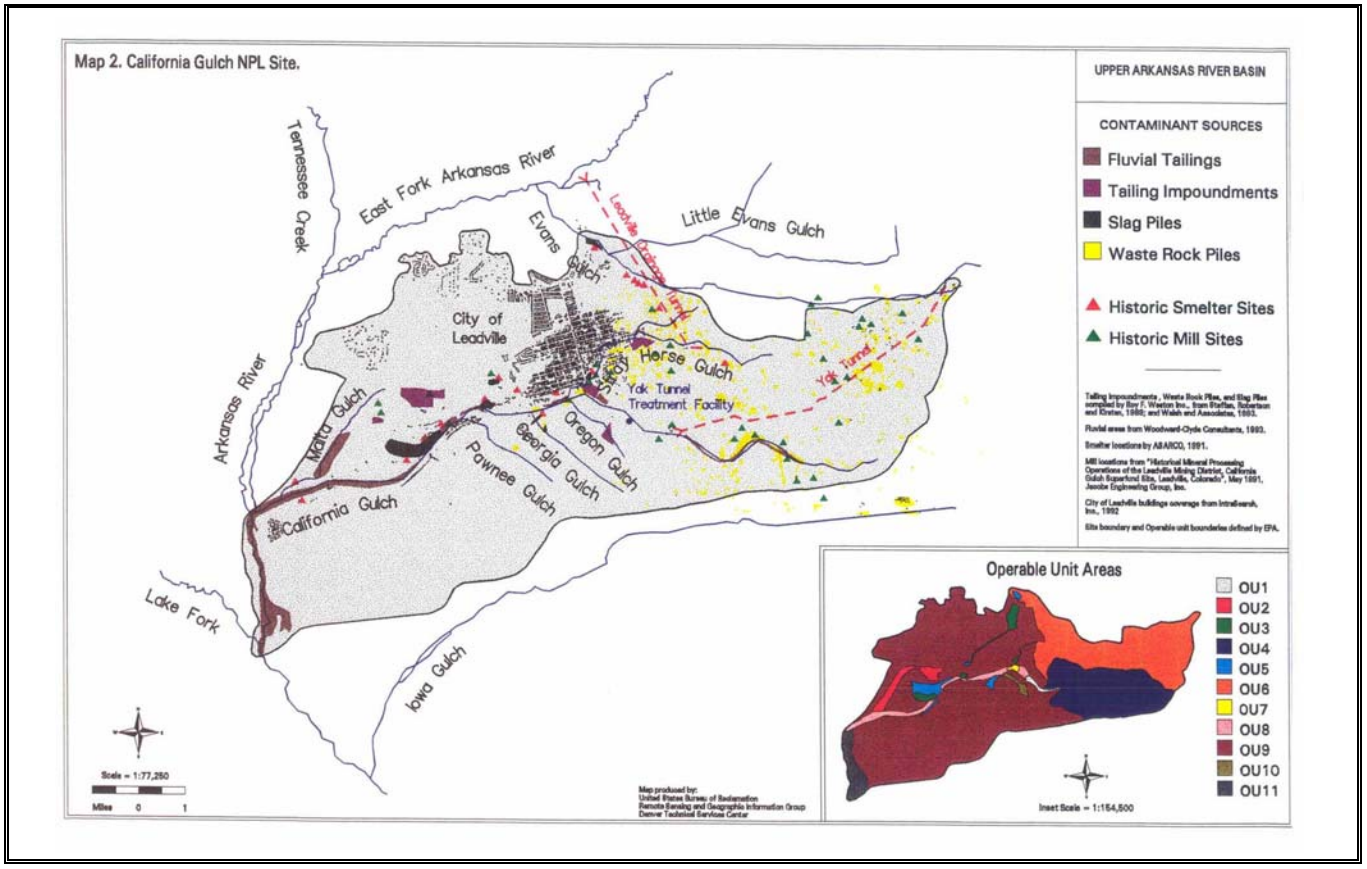
3.6.1 Evidence of Injury

These waste sites have represented major sources of contamination that have contributed to the injury of surface and groundwater as well as beds and banks and wildlife; therefore, they are considered injured geological resources. Table 3-8 presents acreages and descriptions of mine waste in OUs 4, 5, 7, 8 and 10. The abundance and diversity of vegetation is severely limited or absent on and near waste rock pile locations, as shown in Figure 3-9.

