Application of the SFCDR Watershed Groundwater Flow Model to the Revised Groundwater Components of the Upper Basin Selected Remedy for Mainstem SFCDR Watershed Segment 01

PREPARED FOR: Bill Adams/EPA Region 10

PREPARED BY: Heather Perry/CH2M HILL

COPY TO: Rebecca Maco/CH2M HILL
Peter Lawson/CH2M HILL
Joan Stoupa/CH2M HILL
Brian Tracy/CH2M HILL

DATE: April 5, 2012

This Technical Memorandum (TM) provides the basis and technical support for changes made to the hydraulic isolation and groundwater collection actions for Segment 01 of the Mainstem South Fork Coeur d'Alene River (SFCDR) Watershed as presented in the Preferred Alternative in the Upper Basin Proposed Plan (U.S. Environmental Protection Agency [EPA], 2010). Segment 01 of the Mainstem SFCDR Watershed is located within Upper Basin portion of Operable Unit (OU) 3 of the Bunker Hill Mining and Metallurgical Complex Superfund Site.

Changes to remedial actions were made based on comments received on the Upper Basin Proposed Plan. Previously, in the Draft Final Focused Feasibility Study (FFS) Report for the Upper Basin (CH2M HILL, 2010), hydraulic isolation and groundwater collection actions along the SFCDR between Wallace and Elizabeth Park (a reach over 10 miles in length) were included for Segment 01 in Alternative 3+(d), which was the Preferred Remedial Alternative presented in the Upper Basin Proposed Plan. Those remedial actions are no longer included in the Selected Remedy that is being documented in the Record of Decision (ROD) Amendment for the Upper Basin (EPA, in preparation). Instead, a French drain (a groundwater interception drain) only in the Osburn Flats area (a reach less than 1 mile in length) is included. The stream liner along the SFCDR between Wallace and Elizabeth Park that was previously included in the Preferred Remedial Alternative is also no longer part of the Selected Remedy. The revised remedial action for Segment 01 of the Mainstem SFCDR Watershed is presented in Figure 1.[1]

This TM documents the application of the SFCDR Watershed groundwater flow model (hereafter referred to as the SFCDR Model) to perform remedial effectiveness assessments of the revised remedial action for Segment 01 of the Mainstem SFCDR Watershed. The SFCDR Model is a numerical tool that was developed to characterize the distribution of dissolved metals loading to the SFCDR from the groundwater system under current conditions, and to evaluate the relative effectiveness of various potential remedial actions. The SFCDR Model uses MicroFEM, an integrated groundwater modeling software program (Hemker and Nijsten, 2003). Construction and initial calibration of the SFCDR Model are documented in the *South Fork of the Coeur d'Alene River Watershed: Basinwide Groundwater Flow Model Documentation* (CH2M HILL, 2009a), while groundwater flow model refinements, additional calibration,

[1] The figures referenced in the text of this TM are provided following the references that end on page 6.

and application of the tool to the Upper Basin remedial alternatives are documented in the Draft Final FFS Report (CH2M HILL, 2010).

Application of Groundwater Flow Model to Revised Remedial Alternative for OU 3

Figure 1 shows the location and nature of the revised remedial action for Segment 01 of the Mainstem SFCDR Watershed. As described in Section A.5.6 in Appendix A of the Draft Final FFS Report, the objective of the previously anticipated remedial actions along the SFCDR between Wallace and Elizabeth Park was to hydraulically isolate this entire reach via stream lining and collection and treatment of dissolved-metals-contaminated groundwater that would otherwise discharge to the SFCDR. The revised remedial action focuses on reducing metals loading to the SFCDR in Osburn Flats, for two reasons: (1) because of the uncertainty associated with the nature of groundwater-surface water interaction and the distribution of dissolved-phase metals loading to the Mainstem SFCDR in the majority of the watershed upstream from Elizabeth Park; and (2) because of the estimated costs associated with implementing the previously anticipated actions between Elizabeth Park and Wallace. The revised remedial action involves installing a French drain parallel to the SFCDR in the highest dissolved-metals-loading reach in Osburn Flats, between Twomile Creek and Terror Gulch. The drain will be installed on the south side of Interstate 90.

Simulation Results

The French drain in the revised remedial action was simulated using the SFCDR Model. French drain elevations were set at 10 feet below the baseflow groundwater table elevation. Because of the coarse-grained nature of the aquifer materials in Osburn Flats (horizontal hydraulic conductivities ranging from approximately 400 to 2,000 feet per day), no additional coarse backfill material was simulated.

The modeling simulation was performed to obtain an estimate of the effectiveness of the action in reducing dissolved metals loading to the SFCDR. The effectiveness of the action was estimated by running a model simulation with the remedy in place, and comparing the results with a baseline no-action simulation. The difference in metals loading between the two simulations represents the benefit of implementing the revised remedial action. Other information obtained from the modeling simulation included estimated flow rates of groundwater into the French drain and estimated metals loading associated with those flows. The estimated metals loading entering the drain represents the mass of metals that would be removed from the system through treatment at the Central Treatment Plant (CTP) in Kellogg, Idaho. The methodology used to estimate metals loading is described in Section A.4 in Appendix A of the Draft Final FFS Report (CH2M HILL, 2010).