Table 3-8 Waste Rock Coverage in OUs 4, 5, 7, 8, 10		
Operating Unit	**Waste Rock (acres)**	**Key Sites**
OU 4	87	Garibaldi, Agwalt, Printer Girl mine waste sites
OU 5	28	Elgin, Grant/Union, Western Zinc, Arkansas Valley Slag/Smelter Sites; Arkansas Valley/ Colorado Zinc-Lead (AV/CZL) site
OU 7	14	North and Main Impoundments
OU 8	6	CZL Tailing Impoundment
OU 10	10	Oregon Gulch Tailing Impoundment
Total	**145**	

Figure 3-9

Unvegetated Waste Rock Piles in OUs 4, 5, 7, 8, and 10



Thus, readily available data suggest that waste rock piles in OUs 4, 5, 7, 8 and 10 are adversely affecting the ability of vegetation to establish and sustain itself, as would be expected in the absence of the piles. For PED purposes, preliminary estimates of service loss reflect expected reductions in vegetative cover, based on field observations and Trustee judgment. Preliminary, quantitative estimates of service loss and recovery time for this potential irrigated meadow resource injury are addressed in the final section of this chapter.

Additional waste rock piles may be present in the study area (e.g., Stray Horse Gulch and Evans Gulch). Readily available information is insufficient to include such additional areas in the preliminary estimates of damages presented in this document. The Trustees may collect and evaluate additional data as part of future natural resource damage assessment activities.

3.7 SUPERFUND ACTIONS

In response to observed metals contamination and associated human health and ecological risk concerns, EPA and Responsible Parties implemented a variety of response actions in the past and plan to undertake more in the future. Superfund OUs for the site and associated

remediation actions are briefly described in Chapter 2. As the preliminary natural resource damage estimates relate to injuries that precede and are residual to the completion of response activities, such activities are described briefly below. Preliminary damage estimates presented at the end of this chapter account for improvements in resource condition over time due to these remedial activities and natural recovery processes.

3.7.1 Summary of Relevant OU 11 Remedial Actions

Beginning in 1998, USEPA began a series of response actions within OU11, including:

- Revegetation of select mine waste deposits along the banks of the Arkansas River;
- A stream bank stabilization project (ROD OU11 2005, p. D-2).

Currently available information indicates that USEPA will implement additional response actions, including:

- Treatment and maintenance of Irrigated Meadows Areas A and B (see Figure 3-10). Initial treatment will consist of lime amendment for Area A and lime/organic amendment for Area B, deep tilling followed by seeding;
- Continued maintenance of Fluvial Mine Waste Deposits treated during prior response actions. Maintenance will include inspections and periodic application of lime and/or organic amendments;
- Treatment and maintenance of remaining untreated Fluvial Mine Waste Deposits. Initial treatment will consist of lime and organic amendment, deep tilling followed by seeding to physically stabilize the mine wastes through the establishment of vegetation; and
- No active remediation of the Riparian Areas (ROD OU11 2005, p. D-3).

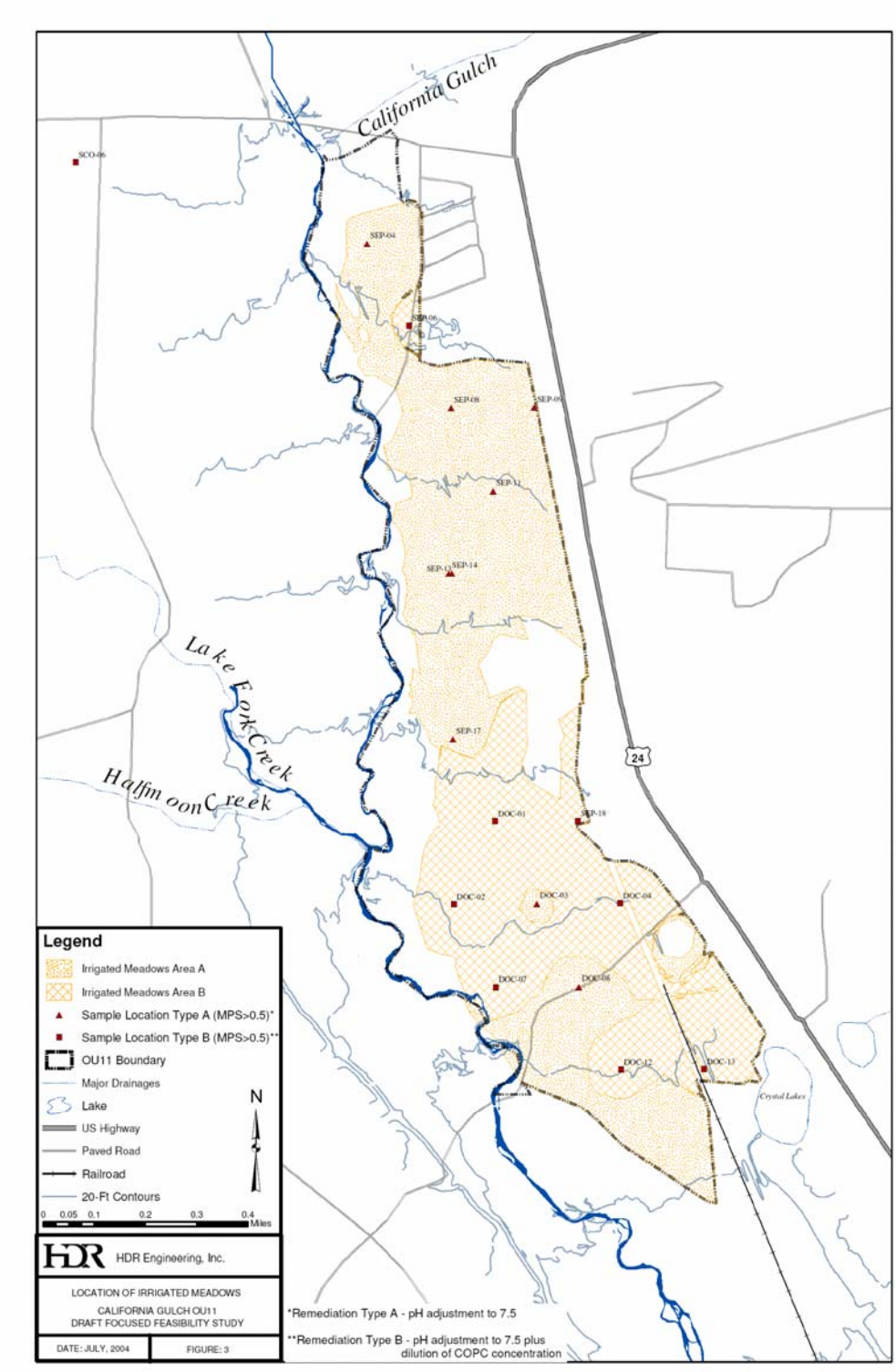
3.7.2 Summary of Relevant OU 4 and 8 Fluvial Tailings Remedial Actions

As part of an interim removal action, in 1998 approximately 5,794 cubic yards of fluvial tailing were excavated from poorly vegetated, erosion-prone areas within OU8 (specifically, FTS2, FTS3, FTS6, and FTS8). The excavated tailing was transported and placed on the Oregon Gulch Tailing Impoundment (OU10). Of the approximately 60 acres of fluvial tailing in OU8, approximately 11.5 acres of wetland and 13.3 acres of upland have been identified for this revegetation. Wetland areas will be revegetated with the same native wetland plant species that currently dominate the California Gulch wetlands. The upland areas will be regraded and vegetation established with soil amendments, as needed, including lime, nutrients and organic matter. In addition, erosion-prone areas will be protected with riprap and a suitable filter fabric" (ROD OU8 2000, p. DS-43).