The revised remedial action was simulated under four different hydraulic conditions:

1. Steady-state baseflow conditions observed during the fall of 2008 (representing an approximate 25th percentile flow as defined by the SFCDR flow at the U.S. Geological Survey stream gauge at Pinehurst [station SF-271]). "Baseflow" generally represents the low-flow period that occurs in late summer and early fall each year.

2. A 7Q10 flow, representing extreme low-flow conditions. The 7Q10 flow is defined as the lowest 7-day average flow that occurs on average only once every 10 years.

3. A 90th percentile flow condition. This represents the high-flow conditions that typically occur each spring.

4. An average annual flow condition. This was evaluated by performing a transient model simulation based on daily data collected over the course of a 365-day period (July 1, 2008 through June 30, 2009) and then averaging the daily results.

Simulation of these four hydraulic conditions in the SFCDR Model provided information on the estimated range of performance of the revised remedial action throughout the year under varying hydrologic regimes. Discussions of these hydrologic conditions are presented in Section A.3 in Appendix A of the Draft Final FFS Report.

Figure 2 presents simulated upstream groundwater flowlines from "gaining" reaches of the SFCDR in Osburn Flats under no-action, baseflow conditions (patterns are similar for other hydrologic conditions). ("Gaining" reaches are defined as those where groundwater discharges to surface water; similarly, "losing" reaches are those where surface water discharges to groundwater.) Flowlines present a two-dimensional graphical depiction of the simulated three-dimensional groundwater flow field. Flowlines are started at a given node or nodes and can be tracked forward or backward along a groundwater flowpath through time/space. For this analysis, flowlines were started in model nodes representing the groundwater discharge point (where groundwater is exiting the model domain/simulation) represented by the western gaining reach of the SFCDR in Osburn Flats (see Figure 2), and were tracked backward to investigate the source of water to this reach. By following the path of a given flowline from the gaining reach to the terminus, Figure 2 shows that the sources of water to the SFCDR include upstream losing portions of the SFCDR (flowlines that terminate at the SFCDR in the eastern portion of Osburn Flats), tributaries (flowlines that track up Terror Gulch and/or other tributary canyons north and south of Osburn Flats), and groundwater underflow from the SFCDR alluvial system upstream (flowlines that track eastward within the alluvial aquifer system).

Figure 3 shows simulated upstream groundwater flowlines from the same gaining reaches of the SFCDR and depicts sources of water to the SFCDR with the revised remedial action (the French drain) in place. Comparison of Figures 2 and 3 shows that the area of the SFCDR that was gaining under the "no action" scenario presented in Figure 2 is still gaining under the "with action" scenario presented in Figure 3, although the source of the water entering the SFCDR changes. With no action in place (Figure 2), sources of water to the SFCDR include upstream losing portions of the SFCDR, tributaries, and the SFCDR alluvial aquifer system. As shown on Figure 3 (which presents simulated flowlines with the revised remedial action in place) there is a much lower density of flowlines that track to the eastern losing reach of the SFCDR in Osburn Flats and the upstream SFCDR alluvial aquifer system, and there is a higher density of flowlines that track upstream to the tributary alluvial aquifer systems in Terror Gulch and Twomile Creek, suggesting that operation of the French Drain impacts groundwater-surface water interactions. The alluvial aquifers in Terror Gulch and Twomile Creek are significantly less contaminated than the SFCDR alluvial aquifer system, which will contribute to the net reduction in dissolved metals loading to the SFCDR resulting from the revised remedial action. Figure 4 presents simulated upstream groundwater flowlines from the French drain with the revised remedial action in place, and therefore depicts sources of water to the drain (primarily the eastern losing reach of the SFCDR in Osburn Flats). A comparison of Figures 2, 3, and 4 suggests that the majority of groundwater underflow that discharged to the SFCDR under the no-action scenario would discharge to the French drain with the remedy in place.

Tables 1 through 4[2] present summaries of simulated flows for no action, the remedial actions previously anticipated in Alternative 3+(d) and the Preferred Remedial Alternative in the Upper Basin Proposed Plan, and the revised remedial action under the four hydraulic conditions discussed above: baseflow, 7Q10, 90th percentile, and average annual flow conditions, respectively. These tables show the following:

- Within Segment 01 of the Mainstem SFCDR Watershed, between Wallace and Elizabeth Park under no-action conditions, the SFCDR Model suggests that the SFCDR would gain between 9 cubic feet per second (cfs) and 10 cfs and lose between 10 and 12.3 cfs.

[2] The tables referenced in the text of this TM are provided at the end of the document, following the figures.

- With the previously anticipated components of Alternative 3+(d) in place, there would be no groundwater-surface water interaction along the SFCDR as a result of stream lining; that is, the SFCDR would not gain any groundwater, nor would it lose any water to groundwater. The French drain inflow would range from 6.3 to 8 cfs.
- With the revised remedial action in place, the SFCDR Model suggests that the SFCDR would gain between 5.6 and 6.4 cfs and lose between 14.1 and 16.8 cfs.

The net reduction in streamflow (reduction in stream gain plus increase in stream loss) between the no-action and revised remedial action simulations under the various hydrologic conditions ranges from 6.9 to 8.0 cfs. This means that, in comparison to the no-action scenario, when the revised remedial action is implemented there would be an estimated net reduction of stream flow in the SFCDR. Estimated stream flow reductions associated with the Upper Basin Selected Remedy are discussed in detail in the TM *Estimated Stream Flow Reductions Resulting from Groundwater Remedial Actions, Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site* (CH2M HILL, 2012).