The decision of whether to remediate OU4/Oro City will be made during evaluations conducted for OU12, site-wide surface and groundwater (ESD OU4 2004, p. 5).

Figure 3-10

Location of Irrigated Meadows



Source: ROD OU11 2005

3.7.3 Summary of Relevant OU 4, 5, 7, 8 and 10 Waste Pile Remedial Actions

Various remedial actions have been undertaken on mine waste piles outside of fluvial regions. The three basic categories of actions are removal, diversion of water flow, and containment/capping. Removals have primarily consisted of consolidation of smaller waste piles into the larger tailings impoundments (e.g. into the Main Impoundment in OU7 or the Oregon Gulch Tailings Impoundment in OU10). Diversions include redirection of surface water around piles and interception of groundwater, with the intent of reducing aqueous transport of contaminants from the piles. Containment projects include regrading, capping, soil amendment, and revegetation. For example, the Oregon Gulch Impoundment has a multi-layer composite cover, including a geosynthetic infiltration barrier covered with 18 inches of soil. The soil surface was graded, amended, and vegetated with grasses and forbs (ROD OU10 2004, p. DS-41). Waste pile remediation projects began in the mid-1990s and have continued since that time. Several vegetation projects have required repeated follow-up actions (USEPA 2005).

3.8 PRELIMINARY ESTIMATE OF DAMAGES

Similar to the aquatic resource analysis presented in Chapter 2, for PED purposes the potential magnitude of terrestrial damages is assessed through development of preliminary estimates of the cost of restoration and/or habitat protection projects potentially appropriate to offset terrestrial resource injury. Restoration and/or habitat protection project costs are a commonly used measure of natural resource damages, and appropriate in this case for several reasons. For this preliminary PED analysis, the Trustees assume that natural resource damage restoration efforts will focus on the purchase of conservation easements intended to prevent future loss and/or degradation of ecologically important and sensitive terrestrial habitats near the Arkansas River and/or other surface water resources as opportunities allow.

The Trustees have undertaken an initial evaluation of placing a conservation easement on the Moyer Ranch, which encompasses 3,261 acres of terrestrial habitat, including 775 acres of wetlands. Undeveloped, the Moyer Ranch provides a land bridge between public lands to the north and south, and to the east and west sides of the Arkansas River valley, forming migration corridors between Mosquito and Sawatch Ranges. The easement would also provide a buffer between Leadville and some interspersed private lands and the public lands of the San Isabel Forest, while protecting and enhancing wildlife, recreational and scenic values of over 8,000 acres of surrounding open space.

The habitat that would be protected by an easement includes a range of terrestrial habitat types, from Alpine tundra and coniferous and aspen forests to graminoid wetlands, shrublands and grasslands. Approximately one mile of Arkansas River, four tributaries – two perennial and two intermittent – and 9.5 miles of tributary riparian habitat add to the diversity of the ecosystem. The ranch provides critical winter range for mule deer and a herd of over 300 elk, habitat for elk calving and deer fawning, and summer range for these large mammals as well as mountain goats and bighorn sheep. Water rights would accompany the protected land.

Maintenance of these rights for current uses would help ensure a healthy aquatic and riparian system along Empire Gulch.

Consistent with PED objectives, the Trustees provide a preliminary HEA analysis to help assess the approximate magnitude of potential restoration scale (and cost). More detailed analysis and/or alternative approaches may be undertaken as part of future assessment activities.