The SFCDR will not be lined as part of the revised remedial action; therefore, the increase in stream loss between the no-action and revised remedial action simulations is due to induced stream leakage in a portion of the SFCDR that was gaining in the absence of the French drain. Additionally, although the French drain length will be shorter under the revised remedial action than under Alternative 3+(d) and the Preferred Remedial Alternative, there is an increase in drain flow ranging from 0.9 to 2.1 cfs because of induced streamflow from the unlined SFCDR and the deeper drain elevation under the revised remedial action.

In summary, the groundwater flow modeling demonstrates that compared with both no action and the previously anticipated remedial actions, the revised remedial action is expected to result in a greater reduction in net stream flow. In addition, the average annual flow to the French drain under the revised remedial action is estimated to be 8.9 cfs. This value will be used for planning purposes for treatment at the CTP in Kellogg.

Tables 5 through 8 present summaries of the simulated dissolved zinc loading for no action, the remedial actions previously anticipated in Alternative 3+(d) and the Preferred Remedial Alternative in the Upper Basin Proposed Plan, and the revised remedial action under the baseflow, 7Q10, 90th percentile, and average annual hydrologic conditions, respectively. These data suggest that under no-action conditions, the net dissolved zinc loading to Mainstem SFCDR Watershed Segment 01 would be between 41 and 57 pounds per day (lb/day) under the various flow conditions. Tables 5 through 8 also show the following:

- The previously anticipated remedial actions would remove the no-action dissolved zinc load from the SFCDR system; however, the load to the remedial action drains (the treatment load) would range from 61 to 77 lb/day.
- Under the revised remedial action there would be a reduction in load to the SFCDR ranging from 47 to 52 lb/day under the various hydrologic conditions. The treatment load to the French drain under the revised remedial action would range from 111 to 134 lb/day.

The increase in treatment load between the previously anticipated remedial actions and the revised remedial action (ranging from 41 to 57 lb/day) is the result of increased drain flow (discussed above) and a difference in assumed dissolved zinc concentrations. For the revised remedial action, it was assumed that the French drain system would be set far enough away from the SFCDR that any induced flow from the river would flow through contaminated sediments before discharging to the drain system and would, therefore, enter the drain with dissolved zinc concentrations similar to those measured in the groundwater system. Analytical data from wells and piezometers nearest the French drain were assumed to be representative of drain inflow concentrations. It was further assumed that the inflow to the eastern portion of the drain would have a dissolved zinc concentration of 3.2 milligrams per liter

(mg/L) (the concentration at well SF-OB-MW-08 in 2008), and that inflow to the western portion of the drain would have a dissolved zinc concentration of 1.5 mg/L (the concentration at piezometer SF-OB-PZ-19 in 2008).

Along the SFCDR between Wallace and Elizabeth Park, there is a greater density of groundwater data for the Osburn area than there is for the rest of this approximately 10-mile reach. This density of data allowed for the treatment load estimation approach described above, where the concentration of dissolved zinc entering the French drain under the revised remedial action varies from one end of the drain to the other based on adjacent groundwater monitoring well data. For the previously anticipated remedial actions along the entire reach (from Wallace to Elizabeth Park), such groundwater data were not available and a different approach was used. For the previously anticipated actions, a uniform dissolved zinc concentration equal to the average concentration measured in Osburn Flats monitoring wells in the fall of 2008 (1.8 mg/L) (CH2M HILL, 2009b) was used. The approach used for estimating treatment load for the revised remedial action therefore represents a more refined estimate due to the greater density of groundwater data in the vicinity of the French drain.

To understand the potential impact of these two different approaches on the estimation of treatment load under the revised remedial action, calculations were made using both the "variable" zinc concentration approach (the approach described above in which the concentration varies along the drain length based on nearby groundwater well data) and the "uniform" zinc concentration approach, in which the dissolved zinc concentration entering the drain is assumed to be 1.8 mg/L. The results of this sensitivity analysis showed that the estimated treatment load was consistently higher using the variable concentration assumption (ranging from 30 to 37 lb/day higher, depending on the hydraulic condition). Groundwater concentrations in the vicinity of the French drain and the resulting dissolved zinc loading are subject to significant uncertainty at this time, and the difference in results using these two approaches provides some indication of the range of results that may be expected. Prior to implementation, additional pre-design studies will be needed to better define dissolved zinc concentrations in groundwater and assess how these may affect the estimated treatment load and net load reduction to the SFCDR with the operation of the French drain.

In summary, the estimated load reduction in Segment 01 of the Mainstem SFCDR Watershed achieved by the revised remedial action would be similar to the estimated load reduction achieved by the remedial actions previously anticipated under Alternative 3+(d) and the Preferred Remedial Alternative in the Upper Basin Proposed Plan. Additionally, this load reduction would be achieved at a much lower cost. Table 9 summarizes the estimated costs of the previously anticipated remedial actions, the revised remedial action, and the differences between them. The revised remedial action will result in a capital cost savings of more than $337 million and an annual operations and maintenance cost savings of more than $4 million.

References

CH2M HILL. April 2009 (2009a). *South Fork of the Coeur d'Alene River Watershed: Basinwide Groundwater Flow Model Documentation*. Prepared for U.S. Environmental Protection Agency, Region 10.

CH2M HILL. July 2009 (2009b). *Technical Report, Osburn Flats Groundwater-Surface Water Interaction Study, Upper Coeur d'Alene Basin, Osburn, Idaho*. Prepared for U.S. Environmental Protection Agency, Region 10.

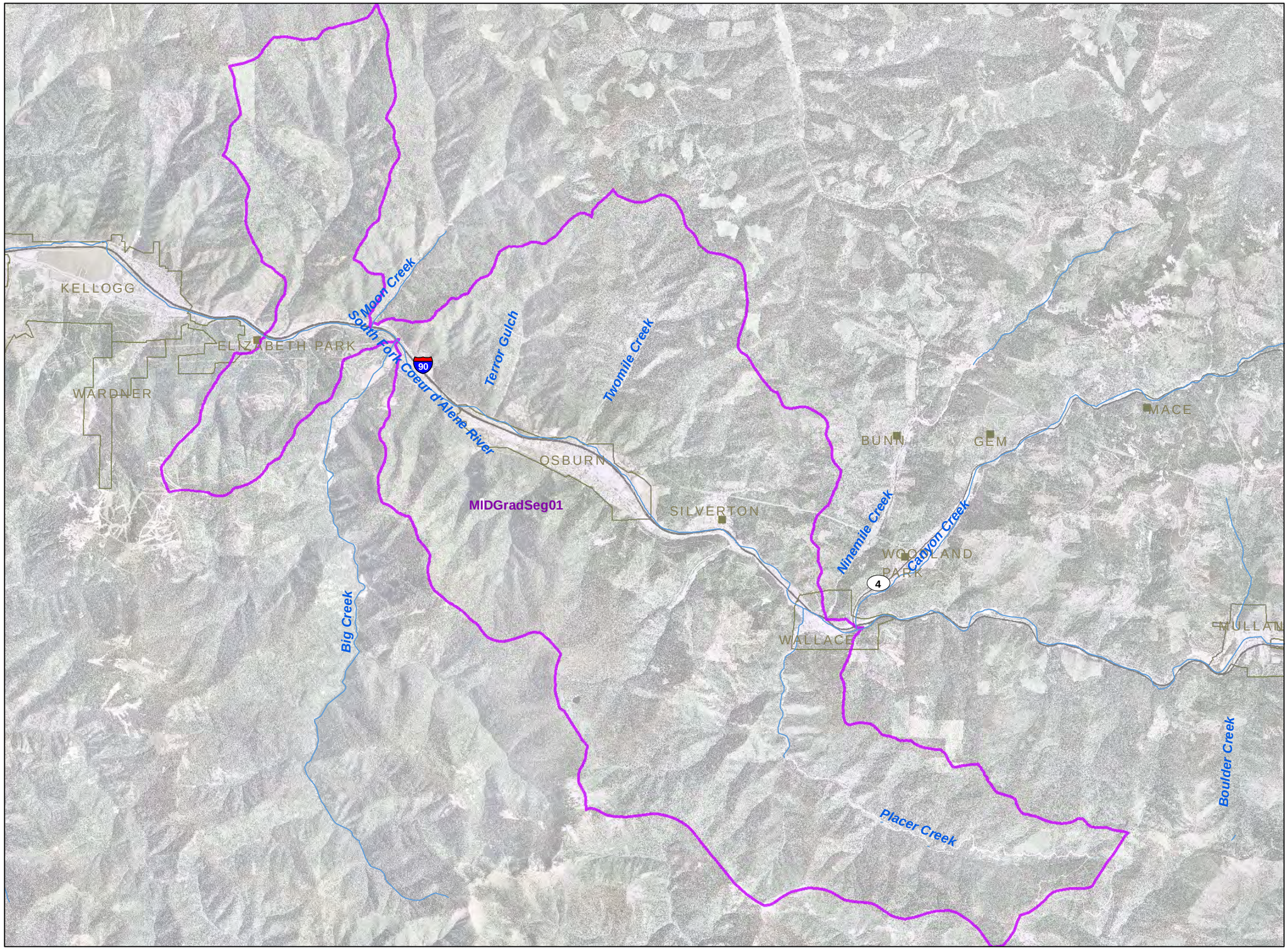
CH2M HILL. July 2010. *Draft Final Focused Feasibility Study Report, Upper Basin of the Coeur d'Alene River, Bunker Hill Mining and Metallurgical Complex Superfund Site*. Prepared for U.S. Environmental Protection Agency, Region 10.

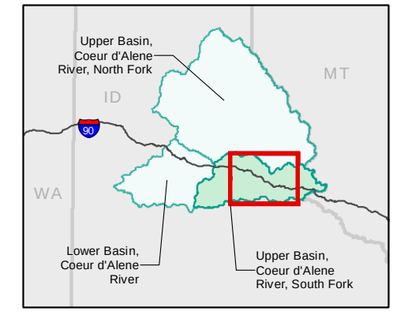
CH2M HILL. April 2012. *Technical Memorandum: Estimated Stream Flow Reductions Resulting from Groundwater Remedial Actions, Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site*. Prepared for U.S. Environmental Protection Agency, Region 10.