3.8.1 HEA Inputs and Results

Consistent with standard practice in natural resource damage assessments, calculation of service losses begins in 1981. Preliminary, simplified assumptions regarding the areal extent, magnitude and timing of service losses are summarized below and in Table 3-9:

- Irrigated Meadows – Areas predicted to be mildly (234 acres), moderately (408 acres) and highly (41 acres) phytotoxic (based on the 2003 ERA Addendum) are assigned service losses of 18 percent, 38 percent, and 63 percent, respectively.[7] These levels of loss are assumed to begin in 1981, and held constant through 2006. Readily available information suggests that as part of the CERCLA Superfund process, 324 and 32 acres of moderately and highly phytotoxic irrigated meadows, respectively, will be treated by lime or organic amendments, followed by deep tilling and seeding with native grasses, likely beginning in 2007. Based on Trustee revegetation experience and professional judgment, service loss in treated areas is assumed to decrease by 50 percent by 2012, by 80 percent by 2057, and by 100 percent by 2107, with linear improvements between each point. Service loss estimates for untreated areas are held constant for the entire 1981 through 2106 period, reflecting preliminary Trustee judgment that natural recovery processes are unlikely to improve resource condition for many decades.

- Riparian Areas – Areas predicted to be mildly (209 acres), moderately (305 acres) and highly (39 acres) phytotoxic (based on the 2003 ERA Addendum) also are assigned service losses of 18 percent, 38 percent, and 63 percent, respectively. These levels of loss are assumed to begin in 1981 and held constant through 2106, reflecting the Trustees' expectation that remediation will not be undertaken at these locations and preliminary judgment that natural recovery processes are unlikely to improve resource condition for many decades.

- OU11 Fluvial Mine Waste Deposits – Fluvial mine waste deposits are assigned a service loss of 100% based on the severely reduced quantity and quality of vegetation, and reflect a complete loss of ecological services normally provided by this habitat. These levels of loss are assumed to begin in 1981, and are held constant through 2006, reflecting Trustees' observation of slow recovery of these areas even with initial implementation of remediation (*in situ* treatments and revegetation) in the late 1990s. Additional remediation plans, encompassing tilling, soil amendment, and revegetation with native

[7] Phytotoxicity categories are assigned to a range of percent reduction in services based on comparison to plant growth at reference stations (USEPA 2003, p. 4-4). These are 11-25 percent for mildly phytotoxic, 26-50 percent for moderately phytotoxic, and 51-75 percent for highly phytotoxic. The mid-point of the range is used in calculations.

grasses, are expected to start in 2007. Based on Trustee revegetation experience and professional judgment, service loss is estimated to be reduced by 50 percent after five years (2012), 80 percent after fifty years (2057) and 100 percent after one hundred years (2107).

- OUs 4 and 8 Fluvial Mine Waste Deposits – Similar to OU11 fluvial mine waste deposits, the deposits in OU4 and 8 fluvial habitats are assigned a service loss of 100%, based on the low vegetative cover and elevated metals concentrations. These levels of loss are assumed to begin in 1981, and are held constant through 2006.[8] Roughly 25 acres of deposits have been revegetated, and are expected to improve on a similar schedule to that described above for OU 11 fluvial deposits. Service loss estimates for untreated areas (approximately 45.8 of the 76 acres of OU 4 and 8 fluvial deposits) are held constant for the entire 1981 through 2106 period. These estimates of service loss do not include potential impacts associated with remedial activities (e.g., impacts to riparian vegetation along channel with riprap).

- OUs 4, 5, 7, 8 and 10 Waste Rock Deposits – Waste rock piles are assigned an initial service loss of 75 percent, reflecting limited quantity and quality of vegetation in and near these areas. While *in situ* remediation actions have been implemented at some deposits, and vegetated covers have or will be installed over several waste impoundments, existing vegetated covers do not support a high quantity or diversity of plant life. This level of loss is assumed to begin in 1981, and held constant through 2106, reflecting the Trustees' expectation that removal of contaminants will not be undertaken at these locations and preliminary judgment that natural recovery processes are unlikely to improve resource condition for many decades.