Hemker, C.J., and G.J. Nijsten. 2003. *Groundwater Flow Modeling Using MicroFEM©.*

U. S. Environmental Protection Agency (EPA). July 12, 2010. *Proposed Plan, Upper Basin of the Coeur d'Alene River, Bunker Hill Mining and Metallurgical Complex Superfund Site.*

Figures





French Drain
River/Creek
City Limit

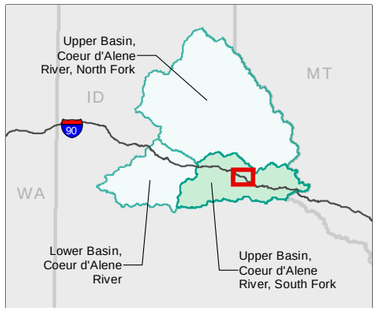
N
0 3,000 6,000 12,000 Feet

Source: NHDPlus (Rivers, Waterbodies); ESRI base data (Interstates 2006, Major Highways 2008); IDWR (Aerial Imagery 2006).

Figure 1
Revised Remedial Action for Mainstem SFCDR Watershed Segment 01
Application of SFCDR Model to Revised Remedial Action
BUNKER HILL SUPERFUND SITE

KHEIDEMAN 2/1/2011 09:42:45

EPA



Simulated Groundwater Flowpath
Simulated Groundwater Flow Direction
Gaining Stream Reach
River/Creek
City Limit

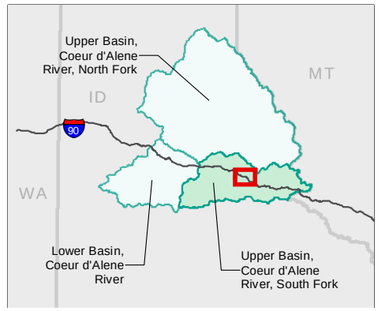
N
0 750 1,500 3,000 Feet

Source: NHDPlus (Rivers, Waterbodies); ESRI base data (Interstates 2006, Major Highways 2008); IDWR (Aerial Imagery 2006).

Figure 2
Simulated Upstream Groundwater Flowlines from the SFCDR, Mainstem SFCDR Watershed Segment 01, No Action, Baseflow Conditions
Application of SFCDR Model to Revised Remedial Action
BUNKER HILL SUPERFUND SITE

KHEIDEMAN 2/1/2011 09:42:45

EPA



- French Drain
- Simulated Groundwater Flowpath
- Simulated Groundwater Flow Direction
- Gaining Stream Reach
- River Creek
- City Limit