[8] While a 1998 Action Memorandum resulted in excavation of tailing deposits at several fluvial sites in OU8, vegetative cover remains low.

Table 3-9

Preliminary Calculation of Service Loss for Terrestrial Injuries
Input Parameters and Service Acre-Years (Discounted to 2006)

	Area (acres)	1981-2007	2012	2057	2107	Discounted Loss (Acre-Yrs)
Irrigated Meadows - 11-mile Reach						
mildly PT, no treatment	234	18%	18%	18%	18%	2,956.9
moderately PT, no treatment	84	38%	38%	38%	38%	2,240.9
moderately PT, revegetated	323.5	38%	19%	8%	0%	6,286.4
highly PT, no treatment	8.76	63%	63%	63%	63%	387.4
highly PT, revegetated	31.6	63%	32%	13%	0%	1,018.1
Riparian Areas - 11-mile Reach						
mildly PT, no treatment	209.2	18%	18%	18%	18%	2,643.5
moderately PT, no treatment	304.7	38%	38%	38%	38%	8,128.5
highly PT, no treatment	39.34	63%	63%	63%	63%	1,739.9
Fluvial Tailing Deposits						
11-mile Reach, revegetated	65	100%	50%	20%	0%	3,324.0
OUs 4 and 8, revegetated	24.8	100%	50%	20%	0%	1,268.2
OUs 4 and 8, no treatment	45.8	100%	100%	100%	100%	3,215.3
OU 4,5,7,8,10 mine waste piles, no treatment	145	75%	75%	75%	75%	7,634.5
					TOTAL	**40,843.6**

Note: Revegetation presumes soil amendment, tilling, and planting of native grasses.

As described above, the Trustees have identified the purchase of an easement on the Moyer property (3,261 acres) as a reasonable restoration project that will protect and preserve wildlife habitat similar to wildlife habitat injured by the responsible parties. Specifically, the easement will protect the habitat from future development and encroachment, and will maintain and improve ecological services through preservation of water supply and enhanced grazing management. Benefits were calculated separately for irrigated meadows and upland habitat associated with the Moyer property. In addition to the easement on the Moyer property, the Trustees also identified riparian revegetation as a reasonable restoration project that would restore riparian wildlife habitat similar to riparian habitat that was injured by the responsible parties, including areas injured by fluvial tailings.

The following methods were used to calculate the benefits associated with purchasing an easement for irrigated meadow habitat on the Moyer property. The service gain associated with the conservation easement is the avoided loss of habitat value if the current habitat were degraded in the future. In this case, the service gain is the difference in habitat value between the irrigated meadows currently maintained using the Moyer's senior water rights and dry sagebrush habitat that would likely replace the irrigated meadows if the water rights were purchased separately from the land and transferred to a municipality or other entity. This potential loss of habitat value would be avoided if the conservation easement were put in place and the transfer of water rights did not occur. The service gain was estimated to be 58% for the irrigated meadows, based on a documented increase in bird species number for irrigated meadows compared to dry sagebrush habitat (McAdoo, 1999). The service difference was assumed to occur over the period

of 2007-2012 to reflect the likely quick loss of water rights if the property were sold without an easement in place.

The following methods were used to calculate the benefits associated with purchasing an easement for upland habitat on the Moyer property. The service gain associated with the conservation easement is the avoided loss of habitat value where the uplands currently associated with a large ranching operation converted to "exurban" residential use (35-acre minimum lot size). This potential loss of habitat value would be avoided if the conservation easement were put in place. For each potential homestead avoided through a conservation easement on the Moyer property, the estimated area of habitat benefit extends across a 180 m radius surrounding the development. Across this area (approximately 25 acres per homestead site), a service difference of 50% was assigned based on the estimated avoided loss for sensitive birds that experience a decline in density for 180 m near exurban development (Odell and Knight, 2001). The service difference was phased in over the period of 2007-2033 to reflect the likely pace of development that would occur if an easement were not put in place. The service gain associated with the easement was assumed to be maintained through 2107.