N

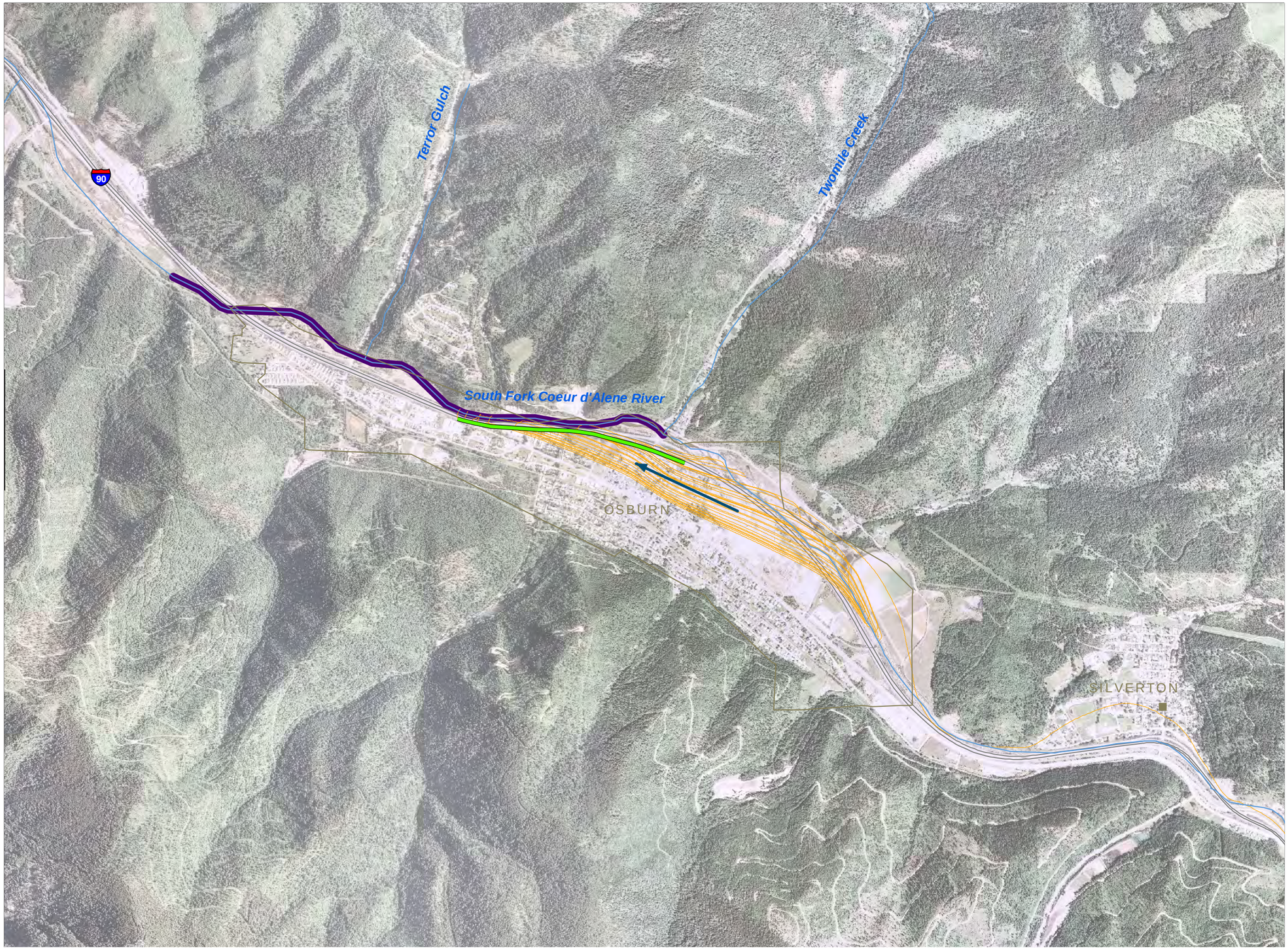
0 750 1,500 3,000 Feet

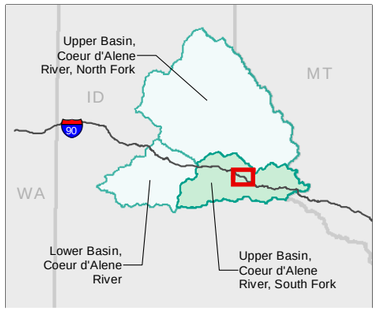
Source: NHDPlus (Rivers, Waterbodies); ESRI base data (Interstates 2006, Major Highways 2008); IDWR (Aerial Imagery 2006).

Figure 3
Simulated Upstream Groundwater Flowlines from the SFCDR, Mainstem SFCDR Watershed Segment 01, Revised Remedial Action, Baseflow Conditions
Application of SFCDR Model to Revised Remedial Action
BUNKER HILL SUPERFUND SITE

KHEIDEMAN 2/1/2011 09:42:45

EPA





French Drain
Simulated Groundwater Flowpath
Simulated Groundwater Flow Direction
Gaining Stream Reach
River/Creek
City Limit

N
0 750 1,500 3,000 Feet

Source: NHDPlus (Rivers, Waterbodies); ESRI base data (Interstates 2006, Major Highways 2008); IDWR (Aerial Imagery 2006).

Figure 4
Simulated Upstream Groundwater Flowlines from the French Drain, Mainstem SFCDR Watershed Segment 01, Revised Remedial Action, Baseflow Conditions
Application of SFCDR Model to Revised Remedial Action
BUNKER HILL SUPERFUND SITE

KHEIDEMAN 2/1/2011 09:42:45

EPA

Tables

TABLE 1

Model-Simulated Flows – Baseflow Conditions

Application of SFCDR Model to Revised Remedial Action, Mainstem SFCDR Watershed Segment 01

Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Simulation	Total SFCDR Gain (cfs)	Total SFCDR Loss (cfs)	French Drain Inflow (cfs)
Mainstem SFCDR Watershed Segment 01 - No Action	9.7	11.0	NA
Mainstem SFCDR Watershed Segment 01 - Previously Anticipated Components of Alternative 3+(d)	0.0	0.0	7.6
Mainstem SFCDR Watershed Segment 01 - Revised Remedial Action	6.1	15.0	8.9
Increase in French Drain Inflow			1.3

	Reduction in SFCDR Gain (cfs)	Increase in SFCDR Loss (cfs)	Net Stream Flow Reduction (cfs)
Comparison of Revised Remedial Action and No Action Scenarios	3.6	4.0	7.6

Notes:

cfs = cubic feet per second

NA = not applicable

SFCDR = South Fork Coeur d'Alene River

TABLE 2

Model-Simulated Flows – 7Q10 Flow Conditions

Application of SFCDR Model to Revised Remedial Action, Mainstem SFCDR Watershed Segment 01

Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Simulation	Total SFCDR Gain (cfs)	Total SFCDR Loss (cfs)	French Drain Inflow (cfs)
Mainstem SFCDR Watershed Segment 01 - No Action	9.0	11.5	NA
Mainstem SFCDR Watershed Segment 01 - Previously Anticipated Components of Alternative 3+(d)	0.0	0.0	6.3
Mainstem SFCDR Watershed Segment 01 - Revised Remedial Action	5.6	15.0	8.4
Increase in French Drain Inflow			2.1

	Reduction in SFCDR Gain (cfs)	Increase in SFCDR Loss (cfs)	Net Stream Flow Reduction (cfs)
Comparison of Revised Remedial Action and No Action Scenarios	3.4	3.5	6.9

Notes:

cfs = cubic feet per second

NA = not applicable

SFCDR = South Fork Coeur d'Alene River

TABLE 3

Model-Simulated Flows – 90th Percentile Flow Conditions

Application of SFCDR Model to Revised Remedial Action, Mainstem SFCDR Watershed Segment 01

Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Simulation	Total SFCDR Gain (cfs)	Total SFCDR Loss (cfs)	French Drain Inflow (cfs)
Mainstem SFCDR Watershed Segment 01 - No Action	9.8	12.3	NA
Mainstem SFCDR Watershed Segment 01 - Previously Anticipated Components of Alternative 3+(d)	0.0	0.0	8.0
Mainstem SFCDR Watershed Segment 01 - Revised Remedial Action	6.3	16.8	10.0
Increase in French Drain Inflow			2.0

	Reduction in SFCDR Gain (cfs)	Increase in SFCDR Loss (cfs)	Net Stream Flow Reduction (cfs)
Comparison of Revised Remedial Action and No Action Scenarios	3.5	4.5	8.0

Notes:

cfs = cubic feet per second

NA = not applicable

SFCDR = South Fork Coeur d'Alene River

TABLE 4

Model-Simulated Flows – Average Annual Flow Conditions

Application of SFCDR Model to Revised Remedial Action, Mainstem SFCDR Watershed Segment 01

Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Simulation	Total SFCDR Gain (cfs)	Total SFCDR Loss (cfs)	French Drain Inflow (cfs)
Mainstem SFCDR Watershed Segment 01 - No Action	10.0	10.0	NA
Mainstem SFCDR Watershed Segment 01 - Previously Anticipated Components of Alternative 3+(d)	0.0	0.0	8.0
Mainstem SFCDR Watershed Segment 01 - Revised Remedial Action	6.4	14.1	8.9
Increase in French Drain Inflow			0.9

	Reduction in SFCDR Gain (cfs)	Increase in SFCDR Loss (cfs)	Net Stream Flow Reduction (cfs)
Comparison of Revised Remedial Action and No Action Scenarios	3.6	4.1	7.7

Notes:

cfs = cubic feet per second

NA = not applicable

SFCDR = South Fork Coeur d'Alene River

TABLE 5
Simulated Dissolved Zinc Loading – Baseflow Conditions
Application of SFCDR Model to Revised Remedial Action, Mainstem SFCDR Watershed Segment 01
Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Simulation	Net Load to SFCDR[a] (lb/day)	Reduction in Load from No Action (lb/day)	Treatment Load (lb/day)
Mainstem SFCDR Watershed Segment 01 - No Action[b]	50	0	NA
Mainstem SFCDR Watershed Segment 01 - Previously Anticipated Components of Alternative 3+(d)[b]	0	50	74
Mainstem SFCDR Watershed Segment 01 - Revised Remedial Action[c]	-1	51	118
Increase in Treatment Load, Revised Remedial Action Assuming Variable Zinc Concentrations			44

Notes:

lb/day = pound(s) per day
NA = not applicable
SFCDR = South Fork Coeur d'Alene River

[a]Net load to the SFCDR is calculated as estimated load from gaining reaches minus estimated load from losing reaches of the SFCDR.

[b]Limited dissolved zinc data in groundwater are available for the majority of this reach (Wallace to Elizabeth Park). Load estimates were calculated assuming that the average dissolved zinc concentration in Osburn (the only area where groundwater data are available), 1.8 milligrams per liter (mg/L), applies to the entire reach.

[c]For the French drain system under the revised remedial action, analytical data from wells and piezometers nearest the French drain were assumed to be representative of drain inflow concentrations. It was assumed that the inflow to the eastern portion of the drain would have a dissolved zinc concentration of 3.2 mg/L (the concentration at well SF-OB-MW08 in 2008) and inflow to the western portion of the drain would have a dissolved zinc concentration of 1.5 mg/L (the concentration at piezometer SF-OB-PZ-19 in 2008). The resulting estimated concentration to the drain is a flow-weighted average and represents a more refined concentration estimate than was possible for the no-action and previously anticipated action scenarios due to lack of data outside the Osburn area.

TABLE 6

Simulated Dissolved Zinc Loading – 7Q10 Flow Conditions

Application of SFCDR Model to Revised Remedial Action, Mainstem SFCDR Watershed Segment 01

Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Simulation	Net Load to SFCDR[a] (lb/day)	Reduction in Load from No Action (lb/day)	Treatment Load (lb/day)
Mainstem SFCDR Watershed Segment 01 - No Action[b]	41	0	NA
Mainstem SFCDR Watershed Segment 01 - Previously Anticipated Components of Alternative 3+(d)[b]	0	41	61
Mainstem SFCDR Watershed Segment 01 - Revised Remedial Action[c]	-6	47	111
Increase in Treatment Load, Revised Remedial Action Assuming Variable Zinc Concentrations			50

Notes:

lb/day = pound(s) per day
NA = not applicable
SFCDR = South Fork Coeur d'Alene River

[a]Net load to the SFCDR is calculated as estimated load from gaining reaches minus estimated load from losing reaches of the SFCDR.

[b]Limited dissolved zinc data in groundwater are available for the majority of this reach (Wallace to Elizabeth Park). Load estimates were calculated assuming that the average dissolved zinc concentration in Osburn (the only area where groundwater data are available), 1.8 milligrams per liter (mg/L), applies to the entire reach.