The following methods were used to calculate the benefits associated with riparian revegetation. The service gain associated with riparian revegetation is based on the estimated difference in habitat value between highly degraded riparian areas and areas replanted successfully with native willow and other native riparian species. Planting of native vegetation in degraded riparian areas was assumed to increase habitat services by 75%, based on an estimated increase in vegetation cover between degraded and restored areas. The area of service gain was based on a strip of revegetated riparian vegetation 2.5 feet wide and an estimated 25-foot buffer area behind the revegetated strip. This buffer area accounts for an area of increased riparian services as the revegetation areas grow and mature. The service gain was phased in over the period of 2007-2016 based on the time required for willows to grow and mature at high elevations. The service gain associated with riparian revegetation was assumed to be maintained through 2107.

Table 3-10 provides quantitative estimates of service benefits associated with the restoration projects described above.

Table 3-10
Calculation of Potential Ecological Benefits Related to Proposed Restoration Projects (discounted to 2006)

Habitat Type	Discounted Service Acre-Years (DSAYs) of Benefit Per Acre Restored
Irrigated Meadows Habitat Easement	17.3
Upland Habitat Easement	10.9
Riparian Habitat Revegetation	20.7

Cost estimates for the three habitat types (irrigated meadows, upland, and riparian) were based on unit costs to implement the restoration projects described above. These unit costs (costs

per DSAY) were multiplied by the total number of injured DSAYs to estimate the likely costs needed to offset preliminary estimates of quantified injuries.

For irrigated meadows, the unit price for a conservation easement protecting land and associated water rights in Lake County was derived from an appraisal of the Moyer property (Sartucci, 2006). The value of a conservation easement for a wet meadow parcel with irrigation is $8,315 per acre, based on data presented by Sartucci (2006). Because each acre generates 17.3 DSAYs of credit, the cost per DSAY is $482. The estimated debit of contaminated irrigated meadows is 12,890 DSAYs. This debit would not be compensated by the 9,400 DSAYs (rounded) that would be provided by the preservation of 542 acres of irrigated meadow acreage available on the Moyer property, at a total cost of $6.2 million.

For upland habitats, the unit price for a conservation easement protecting land from development was derived from the same appraisal of the Moyer property used above (Sartucci, 2006). The value of a conservation easement for upland acreage is $2,144 per acre, based on data presented by Sartucci (2006). Because each acre generates 10.9 DSAYs of credit, the cost per DSAY is $197. The estimated debit of 7,635 DSAYs of injured upland habitat resulting from on-site mine waste rock piles would be compensated by an easement of 700 acres of upland acreage available on the Moyer property, for a total cost (rounded) of $1.5 million.

For riparian habitats, the unit price for riparian revegetation was estimated to cost $1.89 per square foot or $82,300 per acre (Rod Van Velson, Colorado Division of Wildlife, personal communication, with costs updated to 2006 dollars using the produced price index). These costs are consistent with riparian revegetation costs (soil amendments plus native plants) developed for the Coeur d'Alene Natural Resource Damage Assessment (LeJeune et al., 2004), which estimated costs at $1.91 per square foot or $83,308 per planted acre. A planted area of 1 acre would generate 207 DSAY credits over an area of 10 acres as the revegetated areas grow and mature and the vegetation footprint expands over time, generating a cost per DSAY of $400. The estimated debit of 20,307 DSAYs for the combined injured riparian and fluvial tailings habitats would be compensated by revegetating 981 acres of riparian habitat for a total cost (rounded) of $8.1 million.

In addition, for preliminary evaluation purposes, the Trustees assume a modest annual budget of $15,000 over the 100-year project period to allow for regular monitoring of the property's ecological condition, administration, and enforcement. In present value terms, this adds approximately $0.5 million to the cost of the project. This brings the total estimated costs of terrestrial restoration to over $16.3 million.

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