[c]For the French drain system under the revised remedial action, analytical data from wells and piezometers nearest the French drain were assumed to be representative of drain inflow concentrations. It was assumed that the inflow to the eastern portion of the drain would have a dissolved zinc concentration of 3.2 mg/L (the concentration at well SF-OB-MW08 in 2008) and inflow to the western portion of the drain would have a dissolved zinc concentration of 1.5 mg/L (the concentration at piezometer SF-OB-PZ-19 in 2008). The resulting estimated concentration to the drain is a flow-weighted average and represents a more refined concentration estimate than was possible for the no-action and previously anticipated action scenarios due to lack of data outside the Osburn area.

TABLE 7
Simulated Dissolved Zinc Loading – 90th Percentile Flow Conditions
Application of SFCDR Model to Revised Remedial Action, Mainstem SFCDR Watershed Segment 01
Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Simulation	Net Load to SFCDR[a] (lb/day)	Reduction in Load from No Action (lb/day)	Treatment Load (lb/day)
Mainstem SFCDR Watershed Segment 01 - No Action[b]	45	0	NA
Mainstem SFCDR Watershed Segment 01 - Previously Anticipated Components of Alternative 3+(d)[b]	0	45	77
Mainstem SFCDR Watershed Segment 01 - Revised Remedial Action[c]	-7	52	134
Increase in Treatment Load, Revised Remedial Action Assuming Variable Zinc Concentrations			57

Notes:

lb/day = pound(s) per day
NA = not applicable
SFCDR = South Fork Coeur d'Alene River

[a]Net load to the SFCDR is calculated as estimated load from gaining reaches minus estimated load from losing reaches of the SFCDR.

[b]Limited dissolved zinc data in groundwater are available for the majority of this reach (Wallace to Elizabeth Park). Load estimates were calculated assuming that the average dissolved zinc concentration in Osburn (the only area where groundwater data are available), 1.8 milligrams per liter (mg/L), applies to the entire reach.

[c]For the French drain system under the revised remedial action, analytical data from wells and piezometers nearest the French drain were assumed to be representative of drain inflow concentrations. It was assumed that the inflow to the eastern portion of the drain would have a dissolved zinc concentration of 3.2 mg/L (the concentration at well SF-OB-MW08 in 2008) and inflow to the western portion of the drain would have a dissolved zinc concentration of 1.5 mg/L (the concentration at piezometer SF-OB-PZ-19 in 2008). The resulting estimated concentration to the drain is a flow-weighted average and represents a more refined concentration estimate than was possible for the no-action and previously anticipated action scenarios due to lack of data outside the Osburn area.

TABLE 8

Simulated Dissolved Zinc Loading – Average Annual Flow Conditions

Application of SFCDR Model to Revised Remedial Action, Mainstem SFCDR Watershed Segment 01

Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Simulation	Net Load to SFCDR[a] (lb/day)	Reduction in Load from No Action (lb/day)	Treatment Load (lb/day)
Mainstem SFCDR Watershed Segment 01 - No Action[b]	57	0	NA
Mainstem SFCDR Watershed Segment 01 - Previously Anticipated Components of Alternative 3+(d)[b]	0	57	77
Mainstem SFCDR Watershed Segment 01 - Revised Remedial Action[c]	5	52	118
Increase in Treatment Load, Revised Remedial Action Assuming Variable Zinc Concentrations			41

Notes:

lb/day = pound(s) per day
NA = not applicable
SFCDR = South Fork Coeur d'Alene River

[a]Net load to the SFCDR is calculated as estimated load from gaining reaches minus estimated load from losing reaches of the SFCDR.

[b]Limited dissolved zinc data in groundwater are available for the majority of this reach (Wallace to Elizabeth Park). Load estimates were calculated assuming that the average dissolved zinc concentration in Osburn (the only area where groundwater data are available), 1.8 milligrams per liter (mg/L), applies to the entire reach.

[c]For the French drain system under the revised remedial action, analytical data from wells and piezometers nearest the French drain were assumed to be representative of drain inflow concentrations. It was assumed that the inflow to the eastern portion of the drain would have a dissolved zinc concentration of 3.2 mg/L (the concentration at well SF-OB-MW08 in 2008) and inflow to the western portion of the drain would have a dissolved zinc concentration of 1.5 mg/L (the concentration at piezometer SF-OB-PZ-19 in 2008). The resulting estimated concentration to the drain is a flow-weighted average and represents a more refined concentration estimate than was possible for the no-action and previously anticipated action scenarios due to lack of data outside the Osburn area.

TABLE 9

Cost Comparison - Previously Anticipated Remedial Actions and Revised Remedial Action

Application of SFCDR Model to Revised Remedial Action, Mainstem SFCDR Watershed Segment 01

Upper Basin of the Coeur d'Alene River, Bunker Hill Superfund Site

Simulation	Total Capital Costs	Annual O&M Costs	Total 30-year NPV Costs
Mainstem SFCDR Watershed Segment 01 - Previously Anticipated Remedial Actions	$351,000,000	$8,720,000	$360,000,000
Mainstem SFCDR Watershed Segment 01 - Revised Remedial Action	$13,700,000	$4,680,000	$18,400,000
Net Cost Reduction with Revised Remedial Action	**$ 337,300,000**	**$ 4,040,000**	**$ 341,600,000**

Notes:

NPV = net present value

O&M = operations and maintenance

SFCDR = South Fork Coeur d'Alene River